Application of SPiCT to produce MSY advice for *Nephrops* Functional Unit 31

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INTRODUCTION

Nephrops Functional Unit (FU) 31 (Cantabrian Sea) extends between 6°W and 2°W along the coast of the North of Spain (ICES Division 8c, Figure 1). The species is mostly a by catch of the bottom trawl fleet that targets hake, megrim and monkfish in the area. The exploitation of the FU 31 stock affects the conservation of the large size individuals, which are the most efficient in terms of reproduction. FU 31 *Nephrops* catch has decreased a 98% between 1989 and 2016 (ICES, 2020) and there has also been a contraction of the stock area of 49%. A continuous increase in *Nephrops* mean size since 1983 to 2008 could point out failures in recruitment (ICES, 2020). In the SP-NSGFS Spanish scientific bottom trawl survey *Nephrops* index in the area there are a decreasing trend since 1988 to 2010. ICES advice for this stock has been reducing catch to zero since 2002 (ICES, 2019). The present status of the stock is undesirable (ICES, 2016) and it is considered a stock with an extremely low biomass (ICES, 2017). In 2017 there was established a TAC (total allowable catch) zero for *Nephrops* in division 8c for the triennium 2017-2019 (EU, 2017) and again in 2019 for the period 2020 to 2022 (ICES, 2019).

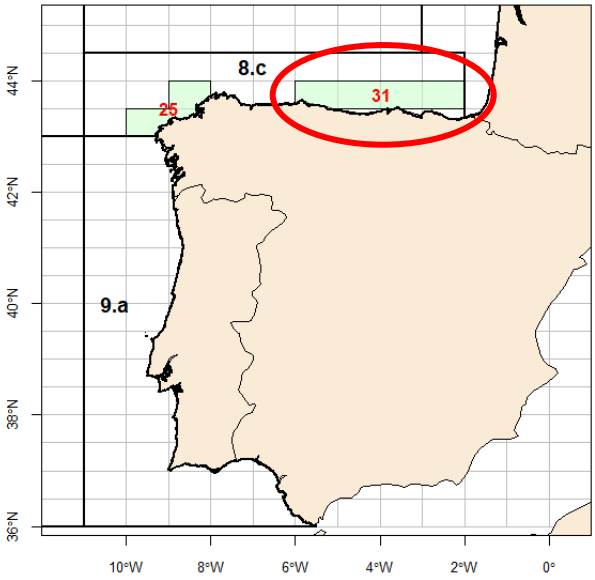

Figure 1 *Nephrops* functional units in Division 8.c. FU 31 covers statistical rectangles 16E4-E7.

In the first part of the 2000 decade the assessment of the stock was analytical using the age-based model XSA (ICES, 2002). Later, in view of the very low levels of landings, the assessment was based in the analysis of the trends of catch per unit effort (CPUE) and catch series (ICES, 2003). The necessity of establishing reference points of the stock in relation with the maximum sustainable yield (MSY) has encouraged the use of new assessment methods for data limited stocks (DLS) as FU 31 *Nephrops* (ICES, 2020b). In that sense ICES planned a workshop about SPiCT in February 2021 (WKMSYSPiCT). Stochastic surplus Production model In Continuous Time (SPiCT) separates random variability of stock dynamics from error in observed indices of biomass and also models the dynamics of the fisheries. This enables error in the catch process

to be reflected in the uncertainty of estimated model parameters and management quantities. Among data limited methods (DLM), SPiCT could be a suitable tool for the analysis of FU 31 *Nephrops* stock since the stock meets the model assumptions and the model takes into account the long history of the fishery. In 2020 there were two WKMSYSPiCT preparatory meetings. This document shows the status of the appliance of SPiCT to FU 31 *Nephrops* stock after that previous work carried out before WKMSYSPiCT.

MATERIAL AND METHODS

In the WKMSYSPiCT preparatory meetings there was a review of the input data quality and the level of progress in the appliance of SPiCT for each of a list of identified data-poor stocks. There were concrete recommendations for each stock to address problems or improve the appliance of the model.

RESULTS

Data Quality

Catch

Data were collected since 1983 by month. Data were provided by ports authorities and crossed with the information provided by scientific personnel in the ports of landing (Table 1, Figure 2).

Table 1 FU 31 *Nephrops* catches series (t) (1983-2019).

Males + Females	FU 31 catches (t)
1983	63
1984	100
1985	128
1986	127
1987	118
1988	151
1989	177
1990	174
1991	109
1992	94
1993	101
1994	148
1995	94
1996	129
1997	98
1998	72
1999	48
2000	34
2001	27
2002	26
2003	35

2004	29
2005	48
2006	37
2007	32
2008	20
2009	10
2010	9
2011	7
2012	10
2013	10
2014	4
2015	3
2016	3
2017	0
2018	3
2019	6

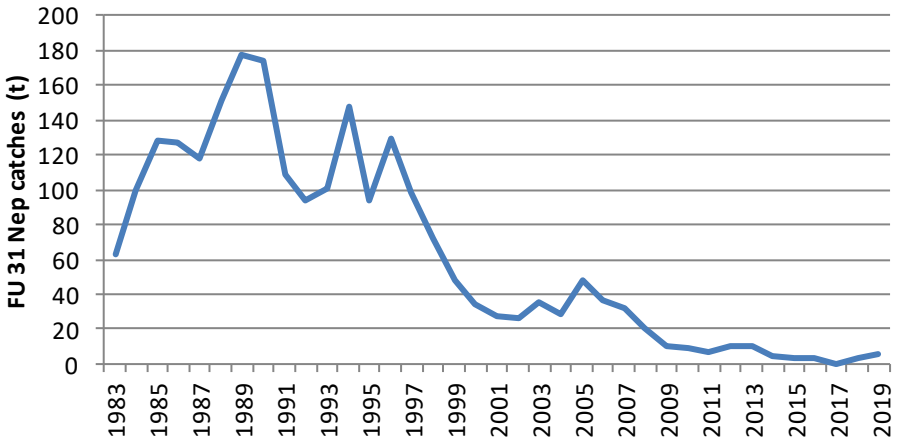

Figure 2 FU 31 *Nephrops* catches series (t) 1983-2019.

Abundance index:

In the case of FU 31 *Nephrops* there was recommended to use preferably as abundance index the Spanish bottom trawl scientific survey (SP-NSGFS) *Nephrops* yield index (Table 2, Figure 3).

Table 2 FU 31 SP-NSGFS survey *Nephrops* index (g/haul) (1983-2019). There was not survey in 1987. Smaller vessel and smaller gear in 1989. New vessel since 2013.

Males + Females	FU 31 *Nephrops* index (g/haul)
1983	97
1984	247
1985	319
1986	371
1987	No survey

1988	729
1989	105
1990	217
1991	178
1992	311
1993	245
1994	99
1995	124
1996	43
1997	104
1998	70
1999	82
2000	84
2001	107
2002	81
2003	108
2004	130
2005	86
2006	60
2007	79
2008	47
2009	39
2010	22
2011	65
2012	74
2013	103
2014	118
2015	176
2016	59
2017	50
2018	79
2019	55

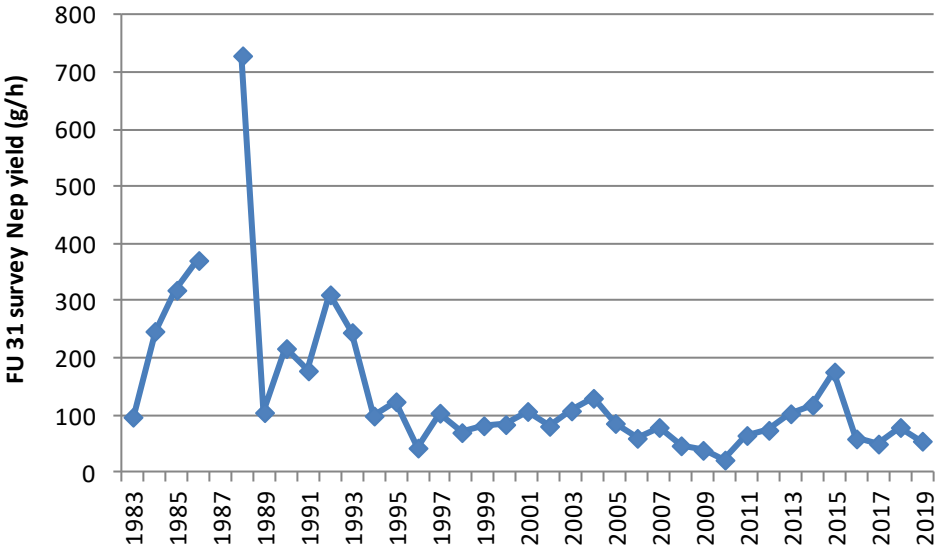

Figure 3 FU 31 SP-NSGFS Survey *Nephrops* index (g/haul) 1983-2019. There was not survey in 1987. Smaller vessel and smaller gear in 1989. New vessel since 2013.

Some issues were raised in 2020 November preparatory meeting in order to check the reliability of the index.

- The 1988 value was checked in the raw data and it was right, corresponds to hauls with very high *Nephrops* catch.

- The number and distribution of the hauls along the survey period have been similar (Figure 4 and Figs. 12.1.5-6abcd of 2020 ICES WGBIE report). Respect to the time of day of the hauls, the hauls in this survey have always been carried out during the daytime, never at nighttime.

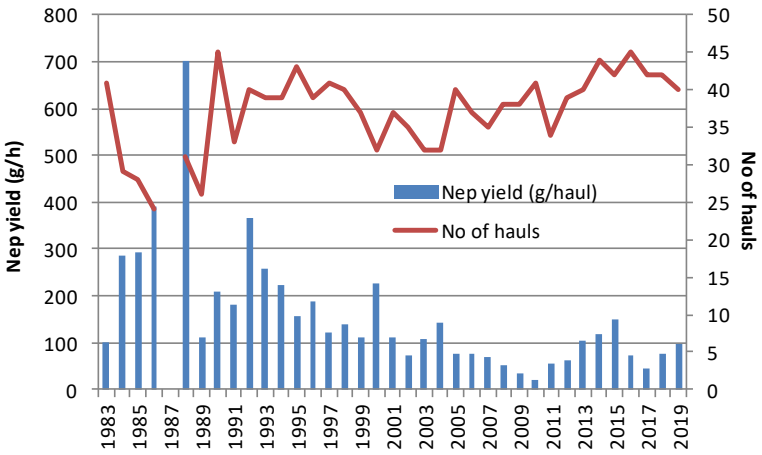

Figure 4 FU 31 SP-NSGFS Survey *Nephrops* index (g/haul) 1983-2019. There was no survey in 1987. In 1989 a smaller vessel and smaller gear were used. New vessel since 2013.

SPiCT model

Survey and fishery *Nephrops* mean sizes:

Frequently the mean size of the individuals collected in a scientific survey is smaller than the mean size from the commercial fleet. In that cases trends observed in the scientific survey data could be reflected in the commercial catch one or two years later. The comparison of the survey and commercial mean sizes series of the FU 31 (Figure 5) shows that in this case it is preferable to lag the survey series 1 year for the appliance of the model.

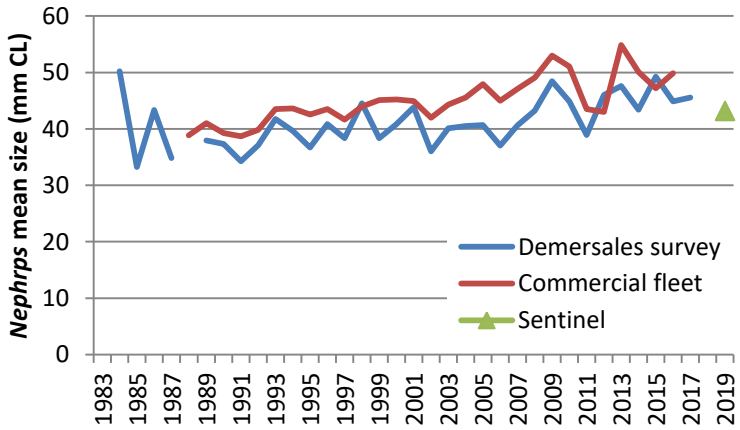

Figure 5 FU 31 *Nephrops* mean size (carapace length in mm) from the commercial fishery + 0 years, the Sentinel fishery + 0 years and the SP-NSGFS bottom trawl survey + 1 year, 1983-2019.

Appliance of the model

Before WKMSYSPiCT, trial runs with males and females data together and quarter and monthly males data (whole series and part of the series) were done. *Nephrops* total allowable catch (TAC) in this area is established by ICES division, 8c, which contains Functional Units 31 and FU 25. For the sake of simplicity, it was decided to carry out the simplest model, annual males and females data together.

The option of using the last part of the time series was rejected because does not take into account the oldest levels of reference and history of the stock (catch decreased a 98% from 1989 to 2016 and the stock area has decreased a 49% between 1983 and 2020).

For better numerical stability the index was scaled to mean 1.

```
> mstd<-function(x) x/mean(x,na.rm=TRUE)

> data$DEM = mstd(data$DEM)
```

The interval for the results was 12 in order to have monthly information.

```
> inp$dteuler=1/12
```

A prior for a medium stock depletion level before the beginning of the available data was used.

```
inp$priors$logbkfrac <- c(log(0.5), 1, 1)
```

Other priors were use in order to decrease the confidence intervals of the results.

```
> inp$priors$logalpha <- c(0,0,0)

> inp$priors$logbeta <- c(0,0,0)

> inp$priors$logsdf <- c(log(3), 0.5, 1)

> inp$priors$logsdc <- c(log(0.1), 0.2, 1)

> inp$priors$logn <- c(log(2),0.5,1)

> inp$stdevfacI <- list(c(rep(2, 12), rep(1, length(inp$timeI[[1]]) - 12)))
```

Model results

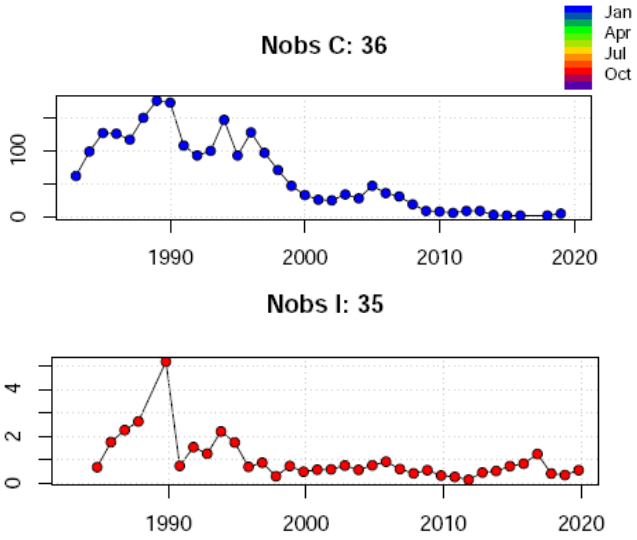

Figure 6 FU 31 *Nephrops* stock. SPiCT model input data. Above: catch, below: index.

The most important outputs of the model are shown in Table 3 and Figure 7.

FU31 biomass in the year 2019 was the 32% of the biomass at maximum sustainable yield (MSY). FU31 fishing mortality in 2019 was a 62% below the fishing mortality at MSY (Table 3).

Table 3 Results of the appliance of SPiCT to FU 31 *Nephrops* stock.

K	3 243 t
$Bmsy_s$	1 596 t
$Fmsy_s$	0.021
MSY_s	34 t
B_{2019}/B_{msy}	0.32
F_{2019}/F_{msy}	0.62

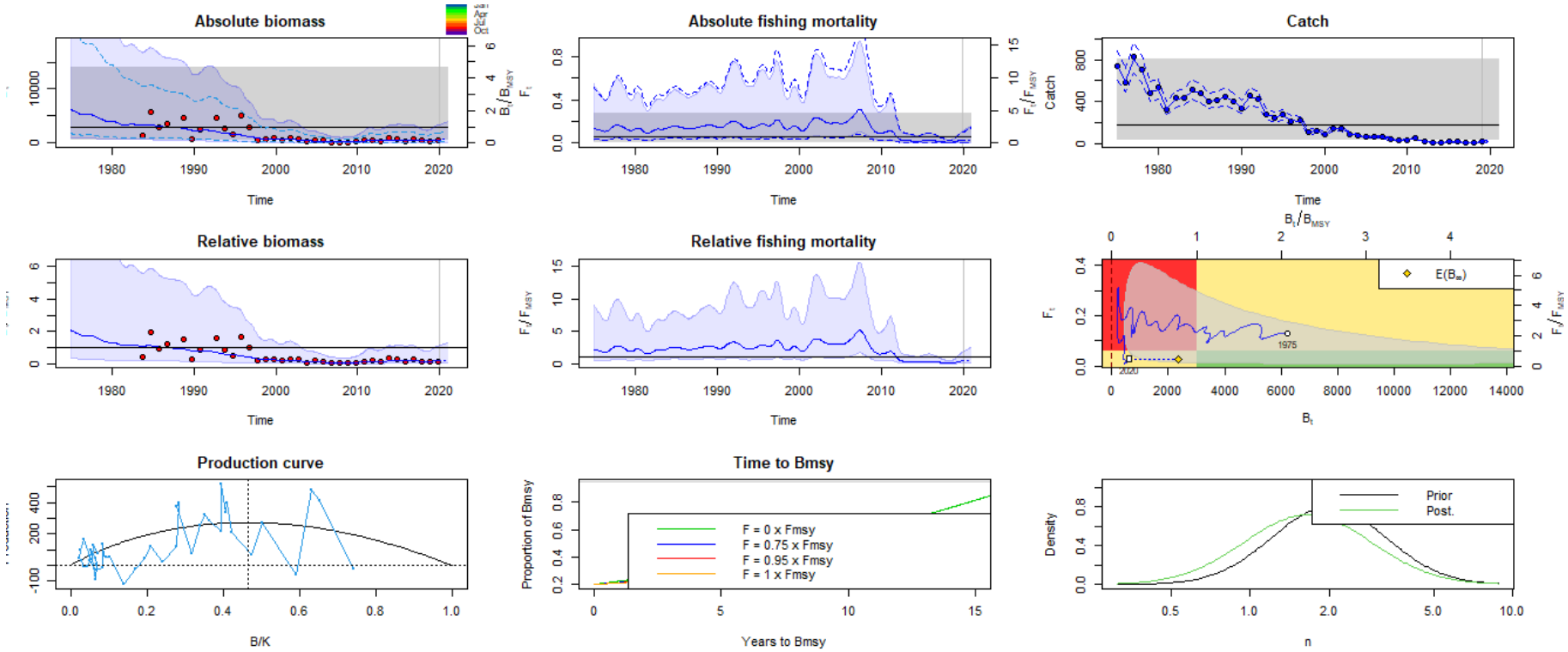

Figure 7 FU 31 *Nephrops* stock. SPiCT model results.

The checklist for the acceptance of the SPiCT assessment is shown in Table 4:

- The model converges,
- the variance of all the model parameters is finite,
- there is not violation of the model assumptions (Figure 8),
- there are consistent patterns in the retrospective analysis (Figure 9),
- the production curve is not skewed,
- the sensitivity to initial parameters is low and
- the main variance parameters is not unrealistically high.

Table 4 Checklist of the model.

Convergence	Yes (0)
Parameters variance finite	TRUE
Model assumptions meet (Diagnosis)	Yes (Figure 8)
Retrospective match	Yes (Figure 9)
Production curve skewed	No (0.49)
Sensitivity to initial values	NULL
Uncertainty B_{2019}/B_{msy} CI range order magnitude	Acceptable (2)
Uncertainty F_{2019}/F_{msy} CI range order magnitude	Ok (1)

CONCLUSION

The results of the SPiCT analysis are coincident with what is considered the status of the FU 31 stock (ICES, 2016, 2017).

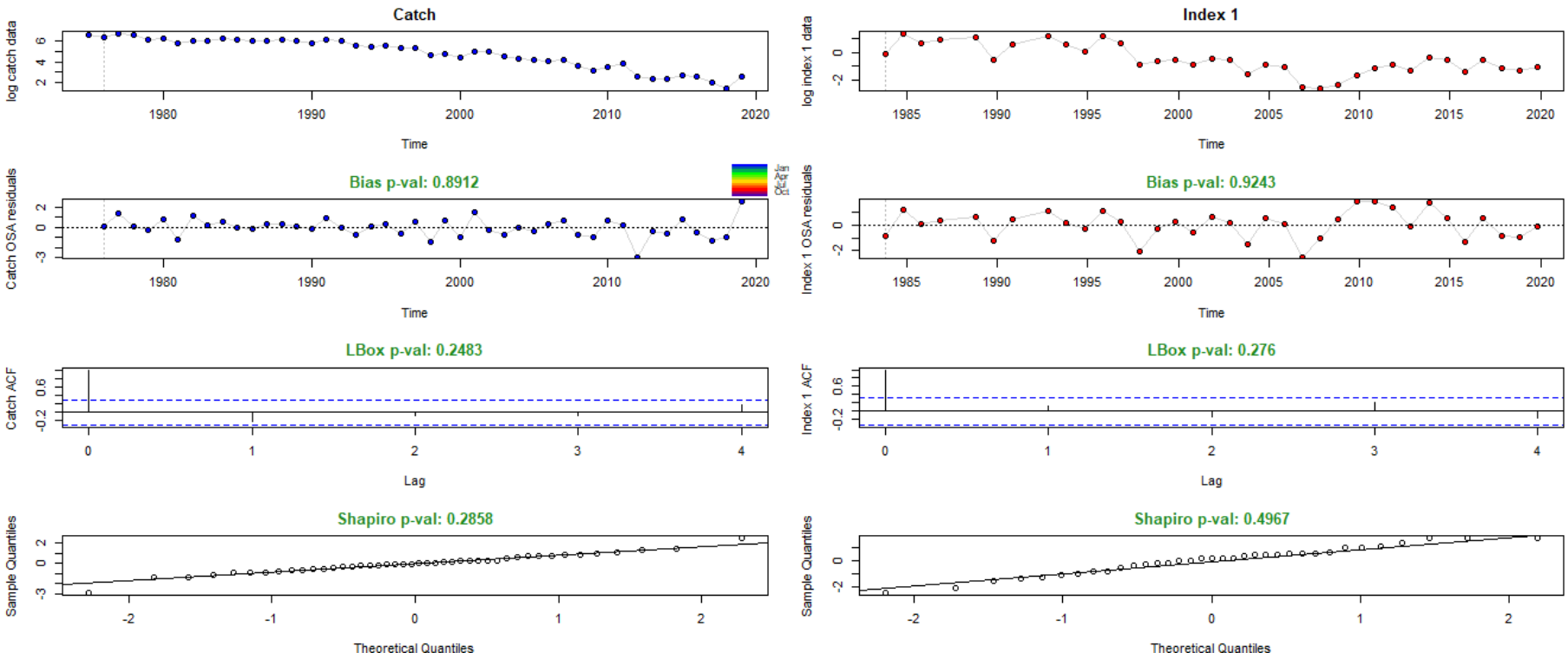

Figure 8 FU 31 *Nephrops* stock. Diagnostics.

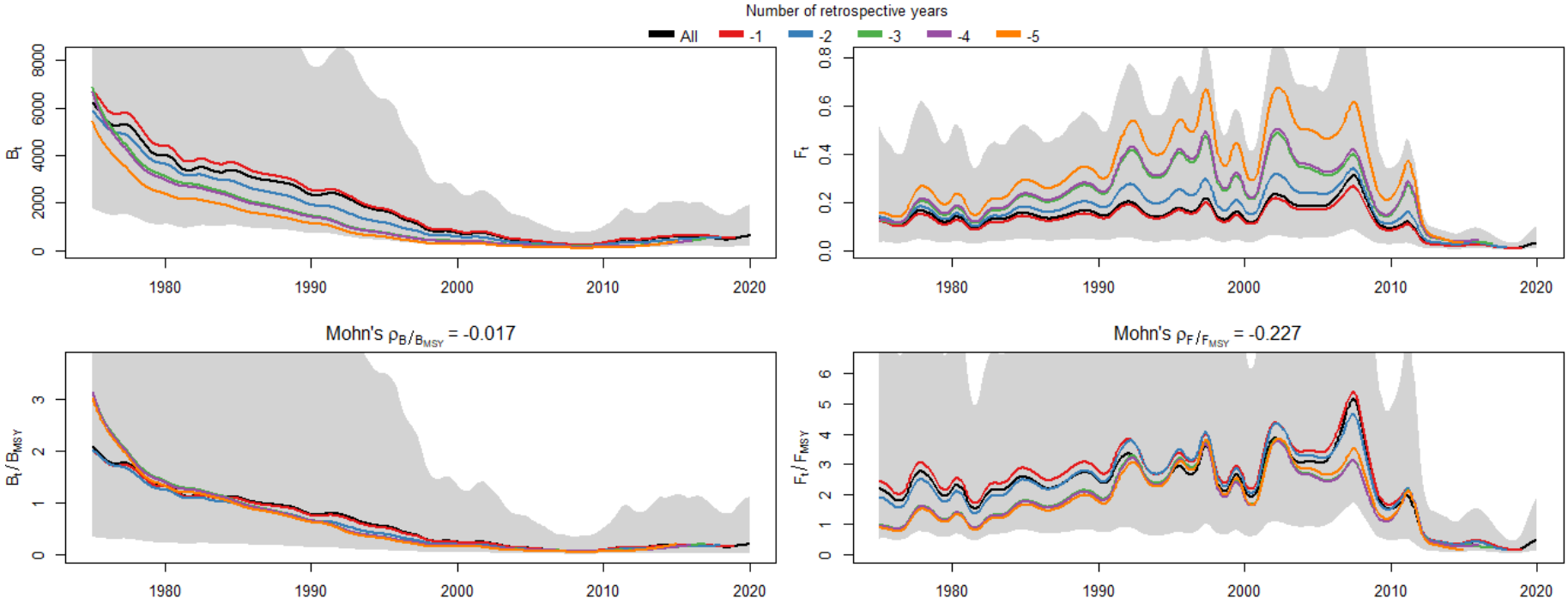

Figure 9 FU 31 *Nephrops* stock. Retrospective analysis.

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