Stock Annex: Norway lobster (*Nephrops norvegicus*) in divisions 7.g and 7.f, Functional Unit 22 (Celtic Sea, Bristol Channel)

Stock-specific documentation of standard assessment procedures used by ICES.

Stock	Norway lobster nep.fu.22_SA
Working group	Working Group for the Celtic Seas Ecoregion (WGCSE)
Created	
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A. General

A.1. Stock definition

Nephrops is limited to muddy habitat, and requires sediment with a silt and clay content of between 10–100% to excavate its burrows, and this means that the distribution of suitable sediment defines the species distribution. The Smalls *Nephrops* stock (FU22) covers ICES rectangles 31–32E3, 31–32E4 within 7.fg. Adult *Nephrops* probably only undertake very small-scale movements (a few 100 m). Recent studies in larval tracking models show that larval transfer may occur between the separate mud patches in the Celtic sea as some patches are donors of larvae to adjacent grounds, For the Smalls some larval are donated to the Labadie but most are retained on the Smalls ground (O'Sullivan *et al*., 2015) .Figure A.1.1 shows the proportion of *Nephrops* in the Irish landings overlaid on international OTB effort and the area of the Smalls is highly visible.

The ground polygon has been defined using integrated VMS data (2008–2010) linked to logbooks. The area is calculated using different projections in ArcGIS and the average value is taken as the final area (Table A.1.1.). The shapefiles of the FU22 ground are available at: http://www.isde.ie and also http://data.marine.ie/downloads/fisheries/NephropsGrounds.zip

A.2. Fishery

Ireland

The Irish fleet has been the main participant in this fishery in recent years. Vessels >18 m target *Nephrops* in several other FUs to optimize catch rates depending on tides and weather. These larger vessels freeze the catches at sea and have become increasingly prevalent since 2006.

France

French trawlers operating in this area fish also in the Celtic Sea (FU22 and FU20–21) and switch to FU19 depending on weather conditions. The fleet operating here has dwindled since the 1990s.

UK

Landings from this FU come mainly from the UK Northern Ireland fleet with lesser amounts reported by UK Scotland and UK England & Wales.

Belgium

Landings are minor from this FU.

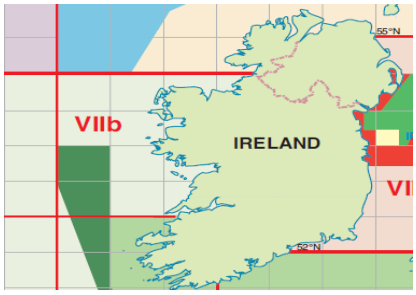
Technical measures

The following TCMs are in place for *Nephrops* in 7 (excluding 7.a) after EC 850/9 in operation since 2000:Minimum Landing Sizes (MLS); total length >85 mm, carapace length >25 mm, tail length >46 mm.This regulation is applied by the Irish and UK fleets, whereas a more restrictive regulation adopted by the French Producers' Organisations (35 mm CL i.e. 11.5 cm total length) is applied by the French trawlers.

The French fleet uses a mesh size of 100 mm for codend since January 2000 (in order to not be constrained by bycatch composition).

The mesh size, catch composition and square mesh panel requirements in the Celtic Sea after EU 737/2012 are shown below in the table and maps below. The majority of Irish *Nephrops* vessels operating in the area use 70–89 mm mesh and are obliged to have a 120 mm square mesh panel (SMP) since 2012. Some Irish vessels and most French *Nephrops* vessels use >100 mm codend mesh with a 100 mm SMP.

Mesh size (mm)	VII (Celtic Sea & West of Ireland)								
	Area VII Outside restricted areas				Celtic Sea Protection Zone				HAKE BOX
	70-79	80-89	90-99	100+	70-79	80-89	90-99	100+	100+
Twine thickness	4mm double or single 6mm								
Headline Panel (mm) (Beam Trawlers see footnote 1)	-	-	-	-	-	-	-	-	-
Square mesh panel (mm)	80	-	-	-	110	110	110	100	-
Maximum number of meshes in codend circumference	120	120	100	100	120	120	100	100	100
Catch Composition	-	Either - Or		-	Either - Or		-	-	-
Maximum % of cod allowed. (Council Reg 39/2013)	-	-	-	-	-	-	-	-	-
Maximum % cod, haddock, saithe allowed	-	-	30	-	-	-	30	-	-
Maximum % of hake allowed	20	20	20	-	20	20	20	-	-
Minimum % of saithe required	-	-	-	-	-	-	-	-	-
Minimum % of Nephrops required	35	30	-	-	35	30	-	-	-
Minimum % of Annex I List (see footnotes)	-	-	70 [2]	-	-	-	70 [2]	-	-
Minimum % of haddock, hake, whiting, megrim, monkfish, rays, saithe and Nephrops	-	-	-	-	-	-	-	-	-



Source: http://www.bim.ie/media/bim/content/downloads/BIM%20Fisheries%20Management%20Chart%202015.pdf

A.3. Ecosystem aspects

Physical oceanography

The larval tracking study has shown that in the Celtic Sea, fast moving water is apparent around the southwest coast of Ireland in the summer months, and water velocity increases moving south around the west coast of Ireland and clockwise along the south coast. Surface water consistently moves quickly through the northern channel of the

Irish Sea and into the Clyde and through Georges Channel in the south. This is forced by strong tides in both areas (O'Sullivan *et al.*, 2015).

Sediment distribution

Information on the spatial extent of the sediment suitable for *Nephrops* from UWTV surveys, seabed mapping programmes and the fishing industry is growing. There is insufficient sediment to explore relationships between burrow density and sediment for these *Nephrops* grounds and to provide detailed sediment maps. Table A.3.1 shows a number of sediment samples collected to date during UWTV surveys.

Bathymetry

In 2006 a multibeam echosounder was used to collect bathymetric and sediment hardness data during the UWTV survey. Stations depths ranged from 73 m to 127 m in the deeper channels (Figure A.3.1). Backscatter data were more or less uniform, denoting a soft type sediment (light grey colour), which was verified as a mud substratum from the video (Figure A.3.2).

B. Data

B.1. Commercial catch

Commercial landings data are supplied by Ireland, France, UK and recently Belgium. These data for all countries were revised as part of a working document presented to WGCSE 2018 (Annex 3, ICES, 2018).

The quality of historic landings data is not well known, but they are perceived to be reasonably accurate. Irish landings data are available from 1989. The time-series of French landings commences in the late 1980s. UK landings are also available from 1989.

Landings statistics for the Irish fleet are obtained from EU logbooks since 1995. Vessels record daily retained catches in operations and make a declaration of total landings on return to port. Since 2012, most vessels in the fleet have been using electronic logbooks (EC Regulation 1224 of 2009 and 404 of 2011). Vessels are required to electronically report catches onboard in each 24 hour period.

Similarly, landings from UK Scotland, England and Wales and Northern Ireland are available from the logbooks. Landings from France and Belgum are obtained from EU logbooks.

Figure B.1.1 shows that the Irish landings from this FU come mainly from ICES statistical rectangle 31E3.

B.2. Sampling Data

Since 2003, a new catch self-sampling programme was put in place. This involves unsorted catch and discard samples being provided by vessels (fisher self-sampling programme) or collected by observers at sea on commercial fishing trips. Sampling effort is stratified monthly. The national sample raising procedures for FU22 were reviewed and fully documented through an r markdown document (Annex 3, ICES, 2018). Up to now unsorted catch samples were partitioned into landings and discards using a quarterly on-board retention ogive. During the review, it became apparent that the number of quarterly samples was insufficient to derive quarterly ogives. In practice, a number of *ad hoc* fill-ins were often made to solve this problem. Also, while there have been

significant changes in the retention ogives over the recent few years there is no evidence that there are consistent quarterly differences. **The Working group concluded that annual discard ogives as presented in Annex 3 should be used instead of quarterly ones in the raising.** These are applied to quarterly length distributions and raised to total quarterly landings before aggregation. A further raising procedure is applied to raise the annual sampled Irish data where this also addresses quarters with missing length samples. Then the data are raised to the international landings. The sampling intensity and coverage has varied over the time-series, but in recent years has been good. Figure B.2.1 shows the sampling levels over the time-series.

Fish and other bycatches in the fishery have been collected by on-board observers since 1994. Discarding by the Irish *Nephrops* trawl fleet is around 38% of the total catch by weight . The main discards are small whole *Nephrops*. The main fish species discarded are whiting, haddock, and dogfish (Anon, 2011).

B.3. Biological

Biological parameters for this stock are outlined in Table B.3.

Length–weight

The annual mean weight in the landings is calculated from the length–frequency data and a length–weight relationship from studies on Scottish stocks by Pope and Thomas (1955). Mean weight by sex (Figure B.3.1) shows a cyclical trend for the females, which is linked to behaviour. Trends in mean weight by sex is calculated using a loess smoother.

Natural mortality

A natural mortality rate of 0.3 was assumed for all length classes and years for males and immature females, with a value of 0.2 for mature females. The lower value for mature females reflects the reduced burrow emergence while ovigerous, and hence an assumed reduction in predation. The accuracy of these assumptions is unknown but the same assumptions are made for most *Nephrops* stocks (WKNEPH 2009; 2013a).

Maturity

Female

The L_{50} for female maturity was estimated at 22 mm was based Irish sampling in FU22 and reported to WKNEPH 2006 (ICES, 2006), Figure B.3.3.

Discard survival

Given the trip durations (5–7 days typically) and behaviour of this fleet means the majority of discards are returned to the sea over suitable sediment. The proportion scavenged by birds is probably quite low. Tow durations, volume of catches, prolonged sorting on deck and moderate density of *Nephrops* on the seabed probably results in relatively low discard survival. This is assumed to be around 25% in line with other *Nephrops* stocks in the Celtic Sea.

B.4. Surveys

UWTV Survey

In 2006, Ireland conducted the first underwater television survey (UWTV) in FU22. The surveys were based on a randomised fixed-grid design. Since 2012, a reduced isometric grid has been employed which results in CV or RSE well below 20%, which is in line with SGNEPS recommendation of an acceptable precision level for UWTV survey estimates of abundance. The methods used during the survey were similar to those employed for UWTV surveys of *Nephrops* stocks around Ireland and elsewhere, and are documented by WKNEPHTV (ICES, 2007), SGNEPS (ICES, 2009; 2010; 2012) and WGNEPS (2013b; 2014). Up to date UWTV survey reports are available at: **http://hdl.handle.net/10793/919**

UWTV Survey relative to absolute conversion factors

In order to use the survey abundance estimate as an absolute, it is necessary to correct for potential biases. For FU22 the field of view of the camera was 0.75 m and expert judgment of the mean burrow diameter was in the range of 0.25–0.4 m. The edge effect is estimated at 1.35, which is similar to FUs of moderate density. In future, it may become possible to quantitatively estimate burrow diameter from mosaics of the footage from this and other areas. Burrow detection rates were thought to be relatively high due to good water clarity and few other burrow systems of similar size. Burrow identification could be slightly overestimated, since a few fish and crab species were observed at burrow entrances. The proposed cumulative correction factor (check) for the area was 1.3 (table below). When compared to with the correction factors applied in other areas it is quite close to the average used on other grounds.

The biases associated with the estimates of *Nephrops* abundance in FU22 are:

	Established	Edge effect	detection rate	species identification	occupancy	Cumulative bias
FU22: Smalls	2011	1.35	0.9	1.05	1	1.3

IBTS Groundfish Survey

There are two IBTS-GFS catching *Nephrops* in FU19: Irish groundfish survey-Q4: IGFS-WIBTS-Q4 commenced in 2003 (Stokes *et al.*, 2014) and French groundfish survey EVHOE-WIBTS-Q4 since 1997. These data are useful as additional indicators of trends in recruitment, mean weight and sex ratio for this *Nephrops* stock. These are not used in the assessment, but for data exploration. Figure B.4.1 displays IGFS stations with *Nephrops* catches in FU22. Figure B.4.2 and B.4.3 shows the mean weight (grs) by sex from IGFS and EVHOE surveys in the Celtic Sea.

B.5. Commercial cpue

Disaggregated effort and lpue data are available for the Irish *Nephrops* directed fleet in FU22 from 1995–2014 for all vessels >18 metres total length. The lpue and effort-series is based on the same criteria for FU15, 16, 17, 22 and 20–21 (30% landings threshold) and will be contingent on the accuracy of landings data reported in logbooks. Effort and lpue data are not standardised, and hence do not take into account vessel capabilities, efficiency, seasonality or other factors that may bias perception of lpue abundance trend over the longer term. These data are not used in the assessment. WGCSE 2015

agreed that effort data in Kw days should be presented as these data are more informative than uncorrected lpue data.

C. Assessment: data and method

Model used: UWTV Based Approach to generate catch options.

Software used: separable SCA model Bell analysis in r.

At WGCSE 2011, in response to the recommendations of WKFRAME (2010), the Bell/Dobby combined sex–length cohort analysis (LCA) model (WKNEPH, 2009) was used to determine Harvest Rates associated with fishing at various potential F_{MSY} proxies i.e. $F_{35\%SPR}$, $F_{0.1}$ and F_{MAX}. This approach has previously been applied to all other *Nephrops* stocks with UWTV and catch sampling data. Length distributions for male and female landings and discards were available for Irish sampling from FU22 (Smalls) from 2003–2010 and the reference period 2008–2010 were used as input to the SCA model. The length distributions in the reference period were very stable. Other SCA inputs such as growth parameters and discard survival were all taken from the stock annex.

D. Catch option table based on UWTV surveys

1) Survey indices are worked up annually resulting in the TV index.

2) Comment if some patches not surveyed (take previous years estimate or average if time-series available).

3) Adjust the annual survey index by the bias correction factor to calculate the adjusted survey index.

4) Generate mean weight in landings and discards. Check the time-series of mean catch weights for evidence of changes in the most recent period. If there is no firm evidence of a recent change in mean weight, then use a three year average. It may be necessary to deviate from this procedure in cases where there are changes to mean weight related to recruitment or sampling issues.

5) The last three years should be used for estimating the discard proportion in number and the dead discard rate.

6) The catch option table will include the harvest ratios associated with fishing at combined sex $F_{0.1}$, $F_{35\%SpR}$ and F_{MAX}.

7) Multiply the adjusted survey abundance by the harvest ratios to give the number of total removals.

8) Create a landings number by applying the discard ratio (dead discard rate) and multiply by the mean weight of landings to calculated a landings biomass.

9) Discards are calculated by applying 1- the discard ratio and multiply by the mean weight of discards. Discards are apportioned into dead and surviving discard components.

10) Produce landings biomass by applying mean weight.

11) In the context of the Landings Obligation all discards are assumed to be landed, so discard survival is assumed to be zero and catch options are calculated on that basis. This will need to be kept under review as the LO is implemented.

E. Medium-term projections

F. Long-term projections

G. F_{MSY} reference points

The reference points derived by WKMSYRef4 (ICES, 2016d; 2016e) for FU22 are updated on the basis of an average of estimated F_{MSY} proxy harvest rates over a period of years, this corresponds more closely to the methodology for finfish. In cases where there is a clear trend in the values a five-year average was chosen. Similarly, the five-year average of the F at 95% of the YPR obtained at the F_{MSY} proxy reference point was proposed as the F_{MSY} lower bound and the five year average of the F above F_{MAX} that leads to YPR of 95% of the maximum as the upper bound. Using an average value also has the advantage of reducing the effect of any unusually high or low estimates of the F_{MSY} proxy which occasionally appear.

This stock previously did not have MSY $B_{trigger}$ specified,the time-series and range of indicator biomass is also limited such that direct use of B_{loss} is considered too close to equilibrium biomass. The workshop proposed to use the 5% interval on the probability distribution of indicator biomass assuming a normal distribution, which is analogous to the 5% on B_{MSY} proposed for finfish stocks assuming these *Nephrops* FU have been exploited at a rate close to near HR_{MSY}. The MSY $B_{trigger}$ for FU22 is 937 million individuals rounded to 900 million.

Stock code	MSY Flower*	F_{MSY}*	MSY Fupper* with AR	MSY $B_{trigger}$	MSY Fupper* with no AR
nep-22	10.2%	12.8%	12.8%	990***	12.8%

*** Harvest rate (HR).**

***** Abundance in millions.**

H. Other issues

H.1. Historical overview of previous assessment methods

WGCSE 2011

Model used: UWTV Based Approach to generate catch options.

Software used: separable SCA model Bell analysis in r.

In response to the recommendations of WKFRAME (2010), the Bell/Dobby combined sex–length cohort analysis (LCA) model (WKNEPH, 2009) was used to determine Harvest Rates associated with fishing at various potential F_{MSY} proxies i.e. $F_{35\%SPR}$, $F_{0.1}$ and F_{MAX}. This approach has previously been applied to all other *Nephrops* stocks with UWTV and catch sampling data. Length distributions for male and female landings and discards were available for Irish sampling from FU22 (Smalls) from 2003–2010 and the reference period 2008–2010 were used as input to the SCA model. The length distributions in the reference period were very stable. Other SCA inputs such as growth parameters and discard survival were all taken from the stock annex.

The results of the final SCA model carried out at WGCSE 2011, are given in the text table below. The F multipliers required to achieve the potential F_{MSY} proxies, the harvest rates that correspond to those multipliers and the resulting level of spawner per recruit as a percentage of the virgin level.

		F_{BAR} 20–40 mm		Harvest Rates	SPR	
		Female	Male		Female	Male
$F_{0.1}$	Combined	0.08	0.15	7.5%	57.2%	37.9%
	Female	0.13	0.26	10.9%	45.2%	25.5%
	Male	0.06	0.13	6.5%	61.5%	42.8%
$F_{35\%SPR}$	Combined	0.13	0.26	10.9%	45.2%	25.5%
	Female	0.22	0.43	15.3%	34.1%	15.9%
	Male	0.09	0.18	8.4%	53.5%	33.9%
F_{MAX}	Combined	0.15	0.31	12.3%	41.2%	21.8%
	Female	0.28	0.56	17.7%	29.5%	12.6%
	Male	0.13	0.26	10.9%	45.2%	25.5%

WGCSE took into account the following considerations based on the checklist presented in Section 2.2:

- Compared to other *Nephrops* fisheries in the ICES area the population density of FU22 is the moderate ~0.5/m². These moderate densities have been fairly consistent throughout time and space (Figure 7.7.5) with the exception of 2006 when strong recruitment was observed. The time-series of UWTV estimates is short.
- The biological parameters in the Celtic Sea are rather old indicating slightly faster growth in males than in other areas. Natural mortality estimates are assumed in line with other stocks.
- Fishery operates throughout the year but there has been some variability of the seasonality depending on *Nephrops* emergence.
- The observed harvest rate has fluctuated over the time-series, but is relatively stable over the most recent years.
- Overall the indicators suggest that the adult stock has been relatively stable or increasing for more than a decade.

WGCSE 2011 concluded that the default proxy of combined sex $F_{35\%Spr}$ is appropriate as an F_{MSY} proxy. This corresponds to a harvest rate of 10.9%; this is in line with several other stocks in the remit of this WG. Fishing at the combined sex $F_{35\%Spr}$ is predicted to keep the SPR for both sexes >25% and should deliver long-term yield with a low probability of recruitment overfishing. No $B_{trigger}$ can be proposed given the shortness of the UWTV series, although other indicators suggest that the stock is currently at a high level relative to the past.

Table H.1 below gives the von Bertalanffy growth parameters, natural mortality and weight–length parameters by sex for various *Nephrops* stocks.

FU	Ground	VBK. Female	L.INF. Female	M. Female	VBK. Male	L.INF. Male	M. Male	a. Female	b. Female	a. Male	b. Male	L50 Female maturity
6	Farn Deeps	0.06	58	0.2	0.16	66	0.3	0.00091	2.895	0.00038	3.17	25
7	Fladen	0.1	56	0.2	0.16	66	0.3	0.00074	2.91	0.00028	3.24	25
8	Firth of Forth	0.065	58	0.2	0.163	66	0.3	0.00085	2.91	0.00028	3.24	26
9	Moray Firth	0.06	56	0.2	0.165	62	0.3	0.00074	2.91	0.00028	3.24	25
11	North Minch	0.06	60	0.2	0.16	70	0.3	0.00074	2.91	0.00028	3.24	25
12	South Minch	0.06	59	0.2	0.16	66	0.3	0.00074	2.91	0.00028	3.24	25
13	Clyde	0.06	60	0.2	0.16	73	0.3	0.00074	2.91	0.00028	3.24	25
15	western Irish Sea	0.1	56	0.2	0.16	60	0.3	0.00068	2.96	0.00032	3.21	24
14	eastern Irish Sea	0.1	56	0.2	0.16	60	0.3	0.00068	2.95	0.00032	3.21	24
17	Aran	0.1	56	0.2	0.16	60	0.3	0.000684	2.963	0.000322	3.207	22
16	Porcupine	0.16	50	0.2	0.14	75	0.2	0.00009	3.55	0.00009	3.55	26.2
19	S&SW coast Ireland	0.8	56	0.2	0.16	60	0.3	0.000684	2.963	0.000322	3.207	24
22	Smalls	0.1	49	0.2	0.17	68	0.3	0.000684	2.963	0.000322	3.207	22

WG *Nephrops* 2003

Age-structured XSA assessment for this stock was carried *Nephrops* WG in 2003 (ICES, 2003). The results were considered unreliable for several reasons most importantly; inadequate historical sampling of catch, growth and natural mortality assumptions and concern about accuracy of tuning data. Since then the focus has been on developing a time-series of UWTV survey data as the basis of assessment and advice for this stock.

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Table A.1.1. *Nephrops* in FU22 (Smalls). Area (km²) calculation by projection method in ArcGIS and final average.

FU	VMS grounds Polygons	WGS_1984 UTM_ZONE 30N (km²)	Eckert VI (world) (km²)	Irish National Grid (km²)	Cylindrical Equal Area (km²)	Average (km²)
22	Smalls	2439.93	2435.34	2439.39	2439.39	2438.04

Table A.3.1. *Nephrops* in FU22 (Smalls). Sediment data collected during UWTV surveys.

Year	Number of Sediment Samples
2006	110
2007	107

Table B.2.1. *Nephrops* in FU22. Sampling levels.

	Number of Samples		Total numbers of *Nephrops* measured	
Year	Catch	Discards	Catch	Discards
2003	11	10	7774	7599
2004	10	8	5918	9952
2005	4	3	6799	5509
2006	26	4	20 576	3302
2007	34	12	20 158	4049
2008	19	24	6323	9210
2009	33	32	9248	12 563
2010	36	35	10 261	11 769
2011	34	31	10 968	10 278
2012	55	47	15 510	16 399
2013	29	29	8772	10 477
2014	27	25	8146	8299
2015	15	16	5536	5133
2016	32	31	10242	10796
2017	30	29	9313	12521

Table B.1. Biological Input Parameters for FU 22 *Nephrops* Stock.

Parameter	Value	Source
Discard Survival	25%	assumed in line with other stocks
MALES		
Growth - K	0.17	
Growth - L(inf)	68	
Natural mortality - M	0.3	assumed, in line with other stocks
Length/weight - a	0.000322	based on Scottish data (Pope and Thomas, 1955)
Length/weight - b	3.207	"
FEMALES		
Immature Growth		
Growth - K	0.17	
Growth - L(inf)	68	
Natural mortality - M	0.3	assumed, in line with other stocks
Size-at-maturity (L50)	22	WKNEPH 2006
Mature Growth		
Growth - K	0.1	
Growth - L(inf)	49	
Natural mortality - M	0.2	assumed, in line with other stocks
Length/weight - a	0.000684	based on Scottish data (Pope and Thomas, 1955)
Length/weight - b	2.963	"

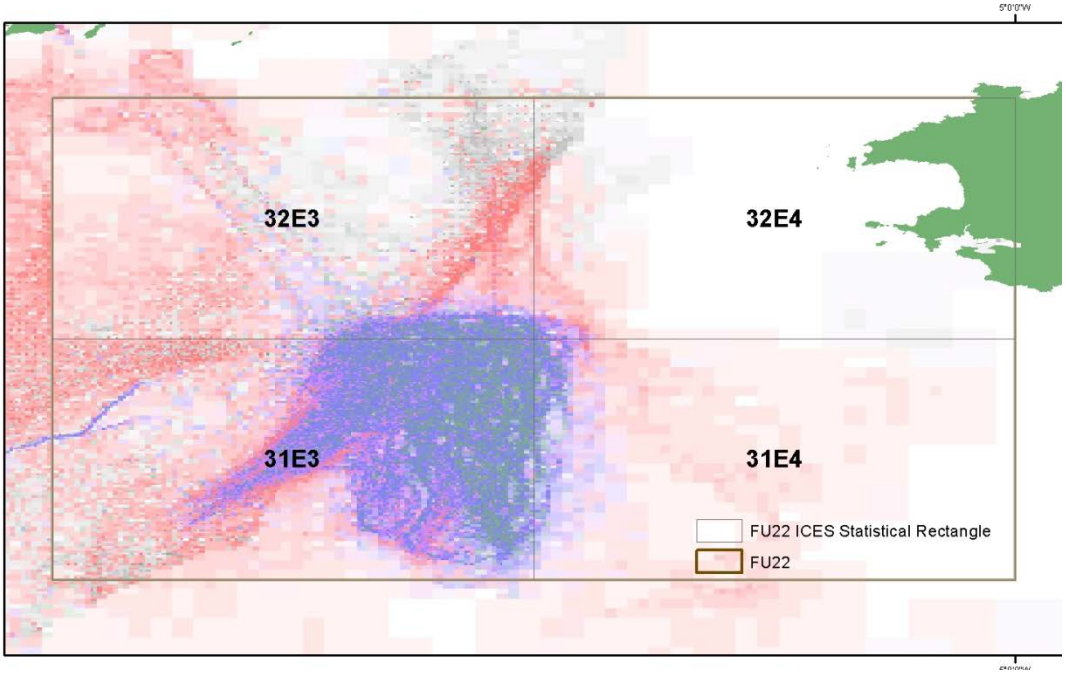

Figure A.1.1. ***Nephrops*** **in FU22 (Smalls). Proportion of** ***Nephrops*** **in the Irish landings overlaid on international OTB effort (red=0%** ***Nephrops;*** **blue=50–60%** ***Nephrops;*** **grey=unknown (no Irish landings) and ICES statistical rectangles.**

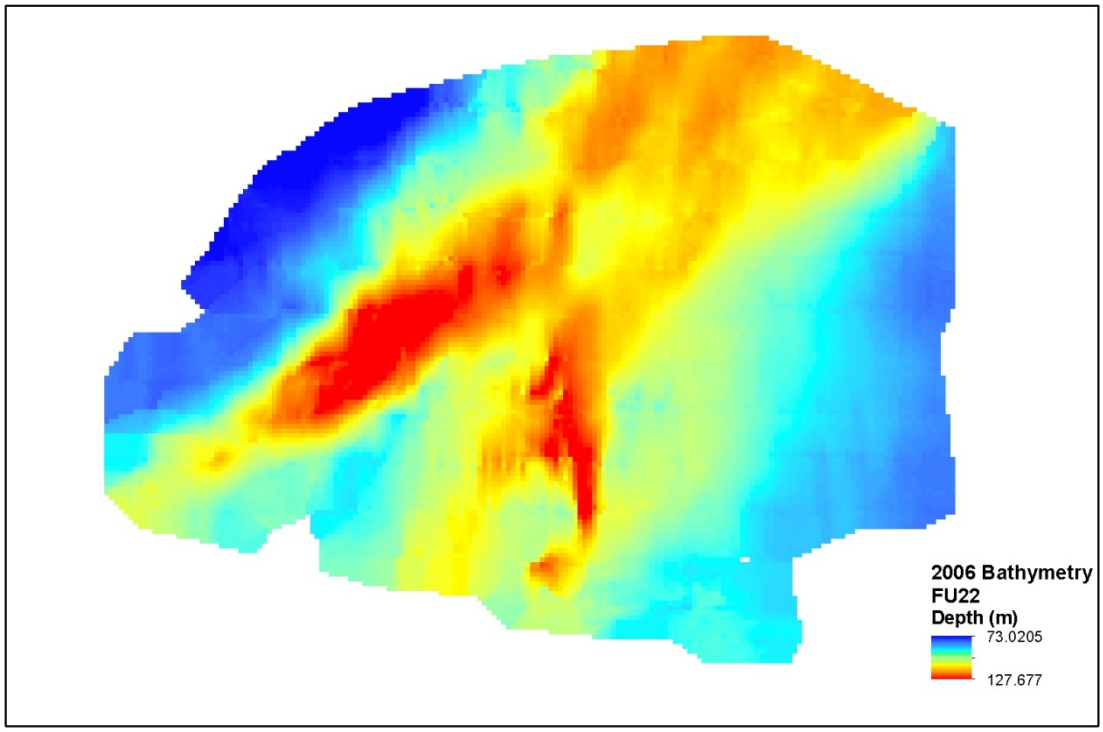

Figure A.3.1. ***Nephrops*** **in FU22 (Smalls). 2006 bathymetric data in metres.**

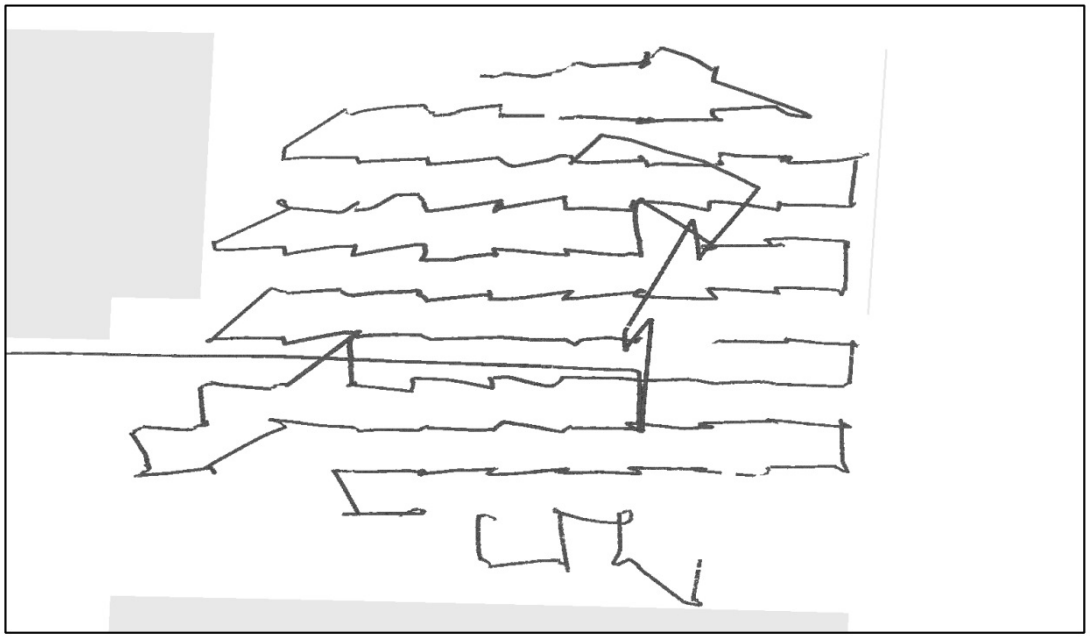

Figure A.3.2. *Nephrops* **in FU22 (Smalls). 2006 Backscatter data collected.**

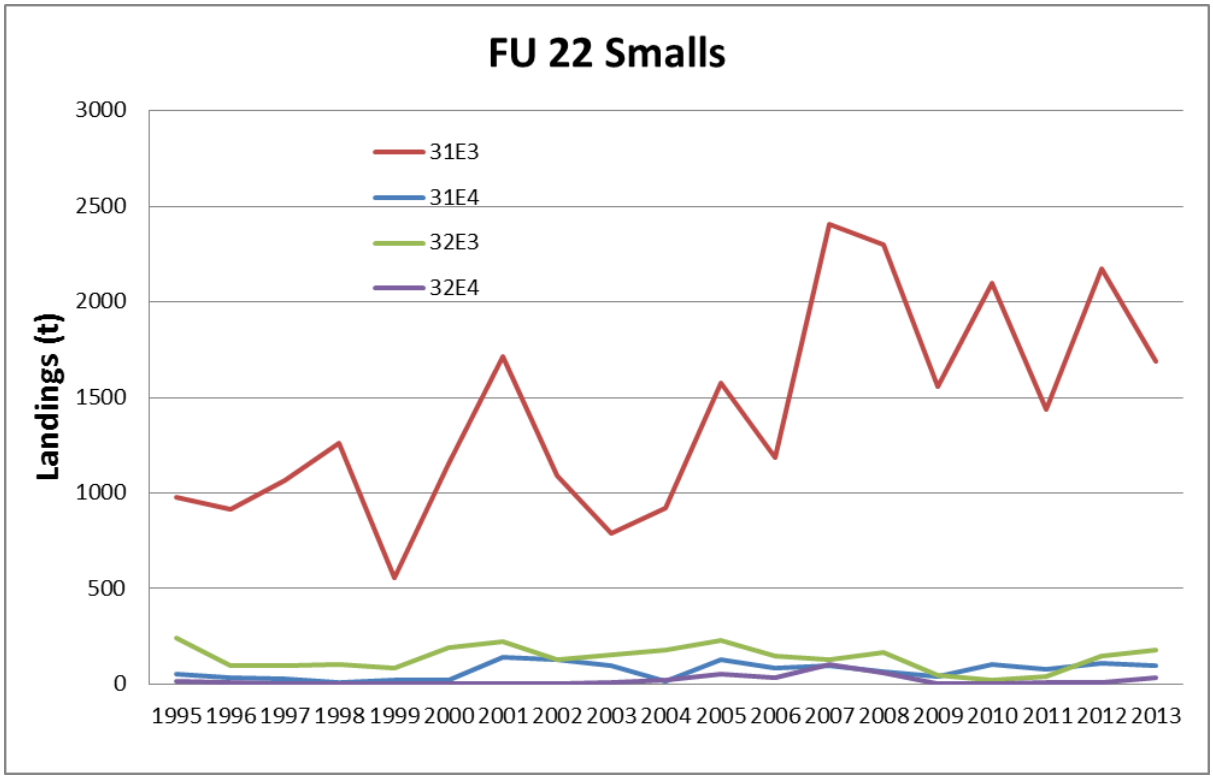

Figure B.1.1. *Nephrops* **in FU22 (Smalls).Irish landings (t) by ICES statistical rectangle.**

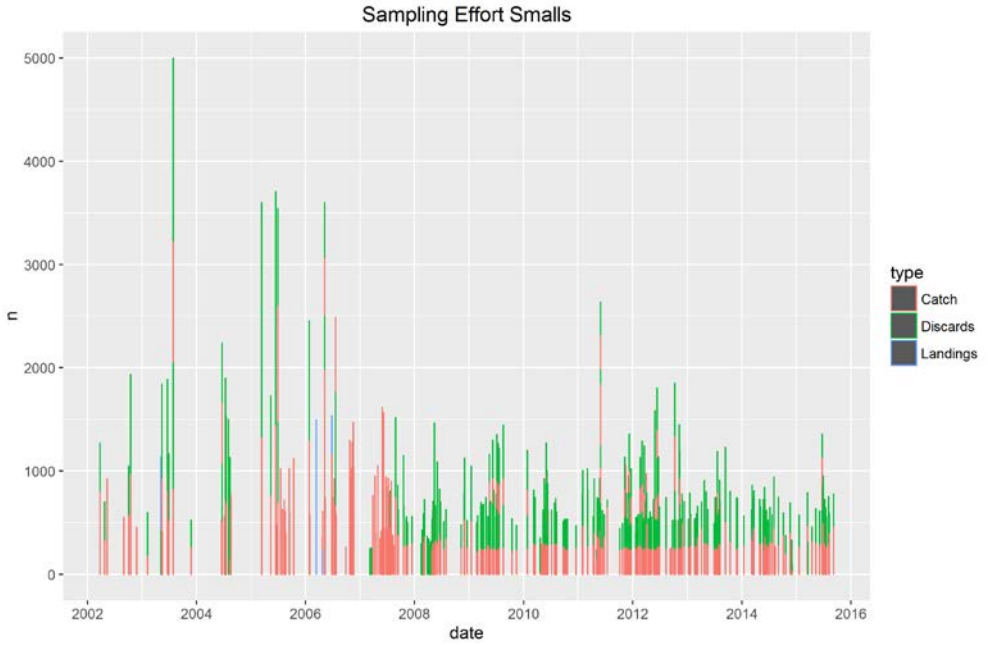

Figure B.2.1. ***Nephrops*** **in FU22 (Smalls).Time-series of sampling levels.**

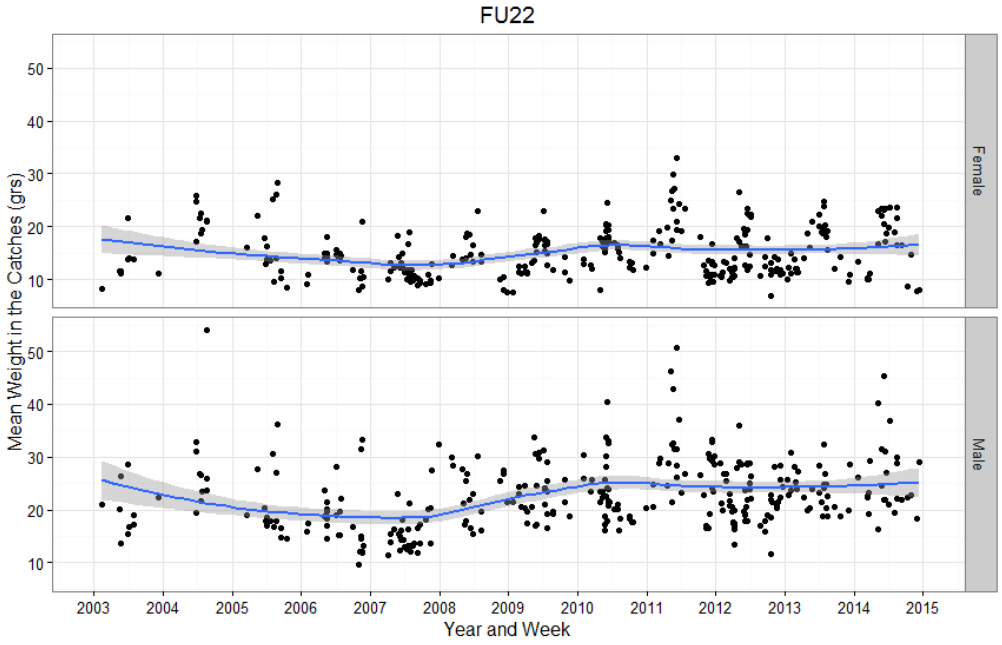

Figure B.3.1. ***Nephrops*** **in FU22 (Smalls). Mean weight (gr) trend by sex from catch sample data.**

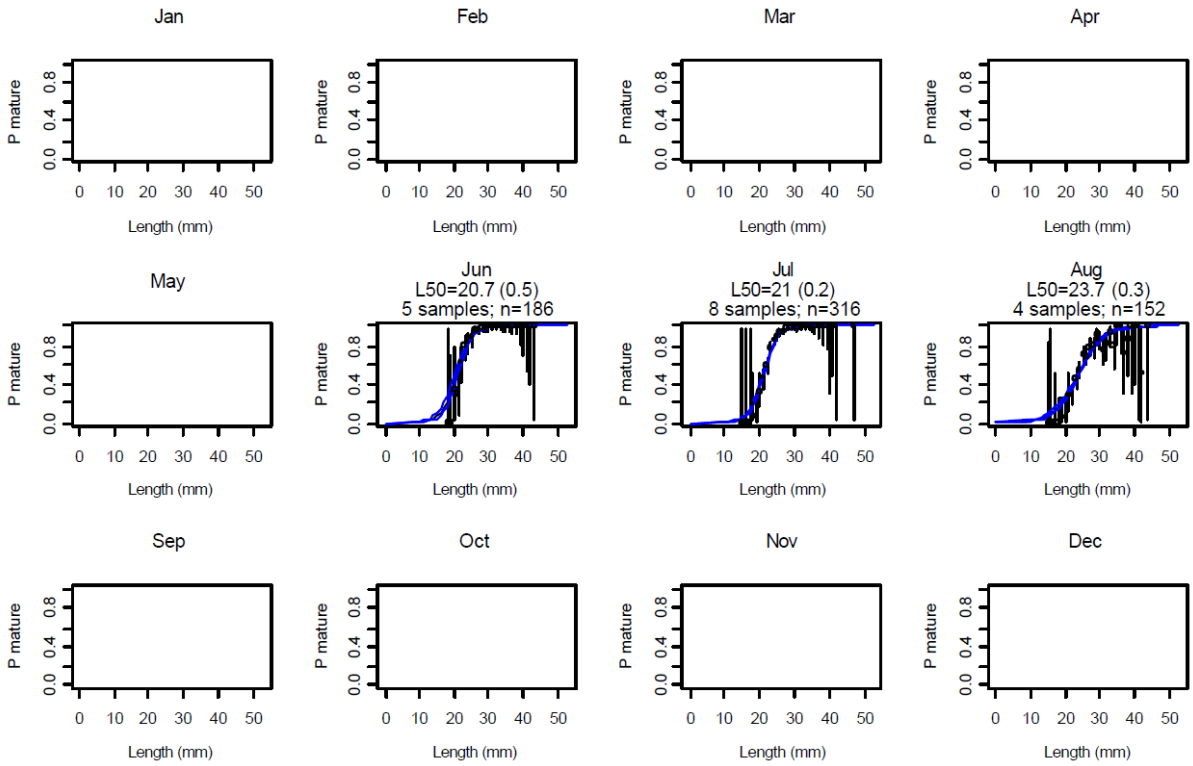

Figure B.3.3. *Nephrops* **in FU22 (Smalls). Female proportions mature-at-length for FU22. The 95% confidence limits of the proportions mature-at-length are indicated by the vertical bars. The black curve indicates the model and its standard errors are given by the blue lines. The L_{50} is the estimated length at 50% maturity, and its standard error is given between brackets. Blank plots indicate no sampling took place.**

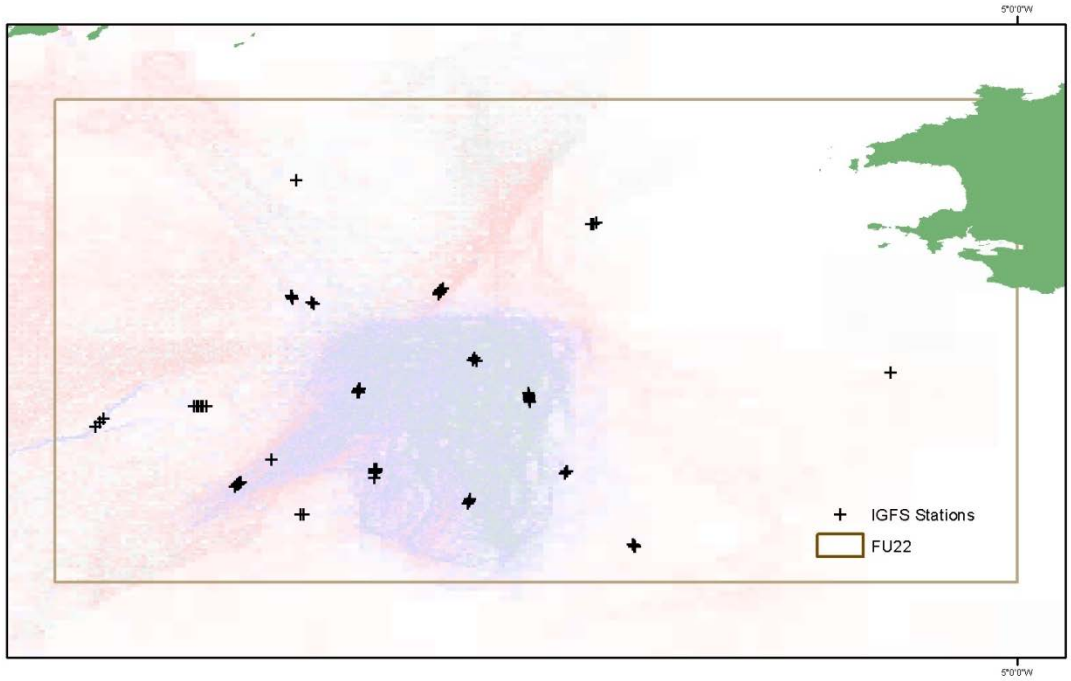

Figure B.4.1. *Nephrops* **in FU22 (Smalls). Station positions with** *Nephrops* **catches from Irish (green cross) groundfish survey.**

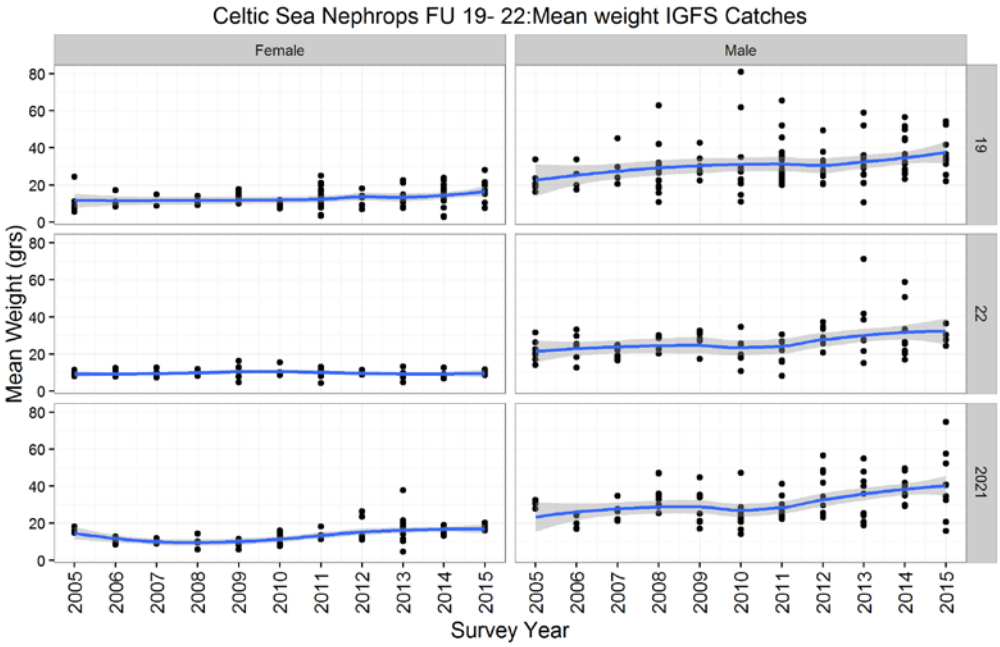

Figure B.4.2. *Nephrops* **in FU19 (S and SW Ireland). Time-series of mean weights (grs) by sex in catches from IGFS for Celtic Sea** *Nephrops* **FUs.**

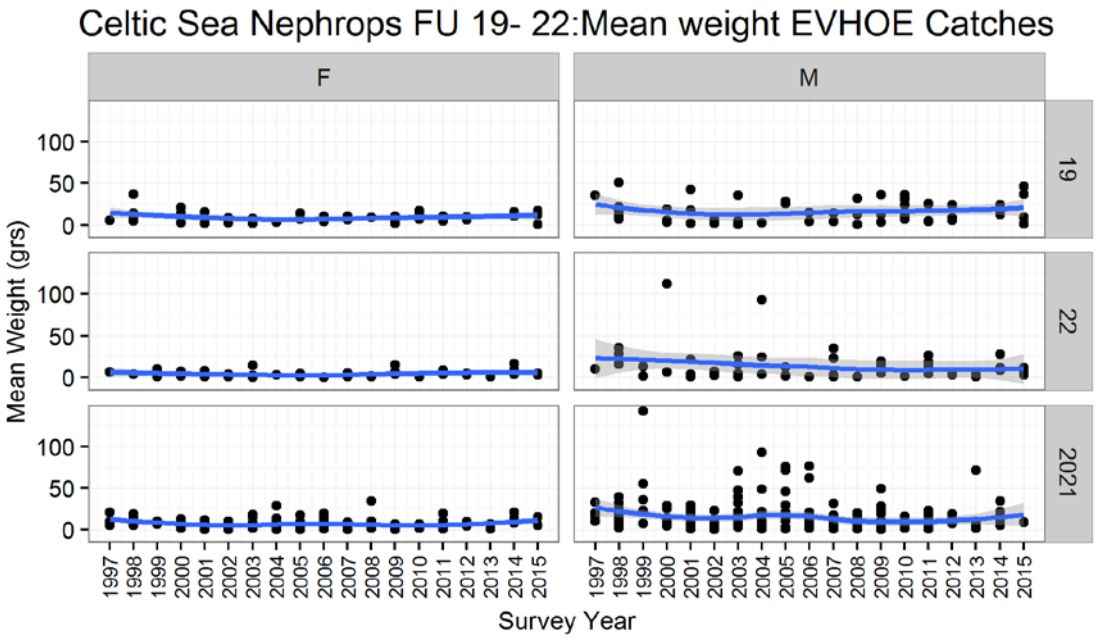

Figure B.4.3. *Nephrops* **in FU19 (S and SW Ireland). Time-series of mean weights (grs) by sex in catches from EVHOE for Celtic Sea** *Nephrops* **FUs.**

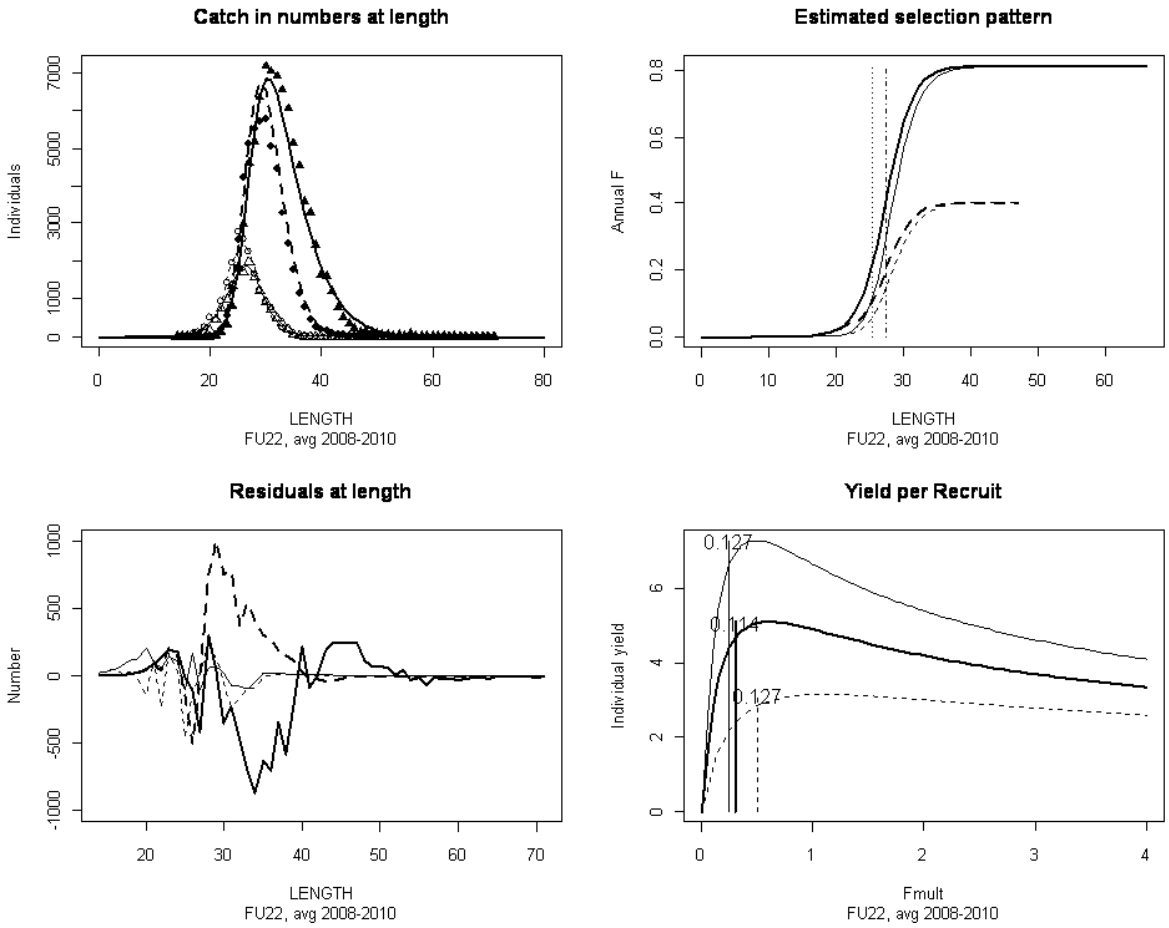

Figure C.1. ***Nephrops*** **in FU22 (Smalls). Separable Cohort Analysis model fit. Solid lines are for males, dashed lines are females, thick lines represent the landings component and the thin lines represent the discarded component. The top left panel gives observed and predicted numbers-at-length 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.**