

Stock Annex: *Nephrops* FU2021

Stock specific documentation of standard assessment procedures used by ICES.

Stock *Nephrops* (FU2021) FU 20 (Labadie, Baltimore and Galley), FU 21 (Jones and Cockburn)

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General

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 knowledge of the distribution of suitable *Nephrops* habitat in this area is developing. Information so far suggests that *Nephrops* are found in complex channels, which are probably the remnants of fluvial channels related to the deglaciation of the Irish ice sheet at the end of the last ice age.

The spatial extent of the *Nephrops* grounds in FU20–21 has been re-defined using Irish 2006–2011 integrated VMS-logbook data using the methods described in Gerritsen and Lordan (2011). Here, *Nephrops* directed activity was defined for VMS pings where >30% of daily operational landings was reported to be *Nephrops*. Integrated French VMS data 2008–2012 is also available. The knowledge of the distribution of suitable *Nephrops* habitat in this area is developing. Information so far suggests that *Nephrops* are found in complex channels, which are probably the remnants of fluvial channels related to the deglaciation of the Irish ice sheet at the end of the last ice age. The initial ground perimeter used during this survey was established using a combination of integrated logbook VMS data (using the methods described in Gerritsen and Lordan, 2011), BGS sediment maps and data collected on observer trips. The total area of this polygon is 9840 km² (Table 5.1.1.; Figure 5.1.1). The shapefiles of the FU12021 ground are available at: <http://data.marine.ie/downloads/fisheries/NephropsGrounds.zip>

Table 5.1.2 gives the decimalised positions of the polygon.

The Functional Unit for assessment includes some parts of the following ICES Divisions VIIg,h. The fishery data for this includes the following ICES Statistical rectangles: 28 EO-E2; 29 E0-E3; 30E1-E3; 31E2 (Figure 5.1.2) and was revised to include the spatial area of the polygon.

Adult *Nephrops* probably only undertake very small-scale movements (a few 100 m). Recent studies in larval tracking models show that larval transfer in this area is minimal where this ground retains most of the larvae whereas other *Nephrops* grounds in the Celtic sea may donate larvae to this ground such as the offshore Galley Grounds 4 in FU19 (O' Sullivan *et al.*, 2015).

Fishery

France and Ireland are the main countries involved in the FU20–21 *Nephrops* fishery. The fishery is almost exclusively an otter trawl fishery with most vessel using twin

rigs. There are a large number of species taken as bycatch in the fishery. Economically whiting, monkfish, cod and megrim and to a lesser degree haddock, tend to be the most important species retained with *Nephrops*. The fishery has a seasonal trend where landings are mainly in quarter 2 and 3 from both countries (Figure 5.1.3).

Ireland

The Irish fleet has been the main participant in this fishery in recent years. Vessels >18 m tend to fish the offshore *Nephrops* and target *Nephrops* on several in 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. The Irish fishery is more mixed (~50% *Nephrops* by weight) in the northern part of the area whereas further south *Nephrops* dominate the landings (>75% by weight) (Gerritsen *et al.*, 2012).

The Irish fishery has expanded since the early 2000's where the fleet has expanded into the southern side of the grounds in more recent times. Figure 5.1.4. shows the landings (t) by ICES statistical rectangle for the Irish fleet where the Irish fleet is expanding into the southern part of the grounds. The fishery shows a distinctive seasonal pattern with highest landings in April to June. The standardised monthly landings time-series is shown in Figure 5.1.5.

The main ports for FU20–21 landings are Cobh, Castletownbere and Union Hall in the south coast.

France

French trawlers operating in this area fish also in the Celtic Sea (FU22 and FU20–21) and switch between FUs depending on weather conditions. The French fishery is general more mixed (~10% *Nephrops* by weight) with where vessels often switch target species between *Nephrops* and gadoid species.

The French trawlers' trips have a typical long duration of 12–15 days and cover more than one FU. As consequence of that, there are many mixed French trips (*i.e.* vessels covering FU20–21 and F22) sampled for LFDs on landings and discards. The major part of this fleet currently catches by almost 85–90% of *Nephrops* on the FU20–21 grounds (75% averaged on years 1995–2014), thus a part of information from the whole Celtic Sea such as LFDs is considered as representative for FU20–21.

Table 5.1.3 shows the landings (t) by ICES statistical rectangle for both the French and Irish fleet.

UK

Variable participation by the UK in this fishery. In 2016 the majority of the landings reported into UK England and Wales ports were from UK Scottish vessels. 2016 UK E&W landings were from ICES statistical rectangle 28 E1-E2 and 29 E1-E2.

Technical Measures

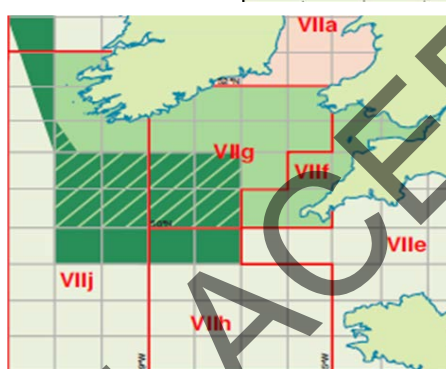
The following TCMs are in place for *Nephrops* in VII (excluding VIIa) after EC 850/9 in operation since 2000: Minimum Landing Sizes (MLS); total length >85 mm, carapace length >25 mm, tail length >46 mm. This regulation is applied by the Irish and UK fleets whereas a more restrictive regulation adopted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

The French minimum mesh size of codend was set at 100 mm in January 2000.

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 cod end 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	-	-	-	-	-	-	-	-	-
Headline Panel (mm) (Beam Trawlers see footnote 1)	-	-	-	-	-	-	-	-	-
Square mesh panel (mm)	-	-	-	-	-	-	-	-	-
Maximum number of meshes in codend circumference	-	-	-	-	-	-	-	-	-
Catch Composition	-	-	-	-	-	-	-	-	-
Maximum % of cod allowed. (Council Reg 39/2013)	-	-	-	-	-	-	-	-	-
Maximum % cod, haddock, saithe allowed	-	-	-	-	-	-	-	-	-
Maximum % of hake allowed	-	-	-	-	-	-	-	-	-
Minimum % of saithe required	-	-	-	-	-	-	-	-	-
Minimum % of <i>Nephrops</i> required	-	-	-	-	-	-	-	-	-
Minimum % of Annex I List (see footnotes)	-	-	-	-	-	-	-	-	-
Minimum % of haddock, hake, whiting, megrim, monkfish, rays, saithe and <i>Nephrops</i>	-	-	-	-	-	-	-	-	-



Source: http://www.bim.ie/media/bim/content/newsandevents/BIM_Fisheries_Management_Map_2013.PDF

Ecosystem aspects

Physical oceanography

There is evidence of a cyclical gyre in the Labadie. Outputs from the larval tracking modelling study suggest that surface water flow above the Labadie is strongest during summer. Retention of larvae is quite high on this ground which indicates that some gyre formation may be in effect entraining the larvae within the area. This is most apparent in April and May with surface water adopting a south-westerly orientation about the domain during June (O' Sullivan *et al.*, 2015).

Sediment distribution

Current available sediment information is based on British Geological survey data which is not of a fine spatial resolution. The Celtic Sea contains a fan-like system of shelf-crossing ridges which are thought to be palaeo-tidal sandbanks with a glacial origin (Praeg *et al.*, 2010). Mapping of VMS data linked to *Nephrops* landings can be viewed as a proxy for sediments distribution.

Bathymetry

UWTV station depths ranged from 95 to 134 metres on the Labadie, Jones and Cockburn Banks.

Data

Commercial catch

Commercial landings data are supplied by Ireland, France and the UK for FU20–21 since 1999. Previously landings were available for FU20–22.

Landings statistics for the Irish fleet are obtained from EU logbooks since 1999. Vessels record daily retained catches in operations and make a declaration of total landings on re-turn 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 on board in each 24 hour period. Similarly landings from UK Scotland and England, Wales and Northern Ireland are available from the logbooks. Landings from France are obtained from EU logbooks.

Sampling Data

Sampling of this *Nephrops* stock has been very limited by both countries due to the remoteness of the fishery and consequent logistic problems.

Ireland

Sampling is very limited (5 samples in 2012, 7 in 2013). A catch self-sampling programme has been in operation where this involves unsorted catch and discard samples being provided by vessels or collected by observers at sea on discard trips. The catch sample is partitioned into landings and discards using an on-board discard selection ogive derived for the discard samples. Occasionally the graded landings are sampled by on-board observers, however these are not used in the assessment as yet.

Sampling levels for Ireland are shown in Table 5.1.4 and Figure 5.1.6. Figure 5.1.7 shows the sampling by ground.

France

Sampling of the landings with occasional on board sampling which is also limited.

For France data was available for 1997, 2010, 2012 to 2013 (see WGCSE 2013 and 2014 report). Due to changes in on-board practices a significant increasing proportion of tailed individuals were present in French landings where from 2005–2015, tailed *Nephrops* accounted between 11 to 23% of the landings where previously it was around 5%. This is linked to increasing fuel prices with higher proportions of tailed individuals retained to compensate this loss according to the French industry. Two methods were derived to reconstruct the landings LFDs but are now considered inappropriate as the increasing proportion of tails probably results in changes to discard practices. One method extrapolated tails to CL, the other approach assumes that the tails have the same LFD as the smallest market category.

Biological

Biological parameters for this stock are outlined in Table 5.1.5.

Length–weight

The annual mean weight for Irish landings is estimated from the length–frequency data and a length–weight relationship from studies on Scottish stocks by Pope and Thomas (1955). The annual mean weight for French landings is estimated using parameters derived from Scottish weight–length relationships (Pope and Thomas, 1955).

No changes in these parameters were made at WKCELT 2014.

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. No changes in these parameters were made at WKCELT 2014.

Maturity

Female

L_{50} is taken from FU22, to date there has been no maturity ogive estimated for this area.

Male

To date there has been no maturity ogive estimated for this area.

Discard survival

Trip durations (French trips ~15 days, Irish Trips ~7-15 days) and behaviour of the 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 a moderate discard survival. This is estimated to be around 25% (Chareau *et al.*, 1982). No changes in these parameters were made at WKCELT 2014.

Surveys

UWTV Survey

In 2006 Ireland conducted the first underwater television survey (UWTV) in FU2021, however only 9 stations were completed. From 2012 to 2013 an average of 56 stations have been completed. The 2013 survey design was based on a randomized isometric grid of 95 stations with a 6.0 nautical mile spacing was planned. Stations depths varied from 95 m to 134 m and the completed stations ranged from 55 to 135 nautical miles (nmi) offshore. 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 (2013). 60% of the grounds has been covered by the 2013 UWTV survey. Since 2014 100% of the grounds has been covered by UWTV survey with an average of 95 stations. UWTV survey methodology and results are available at <http://hdl.handle.net/10793/915>.

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 FU2021 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 1.25 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. Burrow identification could be slightly overestimated since burrows with the classical *Nephrops* signatures are common but they are interspersed with burrows of various crab and other burrowing megafauna species. The proposed cumulative correction factor for the area was 1.3 (text 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 FU19 are:

	Established	Edge effect	detection rate	species identification	occupancy	Cumulative bias
FU2021:	2012	1.25	0.9	1.15	1	1.3

IBTS Groundfish Survey

There are two IBTS-GFS catching *Nephrops* in FU20–21: French groundfish survey EVHOE-WIBTS-Q4 since 1997 and Irish groundfish survey-Q4: IGFS-WIBTS-Q4 commenced in 2003 (Stokes *et al.*, 2014). These data are useful as additional indicators of trends in recruitment, mean size, mean weight and sex ratio for this *Nephrops* stock. Figure 5.1.8. shows IGFS and EVHOE stations with *Nephrops* catches in FU2021. Figure 5.1.9 and 5.1.10 shows the mean weight (grs) by sex from IGFS and EVHOE survey in the Celtic Sea.

Commercial cpue

Disaggregated effort and lpue data are available for the Irish *Nephrops* directed fleet in FU2021 from 1999 for all vessels >18 metres total length. The lpue and effort-series is based on the same criteria for FU15, 16, 17, 19, 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 standardized, 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.

French time series is based on a 10% threshold for *Nephrops* targeting and is for all of the Celtic Sea (FU20–22). Effort data are available from 1983 to 2008 for the French *Nephrops* fleet for the overall Celtic Sea. Since 2009, the new registration system of official French statistics has changed the way fishing effort is computed. As a consequence, there is no reference to the number of hours for use of a fishing gear and that hampers unbiased estimates while vessels alternate fishing gears and targeted species during the same trip. To circumvent this problem, new allocation method was tested to characterize a *Nephrops* trawler based on thresholds of *Nephrops* landings weight with no reference to the other species composing the landings by trip. Estimators based on a simple threshold of 500 kg landed *Nephrops*/trip gave satisfactory results compared to the previous estimators (see Stock Annex). Thus, estimates of French fishing effort (h) and LPUE (kg/h) since 2009 have been calculated by this way.

Since FU20–21 and FU22 have been split the WGCSE investigated the disaggregated LPUE series for FU20–21 and FU22 separately for Irish trawlers but inseparably for French trawlers which are essentially operating in FU20–21 and the bias induced is considered to be minor. The highest LPUEs simultaneously for both countries were observed in 2008–2009 with a reduction evident in 2010. In 2011 Irish LPUE indices remain relatively stable whereas French series declined. In the two recent years no change occurred for the French LPUEs although Irish indices grew up and reached the historical highest level of the time series.

WGCSE 2015 recommended that effort data in Kw days should be presented as these data are more informative than uncorrected effort data. Effort data are available from 1995 for the Irish otter trawl *Nephrops* directed fleet.

Assessment: data and method

UWTV survey approach

The UWTV survey approach should be applied to this FU when improved survey coverage is achieved in future. In the interim *Nephrops* data limited approach should be used. Any improvements in mean weights and discard rates are to be included in this approach. This approach was first carried out by WGCSE 2016.

Medium-term projections

None presented.

Long-term projections

None presented.

F_{MSY} reference points

New reference points were estimated by WGCSE 2016 using the same method and approach used at WKMSYREF4 (ICES, 2016). The detailed analysis is available in working document 11. In the case of FU20–21 there is a limited number of years for which length–frequency data were available so the three year moving window could only be applied to give two estimates. The resulting potential F_{MSY} harvest rates and ranges are given in the following table.

YEAR	F _{MAX}	F _{MAX.LOW}	F _{MAX.UP}	F ₃₅	F _{35.LOW}	F _{35.UP}	F _{0.1}	F _{0.1.LOW}	F _{0.1.UP}
2012	9.12	6.51	12.60	11.03	6.11	13.21	5.91	5.08	15.11
2013	9.45	6.71	13.26	11.17	6.30	13.78	6.10	5.23	15.93

Given the low density in the area and combined sex F_{0.1} was considered and appropriate F_{MSY} proxy.

STOCK CODE	MSY FLOWER*	F _{MSY} *	MSY FUPPER* WITH AR	MSY BTRIGGER	MSY FUPPER* WITH NO AR
nep-2021	6.0%	6.0%	6.0%	Not defined	6.0%

* Harvest rate (HR).

No proposal has been made for MSY Btrigger as the time-series is too short.

A harvest ratio consistent with a combined sex F_{0.1} is considered an appropriate proxy for F_{MSY}. The F_{0.1} estimate from the 2012–2014 is proposed as the best value to use since it is based on the most recent data and is the most conservative of the last three reasonable fits. These should remain under review by WGCSE and may be revised should improved data become available.

Other issues

Historical overview of previous assessment methods

Data limited approach

WKLIFE II (ICES 2012) establishes procedures for generating advice for stocks with various shortcomings in the data. The *Nephrops* data-limited approach which was first used by WGCSE 2012 to provide advice for FU2021 and has now been formally incorporated into the ICES DL framework as Method 4.1.4 'Data borrowing for sedentary species'. This method requires the following inputs to derive Harvest Ratios for given levels of density and landings:

- Absolute bias corrected density from TV survey
- Spatial extent of the grounds
- mean weight in the landings
- percentage of dead discards in numbers

Steps in formulating the data-limited table:

1. Use absolute bias corrected density and survey area to derive *Nephrops* abundance for a range of densities
2. Convert potential landings weight into numbers using landings mean weight for a range of total landings (ten year average, half of ten year average, maximum of time-series);
3. Convert landings numbers into total removals by dividing by (1-discard rate in number);
4. Divide total removals (from 3) by *Nephrops* abundance (from 1) to obtain a matrix of harvest rates which can be compared to F_{MSY} .

Text table below is an example of the data limited approach for FU 2021.

FU 20-21: Labadie				3,710	Area (km2)	34.4	mean weight (g)		28%	percentage discards
Density										
landings	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	
1000	6.7%	5.0%	4.0%	3.4%	2.9%	2.5%	2.2%	2.0%	1.8%	
1250	8.4%	6.3%	5.0%	4.2%	3.6%	3.1%	2.8%	2.5%	2.3%	
1500	10.1%	7.5%	6.0%	5.0%	4.3%	3.8%	3.4%	3.0%	2.7%	
1750	11.7%	8.8%	7.0%	5.9%	5.0%	4.4%	3.9%	3.5%	3.2%	
2000	13.4%	10.1%	8.0%	6.7%	5.7%	5.0%	4.5%	4.0%	3.7%	
2250	15.1%	11.3%	9.0%	7.5%	6.5%	5.7%	5.0%	4.5%	4.1%	
2500	16.8%	12.6%	10.1%	8.4%	7.2%	6.3%	5.6%	5.0%	4.6%	
2750	18.4%	13.8%	11.1%	9.2%	7.9%	6.9%	6.1%	5.5%	5.0%	
3000	20.1%	15.1%	12.1%	10.1%	8.6%	7.5%	6.7%	6.0%	5.5%	
average	2163	14.5%	10.9%	8.7%	7.2%	6.2%	5.4%	4.8%	4.3%	4.0%
maximum	3144	21.1%	15.8%	12.6%	10.5%	9.0%	7.9%	7.0%	6.3%	5.7%
Minimum	972	6.5%	4.9%	3.9%	3.3%	2.8%	2.4%	2.2%	2.0%	1.8%

WGCSE investigated the approach for “data-limited *Nephrops* stocks” (see WGNSSK: FU5 *Nephrops* in Botney Gut-Silver Pit) including those in FU20–21. The area of the *Nephrops* ground was first estimated using the following method. Irish *Nephrops* directed VMS between 2006 and 2011 was mapped using the methods described in Gerritsen and Lordan (2011). The various polygons covering the most intense VMS activity were then manually identified and their areas estimated using a GIS programme (Map Viewer) (see final result for the polygon: Figure 7.17.1). *Nephrops* are known to occur on channels of muddy sediment over a very wide area in the Celtic Sea. The total area delineated was estimated around 3710 km² by WGCSE 2012, but it was revised upwards with the integration of French VMS (although this fleet is multipurpose and alternates targeting *Nephrops* and gadoids), fisheries observer data and other habitat data (e.g. sediment maps, depth, multibeam information, etc.). The benchmark 2014 estimated the FU20–21 polygon at 10 014 km² and this value was retained by the WGCSE 2014 (ICES, 2014b). The total surface was fixed at 9835 km² by the WGCSE 2015.

Aside from the area, mean weight in the landings and percentage of dead discards (25% discard survival rate: Charuau *et al.*, 1982) in numbers are needed to derive Harvest ratios for given levels of density and landings. The fishery in FU20–21 has historically been dominated by French vessels. In recent years a higher proportions of the landings are made by Irish vessels. There is a limited common dataset for French and Irish LFDs on only three years (2012–2014) (see mean sizes in Table 7.17.4). The mean weight in the landings and discard rates in numbers for French vessels is higher than Irish vessels. To derive mean weight in the landings the following approach was used.

The sex combined mean weight and dead discards proportion (averaged on years 2012–2014) were weighed by the relative landings of each country. Table 7.17.10 shows the mean weights of each country and the weighted estimates by year. WGCSE considered that mean weight and discard assumptions calculated in this way can be considered to be the most realistic value given the current share of landings by both countries Table 7.17.11 provides the combined results for harvest rates for a range of landings (1000–3000 t) and across a range of densities (0.15–0.55 individuals/m²). The average *Nephrops* density for FU20–21 observed by the Irish UWTV survey in summer 2014 was 0.19/m². This implies that recent harvest rates under averaged landings 1995–2014 (2196 t) have been below 5% (4.4%) which is very low relative to most other developed *Nephrops* fisheries and similar to the HR in place for the Porcupine Bank (FU16).

Age-structured XSA assessment.

Age structured XSA assessment for this stock was carried *Nephrops* WG in 2003 (ICES, 2003) for FU20–22 and only for male component. 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.

Model used: XSA, LCA

Software used: n/r

Model Options chosen: No Final model was accepted

References

- Anon 2011. Atlas of Demersal Discarding, Scientific Observations and Potential Solutions, Marine Institute, Bord Iascaigh Mhara, September 2011. ISBN 978-1-902895-50-5. 82 pp.
- Charuau A., Morizur Y., Rivoalen J.J. 1982. Survival of discarded *Nephrops norvegicus* in the Bay of Biscay and in the Celtic Sea, ICES-CM-1982/B:13.
- Campbell, N., Dobby, H., and Bailey, N. 2009. Investigating and mitigating uncertainties in the assessment of Scottish *Nephrops norvegicus* populations using simulated underwater television data. ICES Journal of Marine Science 66: 646–655. doi: 10.1093/icesjms/fsp046.
- Gerritsen, H.D. and Lordan C. 2006. The accuracy and precision of maturity parameters from sampling of female *Nephrops* from stocks around Ireland. WD6 in the Report of the Workshop on *Nephrops* stocks. ICES CM 2006/ACFM:12.
- Gerritsen, H.D. and Lordan C. 2011. Integrating Vessel Monitoring Systems (VMS) data with daily catch data from logbooks to explore the spatial distribution of catch and effort at high resolution. ICES J Mar Sci 68 (1): 245-252.
- ICES. 2007. Report of the Workshop on the use of UWTV surveys for determining abundance in *Nephrops* stocks throughout European waters (WKNEPHTV). ICES CM: 2007/ACFM: 14 Ref: LRC, PGCCDBS.
- ICES. 2008. Report of the Workshop and training course on *Nephrops* Burrow Identification (WKNEPHBID). ICES CM: 2008/LRC: 03 Ref: ACOM.
- ICES 2009. Report of the Benchmark Workshop on *Nephrops* assessment (WKNEPH). ICES CM: 2009/ACOM:33.
- ICES 2012a. Report of the Working Group for Celtic Seas Ecoregion (WGCSE). ICES CM: 2012/ACOM:12.
- ICES. 2012b. Report of the Study Group on *Nephrops* Surveys (SGNEPS), 6–8 March 2012, Acona, Italy. ICES CM 2012/SSGESST:19. 36 pp. <http://www.ices.dk/reports/SSGESST/2012/SGNEPS12.pdf>
- O'Sullivan D, Lordan C, Doyle J, Berry A, Lyons K. 2015. Metapopulation connectivity via larval transport of the Norway lobster *Nephrops norvegicus* in waters around Ireland: a modelled approach. Mar Ecol Prog Ser 534:95–106.
- Stokes, D., Gerritsen, H., O'Hea, B., Moore, S.J. & Dransfeld, L., " Irish Groundfish Survey Cruise Report, Sept. 24th – Dec. 17th, 2014", FEAS Survey Series;2014/01. <http://hdl.handle.net/10793/1064>

Table 5.1.1. *Nephrops* in FU20–21. Area calculations of Labadie grounds and final average area.

Labadie FU2021				
	Irish National Grid (km ²)	Eckert VI (world) (km ²)	Cylindrical Equal Area (km ²)	Average (km ²)
Integrated VMS 2008–2012	10 028.27	10 018.02	9995.86	10 014.00

Table 5.1.2. *Nephrops* in FU20–21. Positions of 2014 Labadie polygon.

Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude
1	-7.71	50.94	36	-7.97	49.70	71	-9.07	50.02
2	-7.57	50.91	37	-7.79	49.85	72	-9.16	50.00
3	-7.74	50.83	38	-7.96	49.75	73	-9.27	49.98
4	-7.92	50.81	39	-7.99	49.80	74	-9.08	50.11
5	-7.92	50.73	40	-7.94	49.88	75	-8.88	50.22
6	-7.72	50.81	41	-8.11	49.73	76	-8.72	50.32
7	-7.54	50.76	42	-8.30	49.76	77	-8.93	50.25
8	-7.31	50.74	43	-8.52	49.77	78	-9.14	50.20
9	-7.19	50.72	44	-8.38	49.90	79	-9.16	50.22
10	-7.01	50.61	45	-8.44	49.93	80	-9.25	50.21
11	-6.99	50.40	46	-8.67	49.91	81	-9.23	50.31
12	-7.08	50.45	47	-8.80	49.89	82	-9.02	50.38
13	-7.19	50.53	48	-8.61	50.02	83	-8.80	50.43
14	-7.18	50.36	49	-8.42	50.14	84	-8.59	50.52
15	-7.32	50.49	50	-8.42	50.20	85	-8.39	50.62
16	-7.54	50.51	51	-8.62	50.09	86	-8.20	50.73
17	-7.77	50.51	52	-8.71	50.10	87	-8.37	50.68
18	-7.96	50.39	53	-8.85	49.92	88	-8.58	50.68
19	-8.11	50.23	54	-8.98	49.86	89	-8.66	50.70
20	-7.98	50.23	55	-8.92	49.94	90	-8.70	50.73
21	-8.01	50.11	56	-9.00	49.93	91	-8.48	50.79
22	-7.78	50.13	57	-8.80	50.02	92	-8.27	50.87
23	-7.66	50.04	58	-8.63	50.17	93	-8.14	50.92
24	-7.53	50.12	59	-8.44	50.30	94	-8.16	50.90
25	-7.46	50.08	60	-8.47	50.35	95	-8.37	50.80
26	-7.63	49.95	61	-8.56	50.33	96	-8.43	50.75
27	-7.47	49.84	62	-8.36	50.44	97	-8.25	50.79
28	-7.55	49.93	63	-8.14	50.51	98	-8.05	50.90
29	-7.40	50.05	64	-7.96	50.64	99	-7.87	50.91
30	-7.25	50.13	65	-8.11	50.63	100	-7.71	50.94
31	-7.24	49.94	66	-8.32	50.53			
32	-7.38	49.79	67	-8.51	50.42			
33	-7.58	49.71	68	-8.65	50.24			
34	-7.74	49.79	69	-8.83	50.10			
35	-7.93	49.65	70	-9.02	49.98			

Table 5.1.3. *Nephrops* in FU20–21. Landings (t) by ICES statistical rectangle by year for the French and Irish fleet.

French trawlers										
year	28E2	28E3	29E2	29E3	30E2	30E3	30E4	31E3	other	Total
1993	241	401	529	480	286	474	60	119	166	2757
1994	99	378	368	672	397	711	73	96	159	2953
1995	157	537	467	644	375	878	104	95	162	3419
1996	148	513	325	460	303	802	55	65	50	2721
1997	124	441	216	429	194	414	26	44	68	1957
1998	111	295	149	213	191	454	15	50	106	1583
1999	78	143	101	126	117	286	41	49	104	1045
2000	73	346	181	282	171	421	50	52	81	1656
2001	131	330	298	199	199	427	29	76	56	1745
2002	219	289	534	198	427	736	25	72	55	2556
2003	257	367	647	246	367	802	23	44	44	2797
2004	170	261	354	259	198	781	34	34	60	2151
2005	186	295	280	365	185	580	37	33	65	2024
2006	209	215	259	425	104	767	35	18	43	2075
2007	367	190	402	241	108	437	18	20	32	1817
2008	356	243	355	213	153	651	10	23	44	2047
2009	224	219	451	230	126	594	12	9	42	1906
2010	151	181	127	146	35	293	5	15	30	983
2011	59	130	37	110	32	149	4	14	21	556
2012	46	107	69	56	34	103	2	4	32	453
2013	30	126	68	70	17	87	2	3	83	486
2014	42	104	51	70	14	109	1	5	68	465
2015	21	72	59	52	25	110	0	1	14	355
Irish trawlers										
year	28E2	28E3	29E2	29E3	30E2	30E3	30E4	31E3	28E2	Total
1995	2	1	3	-	57	23	<0.5	23	7	117
1996	-	-	17	1	35	22	1	17	7	101
1997	-	-	9	10	24	2	3	32	2	81
1998	<0.5	-	10	3	81	8	4	22	1	130
1999	-	-	16	1	4	3	15	43	-	83
2000	-	-	25	2	14	4	2	60	-	107
2001	-	-	<0.5	-	25	3	-	33	8	69
2002	<0.5	-	5	-	19	<0.5	3	12	65	104
2003	6	-	34	<0.5	50	<0.5	-	25	33	148
2004	5	-	53	2	131	24	14	38	33	299
2005	12	7	123	6	133	32	62	68	13	455
2006	2	3	110	14	149	94	19	49	10	450
2007	12	1	218	22	165	48	21	108	5	600
2008	20	6	376	22	292	144	11	61	6	937
2009	72	60	476	67	300	142	10	57	18	1202
2010	107	16	268	54	120	107	11	53	19	756
2011	35	107	200	69	99	80	6	30	13	637
2012	158	75	181	21	143	80	6	34	11	708
2013	226	53	333	41	123	30	2	33	3	844
2014	189	370	442	149	101	68	3	20	2	1342
2015*	241	419	626	145	124	62	1	34	6	1658

*Provisional.

Table 5.1.4. *Nephrops* in FU20–21. Sampling levels for Ireland.

IRELAND		NUMBER OF SAMPLES			NUMBERS MEASURED		
Year	Quarter	Catch	Discards	Landings	Catch	Discards	Landings
2009	2	1			489		
2010	2	1			461		
2011	2	1			270		
2012	1	8	5	1	2654	2,024	1,747
2013	1	1	1		319	423	
2013	2	9	7	1	2514	2,038	2,187
2014	2	2	2		718	782	
2015	1			1			1,724
2015	2	6	6	2	2714	3,997	3,204
2015	3			4			4,750
2015	4	2	2		650	419	
2016	2	8	5	1	2,859	1,485	384
2016	4	3	2	1,743	767	1,678	4

Table 5.1.5. Biological Input Parameters for FU20–21 *Nephrops* Stock.

Parameter	Value	Source
Discard Survival	25%	Assumed in line with other stocks
MALES		
Growth - K	0.17	based on FU22
Growth - L(inf)	68	based on FU22
Natural mortality -M	0.3	assumed, in line with other stocks
Length/weight - a	0.000322	Used to raise Irish data. Based on Scottish data (Pope and Thomas, 1955)
Length/weight - b	3.207	"
FEMALES		
Immature Growth		
Growth - K	0.17	based on FU22
Growth - L(inf)	68	based on FU22
Natural mortality - M	0.3	assumed, in line with other stocks
Size at maturity (L50)	22	ICES 2006 (Lordan and Gerritsen).Based on FU22
Mature Growth		
Growth - K	0.1	based on FU22
Growth - L(inf)	49	based on FU22
Natural mortality - M	0.2	assumed, in line with other stocks
Length/weight - a	0.000684	Used to raise Irish data. Based on Scottish data (Pope and Thomas, 1955)
Length/weight - b	2.963	"

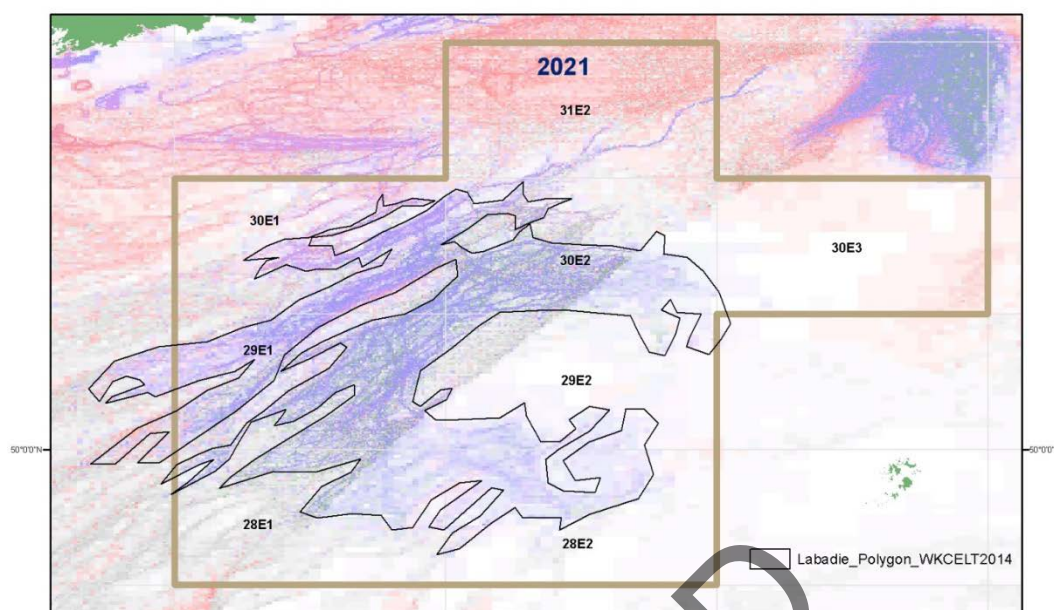


Figure 5.1.1. *Nephrops* in FU20-21. WKCELT Labadie polygon overlaid on proportion of *Nephrops* in the Irish landings (red=0% *Nephrops*; blue=50-60% *Nephrops*; grey=unknown (no Irish landings)).

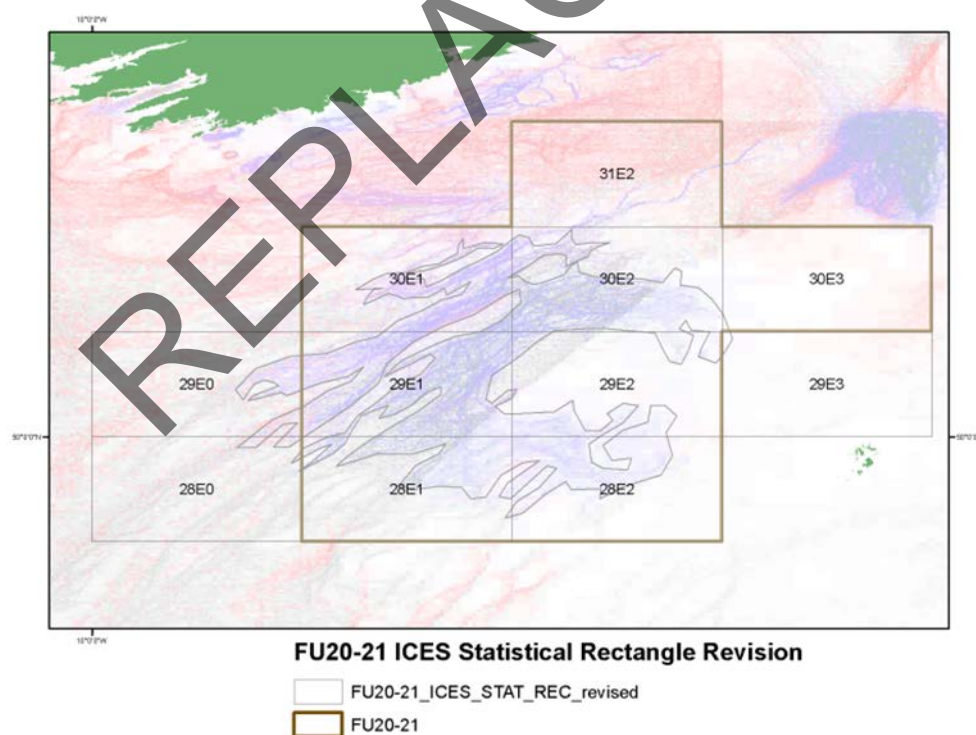


Figure 5.1.2. *Nephrops* in FU20-21. Revision to FU20-21 to include ICES statistical rectangle 28-29E0 and 29E3 to include full survey coverage of ground polygon.

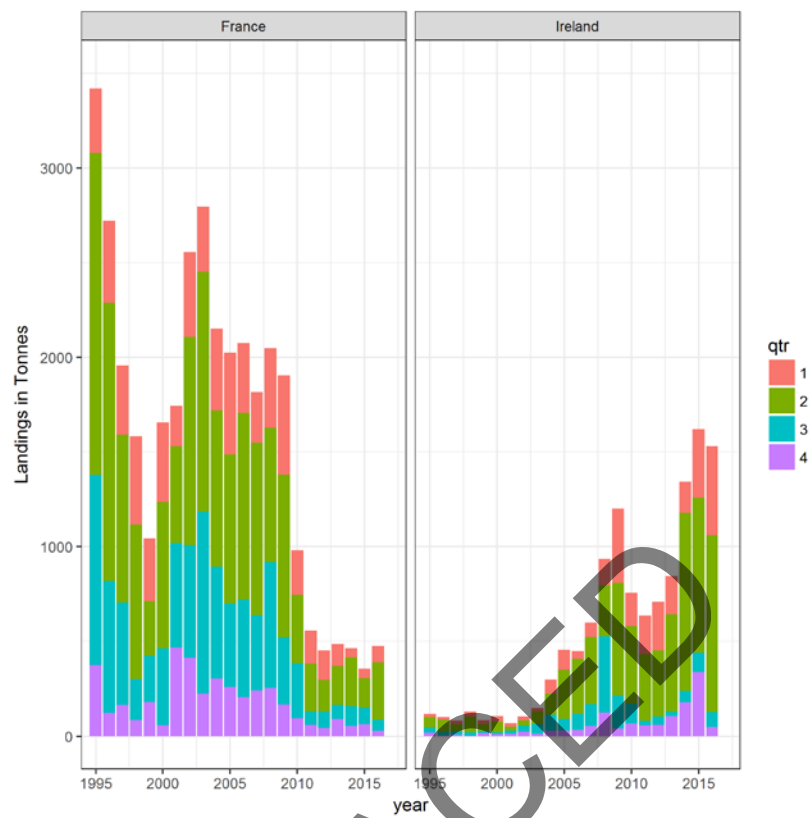


Figure 5.1.3. *Nephrops* in FU20–21. Seasonal trend in landings (t) from Ireland and France.



Figure 5.1.4. *Nephrops* in FU2021. Landings (t) by ICES statistical rectangle for the Irish fleet by year from 2002 (top left)–2016 (bottom left).

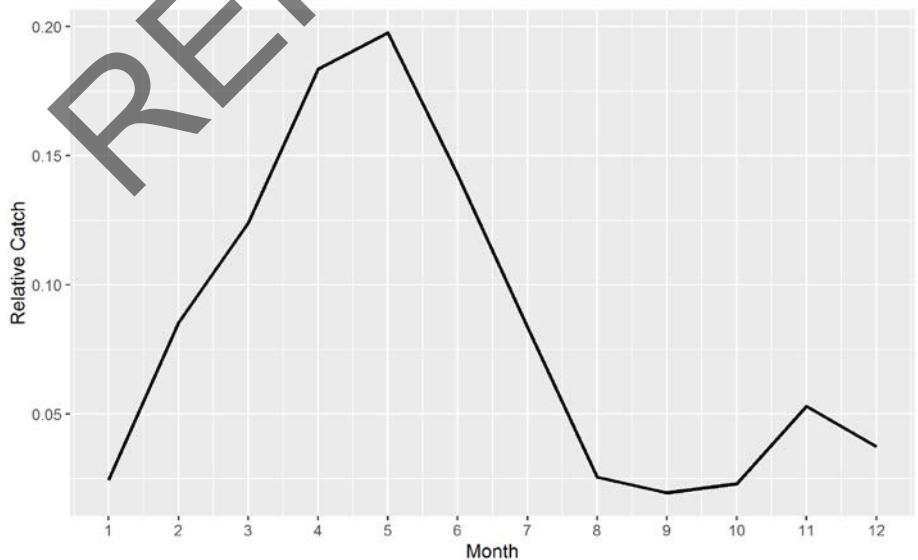


Figure 5.1.5. *Nephrops* in FU2021. Standardised monthly Irish landings showing seasonal trend in the fishery.

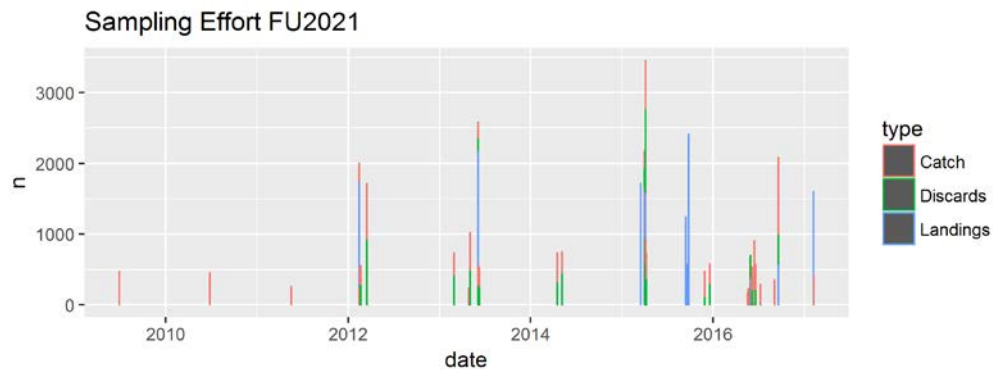


Figure 5.1.6. *Nephrops* in FU20–21. Sampling effort by Ireland.

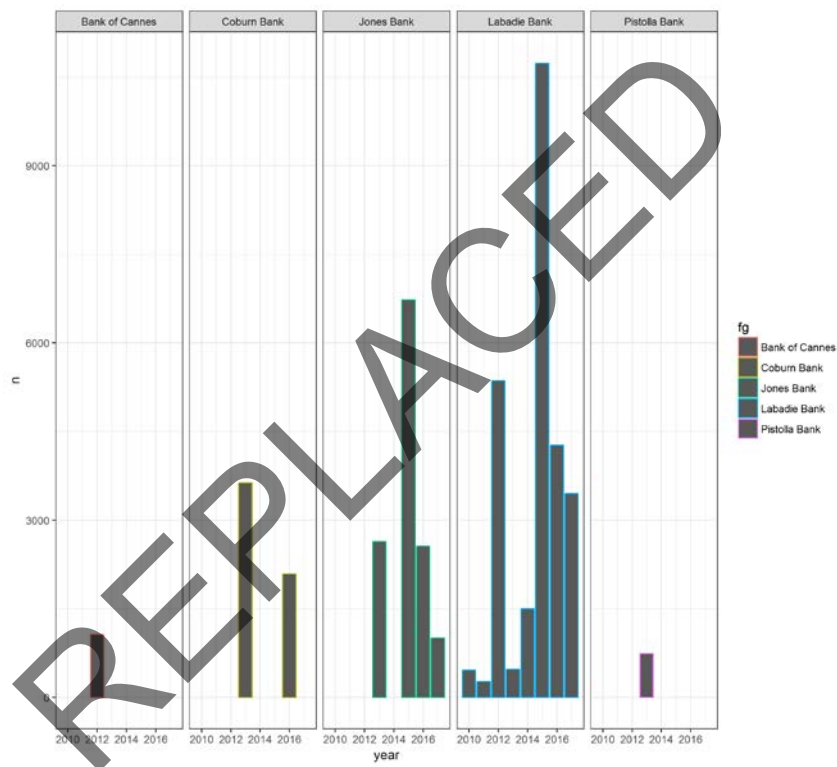


Figure 5.1.7. *Nephrops* in FU20–21. Irish sampling by ground in FU20–21.

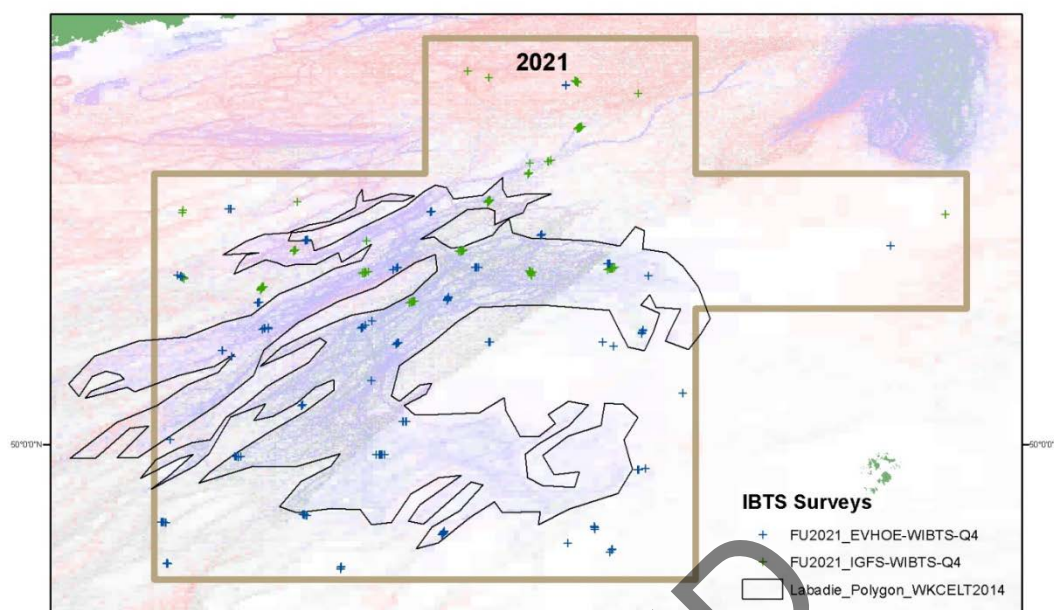


Figure 5.1.8. *Nephrops* in FU2021. The spatial distributions of stations with *Nephrops* catches. Station positions with *Nephrops* catches from Irish (green cross) and French (blue cross) ground-fish survey.

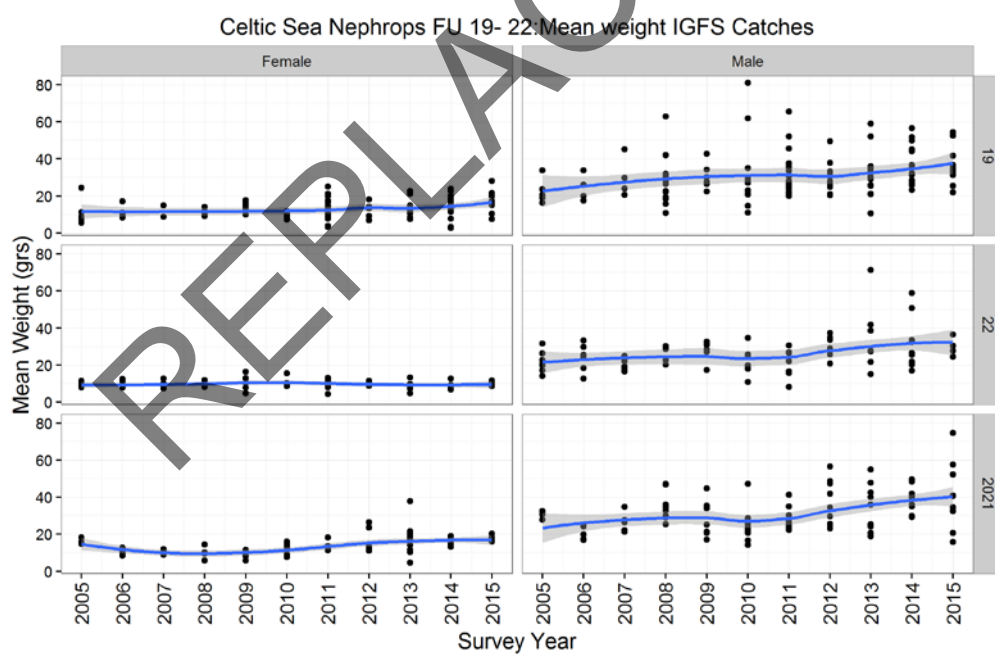


Figure 5.1.9. *Nephrops* in FU2021. Time series of mean weights (grs) by sex in catches from IGFS for Celtic Sea *Nephrops* FUs.

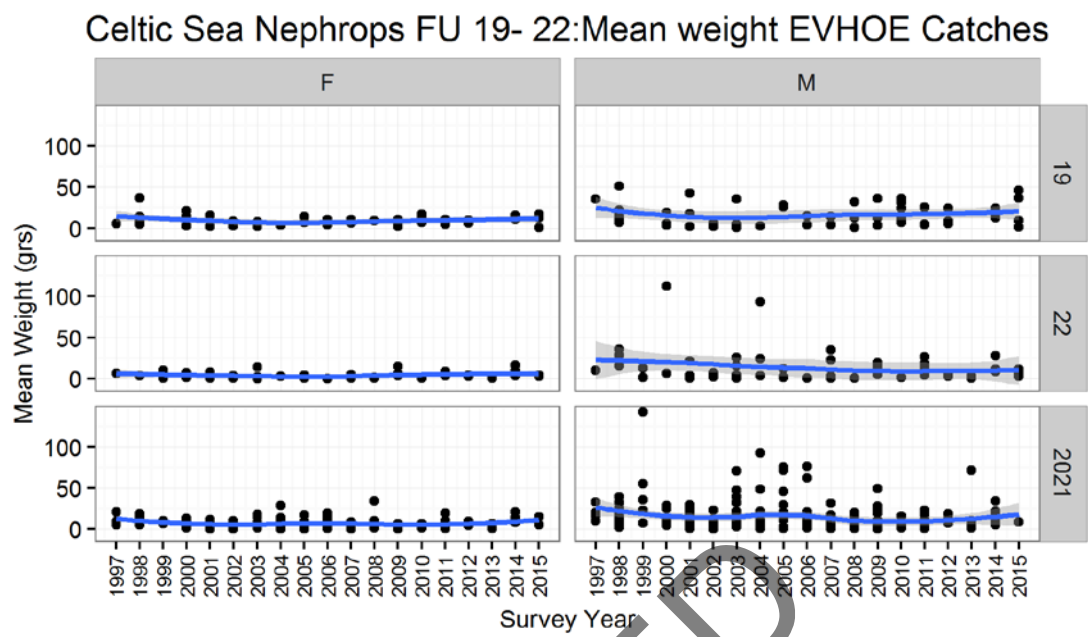


Figure 5.1.10. *Nephrops* in FU2021. Time series of mean weights (grs) by sex in catches from EVHOE for Celtic Sea *Nephrops* FUs.