

Stock Annex: Norway lobster (*Nephrops norvegicus*) in divisions 7.a, 7.g, and 7.j, Functional Unit 19 (Irish Sea, Celtic Sea, eastern part of southwest of Ireland)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Norway lobster
Working group:	Working Group for the Celtic Seas Ecoregion (WGCSE)
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A. 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.

There are several discrete grounds in FU19 and have been named as: Bantry Bay, Galley Grounds 1–4, Cork Channels and Helvick 1–2 and are shown in Figure A.1.1.

The spatial extent of the *Nephrops* grounds in FU19 has been re-defined using 2006–2011 integrated VMS logbook data using the methods described in Gerritsen and Lordan (2011) and also incorporating available backscatter and bathymetry data from the Irish National seabed mapping programme (www.infomar.ie). *Nephrops* directed activity was defined for VMS pings where >30% of daily operational landings was reported to be *Nephrops*. Table A.1.2 shows the data available to redefine the ground boundaries in FU19. The revised polygons were manually drawn and the area calculated using different projections in ArcGIS 10. The average of these calculations was accepted as the area of each ground (Table A.1.2). Positions of the polygons are in Table A.1.3 based on WKCELT calculations. The discrete grounds areas are subject to revision as more seabed mapping and new VMS data becomes available. Any revisions to survey area are to be considered by WGNPS. The shapefiles of the FU19 ground are available at: <http://www.isde.ie> and also <http://data.marine.ie/downloads/fisheries/NephropsGrounds.zip>.

The Functional Unit for assessment includes some parts of the following ICES Divisions 7.j, g, a. The fishery data for this includes the following ICES Statistical rectangles: 31–33D9–E0; 31E1; 32E1–E2; 33E2–E3 (Figure A.1.1).

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 FU19 as some patches are donors of larvae to adjacent grounds (O'Sullivan *et al.*, 2015).

Fishery

Ireland

The Irish fleet has been the main participant in this fishery. Vessels <18 metre total length operate out of many local ports and fish the inshore *Nephrops* patches in periods of good emergence and weather. These smaller vessels account for approximately 70% of the landings from this FU. 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 minimum mesh size in use is 80 mm.

France

French trawlers harvesting *Nephrops* on this area fish also in the Celtic Sea (FU22 and FU20–21) and switch to the FU19 according to meteorological conditions. They have used mesh size 100 mm for codend since January 2000 (in order to not be constrained by bycatch composition) and they apply MLS of 11.5 cm (i.e. 35 mm CL) adopted by French Producers' Organizations larger than the European one (8.5 cm i.e. 25 mm CL).

UK

Landings are minor from this FU.

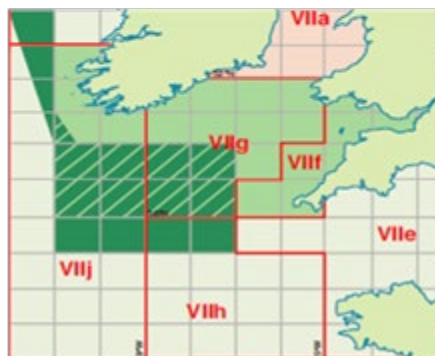
Technical measures

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' Organizations (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 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+	100+
	4mm double or single 6mm									
Twine thickness	-	-	-	-	-	-	-	-	-	-
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	100
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 Nephrops required	-				-				-	
Minimum % of Annex I List (see footnotes)	-				-				-	
Minimum % of haddock, hake, whiting, megrim, monkfish, rays, saithe and Nephrops	-				-				-	



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

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 summer 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.*, in press).

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 and burrow density data to explore relationships between burrow density and sediment for these *Nephrops* grounds and to provide detailed sediment maps. There are limited sediment data from seabed mapping of Bantry Bay suggesting the presence of suitable *Nephrops* substratum where samples contain 60–90% mud shown in Figure A.3.1 (O' Sullivan *et al.*, 2014).

Bathymetry

UWTV station depths ranged from 18 metres in Bantry Bay to 114 metres on the off-shore Galley Grounds 4. Coastal bathymetry data are available from INSS programme and are updated regularly (www.infomar.ie) and these show some channels of soft sediment which correlate to patterns in the VMS integrated data.

Data

Commercial catch

Commercial landings data are supplied by Ireland, France and the UK.

The quality of historic landings data are 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 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.

Revisions to Irish Landings data

Landings data for Ireland were revised and accepted by WGCSE 2019 for years range 2008 to 2017. This resulted in minor revisions in the order of 1 to 5% (Table B.2.1, Figure B.2.1). There was no significant change in the overall perception of the stock in relation to the assessment summary table outputs such as mean weights (Table B.2.2, Figure B.2.2) and discard rates by number and weight (Table B.2.3, Figure B.2.3). WGCSE 2019 agreed to use this updated landings data for the assessment.

Sampling Data

Length–frequency data of the landings were collected on an irregular basis in the years 1996 to 1997, 1999 and 2002 to 2006. Since 2002, a new catch self-sampling programme was put in place. 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 (Table B.2.4). Sampling effort is stratified monthly but quarterly aggregations are used to derive length distributions.

The sampling intensity and coverage has varied over the time-series (Figure B.2.1, Table B.2.4). Since 2007, sampling has been good although the majority of the samples come from Bantry Bay recently (Figure B.2.5). Also sampling of the discards has quite sparse over the time-series. The quality of the sampling has been assessed in terms of precision and accuracy and presented in Annex 2 and 3 of the 2015 data call.

Previously to split the catch numbers into landings a discard ogive from FU22 2006 had been used as discard sampling data has been minimal in FU19. This was explored at WKCELT where discard data observations from 2008 and 2013 from Bantry Bay were used to derive a selection ogive. An averaged discard selection ogive (2008 quarter 1 only and 2013 quarter 3 and 4) was accepted by WKCELT and used to partition the catch data for the reference period 2011–2013. Figure B.2.6 shows the average discard selection ogive accepted at WKCELT. Figure B.2.2 shows the partitioned length–frequency data for the reference period 2011–2013.

Fish and other bycatches in the fishery have been collected by on board observers since 1994. Discarding by the *Nephrops* trawl fleet is around 55% of the total catch by weight. The main discards are small whole *Nephrops*. The main fish species discarded are had-dock, boarfish and dab (Anon, 2011).

Biological

Biological parameters for this stock are outlined in Table B.1.

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

Mean weights over the time-series 2009 to 2013 for Bantry Bay (Figure B.3.1) displayed a seasonal trend in the females where this is related to emergence of females from the burrows in summer to mate (Figure B.3.2).

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 and 2013a). No changes in these parameters were made at WKCELT 2014.

Maturity

Female

The L_{50} in May to July was chosen as the most appropriate estimate given the maturity schedules observed. An updated analysis was available at WKCELT 2014 and the female L_{25}/L_{50} were estimated as 23/24 CL mm from 2008–2013 sampling data (Table B.3.1 and Figure B.3.3).

Male

No update to male maturity was made at WKCELT 2014. The same maturity is assumed as for female L_{25}/L_{50} .

Discard survival

Given the trip durations (1–2 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. No changes in these parameters were made at WKCELT 2014.

Surveys

UWTV Survey

In 2006, Ireland conducted the first underwater television survey (UWTV) in FU19; however, only six stations were completed. From 2011 to 2014, an average of 38 stations have been completed and the majority of the discrete patches surveyed on an annual basis. The survey design is based on randomly picked stations from the ground polygons and the sampling effort on each ground was determined by relative area. 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 (ICES, 2013b; 2014; 2015; 2016; 2017; 2018a) and WKNEPS (ICES, 2016a; 2018b) and Leocádio *et al.*, 2018. Up to date UWTV survey reports are available at: <https://oar.marine.ie/handle/10793/59>.

Given the scale of the area and the number of distinct patches, it is unrealistic to expect sufficient stations (~10) in each individual patch to estimate densities separately. The random stratified approach may cause problems in years where the planned survey coverage is not achieved. WKCELT 2014 concluded that WGCSE or WGNeps should make recommendations on the most appropriate fill in procedure to be adopted in these cases.

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 FU19 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 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 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 FU19 are:

	Established	Edge effect	detection rate	species identification	occupancy	Cumulative bias
FU19: S and SW Ireland	2011	1.25	0.9	1.15	1	1.3

WKCELT 2014 concluded that an UWTV based approach should apply for this stock and that WGCSE and WGNeps review survey results when available.

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 size, mean weight and sex ratio for this *Nephrops* stock. Figure B.4.1 displays IGFS and EVHOE stations with *Nephrops* catches in FU19. Figure B.4.2 and B.4.3 shows the mean weight (grs) by sex from IGFS and EVHOE survey in the Celtic Sea.

Commercial effort

Disaggregated effort and lpue data are available for the Irish *Nephrops* directed fleet in FU19 from 1995–2012 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 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. 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.

Assessment: data and method

Model used: UWTB Based Approach to generate catch options.

Software used: separable SCA model Bell analysis in r.

In 2009, WKNEPH debated the use of the surveys as either an absolute measure of abundance or a relative index (ICES, 2009a). Ultimately, this led to a consensus that bias corrected survey abundance estimates could be used directly in the formulation of catch advice. Two modelling approaches were used to estimate sustainable stock-specific Harvest Ratio reference points; SCA (a separable cohort analysis model Bell) and Age Structured Simulation model (Dobby) (ICES, 2009a). WKCELT 2014 carried out MSY explorations using the most recent data available for FU19 and the SCA Bell model. The model requires landing and discard numbers by length and sex, typically a three-year average to remove strong year-class effects. Additional parameters required are the von Bertalanffy growth parameters, natural mortality and weight-length parameters by sex. Parameters for ogives governing female maturity and the selectivity of the TV survey are also required. Table C.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	L50FEMALE MATURITY
6	Farn Deep	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 and 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

Catch option table based on WTV 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. This should be reviewed annually by WGCSE.
- 5) The catch option table will include the harvest ratios associated with fishing at combined sex $F_{0.1}$, $F_{35\% SpR}$ and F_{MAX} . These values were estimated by WKCELT but may be revised if there are indications of changes to fisheries or biological factors.
- 6) Multiply the adjusted survey index by the harvest ratios to give the number of total removals.
- 7) Create a landings number by applying the discard ratio (dead discard rate).
- 8) Produce landings biomass by applying mean weight.

Medium-term projections

None.

Long-term projections

None.

Biological reference points

WKMSYRef4 updated the F_{MSY} reference points for FU 19 (ICES, 2016; 2016) 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. The updated harvest rate calculated at 9.3% is expected to deliver high long-term yield with a low probability of recruitment overfishing. This is close to the harvest rate calculated by WKCELT (ICES, 2014).

The time-series and range of indicator biomass is limited for FU 19 such that direct use of B_{loss} is considered too close to equilibrium biomass as a basis for $MSY B_{trigger}$. For *Nephrops* stocks, $MSY B_{trigger}$ has been defined as the lowest stock size from which the abundance has increased. 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 FU 19 is 434 million individuals rounded to 430 million.

Text table below gives the reference points:

Stock code	MSY Flower*	FMSY*	MSY Fupper* with AR	MSY Btrigger	MSY Fupper* with no AR
nep-19	8.3%	9.3%	9.3%	430***	9.3%

* Harvest rate (HR).

*** Abundance in millions.

Other issues

Historical overview of previous assessment methods

WKCELT 2014

WKCELT 2014 carried out MSY reference point explorations based on the recommendations of WGCSE 2013. The results are provided below:

FU 19 Harvest Ratio Reference Points			
	Male	Female	Combined
F _{0.1}	8.1	9	8.1
F _{MAX}	12.3	13	12.3
F _{35%SpR}	13	15.2	14.5

WKCELT 2014 took into account the following considerations when proposing a suitable F_{MSY} proxy:

- Compared to other *Nephrops* fisheries in the ICES area the population density of FU19 appears to be moderate ~0.3/m². For this FU the exploitation rate on males is usually higher than on females except in 2013.
- Three years of UWTV survey data are available (2011 to 2013) for this FU.
- The biological parameters are assumed in line with other Celtic Sea stock but probably vary significantly between areas with different density levels. 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 time-series of mean size in the landings/catches is very short and quite noisy. The mean size in survey catches is also short but covers only a few of the patches regularly and the survey only operates in quarter 4.
- The current area estimation of 1973 km² is acceptable as the total area of this stock. WKCELT recommended that the area is subject to refinement when additional backscatter data become available, further sediment sampling and improved VMS data to include vessels of size 12 metres. Also, any future area revisions are to be considered by WGNPs.
- Mean weights have been variable over the available time-series but this is likely to be a result of the variability in sampling of the discrete patches.
- Sampling and discard estimates have been improving over the time-series.

WKCELT 2014 concluded default proxy of combined sex $F_{0.1}$ is appropriate as an $F_{MSY_{proxy}}$. This corresponds to an interim harvest rate of 8.1%, which is in line with several other stocks in the remit of this WG. Fishing at the combined sex $F_{0.1}$ is expected to deliver high long-term yield with a low probability of recruitment overfishing and therefore is chosen as a proxy for F_{MSY} . These calculations assume that the TV survey has a knife-edge selectivity at 17 mm and that the supplied length frequencies represented the population in equilibrium.

WGCSE 2012

This group carried out the first MSY explorations for FU19. In response to the recommendations of WKFRAME (2010), the Bell/Dobby combined sex–length cohort analysis (SCA) 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 was previously 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 FU19 from 2002 to 2011.

Model used: Age Structured Simulation model (Dobby) per recruit analysis in r.

Model Options chosen: The length–frequency distributions reference period 2009–2011 were used. The length distributions in the reference period were relatively stable. The L_{50} for female maturity was estimated at 26 mm and was based on Irish sampling in FU19.

Other SCA inputs such as growth parameters and discard survival were all taken from the stock annex.

PARAMETER	MALES	IMMATURE FEMALES	MATURE FEMALES
L_{∞}	68	68	49
K	0.17	0.17	0.1
Natural Mortality	0.3	0.3	0.2
Discard Survival	10%	10%	10%
A	0.000322	0.000684	0.000684
B	3.207	2.963	2.963

The results of the final SCA model carried out 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.

The L_{50} for female maturity was estimated at 26 mm and was based on Irish sampling in FU19. Figure G.1 shows the estimated YPR and SPR curves. The SCA model fit to both landings and discards of both sexes is fairly good. The YPR plot indicates a more domed YPR for females than males. The results of the model in the table below show 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. The estimated harvest rates are very close to those estimated for several other stocks in 6 and 7.

		FMULT	FBAR 20–40MM		HARVEST RATE %	% VIRGIN SPAWNER PER RECRUIT		
			Male	Female		Male	Female	Comb
F0.1	Male	0.2	0.13	0.04	6.5	42.57	72.19	53.38
F0.1	Female	0.55	0.36	0.11	14.2	18.97	49.02	29.94
F0.1	Comb	0.24	0.16	0.05	7.5	37.60	68.41	48.85
Fmax	Male	0.36	0.24	0.07	10.4	27.48	59.20	39.06
Fmax	Female	1.04	0.68	0.21	21.9	10.54	34.63	19.33
Fmax	Comb	0.47	0.31	0.10	12.7	21.85	52.80	33.15
F35%SpR	Male	0.27	0.18	0.06	8.3	34.51	65.83	45.94
F35%SpR	Female	1.03	0.68	0.21	21.8	10.63	34.83	19.46
F35%SpR	Comb	0.44	0.29	0.09	12.1	23.16	54.40	34.56

***Nephrops* Working group 2003**

A trial LCA assessment for this stock was carried out by the *Nephrops* WG in 2003 (ICES, 2003) and the assessment was not accepted as the quality of the assessment inputs was poor, with only one year's LFD data available for the LCA. More importantly, the WG concluded that the steady state criteria necessary to accept an LCA were not met.

Model used: LCA

Software used: n/r

Model Options chosen: No Final model was accepted

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Table A.1.1. *Nephrops* in FU19 (S and SW Ireland). Data available to define discrete *Nephrops* grounds.

WKCELT 2014							
	Commercial Data		Seabed Mapping Data			Survey Data	
Ground	VMS 2006-2011	Observer Trip Data	Backsc atter	Bathym etry	Sediment Samples	UW TV	Ground Fish
Bantry	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cork Channels	Yes	Yes	Partial	Partial	Yes	Yes	Yes
Galley Grounds1	Yes	Yes	Partial	Partial	No	Yes	Yes
Galley Grounds2	Yes	Yes	Partial	Partial	No	Yes	Yes
Galley Grounds3	Yes	Yes	No	No	No	Yes	Yes
Galley Grounds4	Yes	Yes	No	No	No	Yes	Yes
Helvick 1	Yes	No	Yes	Yes	Yes	Yes	Yes
Helvick 2	Yes	Yes	Partial	Partial	No	Yes	No
Helvick 3	Yes	No	No	No	No	Yes	No
Kenmare Bay	No	Yes	Yes	Yes	Yes	No	Yes

Table A.1.2. *Nephrops* in FU19 (S and SW Ireland). Area Calculations of *Nephrops* grounds and final average areas.

INTEGRATED VMS 2006–2011				
	Irish National Grid (km ²)	Eckert VI (world) (km ²)	Cylindrical Equal Area (km ²)	Average (km ²)
Bantry	121.75	121.54	121.27	121.52
Cork Channels	562.93	562.17	560.91	562.01
Galley Grounds1	60.97	60.88	60.74	60.86
Galley Grounds2	76.87	76.76	76.59	76.74
Galley Grounds3	134.16	133.98	133.68	133.94
Galley Grounds4	926.56	925.40	923.33	925.10
Helvick 1	33.15	33.10	33.03	33.09
Helvick 2	59.62	59.53	59.40	59.52
Total	1976.02	1973.36	1968.95	1972.78

Table A.1.3. *Nephrops* in FU19 (S and SW Ireland). Positions of WKCELT Bantry Bay and Helvick 1–2 polygons.

BANTRY BAY			HELVICK 1			HELVICK 2		
Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude
1	-9.64	51.66	1	-7.43	52.01	1	-7.40	51.76
2	-9.67	51.64	2	-7.43	52.00	2	-7.43	51.75
3	-9.70	51.62	3	-7.43	51.99	3	-7.47	51.74
4	-9.73	51.61	4	-7.44	51.99	4	-7.50	51.75
5	-9.77	51.60	5	-7.45	51.98	5	-7.54	51.75
6	-9.80	51.59	6	-7.46	51.99	6	-7.58	51.75
7	-9.83	51.57	7	-7.47	52.00	7	-7.62	51.75
8	-9.86	51.55	8	-7.47	52.00	8	-7.60	51.76
9	-9.88	51.54	9	-7.48	52.01	9	-7.56	51.76
10	-9.91	51.53	10	-7.49	52.01	10	-7.55	51.79
11	-9.95	51.53	11	-7.50	52.00	11	-7.51	51.81
12	-9.98	51.53	12	-7.51	52.00	12	-7.47	51.81
13	-10.02	51.52	13	-7.52	52.01	13	-7.43	51.80
14	-10.04	51.53	14	-7.51	52.02	14	-7.40	51.82
15	-10.02	51.56	15	-7.50	52.03	15	-7.39	51.80
16	-9.99	51.57	16	-7.49	52.03	16	-7.43	51.79
17	-9.96	51.59	17	-7.48	52.03	17	-7.47	51.79
18	-9.92	51.58	18	-7.47	52.04	18	-7.51	51.79
19	-9.90	51.59	19	-7.47	52.05	19	-7.54	51.77
20	-9.87	51.60	20	-7.46	52.06	20	-7.50	51.76
21	-9.83	51.61	21	-7.45	52.06	21	-7.47	51.76
22	-9.80	51.62	22	-7.44	52.06	22	-7.43	51.76
23	-9.77	51.63	23	-7.43	52.06	23	-7.39	51.77
24	-9.73	51.64	24	-7.42	52.06	24	-7.37	51.80
25	-9.70	51.66	25	-7.42	52.05	25	-7.33	51.81
26	-9.67	51.66	26	-7.42	52.04	26	-7.29	51.83
27	-9.64	51.67	27	-7.43	52.03	27	-7.30	51.80
28	-9.60	51.68	28	-7.43	52.03	28	-7.33	51.79
29	-9.61	51.67	29	-7.43	52.02	29	-7.36	51.77
30	-9.64	51.66	30	-7.43	52.01	30	-7.40	51.76

Table A.1.3. *Nephrops* in FU19 (S and SW Ireland). Positions of WKCELT Cork Channels polygon.

POSITION	CORK CHANNELS		POSITION	CORK CHANNELS		POSITION	CORK CHANNELS	
	Decimal Latitude	Decimal Longitude		Decimal Latitude	Decimal Longitude		Decimal Latitude	Decimal Longitude
1	-7.76	51.74	36	-8.02	51.55	71	-8.08	51.71
2	-7.74	51.71	37	-7.99	51.57	72	-8.12	51.68
3	-7.73	51.69	38	-8.02	51.56	73	-8.15	51.66
4	-7.70	51.67	39	-8.05	51.57	74	-8.19	51.65
5	-7.68	51.63	40	-8.09	51.56	75	-8.23	51.64
6	-7.66	51.60	41	-8.13	51.55	76	-8.26	51.62
7	-7.69	51.60	42	-8.11	51.54	77	-8.28	51.65
8	-7.71	51.64	43	-8.07	51.54	78	-8.24	51.65
9	-7.73	51.67	44	-8.03	51.54	79	-8.20	51.66
10	-7.76	51.69	45	-8.05	51.53	80	-8.17	51.68
11	-7.77	51.73	46	-8.09	51.53	81	-8.14	51.70
12	-7.80	51.74	47	-8.13	51.52	82	-8.10	51.71
13	-7.84	51.72	48	-8.17	51.52	83	-8.08	51.75
14	-7.85	51.69	49	-8.21	51.51	84	-8.05	51.76
15	-7.83	51.65	50	-8.25	51.51	85	-8.01	51.75
16	-7.80	51.62	51	-8.29	51.50	86	-7.97	51.75
17	-7.81	51.59	52	-8.33	51.47	87	-7.95	51.72
18	-7.82	51.62	53	-8.36	51.48	88	-7.91	51.73
19	-7.84	51.64	54	-8.33	51.50	89	-7.88	51.74
20	-7.88	51.65	55	-8.29	51.51	90	-7.84	51.75
21	-7.92	51.65	56	-8.26	51.53	91	-7.80	51.76
22	-7.96	51.64	57	-8.24	51.55	92	-7.77	51.78
23	-7.97	51.61	58	-8.27	51.56	93	-7.77	51.82
24	-7.95	51.58	59	-8.30	51.54	94	-7.80	51.85
25	-7.91	51.58	60	-8.34	51.53	95	-7.76	51.84
26	-7.87	51.60	61	-8.33	51.55	96	-7.74	51.81
27	-7.84	51.60	62	-8.30	51.56	97	-7.70	51.81
28	-7.85	51.58	63	-8.26	51.58	98	-7.72	51.78
29	-7.86	51.57	64	-8.23	51.61	99	-7.75	51.77
30	-7.82	51.57	65	-8.19	51.63	100	-7.76	51.74
31	-7.84	51.57	66	-8.16	51.65			
32	-7.88	51.57	67	-8.13	51.67			
33	-7.92	51.57	68	-8.09	51.68			
34	-7.96	51.55	69	-8.05	51.69			
35	-8.00	51.55	70	-8.04	51.71			

Table A.1.3. *Nephrops* in FU19 (S and SW Ireland). Positions of WKCELT Galley grounds 1–3 polygons.

GALLEY GROUND 1			GALLEY GROUND 2			GALLEY GROUND 3		
POSITION	Decimal Latitude	Decimal Longitude	POSITION	Decimal Latitude	Decimal Longitude	POSITION	Decimal Latitude	Decimal Longitude
1	-9.28	51.46	1	-9.09	51.35	1	-8.59	51.57
2	-9.29	51.44	2	-9.09	51.33	2	-8.59	51.56
3	-9.30	51.42	3	-9.10	51.32	3	-8.62	51.54
4	-9.33	51.42	4	-9.12	51.31	4	-8.66	51.54
5	-9.35	51.42	5	-9.14	51.31	5	-8.70	51.53
6	-9.38	51.41	6	-9.16	51.31	6	-8.73	51.52
7	-9.39	51.40	7	-9.17	51.30	7	-8.74	51.49
8	-9.38	51.38	8	-9.19	51.30	8	-8.75	51.46
9	-9.40	51.37	9	-9.20	51.29	9	-8.79	51.45
10	-9.43	51.37	10	-9.19	51.27	10	-8.83	51.44
11	-9.41	51.38	11	-9.20	51.26	11	-8.87	51.44
12	-9.40	51.40	12	-9.22	51.25	12	-8.90	51.43
13	-9.42	51.40	13	-9.24	51.25	13	-8.94	51.42
14	-9.44	51.41	14	-9.26	51.25	14	-8.98	51.42
15	-9.47	51.41	15	-9.27	51.25	15	-8.98	51.44
16	-9.47	51.42	16	-9.29	51.26	16	-8.95	51.45
17	-9.46	51.44	17	-9.30	51.27	17	-8.91	51.46
18	-9.44	51.44	18	-9.29	51.29	18	-8.88	51.48
19	-9.42	51.44	19	-9.27	51.30	19	-8.91	51.49
20	-9.41	51.46	20	-9.26	51.31	20	-8.92	51.51
21	-9.39	51.46	21	-9.24	51.32	21	-8.88	51.52
22	-9.38	51.46	22	-9.22	51.32	22	-8.85	51.52
23	-9.38	51.44	23	-9.21	51.33	23	-8.81	51.53
24	-9.35	51.44	24	-9.19	51.34	24	-8.77	51.53
25	-9.33	51.45	25	-9.17	51.34	25	-8.73	51.53
26	-9.31	51.45	26	-9.16	51.34	26	-8.69	51.54
27	-9.33	51.46	27	-9.14	51.35	27	-8.66	51.54
28	-9.31	51.48	28	-9.12	51.35	28	-8.62	51.56
29	-9.29	51.48	29	-9.10	51.36	29	-8.62	51.58
30	-9.28	51.46	30	-9.09	51.35	30	-8.59	51.57

Table A.1.3. *Nephrops* in FU19 (S and SW Ireland). Positions of WKCELT Galley ground 4 polygon.

POSITION	GALLEY GROUND 4		POSITION	GALLEY GROUND 4	
	Decimal Latitude	Decimal Longitude		Decimal Latitude	Decimal Longitude
1	-8.51	51.16	31	-8.49	50.95
2	-8.45	51.16	32	-8.44	50.98
3	-8.38	51.15	33	-8.49	51.00
4	-8.32	51.15	34	-8.55	51.00
5	-8.25	51.15	35	-8.53	51.04
6	-8.19	51.15	36	-8.46	51.06
7	-8.13	51.15	37	-8.40	51.07
8	-8.06	51.15	38	-8.34	51.07
9	-8.02	51.13	39	-8.29	51.10
10	-8.01	51.09	40	-8.36	51.10
11	-7.99	51.08	41	-8.42	51.10
12	-8.06	51.08	42	-8.49	51.09
13	-8.11	51.05	43	-8.55	51.08
14	-8.16	51.01	44	-8.61	51.08
15	-8.17	50.95	45	-8.67	51.10
16	-8.22	50.92	46	-8.74	51.10
17	-8.29	50.93	47	-8.80	51.11
18	-8.34	50.93	48	-8.86	51.13
19	-8.40	50.92	49	-8.93	51.13
20	-8.46	50.90	50	-8.99	51.12
21	-8.52	50.87	51	-9.04	51.11
22	-8.57	50.84	52	-9.00	51.15
23	-8.54	50.88	53	-8.94	51.16
24	-8.48	50.91	54	-8.88	51.18
25	-8.42	50.93	55	-8.82	51.19
26	-8.36	50.95	56	-8.75	51.20
27	-8.31	50.99	57	-8.69	51.21
28	-8.34	51.00	58	-8.64	51.18
29	-8.40	50.98	59	-8.58	51.16
30	-8.45	50.95	60	-8.51	51.16

Table B.2.1. *Nephrops* in FU19 (S and SW Ireland). Revision to Irish Landings.

YEAR	WG19	PREVIOUS WG	SCALE
2008	790	805	0.981242
2009	798	764	1.044543
2010	660	694	0.950653
2011	619	585	1.058118
2012	837	758	1.104314
2013	783	771	1.016062
2014	459	459	1.000264
2015	502	502	0.999828
2016	583	583	0.999548
2017	412	412	1.000757

Table B.2.2. *Nephrops* in FU19 (S and SW Ireland). Revision to mean weight (grs) in landings and discards.

YEAR	LANDING MEAN WEIGHT GR	DISCARD MEAN WEIGHT GR	SOURCE	LANDING MEAN WEIGHT GR	DISCARD MEAN WEIGHT GR	SOURCE
2008	33.7	19.4	WG.2019	33.7	19.3	WG.HIST
2009	30.5	14.5	WG.2019	30.5	14.5	WG.HIST
2010	29.6	13.5	WG.2019	29.6	13.5	WG.HIST
2011	24.9	12.6	WG.2019	25	12.6	WG.HIST
2012	26.3	12.7	WG.2019	26.4	12.7	WG.HIST
2013	26.9	11.9	WG.2019	27.4	12.1	WG.HIST
2014	28.6	14.1	WG.2019	28.6	14.1	WG.HIST
2015	29.8	14.1	WG.2019	29.8	13.8	WG.HIST
2016	29.9	14.2	WG.2019	29.9	14.2	WG.HIST
2017	28.8	14.5	WG.2019	28.8	14.4	WG.HIST

TABLE B.2.3. NEPHROPS IN FU19 (S AND SW IRELAND). REVISION TO DISCARD RATE BY NUMBER AND WEIGHT.

YEAR	DIS.RATE.N	DIS.RATE.WT	SOURCE	DIS.RATE.N	DIS.RATE.WT	SOURCE
2008	0.18	0.11	WG.2019	0.18	0.11	WG.HIST
2009	0.39	0.24	WG.2019	0.39	0.24	WG.HIST
2010	0.45	0.27	WG.2019	0.45	0.27	WG.HIST
2011	0.56	0.39	WG.2019	0.56	0.39	WG.HIST
2012	0.54	0.36	WG.2019	0.53	0.35	WG.HIST
2013	0.55	0.35	WG.2019	0.54	0.34	WG.HIST
2014	0.41	0.26	WG.2019	0.41	0.26	WG.HIST
2015	0.41	0.25	WG.2019	0.43	0.26	WG.HIST
2016	0.41	0.25	wg.2019	0.41	0.25	wg.hist
2017	0.4	0.25	wg.2019	0.4	0.25	wg.hist

Table B.2.4. *Nephrops* in FU19 (S and SW Ireland). Sampling levels.

NUMBER OF SAMPLES				TOTAL NUMBERS OF <i>NEPHROPS</i> MEASURED			
Year	Graded Landings	Catch	Discards	Year	Graded Landings	Catch	Discards
2002		3	2	2002		2235	1081
2003	2	12	15	2003	763	3173	7234
2004	1	5	4	2004	152	1278	1169
2005		6	2	2005		3221	1670
2006		8		2006		4716	
2007	2	13		2007	561	22170	
2008		18		2008		12311	
2009		16		2009		7601	
2010	1	18		2010	331	7662	
2011		15		2011		7684	
2012		21		2012		9958	
2013		17	11	2013		8623	4586
2014		23	19	2014		9,267	6,142
2015				2015			

Table B.2.5. *Nephrops* in FU19 (S and SW Ireland). Sampling levels by grounds.

Fishing Grounds	Number of Catch Samples													Number of Discard Samples					
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2002	2003	2004	2005	2013	2014
Ballycotton Ground						1													
Baltimore		2	3	1				1							2	2			
Bantry Bay			1		1	4	7	7	14	15	13	12	19			1		8	13
Canyons		1													1				
Castletownbere						3	4	2			1								
Daunt								1											
Dingle Bay Outer					1		2												
Dunmanus Bay					1	2							1						1
Galley ead	2	4	1		1		1				1		1	2	5	1			1
elvic	1			1															
Kenmare Bay					3	4	2	2	5	1	2	4						2	
Mine ead												1						1	
Not Known		1		4	1			1		2	4				1		2		
Power ead															1				
South Kinsale		1													1				
South of Cape Clear		1													1				
South of Cork								2							1				
Union all		2					1						3		2				4
Total	3	12	5	6	8	13	18	16	19	18	21	17	24	2	15	4	2	11	19

Table B.1. Biological Input Parameters for FU19 *Nephrops* Stock.

PARAMETER	VALUE	SOURCE
Discard Survival	25%	WKCELT 2014 assumed in line with other stocks
MALES		
Growth - K	0.16	WKCELT 2014
Growth - L(inf)	60	WKCELT 2014
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	0.16	WKCELT 2014
Growth - L(inf)	60	WKCELT 2014
Natural mortality - M	0.3	assumed, in line with other stocks
Size at maturity (L50)	24	WKCELT 2014
Mature Growth		
Growth - K	0.08	WKCELT 2014
Growth - L(inf)	56	WKCELT 2014
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	"

Table B.3.1. *Nephrops* in FU19 (SW and SE Ireland). Female Maturity.

PARAMETER	VALUE	SOURCE
Female L25	23	Bantry Bay 2009–2013
Female L50	24	"

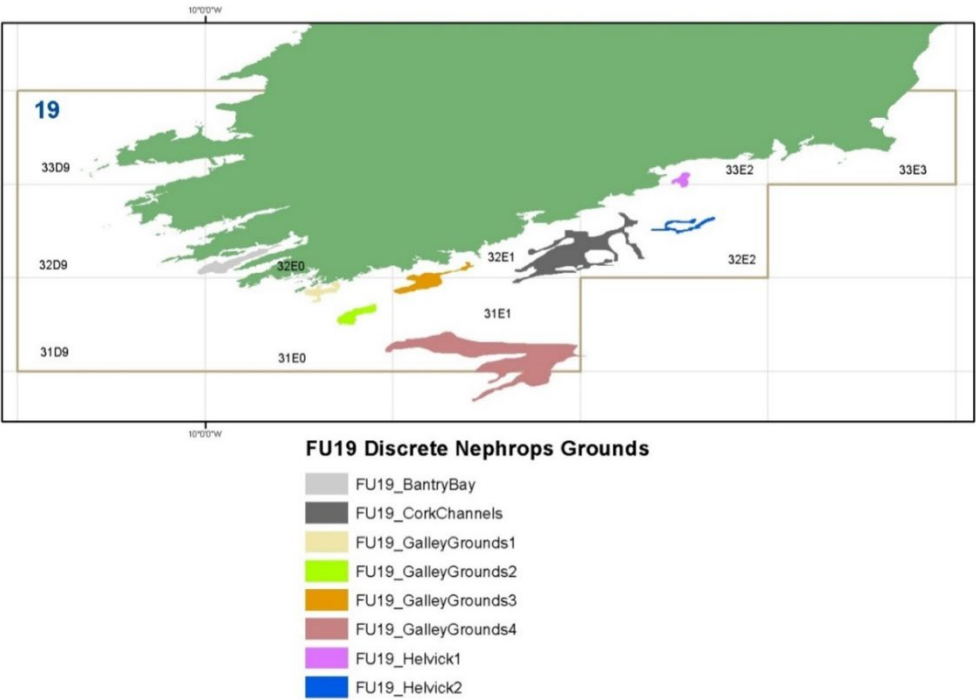


Figure A.1.1. *Nephrops* in FU19 (S and SW Ireland). Discrete *Nephrops* grounds.

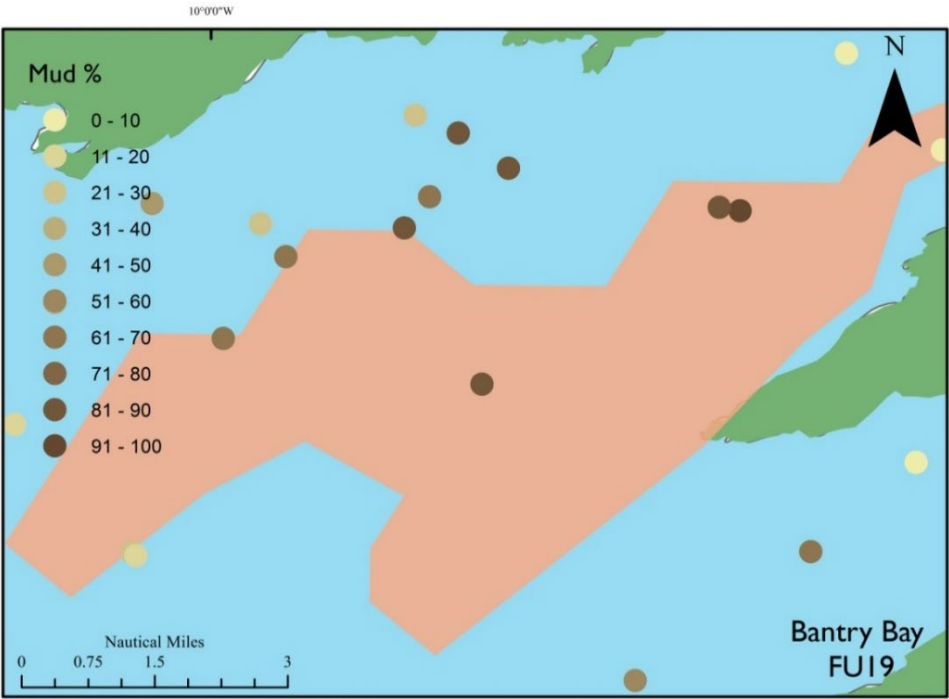


Figure A.3.1. *Nephrops* in FU19 (S and SW Ireland). Sediment samples in Bantry Bay.

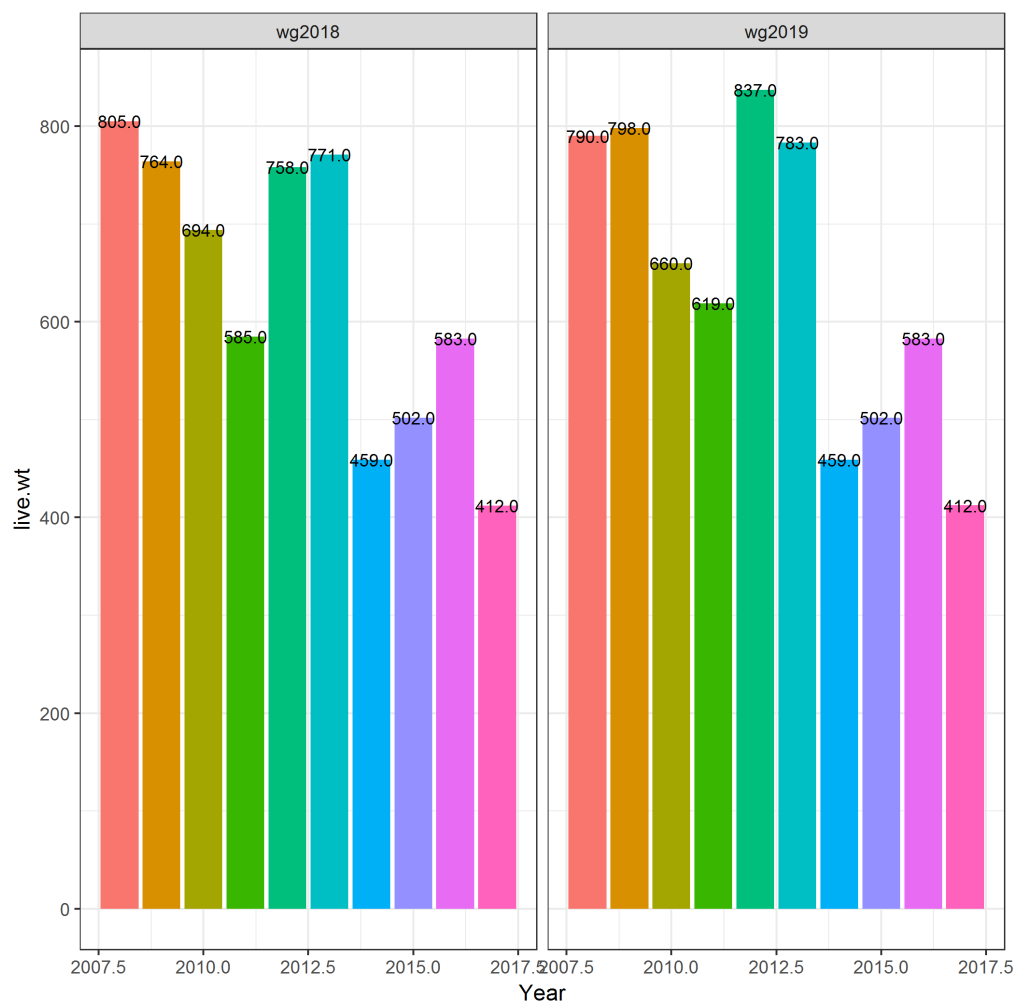


Figure B.2.1. Nephrops in FU19 (S and SW Ireland). Revision to Times-series of Irish Landings presented at WGCSE 2019.

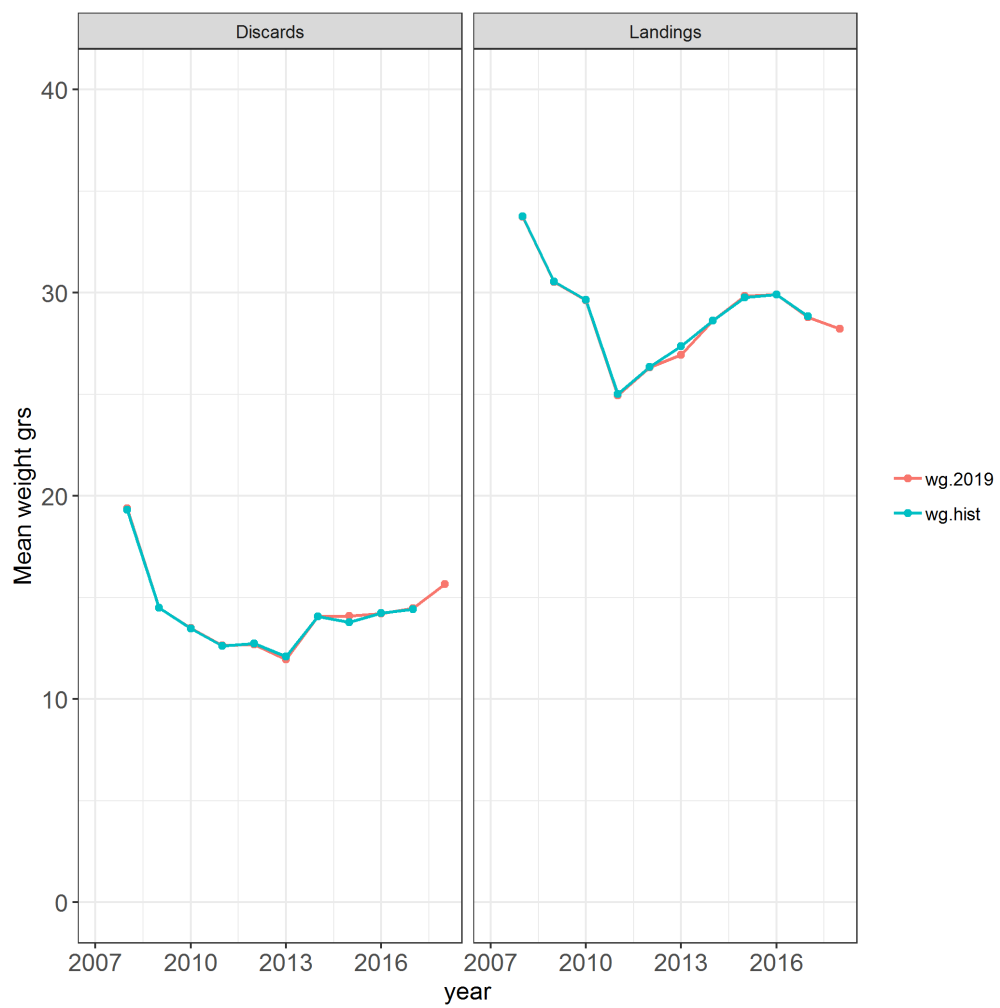


Figure B.2.2. *Nephrops* in FU19 (S and SW Ireland). Revision to mean weight (grs) in landings and discards.

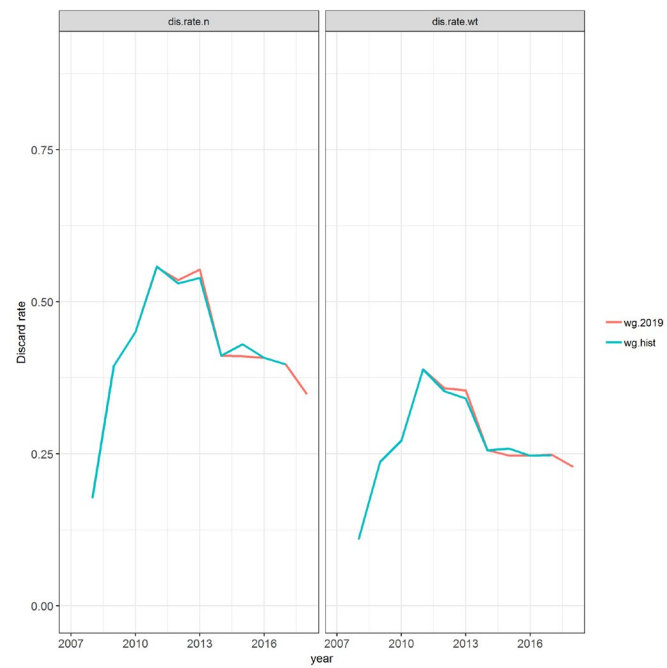


Figure B.2.3. *Nephrops* in FU19 (S and SW Ireland). Revision to discard rate by number and weight.

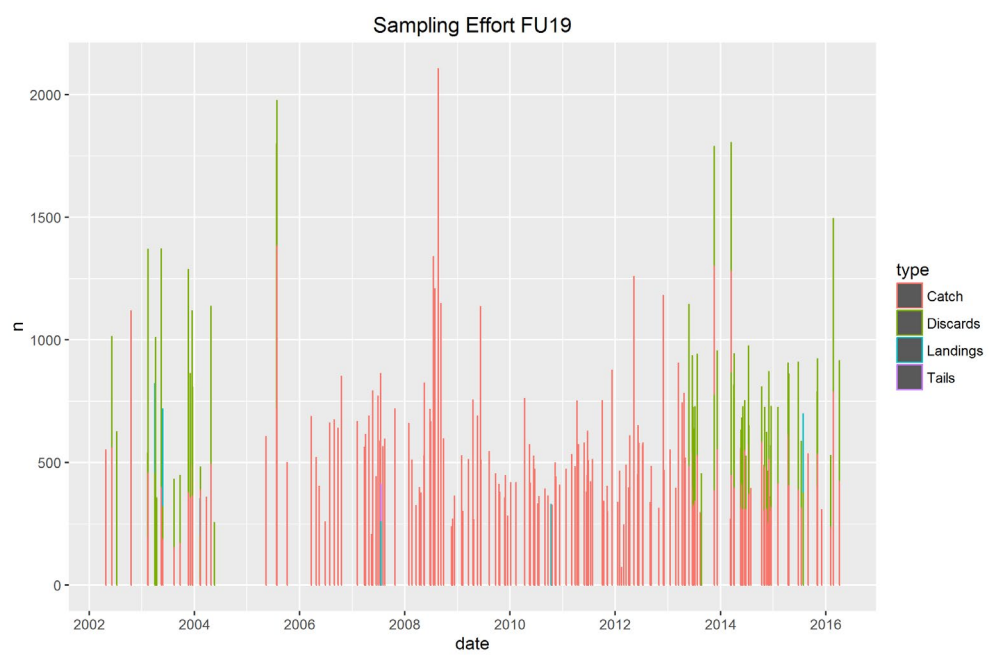


Figure B.2.4. *Nephrops* in FU19 (S and SW Ireland). Times-series of sampling effort.

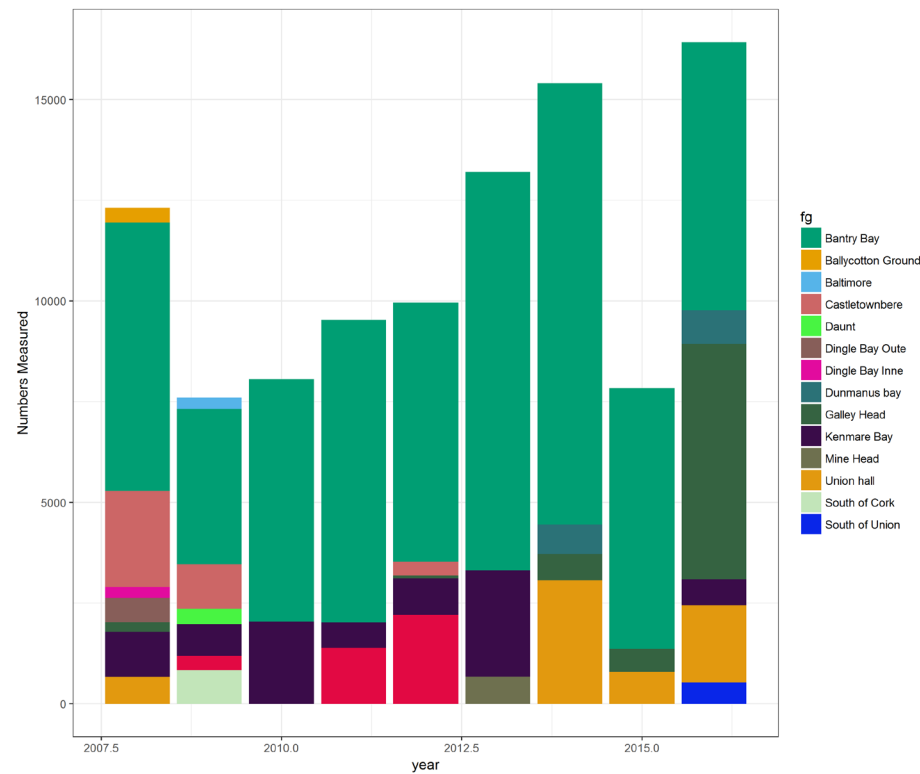


Figure B.2.5. *Nephrops* in FU19 (S and SW Ireland). Sample numbers measured by fishing ground.

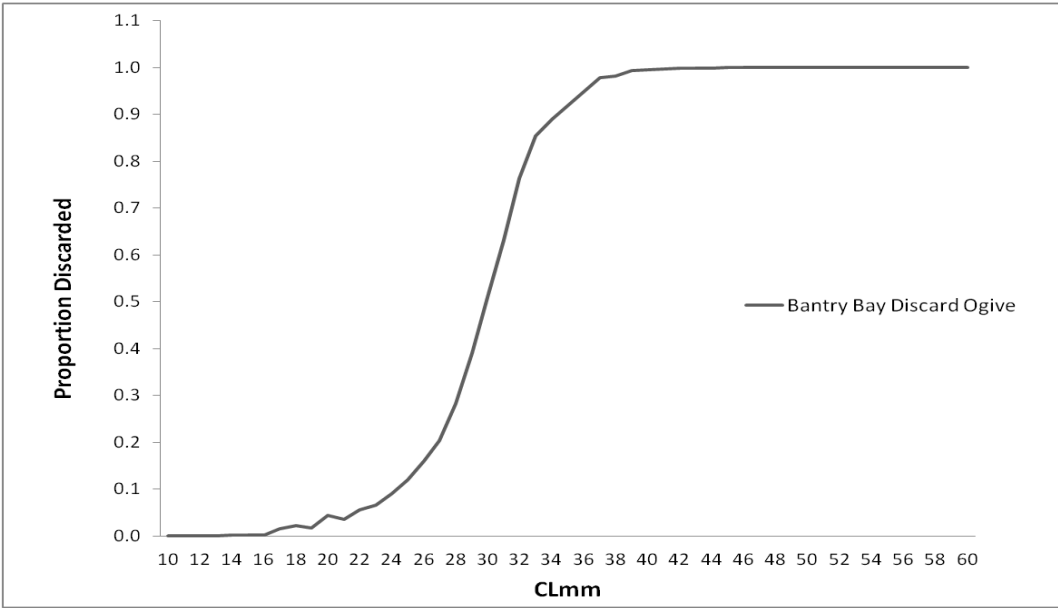


Figure B.2.6. *Nephrops* in FU19 (S and SW Ireland). Discard ogive selected for Bantry Bay based on sample data from 2008 Q1 and 2013 Q3–Q4 averaged.

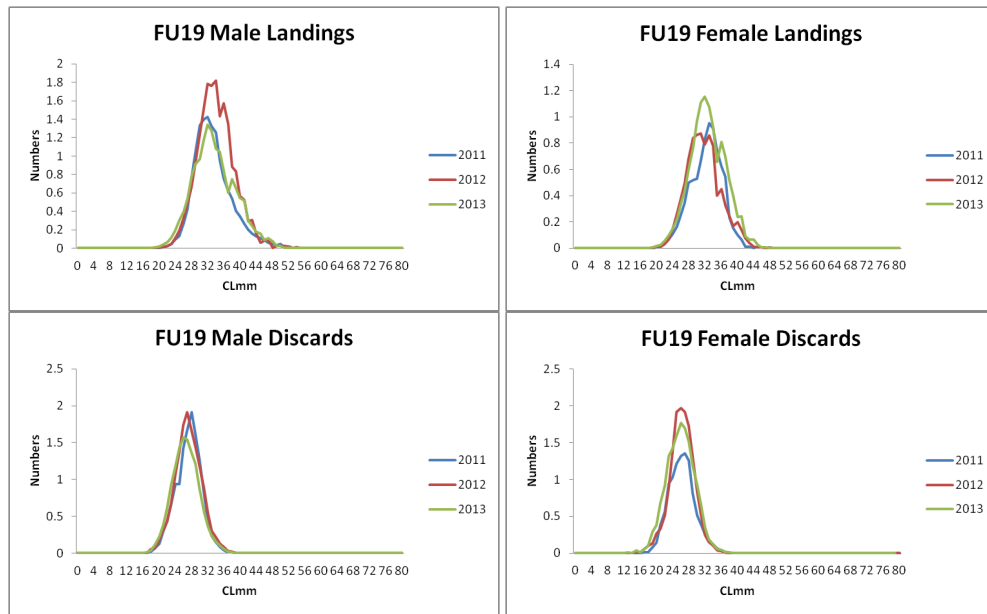


Figure B.2.7. *Nephrops* in FU19 (S and SW Ireland). Length–frequency data by sex for reference period 2011–2013 partitioned using the WKCELT discard selection ogive.

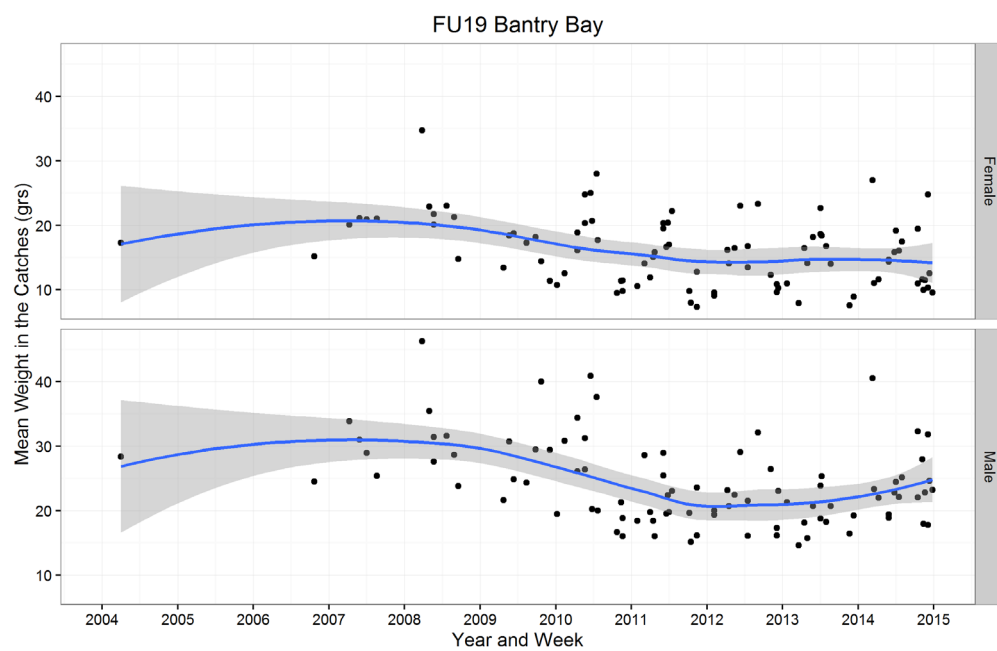


Figure B.3.1. *Nephrops* in FU19 (SW and SE Ireland). Time-series of mean weight (grs) by sex from Bantry Bay catch samples.

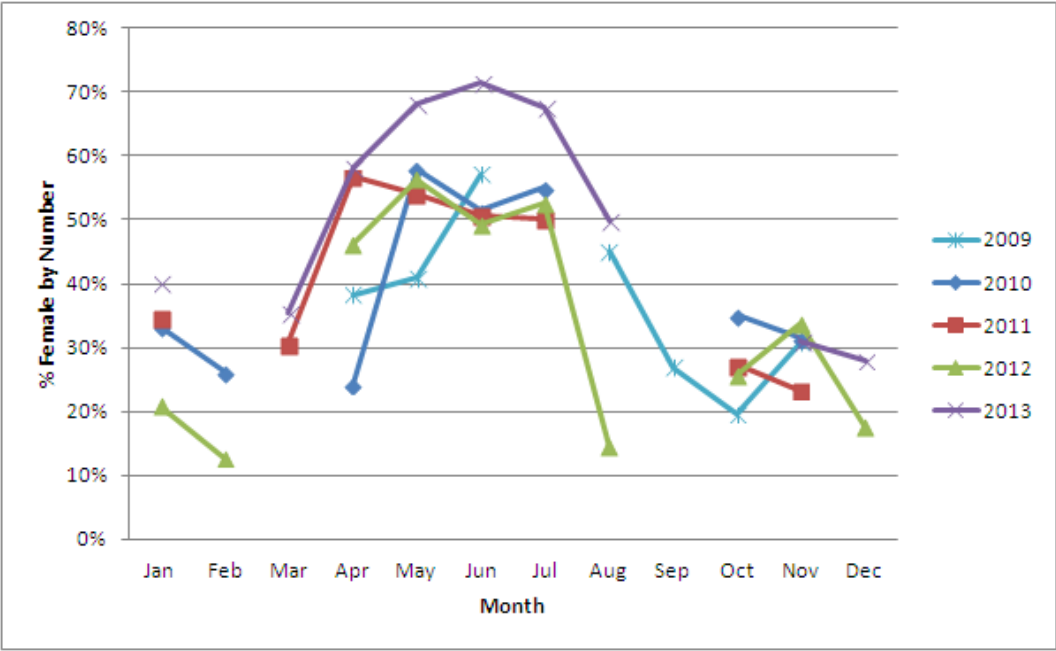


Figure B.3.2. *Nephrops* in FU19 (SW and SE Ireland). Sex ratio by month for Bantry Bay unsorted catch sampling showing a seasonal trend.

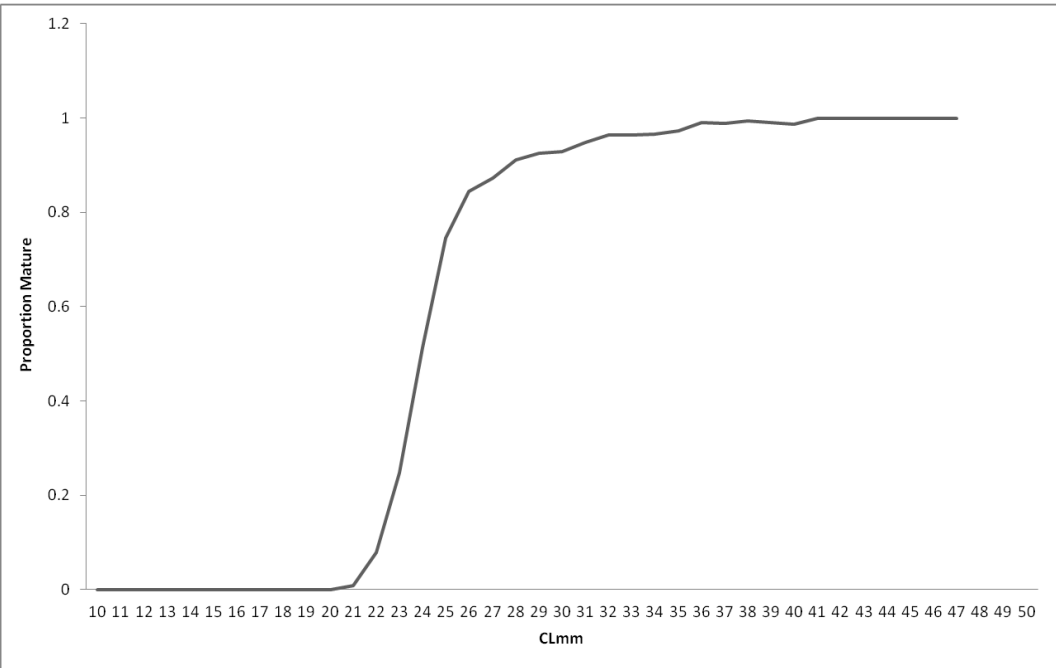


Figure B.3.3. *Nephrops* in FU19 (S and SW Ireland). Female maturity ogive based on sampling data from Bantry Bay 2009–2013.

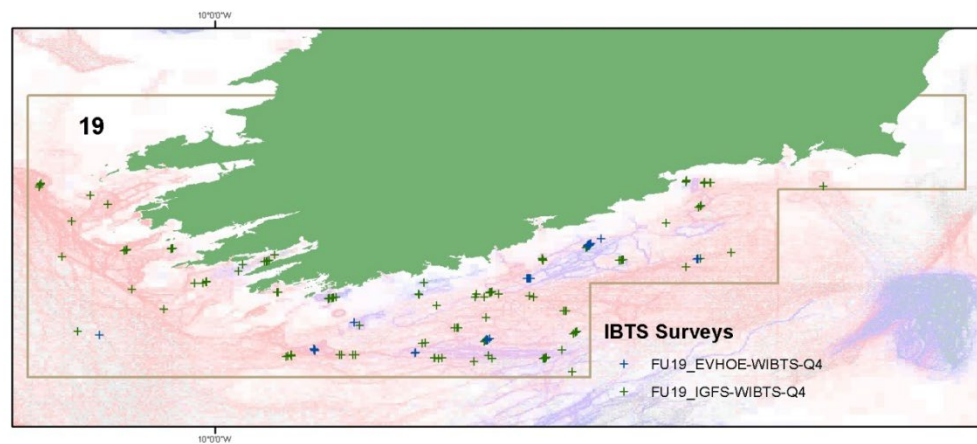


Figure B.4.1. *Nephrops* in FU19 (S and SW Ireland). Station positions with *Nephrops* catches from Irish (green cross) and French (blue cross) groundfish survey.

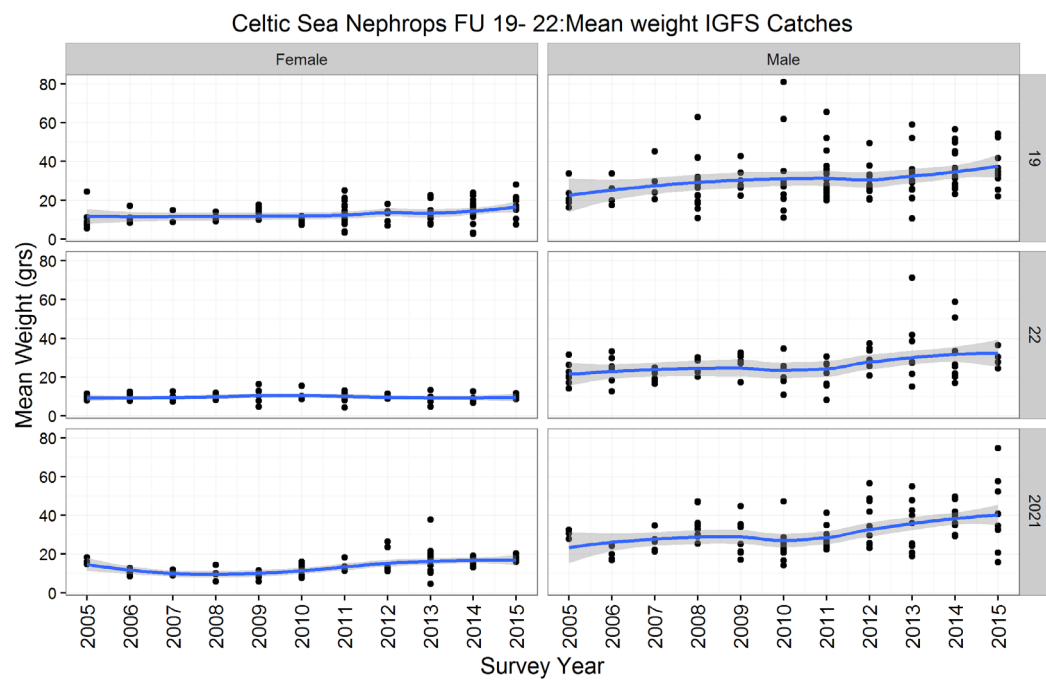


Figure B.4.2. *Nephrops* in FU19 (S and SW Ireland). Time-series of mean weights (grs) by sex in catches from IGFS for Celtic Sea *Nephrops* FUs.

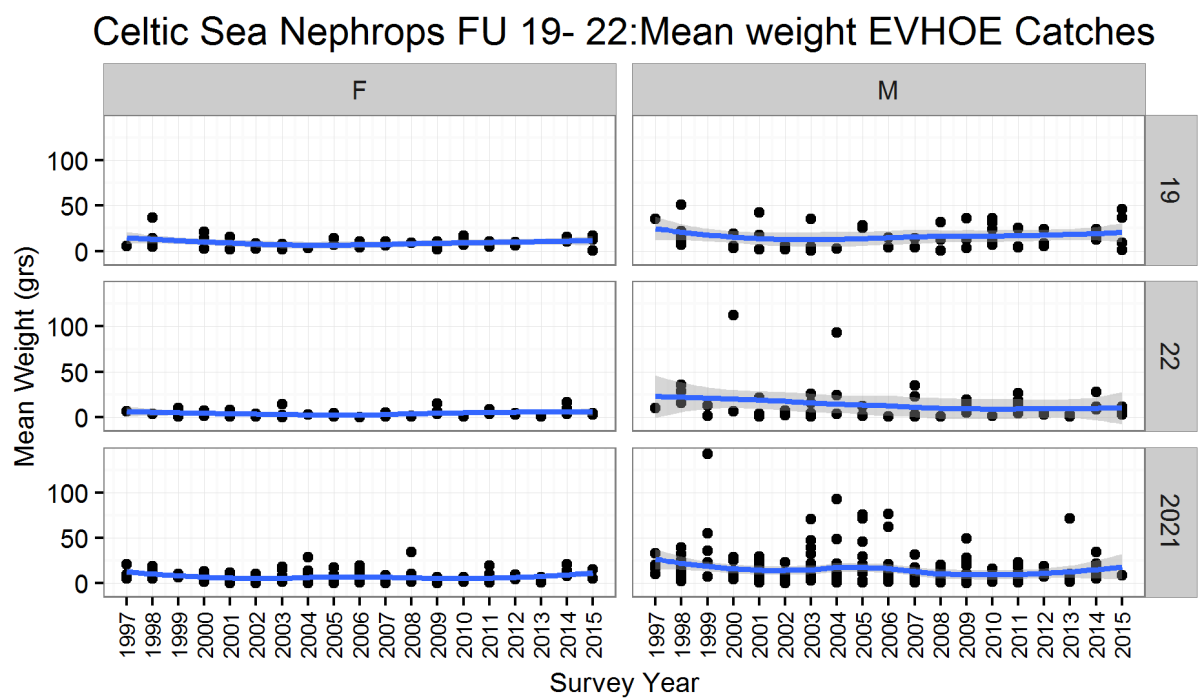


Figure B.4.3. *Nephrops* in FU19 (S and SW Ireland). Time-series of mean weights (grs) by sex in catches from EVHOE for Celtic Sea *Nephrops* FUs.