

Information and data for the application of SPiCT to produce MSY advice for *Nephrops* Stock in FU 26-27 (Western Galicia and Northern Portugal)

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INTRODUCTION

Nephrops stocks in FU26 and FU27 in Division 9a are assessed together and they are considered as data limited stock category 3.1.4. (ICES, 2012). Catches and LPUE have fluctuated along a marked downward trend and are currently very low, indicating that the stock is at a very low abundance. The SP-MATR commercial index (Marin bottom trawl fleet) is used as the index of stock development which is below possible reference points. Last advice was given in 2019 and it is valid for three years. ICES advises when the precautionary approach is applied, there should be zero catch in each of the years 2020, 2021 and 2022 (ICES, 2019), This working document compile the information about the fishery, management regulation and historical assessment, as well as data available for *Nephrops* stocks in FU26-27 for the application of the Stochastic Production model in Continuous Time (SPiCT) to produce MSY advice. The SPiCT work in progress is also included.

STOCK DEFINITION

The Norway lobster (*Nephrops norvegicus*) is distributed along the continental slope off the west Galicia and north of Portugal at depths ranging from 90–500 m (Fariñas, 1996). The *Nephrops* stock in FU 26 and FU 27 are included within the ICES Division 9a. FU 26 extends along the Atlantic area off the northwestern Spanish coast, south of Cape Finisterre (statistical rectangles 14E0, 13E0, 13E1), whereas FU 27 covers the Atlantic area off northern Portugal (statistical rectangles 6E0 - 12E0) (Figure 1). Although FUs 26 and 27 are different stocks, landings records are not differentiated prior 1996 and they are assessed together.

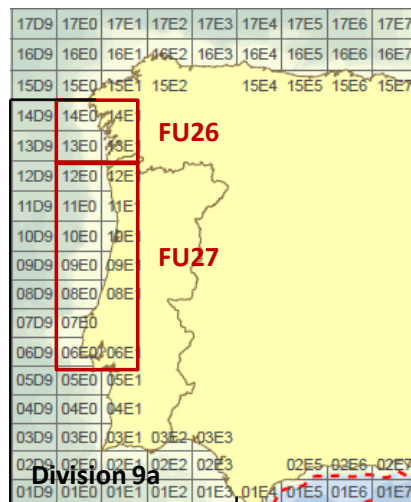


Figure 1. ICES Division 9a. Red square indicates FU26 (Western Galicia) and FU27 (Northern Portugal).

FISHERY AND MANAGEMENT REGULATION

Nephrops is caught in a mixed bottom-trawl fishery by the métier OTB_DEF_>=55_0_0 targeting different species such as hake, anglerfish, megrim, horse mackerel, mackerel and a variety of other fish and cephalopods. *Nephrops* represents a minor percentage in the composition of total trawl landings and can be considered as by-catch although it is a very valuable species. The *Nephrops* fishery takes place throughout the year, with the highest landings usually being made in the spring and summer.

Landings in these FUs are reported by Spain and minor quantities by Portugal. The catches are taken by the Spanish fleets fishing on the West Galicia (FU 26) and North Portugal (FU 27) fishing grounds and by the Portuguese artisanal fleet fishing with traps in FU 27.

Nephrops is managed in the area by an annual TAC (applying to the whole of ICES Division 9a, of which no more than 6 % may be taken in FUs 26 and 27) and technical measures. European Union regulations establish 20 mm carapace length (CL) as a minimum landing size. Few animals are caught under size, so discards are considered negligible and are mainly related to quality (broken or soft shells).

A Recovery Plan for the southern hake and Iberian *Nephrops* stocks was in force since the end of January 2006 (Council Regulation (EC) No. 2166/2005). The aim of the recovery plan was to rebuild the stocks within 10 years, with a reduction of 10% in F relative to the previous year and the TAC set accordingly. Although no clear targets were defined for Norway lobster stocks in the plan, the same 10% reduction was applied to these stocks effort and TAC. The number of allowed fishing days is set in each year regulations. ICES had not evaluated the recovery plan for *Nephrops* in relation to the precautionary approach. This plan was based on precautionary reference points for southern hake that are no longer appropriate.

In order to reduce F on *Nephrops* stocks in this Division even further, a seasonal ban was introduced in the trawl and creel fishery for two boxes, located in FU 26 and 28, in the peak of the *Nephrops* fishing season. These boxes are closed for *Nephrops* fishing in June–August and in May–August, respectively (Council Regulation (EC) No 850/98).

A Fishing Plan for the Northwest Cantabrian ground was established in 2013 (AAA/1307/2013, BOE, 2013) and modified in 2014 (AAA/417/2014, BOE, 2014). These regulations establish a quota assignment system for several stocks (including *Nephrops*) by vessel.

A new Management Plan for Western Waters was established in 2019 for demersal species including *Nephrops* in these FUs (Regulation (EU) 2019/472, of 19 March 2019). In the current Management Plan for Western Waters, applied to 2020 onwards, no effort limitations were established.

Unwanted catches from *Nephrops* are legislated by the discard plan for demersal fisheries in South-Western waters for the period 2019-2021 (Council Regulation (EC) No 2018/2033), under which they are exempted from the landing obligation based on the species' high survival rates. This exemption applies to all catches of Norway lobster from ICES subareas 8 and 9 with bottom trawls, and the discards shall be released whole, immediately and in the area where they were caught.

HISTORICAL STOCK ASSESSMENT

The species had been assessed since 1990 (ICES, 1990). The last analytical assessment for these FUs was carried out by the WGHMM in 2006 (ICES, 2006). XSA was used with “catch-at age” data generated by slicing length distributions employing the L2AGE program. An assessment with combined sexes was carried out, although the slicing was applied for each sex separately and the resulting catch-at-age matrices by sex added up for the assessment. Prior to 2005 an assessment by sex was carried out but the WG proposed to carry out an assessment for both sexes combined, considering the advantages for management.

The 2006 assessment was calibrated using data from a single commercial LPUE series, where the definition of fishing effort was based on nominal effort. The results were accepted only as indicative of stock trends and not used for projections.

After 2006, no improvements in relation to a methodological assessment were achieved and the WG did not attempt any further analytical assessment for this stock. The time-series of fisheries data are updated every year and LPUE series used to depict the stock trends.

Since 2012, the advice for this stock was based on fishery SP-MART LPUE and effort trend, according to the ICES data-limited approach (ICES, 2012). This stock is classified according to Data Limited Stocks (DSL) category 3.1.4.: stocks with extremely low biomass.

DATA AVAILABLE

Table below shows the available data for *Nephrops* stock in FU26-27:

Data	Season	SP_FU26-27		PT_FU27	
Landings	By year	1975-2019		1984-2019	
	By quarter	1984-2019		Not available	
Effort	By year	SP-MATR	1994-2019		
	By quarter		1994-2019		
LPUE	By year	SP-MATR	1994-2019		
	By quarter		1994-2019		
Discards		Negligible			
Survey	October	SP-NSGFS-Q4 IBTS in FU26	1983-2019	PtGFS- WIBTS-Q4 in FU27	1985-2018
	August	GALNEP26 in FU26	2019-2020		
Length	By year and by sex	1988-2019			

Landings

Spanish landings are based on sales notes which are compiled and standardized by IEO. Since 2013, trips from sales notes are also combined with their respective logbooks, which allow geo-referencing the catches. Since 2013, the Spanish concurrent sampling is used to raise the FU26- 27 observed landings to total effort by métier.

Annual landings data by FU and country during the period 1977-2019 are shown in Table 1. Additionally, quarterly landings information in FU26 and FU27 by the Spanish fleet is also available. Landings show an overall decreasing trend during the time series. Since 1990 onwards there has been a marked downward trend in landings, being below 50 t from 2005 to 2011 and below 10 t in 2012. Landings were minimal since that date (mean value 4 t).

Discards

Discards are considered negligible. Few animals are caught under the minimum size being the discard related to quality (i.e. broken or soft shells).

Table 1. *Nephrops* landings by FU and country.

Year	Spain		Portugal	Total
	FU 26**	FU 27	FU 27	FU 26-27
1975	622			622
1976	603			603
1977	620			620
1978	575			575
1979	580			580
1980	599			599
1981	823			823
1982	736			736
1983	786			786
1984	604		14	618
1985	750		15	765
1986	657		37	694
1987	671		71	742
1988	631		96	727
1989	620		88	708
1990	401		48	449
1991	549		54	603
1992	584		52	636
1993	472		50	522
1994	426		22	448
1995	501		10	511
1996	264	50	17	331
1997	359	68	6	433
1998	295	42	8	345
1999	194	48	6	248
2000	102	21	9	132
2001	105	21	6	132
2002	59	24	4	87
2003	39	26	8	73
2004	38	24	9	71
2005	16	16	11	43
2006	15	17	12	44
2007	20	17	10	47
2008	17	12	13	42
2009	16	5	10	31
2010	3	14	4	21
2011	8	8	4	20
2012	3	4	1	8
2013	1	<1	1	3
2014	1	<1	1	4
2015	<1	<1	<1	2
2016	3	<1	2	5
2017	<1	0	2	3
2018	<1	1	0	2
2019	1	1	4	6

**Prior 1996, landings of Spain recorded in FU26 include catches in FU27

Effort and LPUE

Effort and LPUE of Spanish Marin port (SP-MATR) data are available for 1994-2019 period. The overall trend for both time series is decreasing (Figure 2). Fishing effort remained stable at very low level since 2010 (mean value 447 Kg/trip). LPUE series shows the same, so the commercial index was very low since 2012 and lower than 1 Kg/trip since 2014, indicating that the abundance of these FUs is very poor.

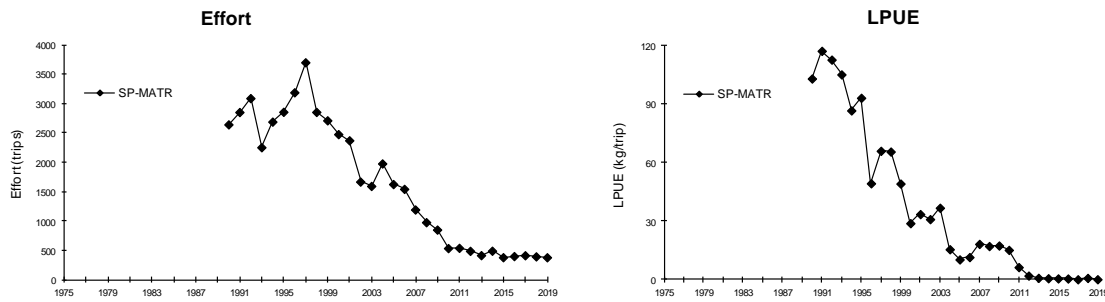


Figure 2. Fishing effort and LPUE from the bottom trawl fleet from Marin (SP-MATR).

Length frequency

Length composition of *Nephrops* in FU26-27 by sex is available for the period 1988-2019 (ICES, 2020).

Surveys

The **SP-NSGFS-Q4 IBTS** covers the northern Spanish shelf comprised in ICES Division 8c and the northern part of 9a, including the Cantabrian Sea and off Galicia waters. It is a bottom trawl survey with a random stratified by depth strata sampling design and extends from 30 to 800 m depths. This survey is not designed to estimate *Nephrops* abundance but it can be used for an analysis of the trend. Survey index is expressed as the mean catch per haul using hauls included in ICES statistical rectangles in FU26 (14E0, 13E0, 13E1). This survey usually starts at the end of the 3rd quarter (September) and finished in the 4th quarter. Figure 3 shows the biomass obtained in SP-NSGFS-Q4 IBTS from 1984 to 2019 and Figure 4 shows the spatial abundance distribution for the survey in FU26 for some years.

The **GALNEP26** is a survey promoted by Marin Fishing Industry (OPROMAR, Productores de Pesca Fresca del Puerto y la Ría de Marín) in 2019 and carried out yearly in August, onboard a commercial vessel in order to estimate *Nephrops* abundance index in FU 26 (Vila et al., 2020) An observer was onboard during the survey and it was supervised by the IEO. This time series is very short to use as input in the SPiCT model.

The **PtGFS-WIBTS-Q4** is carried out in Division 9a covering the Portuguese continental waters from 20 to 500 m of depth. Abundance index is available from 1989 to 2018. The main objective of the survey is to estimate the abundance of the most important commercial species in the Portuguese trawl fishery but it is not specifically designed to estimate the *Nephrops* abundance. It is conducted in autumn (October). *Nephrops* survey index is expressed as the mean catch per haul using hauls included in ICES statistical rectangles in FU27 (6E0 - 12E0). *Nephrops* biomass spatial distribution for the time series is show in Figure 5.

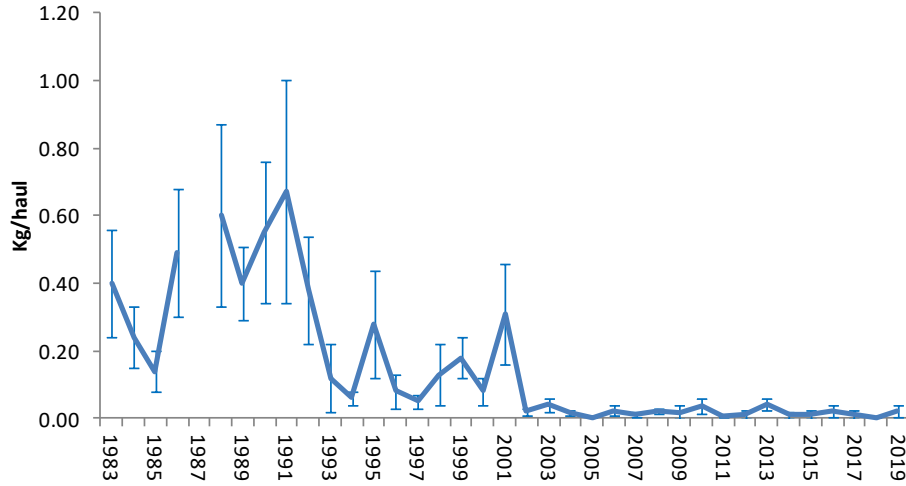


Figure 3. *Nephrops* biomass index in FU26 from Spanish bottom trawl survey (SP-NSGFS-Q4 IBTS) for 1983-2019 period.

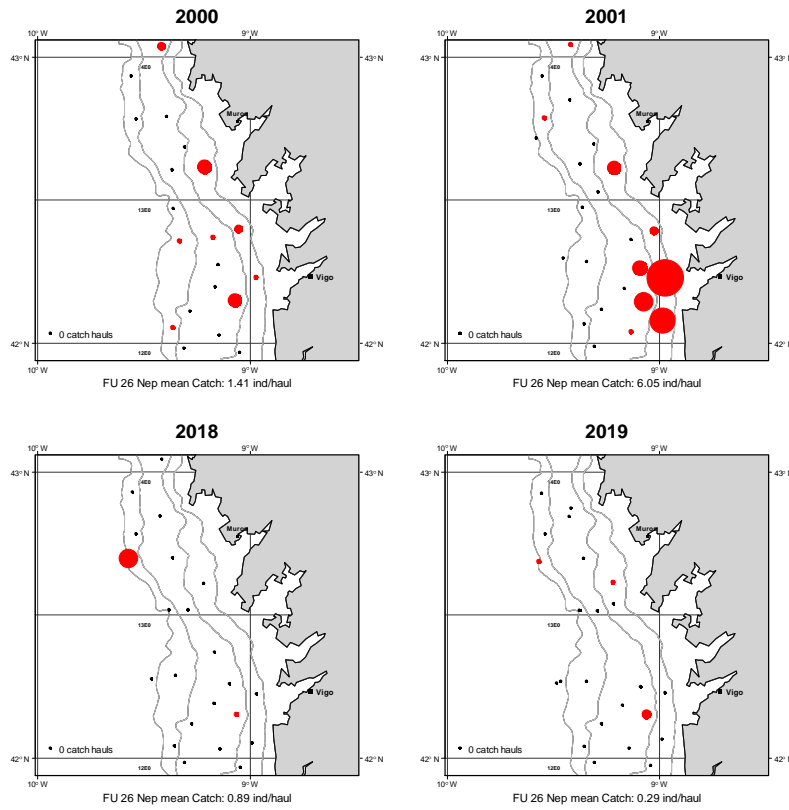
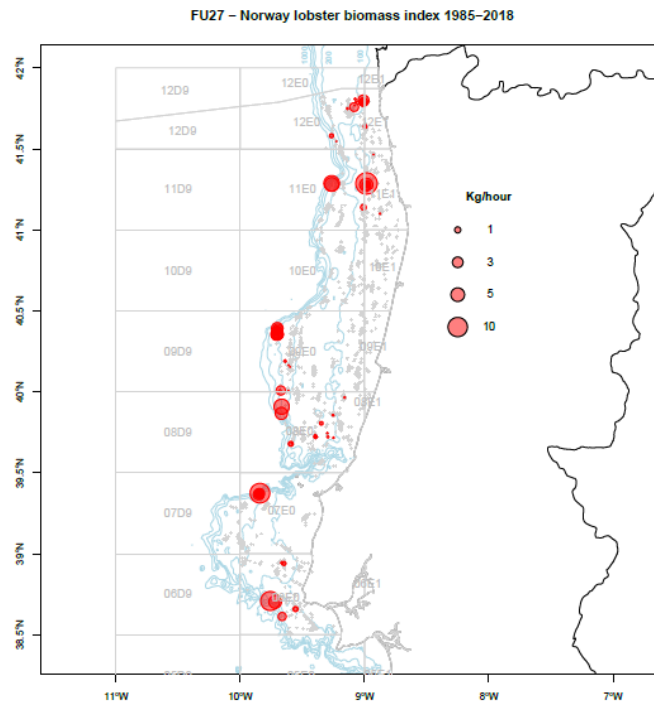


Figure 4. *Nephrops* abundance index distribution in FU26 from Spanish bottom trawl survey (SP-NSGFS-Q4 IBTS) for years 2000, 2001, 2018 and 2019.



Figurexx. *Nephrops* biomass index distribution in FU27 from Portuguese bottom trawl survey (PtGFS-WIBTS-Q4) for 1985-2018 period.

APPLICATION OF SPiCT: EXPLORATORY RESULTS

Different runs have been conducted using a combination of available annual data. Table 2 shows data used in each run while Table 3 shows the data period used.

Table 2. Exploratory runs with SPiCT model.

RUN 1	RUN 2	RUN 3	RUN 4
Catch FU26-27 CPUE	Catch FU26-27 EFFORT	Catch FU26-27 SP-Survey Index FU26 PT-Survey Index FU27	Catch FU26-27 CPUE SP-Survey Index FU26 PT-Survey Index FU27

Table 3. Data and period used in the exploratory runs with SPiCT model.

DATA	PERIOD
Catch FU26-27	1977-2019
CPUE	1994-2019
EFFORT	1994-2019
SP-Survey Index in FU26	1983-2019
PT-Survey Index in FU27	1985-2018

The following settings were used:

- Euler time step (years): 1/16 (default)
- Production curve shape: Schaefer
- Alpha: estimated by the model (default priors).
- Beta: estimated by the model (default priors).

In addition, the Spanish survey index in FU26 and the Portuguese survey index in FU27 were scaled to mean 1 for better numerical stability.

Figures and results obtained in each run are detailed in Annex. The checklist resulting for the different runs is shown in Tables below:

		Catch, CPUE	Catch, Effort
CHECKLIST		RUN 1	RUN 2
1	Convergence	Convergence: 0 MSG: relative convergence (4)	Convergence: 0 MSG: relative convergence (4)
2	Variance parameters of the model are finite	TRUE	TRUE
3	No violation of model assumptions based on one-step-ahead residuals	Bias p-value: Green for Catch and CPUE Lbox p-value: Green for Catch and CPUE. Shapiro p-value: Red for Catch; Green for CPUE.	Bias p-value: Green for Catch and Effort Lbox p-value: Green for Catch and Effort. Shapiro p-value: Red for Catch; Green for Effort.
4	Consistent patterns in the retrospective analysis	rep=retro(res, nretroyear=5) Error in calc.osa.resid(res) : Could not calculate OSA residuals because estimation did not converge. In addition: Warning message: In sqrt(diag(cov)) : NaNs produced	plotspict.retro(rep) : Error in plot.window(...): need finite 'ylim' values. In addition: Warning messages:1: In min(x) : no non-missing arguments to min; returning Inf. 2: In max(x) : no non-missing arguments to max; returning -Inf
5	Realistic production curve	0.4999964	0.5094518
6	Confidence intervals for B/Bmsy and F/Fmsy	Order magnitud: B/Bmsy= NaN; F/Fmsy=NaN	Order magnitud: B/Bmsy= NaN; F/Fmsy=NaN
7	Sensitivity to initial values	NULL	NULL

		Catch, survey index fu26 and survey index fu27	Catch, CPUE, survey index fu26 and survey index fu27
CHECKLIST		RUN 3	RUN 4
1	Convergence	Convergence: 0 MSG: relative convergence (4)	Convergence: 0 MSG: relative convergence (4)
2	Variance parameters of the model are finite	TRUE	TRUE
3	No violation of model assumptions based on one-step-ahead residuals	Bias p-value: Green for Catch, Survey 26, Survey 27 Lbox p-value: Green for Catch, Survey 26, Survey 27 Shapiro p-value: Green for Catch, Survey 26, Survey 27	Bias p-value: Green for Catch, CPUE, Survey 26, Survey 27 Lbox p-value: Green for Catch, CPUE, Survey 27; Red for Survey 26 Shapiro p-value: Green for Catch; Red for CPUE, Survey 26, Survey 27
4	Consistent patterns in the retrospective analysis	Mohn's Rho: B/Bmsy=NaN F/Fmsy= NaN	rep=retro(res, nretroyear=5) Error in calc.osa.resid(rep) : Could not calculate OSA residuals because estimation did not converge.In addition: Warning messages: 1: In nlminb(obj\$par, obj\$fn, obj\$gr, control = inp\$optimiser.control) :NA/NaN function evaluation 4: In sqrt(diag(cov)) : NaNs produced
5	Realistic production curve	0.6845806	0.6320694
6	Confidence intervals for B/Bmsy and F/Fmsy	Order magnitud: B/Bmsy= 1 F/Fmsy= 4	Order magnitud: B/Bmsy= NaN F/Fmsy= NaN
7	Sensitivity to initial values	NULL	NULL

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ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68. 42 pp.

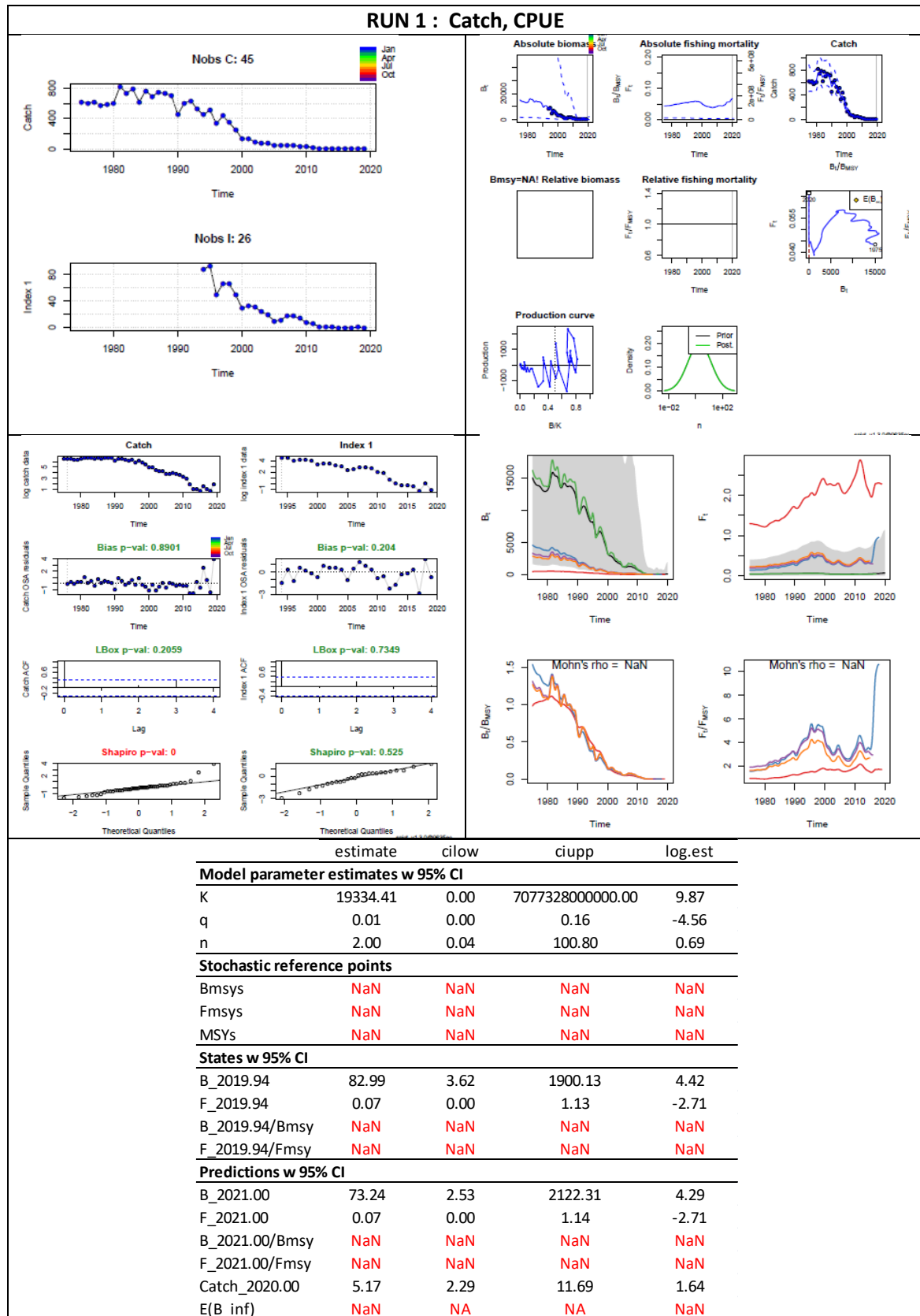
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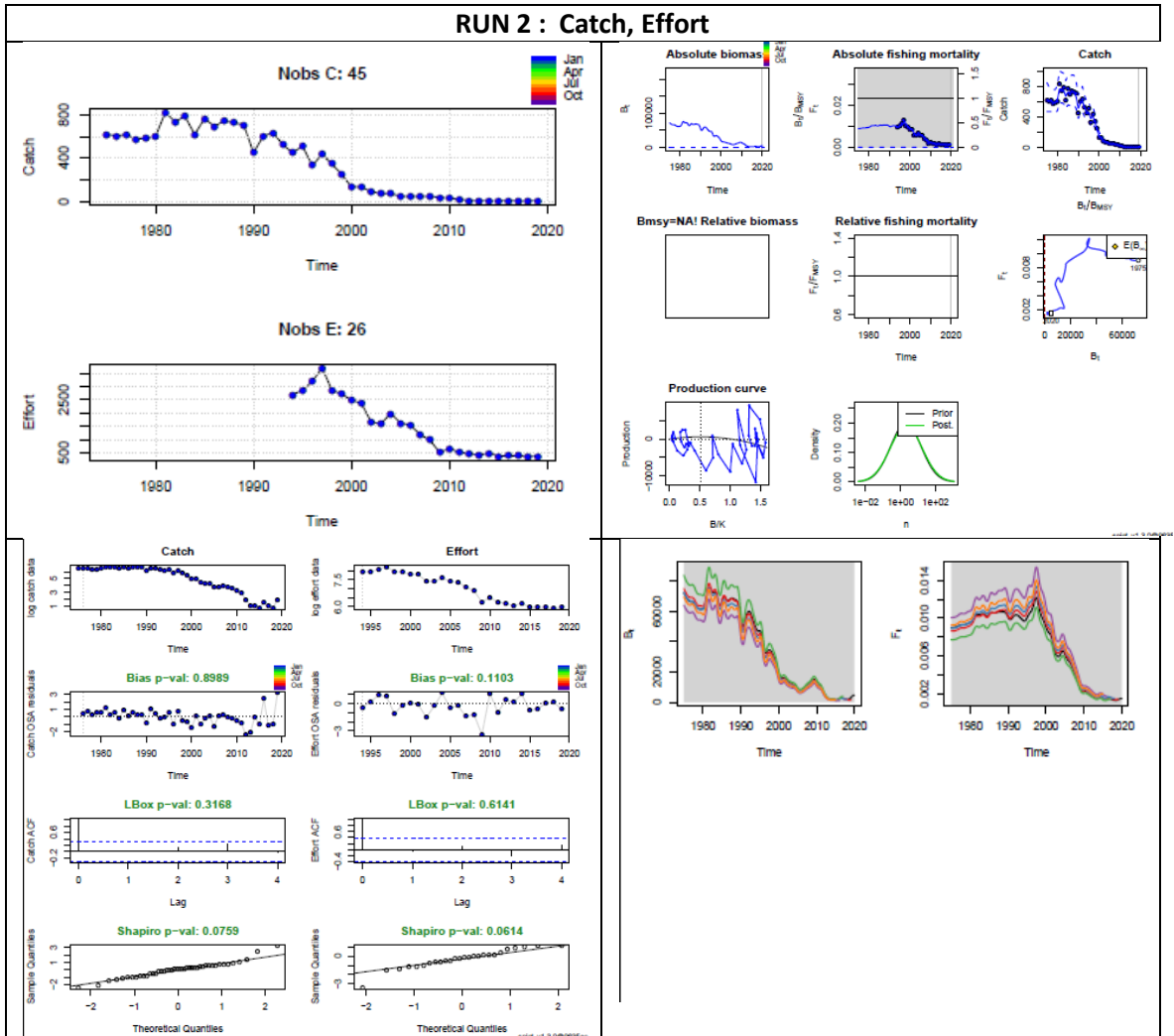
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ANNEX

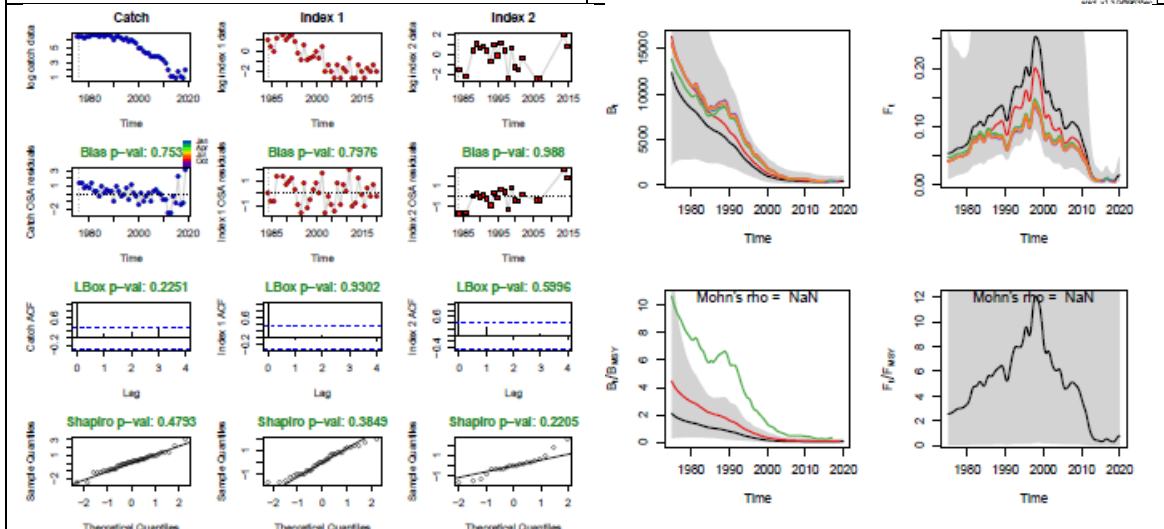
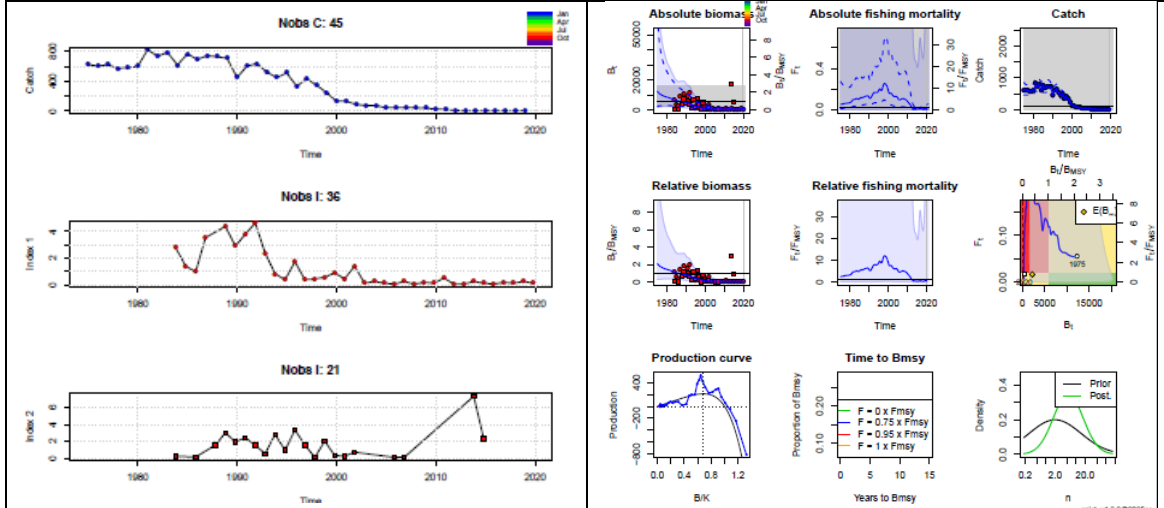


RUN 2 : Catch, Effort



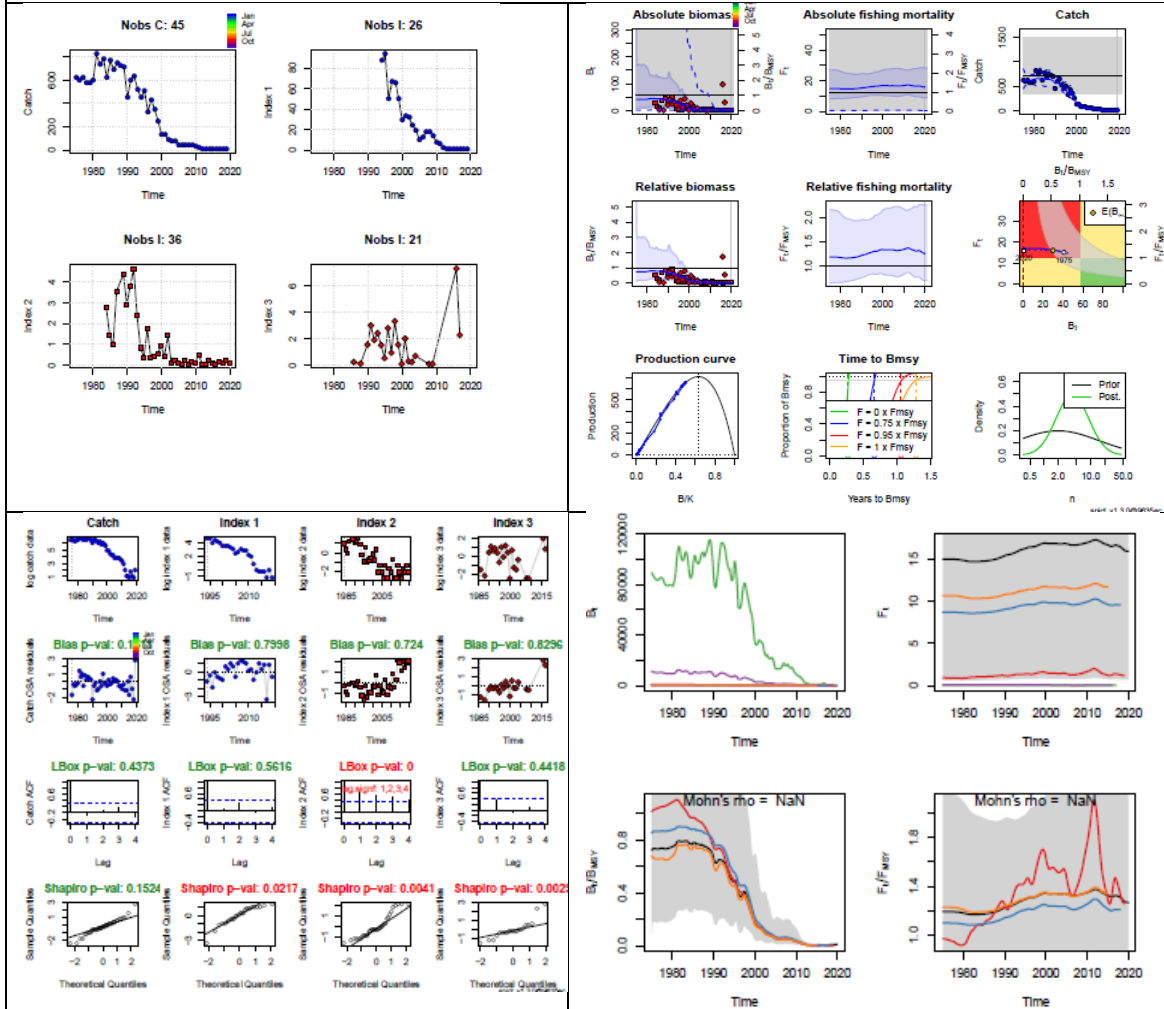
	estimate	ci_low	ciupp	log.est
Model parameter estimates w 95% CI				
K	5E+04	21.36	1E+08	10.76
qf	4E-06	0.00	2E-02	-12.55
n	2E+00	0.03	1E+02	0.74
Stochastic reference points (Srp)				
Bmsys	NaN	NaN	NaN	NaN
Fmsys	NaN	NaN	NaN	NaN
MSYs	NaN	NaN	NaN	NaN
States w 95% CI (inp\$msytype: s)				
B_2019.94	4701.22	0.92	2E+07	8.46
F_2019.94	0.00	0.00	7E+00	-6.54
B_2019.94/Bmsy	NaN	NaN	NaN	NaN
F_2019.94/Fmsy	NaN	NaN	NaN	NaN
Predictions w 95% CI (inp\$msytype: s)				
B_2021.00	4600.97	0.87	2E+07	8.43
F_2021.00	0.00	0.00	7E+00	-6.54
B_2021.00/Bmsy	NaN	NaN	NaN	NaN
F_2021.00/Fmsy	NaN	NaN	NaN	NaN
Catch_2020.00	6.74	2.75	16.57	1.91
E(B_inf)	NaN	NA	NA	NaN

RUN 3 : Catch, Survey Index FU26, Survey Index FU27



	estimate	ciLow	ciupp	log.est
Model parameter estimates w 95% CI				
K	9325.07	5164.36	16837.90	9.14
q1	0.00	0.00	0.00	-7.81
q2	0.00	0.00	0.00	-7.78
n	5.50	0.59	51.43	1.70
Stochastic reference points				
Bmsys	5825.12	2141.18	15847.37	8.67
Fmsys	0.02	0.00	2.47	-3.86
MSYs	116.20	0.64	21021.62	4.76
States w 95% CI				
B_2019.94	409.74	169.14	992.57	6.02
F_2019.94	0.02	0.01	0.05	-4.10
B_2019.94/Bmsy	0.07	0.02	0.29	-2.65
F_2019.94/Fmsy	0.78	0.01	62.11	-0.24
Predictions w 95% CI				
B_2021.00	417.84	173.89	1004.04	6.04
F_2021.00	0.02	0.00	0.06	-4.10
B_2021.00/Bmsy	0.07	0.02	0.30	-2.63
F_2021.00/Fmsy	0.78	0.01	65.89	-0.24
Catch_2020.00	6.85	3.16	14.84	1.92
E(B_inf)	2235.20	NA	NA	7.71

RUN 4 : Catch, CPUE, Survey Index in FU26, Survey Index in FU27



	estimate	ciLow	ciupp	log.est
Model parameter estimates w 95% CI				
K	89.46	12.62	634.26	4.49
q1	3.65	0.16	82.29	1.29
q2	0.09	0.00	2.07	-2.38
q3	0.08	0.00	1.83	-2.59
n	4.05	0.83	19.74	1.40
Stochastic reference points				
Bmsys	56.49	6.72	474.84	4.03
Fmsys	12.59	0.82	192.71	2.53
MSys	711.46	335.39	1509.21	6.57
States w 95% CI				
B_2019.94	0.56	0.06	5.08	-0.58
F_2019.94	15.95	0.67	378.31	2.77
B_2019.94/Bmsy	0.01	0.00	0.02	-4.62
F_2019.94/Fmsy	1.27	0.71	2.26	0.24
Predictions w 95% CI				
B_2021.00	1.16	0.14	9.33	0.15
F_2021.00	15.95	0.67	378.40	2.77
B_2021.00/Bmsy	0.02	0.00	0.15	-3.89
F_2021.00/Fmsy	1.27	0.71	2.26	0.24
Catch_2020.00	13.08	1.65	103.40	2.57
E(B_inf)	29.93	NA	NA	3.40