Aran, Galway Bay and Slyne Head *Nephrops* Grounds (FU17) 2015 UWTV Survey Report and catch options for 2016.

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Abstract

This report provides the main results and findings of the fourteenth annual underwater television on the Aran, Galway Bay and Slyne head *Nephrops* grounds, ICES assessment area; Functional Unit 17. The survey was multi-disciplinary in nature collecting UWTV, fishing, CTD and other ecosystem data. In 2015 a total of 44 UWTV stations were successfully completed, 34 on the Aran Grounds and 5 on each of the Slyne Head and Galway Bay patches. The mean burrow density observed in 2015, adjusted for edge effect, was medium at 0.38 burrows/m². The final krigged burrow abundance estimate for the Aran Grounds was 480 million burrows with a CV (or relative standard error) of 6 %. The final abundance estimate for Galway Bay and Slyne Head was 56 and 20 million burrows with CVs of 15% and 4% respectively. The total abundance estimates have fluctuated considerably over the time series. The 2015 abundance estimate was 42% higher than in 2014 and at 556 million and is just above to the new MSY $B_{trigger}$ (540 million). Using the 2015 abundance estimate and updated stock data implies catch of 991 tonnes and landings of 915 tonnes in 2016 fishing at F_{msy} (assuming all catch is landed). *Virgilaria mirabilis* was the most common of the two sea-pen species observed on the UWTV footage. *Pennatula phosphorea* was observed at one station on the Slyne Head *Nephrops* ground.

Key words: *Nephrops norvegicus*, stock assessment, geostatistics, underwater television (UWTV), benthos, CTD.

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Introduction

Nephrops norvegicus are common around the Irish coast occurring in geographically distinct sandy/muddy areas where the sediment is suitable for them to construct their burrows. The *Nephrops* fishery in VII is extremely valuable with landings in 2014 worth around € 95 m at first sale. The *Nephrops* fishery 'at the back of the Aran Islands' can be considered the mainstay of the Ros a Mhíl fleet. Estimated landings of 825 t in 2014 were worth approximately €5.4 m at first sale. Without this *Nephrops* fishery the majority of vessels in the fleet would cease being economically viable (Meredith, 1999). Given these socio-economic realities good scientific information on stock status and exploitation rates are required to inform sustainable management of this resource.

Nephrops spend a great deal of time in their burrows and their emergence behaviour is influenced by several factors: time of year, light intensity, tidal strength, etc. Underwater television surveys and assessment methodologies have been developed to provide a fishery independent estimate of stock size, exploitation status and catch advice (ICES, 2009a & 2013). This is the fourteenth annual UWTV survey of the 'Aran grounds'. The survey covers three geographically discrete mud patches; the Aran Ground, Galway Bay and Slyne Head all of which lie within the ICES assessment area Functional Unit 17 (Figure 1). The 2015 survey was multi-disciplinary in nature; the specific objectives are listed below:

1. To complete randomised fixed isometric survey grid of 34 UWTV with 3.5 nautical mile (Nmi) spacing stations on the "Aran" *Nephrops* ground.
2. To carry out ≥ 5 UWTV indicator stations on the Galway Bay and Slyne Head *Nephrops* ground.
3. To obtain 2015 quality assured estimates of *Nephrops* burrow distribution and abundance on the "Aran" *Nephrops* ground (FU17). These will be compared with those collected previously.
4. To collect ancillary information from the UWTV footage collected at each station such as the occurrence of sea-pens, other macro benthos and fish species and trawl marks on the sea bed.
5. To collect oceanographic data using a sledge mounted CTD.
6. To sample *Nephrops* and macro benthos using a 4 m beam trawl deployed at ~10 stations.

This report details the final UWTV results of the 2015 survey and also documents other data collected during the survey. Operational survey details are available in form of a survey narrative from the scientist in charge (JD). The 2015 abundance are used to generate catch options for 2016 in line with the recommendations and procedures outlined in the stock annex for FU17 (ICES, 2015).

Material and methods

Since 2012 the Aran survey design has been based a randomised isometric grid with stations every 3.5 Nmi or 6.5km. This spacing was used to achieve good spatial coverage over the known extent of the ground and to generate burrow surface that reflects the underlying abundance. The ground boundary used for the Aran, Galway Bay and Slyne grounds was revised this year (Table 1) by an ICES inter-benchmark process (ICES, 2015a). In the past stations in Galway Bay and Slyne Head were randomly picked from an area defined by previously collected UWTV data, VMS data (Gerritsen & Lordan, 2011) and multi-beam

backscatter data (Figure 1 & 2). Since 2012, the "create random points tool" in ArcGIS was used to pick stations within the defined polygons. Not all stations completed in 2015 and in previous years fell within the new ground polygons and these were excluded from the analysis.

Survey timing was generally standardised to June each year. In 2003, poor weather and technical problems meant that coverage was poor compared with the other years. In 2004, bad weather prevented the completion of the survey in June so approximately 50% of the stations were carried out one month later in July. In 2003 and 2008 due to weather downtime stations could not be completed at Slyne Head. In 2015 the Galway Bay and 14 Aran stations were surveyed on June 10th and 11th on RV Celtic Voyager. The vessel then broke down and the remaining stations (20 Aran and 5 Slyne) were carried out on RV Prince Madog on the 1st and 2nd of July.

The operational protocols used were those reviewed by WKNEPHTV 2007 (ICES, 2007) and employed on other UWTV surveys in Irish waters. They can be summarised as follows: At each station the UWTV sledge was deployed. Once stable on the seabed a 10 minute tow was recorded onto DVD. Time referenced video footage was collected by one video camera with a field of view or 'FOV' of 75 cm. Vessel position (DGPS) and position of sledge (using a USBL transponder) were recorded every 2 seconds. The navigational data was quality controlled using an "r" script developed by the Marine Institute (ICES, 2009b) an example is shown in Figure 3. In 2015 the USBL navigational data was used to calculate distance over ground for all but one of the stations.

In line with SGNEPS recommendations all scientists were trained/re-familiarised using training material and validated using reference footage for the Aran Grounds prior to recounting at sea (ICES, 2009b). Figure 4 shows individual's counting performance in 2015 against the reference footage as measured by Linn's concordance correlation coefficient (CCC). A threshold of 0.5 was used to identify counters who needed further training. Once this training and testing process had been undertaken, all recounts were conducted by two scientists independent of each other on board the research vessel during the survey. During this review process the visibility, ground type and speed of the sledge during one-minute intervals were subjectively classified using a classification key. In addition the numbers of *Nephrops* burrows complexes (multiple burrows in close proximity which appear to be part of a single complex which are only counted once), *Nephrops* activity in and out of burrows were counted and recorded for each one-minute interval. Following the recommendation of SGNEPS the time for verified recounts was 7 minutes (ICES, 2009b).

The occurrence of trawl marks, fish species and other species was also recorded for each minute. Abundance categories of sea-pen species were also recorded due to OSPAR Special Request (ICES 2011). A key was devised to categorise the densities of seapens based on SACFOR abundance scale (Table 2) after ICES (2011). Finally, if there was any time during the one-minute where counting was not possible, due to sediment clouds or other reasons, this was also estimated so that the time window could be removed from the distance over ground calculations. Consistency and bias between individual counters was examined using Figure 5. There is some variability between counters but no obvious bias or excessive deviations.

The recount data were screened for one minute intervals with any unusually large deviation at sea. These minutes were re-verified by means of consensus counts. Mean density was calculated by dividing the total number of burrow systems by the survey area observed. The

field of view of the camera at the bottom of the screen was estimated at 75cm assuming that the sledge was flat on the seabed (i.e. no sinking). This field of view was confirmed using lasers during the 2015 survey. Occasionally the lasers were not visible at the bottom of the screen due to sinking in very soft mud (the impact of this is a minor under estimate of densities at stations where this occurred).

To account for the spatial co-variance and other spatial structuring a geo-statistical analysis of the mean and variance was carried out the RGeostats 10.0.8 (Renard D. et al., 2015). The procedure used is fully documented in the stock annex.

To estimate the abundance for Galway Bay and Slyne Head grounds, the area of each ground polygon was calculated in ArcGIS10 and an average value used (Table 1). The abundance estimation is the product of the mean density and ground area. The sample variances, standard errors, t-values and 95% CI were calculated for each ground.

For each UWTV station a CTD profile was logged for the duration of each tow using a sled mounted and calibrated Seabird SBE37. The sensor takes readings every 5 seconds and will be processed at a later stage. Due to time constraints fishing operations were not carried out this year.

Results

The station positions for the 34 stations on the Aran grounds, 5 in Galway Bay and 4 at Slyne head are shown in Figure 2. A further 5 station were carried out in Galway Bay but these fell outside the newly defined polygon. A combined violin and box plot of the observed burrow densities from 2006 to 2015 is presented in Figure 6. This shows relatively large inter-annual variation in mean, median and density ranges over time. Density increased in first three years of the time series but then declined significantly in 2006. Since then there has been a gradual downward trend. The mean and median density has increased significantly in 2015. It has been very noticeable since 2011 that there was a substantial reduction in density throughout the ground with no high density ($> 0.7/m^2$) observed. Figure 7 and Figure 8 shows the variability in density between minutes and operators (counters) for each station. These show that the burrow estimates are fairly consistent between minutes and counters.

A combined krigged contour plot and bubble plot of the density data are shown in Figure 10. These show that densities have fluctuated considerably over the time series and throughout the ground. The fluctuations are not limited to a single station but instead occur fairly homogeneously across the ground. In general the densities are higher towards the western side of the ground and there is a notable trend towards lower densities towards the east. On the south western boundary there are often high densities close to the boundary. In this area there is a sharp transition from mud to rocky substrate. The increase in densities in 2015 was mainly towards the middle of the ground.

The summary statistics from this geo-statistical analysis for the Aran Grounds are given in Table 3 and Figure 10. The 2015 abundance estimate of 480 million burrows is a 45% higher than in 2015. The estimation variance of the survey is relatively low (CVs in the order <4%).

The summary statistics for the stations on Slyne head and in Galway Bay are given in Table 4. The abundance estimates for Galway Bay *Nephrops* ground and for Slyne Head *Nephrops* ground also are shown in Figure 10. The Galway Bay estimates fluctuate widely but appear to be highly correlated with the Aran ground (except 2004). Estimates for the Slyne Head

ground also fluctuate considerably but show no significant correlation with the other areas. The uncertainty bounds for both areas also fluctuate and inter-annual changes are only statistically significant in a few years. On average the Aran Grounds account for ~88% of the total estimated burrow abundance from FU17. Galway Bay and Slyne Head account for ~8% and ~2% respectively. The 2015 combined abundance estimate was 42% higher than in 2014 and at 556 million and is just above the new MSY $B_{trigger}$ (540 million).

Figure 12 shows the standardised length frequency distributions (LFDs) by sex of *Nephrops* caught using a beam trawl on the Aran grounds between 2006 and 2015 surveys. No fishing was carried out on surveys prior to 2006 or in 2008 and 2015 (due to time constraints as a result of poor weather conditions). For plotting purposes the individuals <10 CL mm caught in 2010 were split evenly between males and females as it is not possible to accurately assign sex to individuals that small. There is weak indication of a year class signal in 2010 and 2011 but few individuals less than 20 CL mm in most years. The mean lengths for both sexes in the survey have been fairly stable over time around the overall average of 27.61 CL mm.

The sea-pen presence-absence observations across the *Nephrops* grounds are mapped in Figure 13 using the key described in Table 2. The majority of sea-pens were identified from the video footage as *Virgularia mirabilis* and there was one observation of *Pennatula phosphorea* on the Slyne Head patch. *V.mirabilis* was also present at stations where trawl marks were recorded. This seapen species was recorded as frequently present at 65% , occasionally present at 41% and commonly present at 6% of total stations. Trawl marks were noted at 34% of the Aran stations surveyed with trawl marks present for the entire video transect for 9% of stations. Trawl marks were present at one station at Galway Bay and at Slyne Head.

The input parameters for the catch option tables, mean weight and proportions of removals retained, are given in Table 5 and 6 (ICES, 2015b). The catch and landings options at various different fishing mortalities are calculated in line with the stock annex using the 2015 survey abundance. Fishing at F_{msy} in 2014 would result in catches of 991 tonnes and landings of 915 t.

Discussion

Observed burrow densities have fluctuated a lot over time in this area. This is in contrast to the rather stable burrow abundance estimates in FU15 and FU22 over similar time frames. The burrow abundance increased significantly in 2015 just above the newly established $MSY_{Btrigger}$. The voluntary effort restrictions put in place by the fishing industry will have contributed to the increase by reducing overall mortality in advance of the UWTV survey.

Discard rates for this FU are estimated to have reduced significantly in the in the last three years and are now around 7%. Because harvest rates are calculated on the basis of numbers and 25% of the *Nephrops* in this area are assumed to have survived discarding up to now this presents a problem in calculating catch options for 2016. *Nephrops* in this area will be covered under the landings obligation in 2016 but it is not yet clear how this will be implemented in practice. Under the Landings Obligation scenario in Table 6 it is assumed that all catches will be landed in 2016 so the discards that would have survived up to now are also removed from the fishery. In this scenario fishing at F_{msy} in 2016 would imply total catches of 991 t which implies; landings or in ICES terminology “wanted catch” of 915 t and discards or “unwanted catch” of 76 t. Under the discarding is allowed scenario, two options are presented. The first assumes that discarding continues at its current rate, here total catches

would be higher (1026 t). This is because 25% of the discards are assumed to survive increasing the mean weight of the dead removals (L +DD). The second scenario assumes that discards are around 7% by weight in 2016. Because recent discards are very close to 7% both have very similar levels of advised catch.

The imposition of the landings obligation on *Nephrops* fisheries in 2016 should result in changes in selectivity. This is not taken into account in any of the catch advice because it is not possible to predict exactly what might happen. The main message is that any improvements in selectivity in the fishery and reductions in discards will result in increased mean weight in the catches. This will in turn reduce overall mortality on the stocks and allow for catch increases in the future.

An important objective of this UWTV survey is to collect ancillary information. The occurrence of trawl marks on the footage is notable for two reasons. Firstly, it makes identification of *Nephrops* burrows more difficult as the trawl marks remove some signature features making accurate burrow identification more difficult. Secondly, only occupied *Nephrops* burrows will persist in heavily trawled grounds and it is assumed that each burrow is occupied by one individual *Nephrops* (ICES 2009b).

The CTD data collected during the survey will augment the knowledge base on habitat and oceanographic regime.

Monitoring the occurrence and frequency of sea-pens observed on these *Nephrops* patches is important in the context of OSPAR's designations of sea-pen and burrowing megafauna communities as threatened. The two sea-pen species *Virgularia mirabilis* and *Pennatula phosphorea* which were seen in 2015 have been observed on previous surveys of FU17. Monitoring *Nephrops* stock and the benthic habitat is also important in the context of the MFSD indicators (e.g. sea floor integrity).

The main objectives of the survey were successfully met for the fourteenth successive year. The UWTV coverage and footage quality was excellent throughout the survey. The multi-disciplinary nature of the survey means that the information collected is highly relevant for a number of research and advisory applications.

Acknowledgments

We would like to express our thanks and gratitude to Colin McBrearty (Master) and crew of the RV. Celtic Voyager and Eric Lloyd (Master) and crew of RV Prince Madog for their good will and professionalism throughout the survey. Thanks also to P&O Maritime IT & Instrumentation Technicians for handling all onboard technical difficulties. Thanks to Aodhan Fitzgerald RVOPs and Rob Bunn FEAS at the Marine Institute for organising survey logistics. Thanks to Gordon Furey, Barry Kavanagh and Tom O'Leary P&O Maritime for shore side support.

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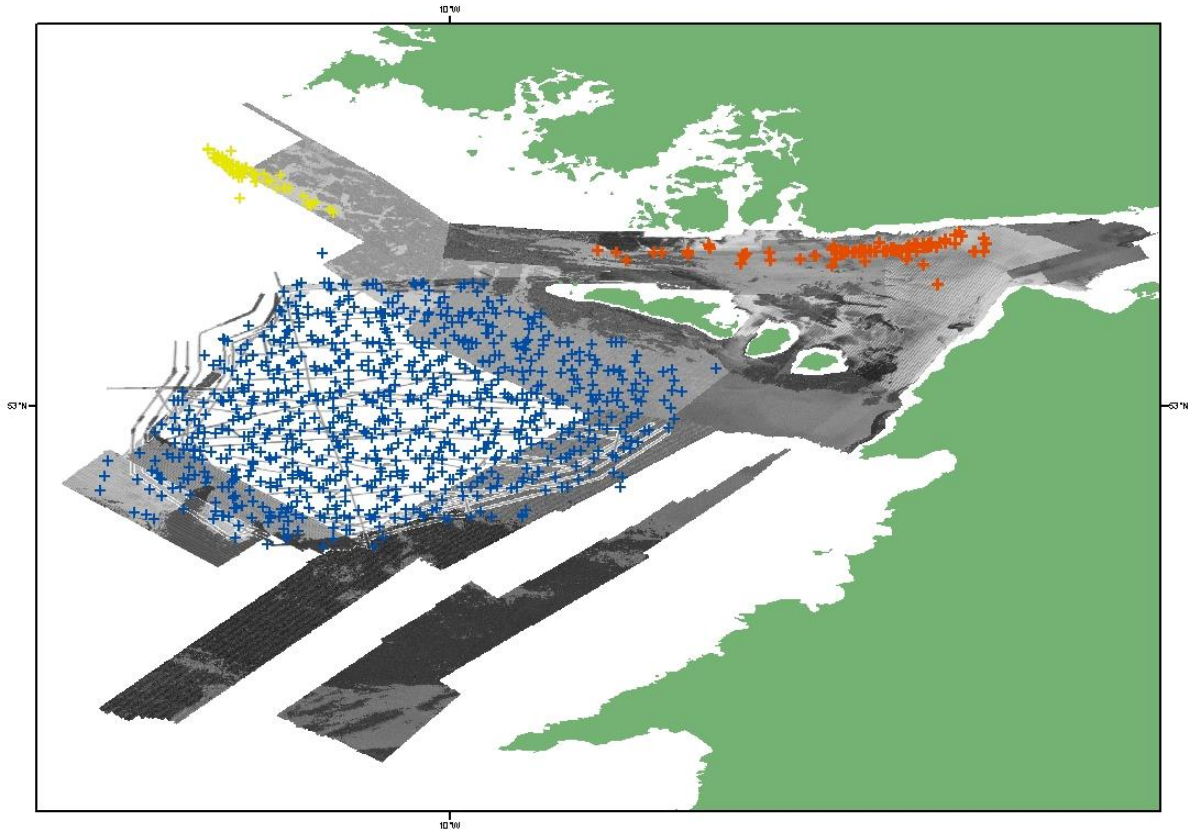

Figure 1: The spatial distribution of all UWTV survey stations from 2002-2015 in Functional Unit 17 overlaid on multibeam backscatter data (source: INFOMAR 2005-2014). Darker backscatter indicates harder seabed substrate.

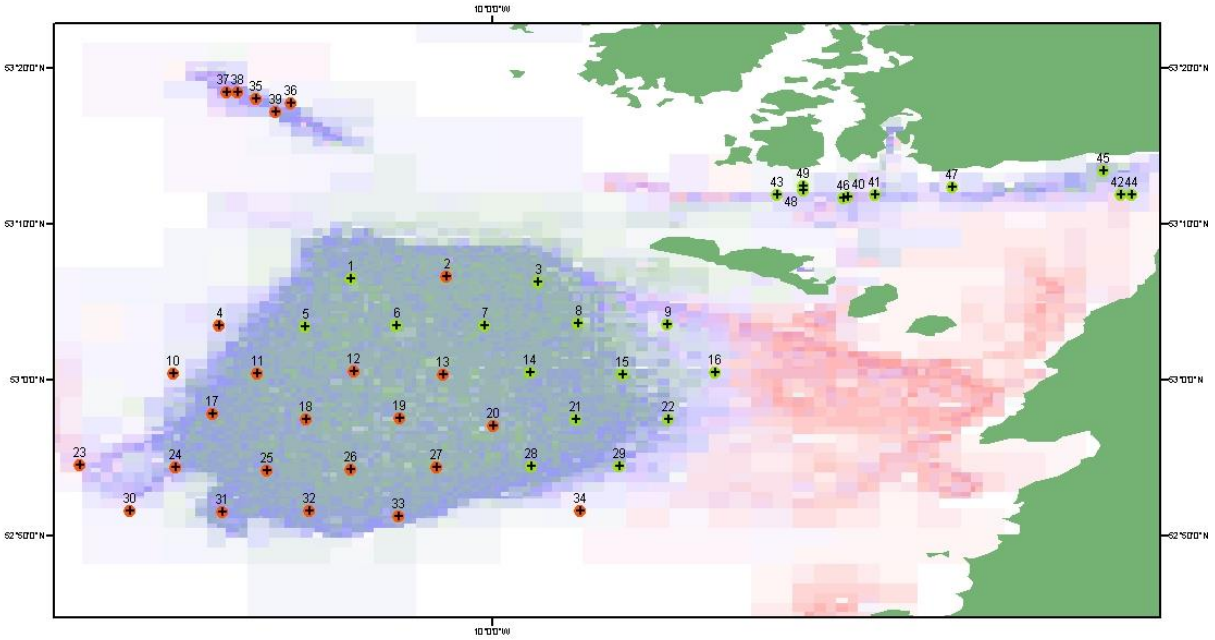

Figure 2: FU17 Aran grounds: UWTV Stations completed in 2015 overlaid on a heat map *Nephrops* directed fishing activity between 2006-2014. Green dots stations completed by RV.Celtic Voyager, orange dots stations completed by RV.Prince Madog.

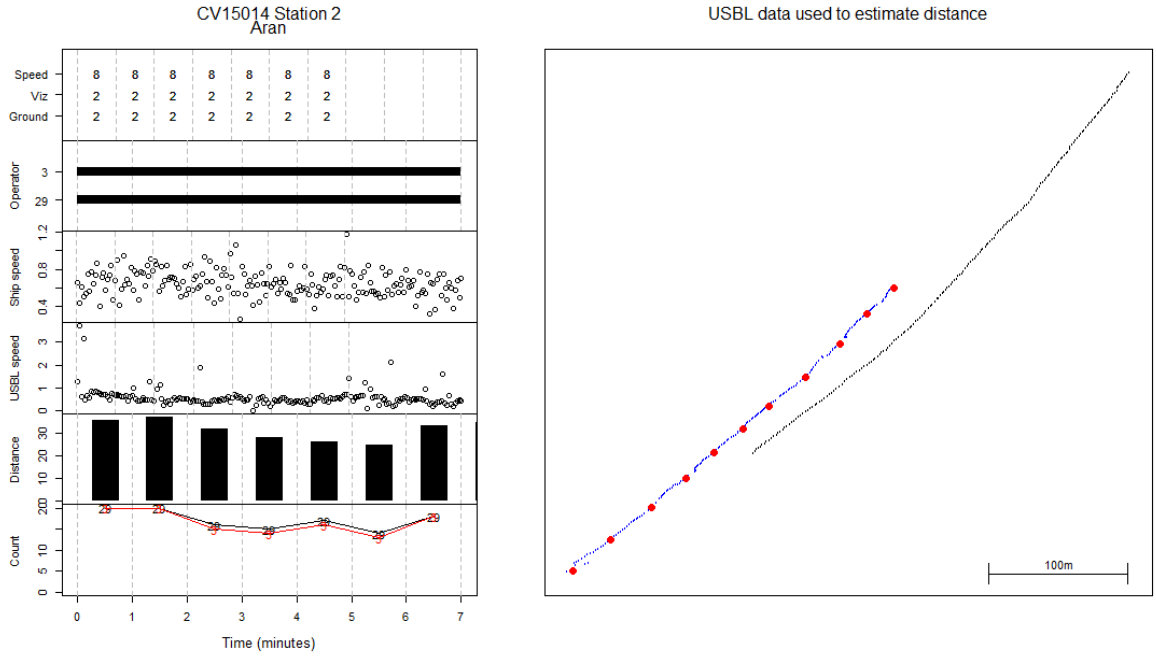

Figure 3 : FU17 Aran grounds: r - tool quality control plot of station 2 of the 2015 survey.

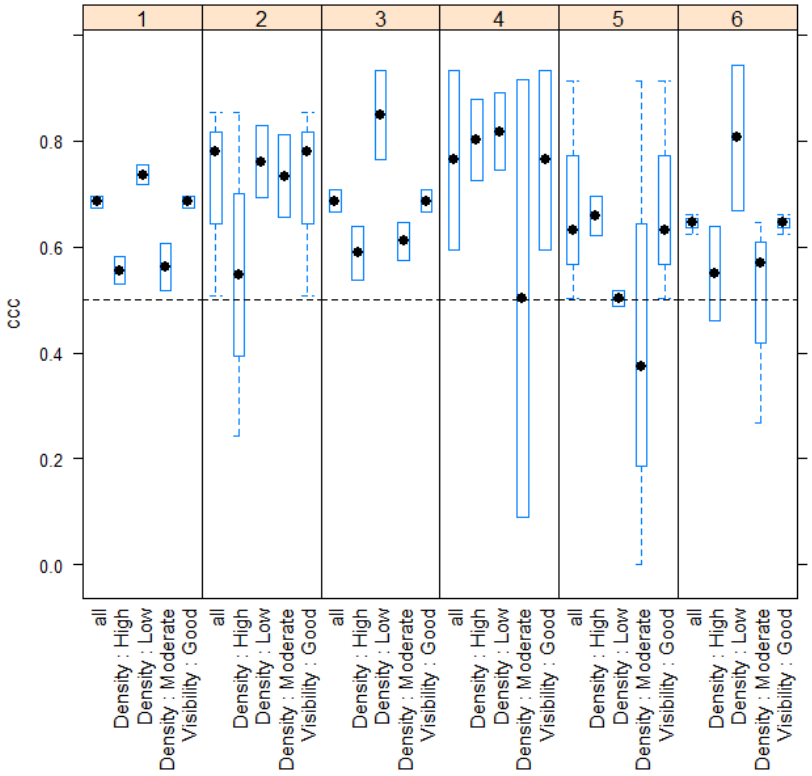

Figure 4: FU17 Aran grounds: 2015 Counting performance against the reference counts as measured by Linn's CCC for FU17 "Aran grounds". Each panel represents an individual. The x-axis (from left to right), all stations pooled, high density, low density, moderate density and visibility good.

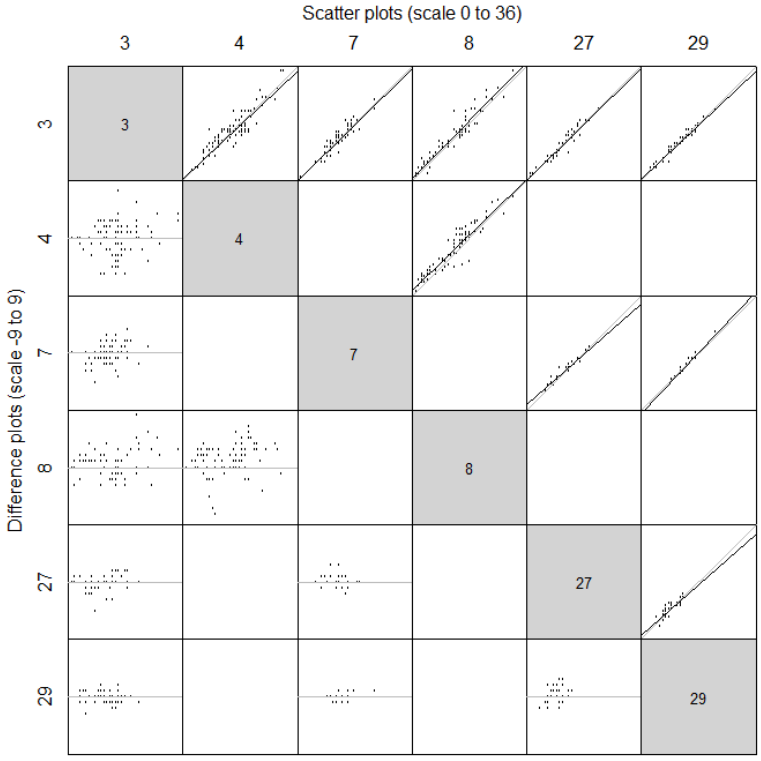

Figure 5: FU17 Aran grounds: Scatter plot analysis of counter correlations for the 2015 survey.

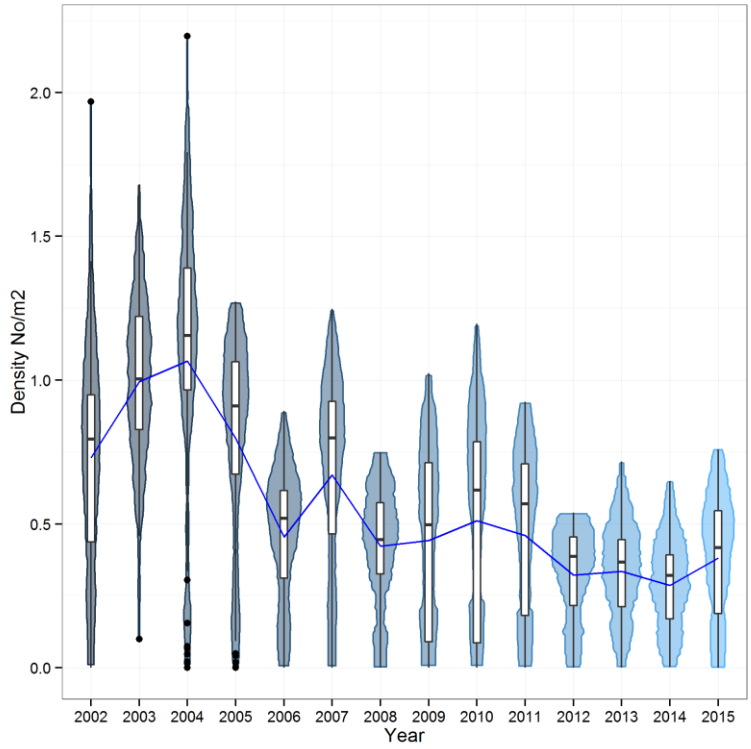

Figure 6: FU17 Aran grounds: Violin and box plot a of adjusted burrow density distributions by year from 2006-2015. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the inter quartile range, the black vertical line is the range and the black dots are outliers.

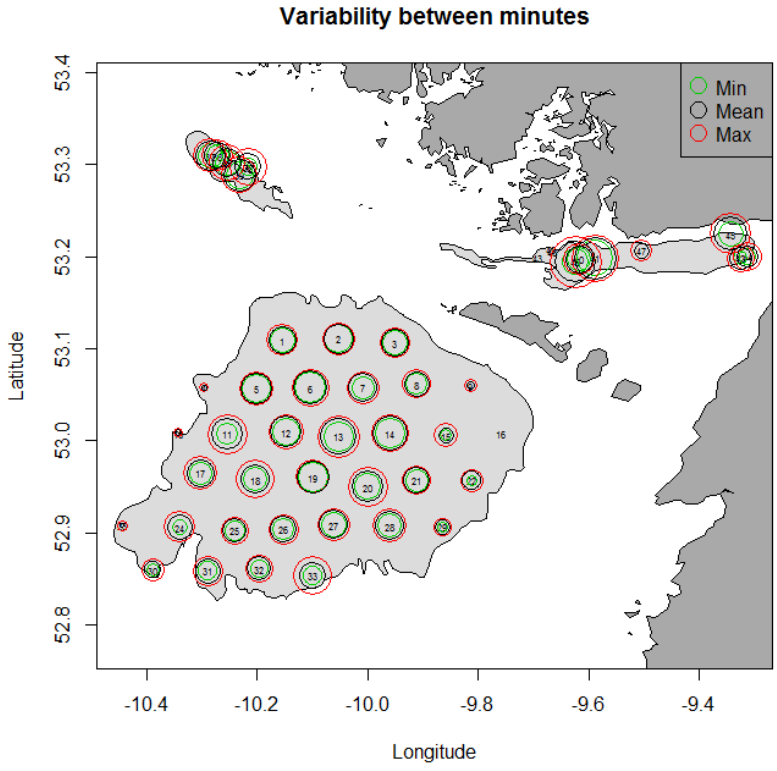

Figure 7: FU17 Aran grounds: Plot of the variability in density between minutes for each station in 2015.

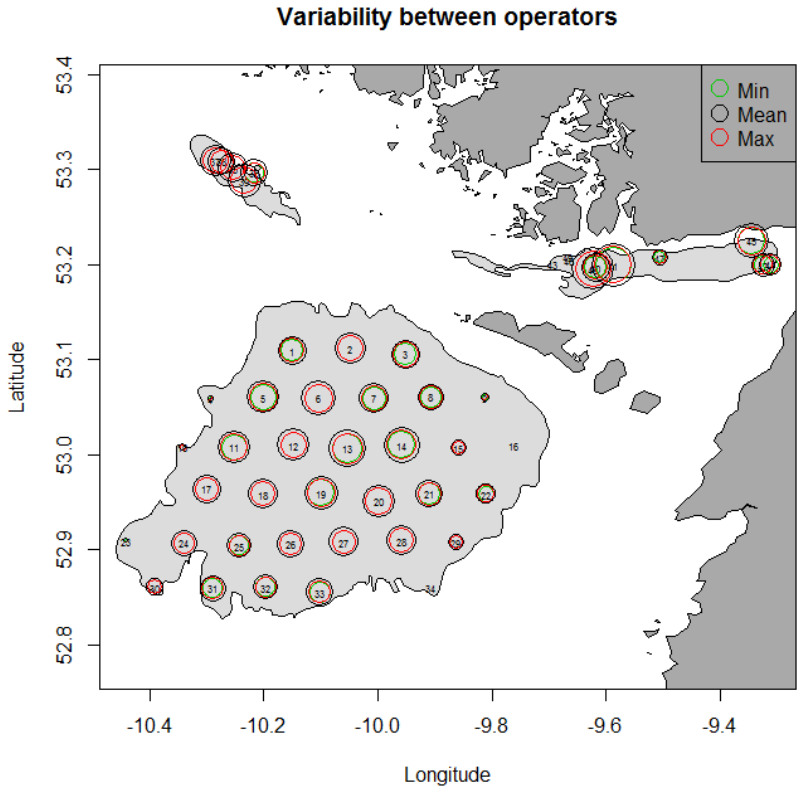

Figure 8: FU17 Aran grounds: Plot of the variability in density between operators (counters) for each station in 2015.

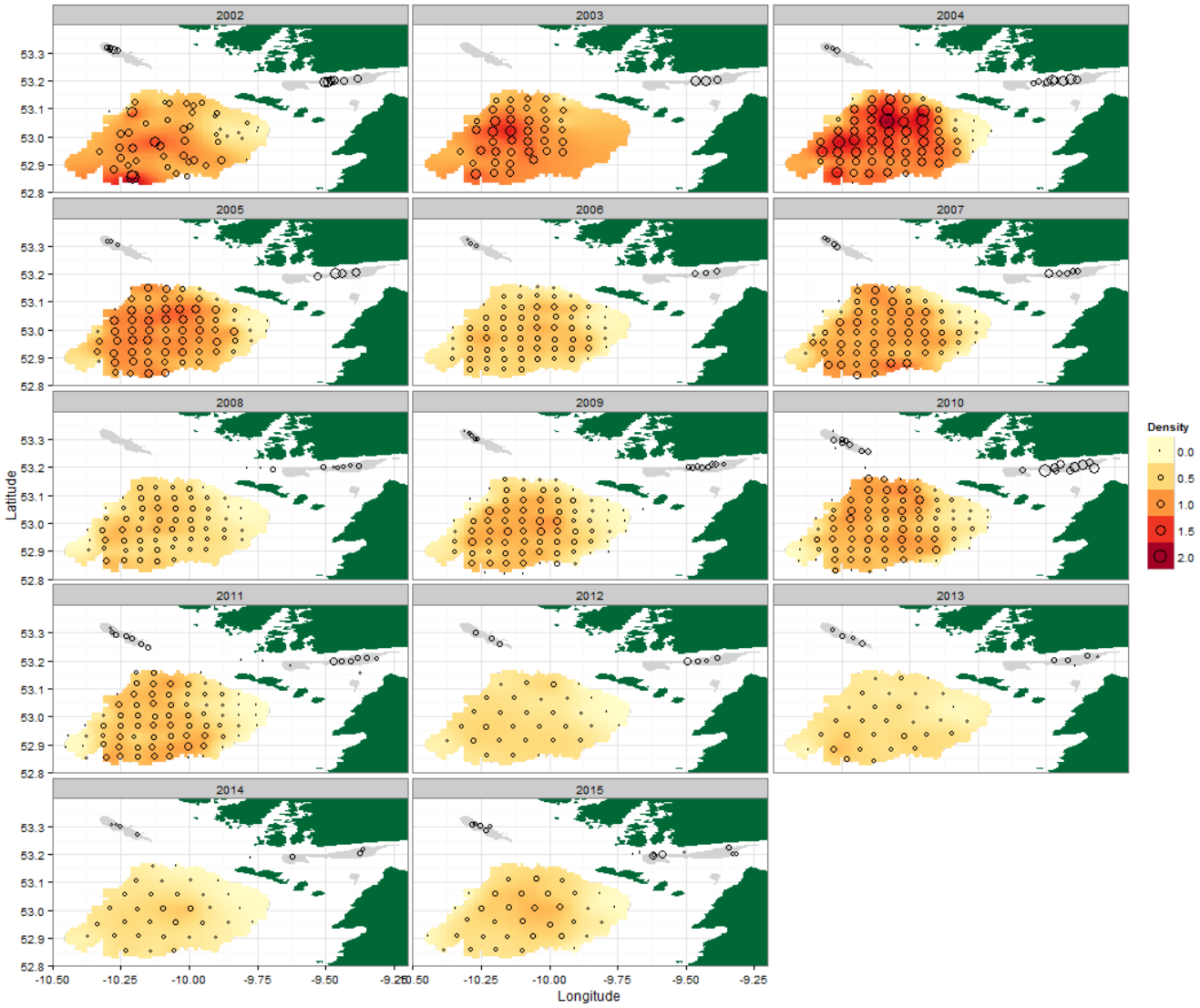

Figure 9: FU17 Aran grounds: Contour plots of the krigged density estimates by year from 2002 (top left) - 2015 (bottom left).

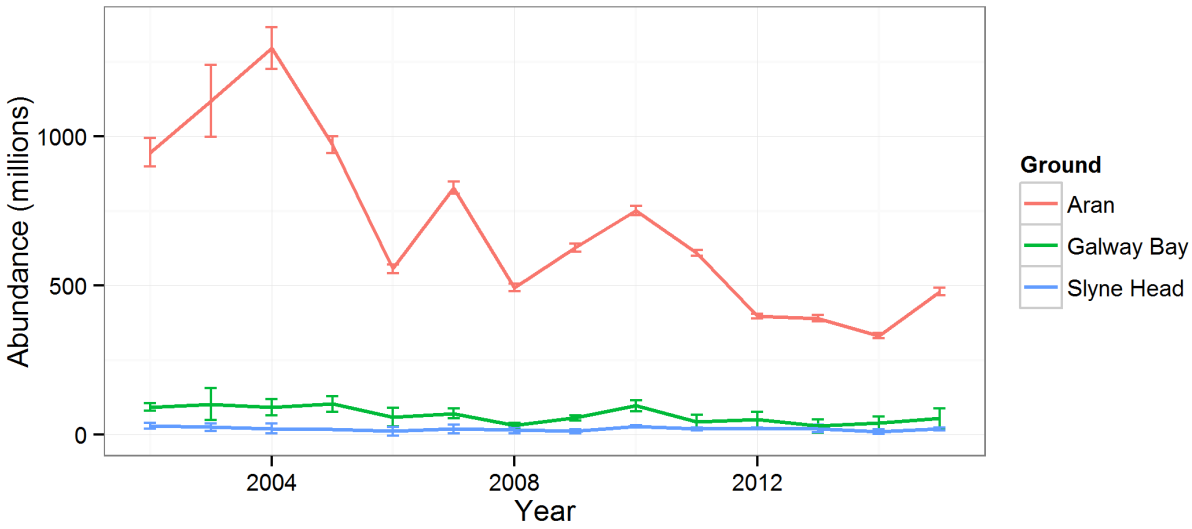

Figure 10: FU17 Aran grounds: Time series of abundance estimates for the Aran Grounds, Galway Bay and Slyne Head (error bars indicate 95% confidence intervals).

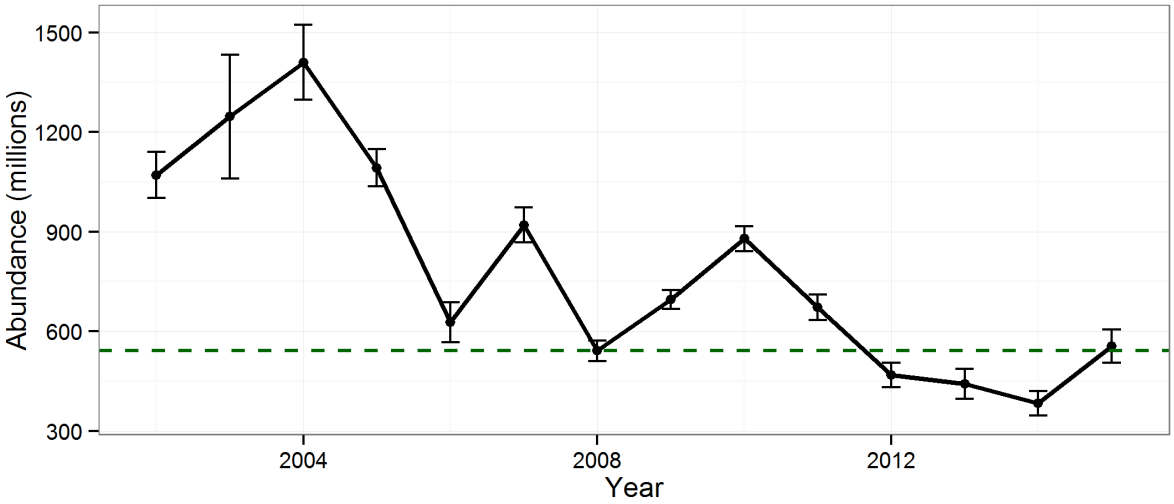

Figure 11: FU17 Aran grounds: Time series of total abundance estimates for FU17 (error bars indicate 95% confidence intervals) and $B_{trigger}$ is dashed green line.

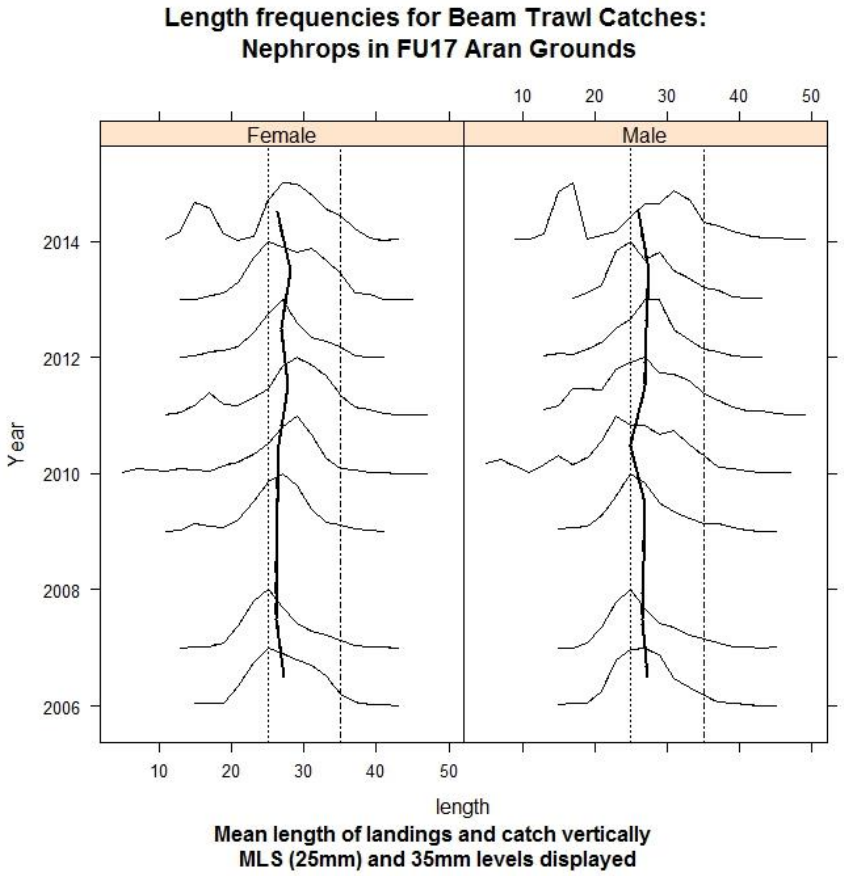

Figure 12: FU17 Aran grounds: Standardised length frequency distributions for male and female *Nephrops* caught using beam trawl during 2006 to 2014 UWTV surveys on the "Aran Grounds" (except 2008 and 2015).

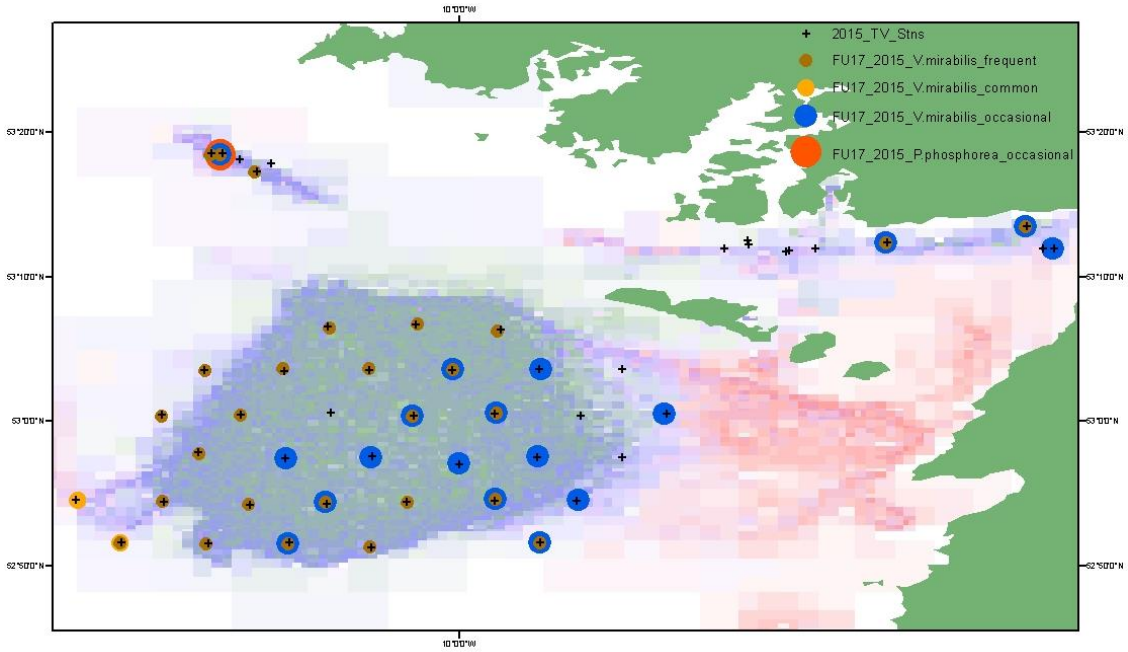

Figure 13: FU17 Aran grounds: Stations where *Virgilaria mirabilis* and *Pennatula phosphorea* were identified during 2015 overlaid on a heat map *Nephrops* directed fishing activity.

Table 1: FU17 Aran grounds: Area calculations for Aran grounds, Galway Bay and Slyne Head *Nephrops* grounds in ArcGIS10.

Ground	Area (km²)
Aran	1202
Galway Bay	79
Slyne Head	39.1
Total	1320.1

Table 2: Key for classification of Seapen abundance as used on Irish UWTV surveys.

	Number/Min
Common	20-200
Frequent	2-19
Ocasional	<2

Species
Virgularia mirabilis
Pennatula phosphorea
Funiculina quadrangularis

Sea Pens								
V. mirabilis			*P. phosphorea*			*F. quadrangularis*		
C	F	O	C	F	O	C	F	O

Table 3: FU17 Aran grounds: Overview Aran of geostatistical results from 2002-2015.

Year	Number of Stations	Mean Density (burrows/m²)	Estimation Standard Deviation	Area (km²)	Geostatistical abundance estimate (millions of Burrows)	CV on Burrow estimate
2002	49	0.79	0.17	1196	947	3%
2003	41	0.94	0.09	1196	1118	6%
2004	64	1.08	0.27	1196	1297	3%
2005	70	0.81	0.12	1196	972	2%
2006	67	0.46	0.06	1196	556	3%
2007	71	0.69	0.12	1196	828	2%
2008	63	0.41	0.05	1196	494	3%
2009	82	0.52	0.10	1196	627	2%
2010	87	0.63	0.10	1196	752	2%
2011	76	0.51	0.09	1196	609	2%
2012	31*	0.33	0.03	1196	397	3%
2013	31*	0.33	0.03	1196	390	4%
2014	33*	0.28	0.03	1196	332	4%
2015	34*	0.40	0.06	1197	480	4%

* reduced isometric grid

Table 4: FU17 Aran grounds: Summary statistics for the Galway Bay and Slyne Head *Nephrops* grounds from 2002-2015.

Year	Ground	Number of stations	Mean Adjusted Density (burrow/m²)	CViid (Relative SE)	Area (km²)	Raised abundance estimate (million burrows)	Upper CI on abundance	Lower CI on abundance
2002	Galway Bay	7	1.18	7%	78.966	93.1	105.9	80.3
2003	Galway Bay	3	1.30	16%	78.966	102.6	155.7	49.6
2004	Galway Bay	8	1.17	14%	78.966	92.2	119.1	65.3
2005	Galway Bay	4	1.30	11%	78.966	103.0	130.0	76.0
2006	Galway Bay	3	0.74	9%	78.966	58.8	90.4	27.2
2007	Galway Bay	5	0.91	8%	78.966	71.8	89.0	54.6
2008	Galway Bay	5	0.40	4%	78.966	31.6	39.9	23.3
2009	Galway Bay	8	0.71	4%	78.966	56.3	64.6	48.0
2010	Galway Bay	10	1.24	11%	78.966	97.6	116.5	78.7
2011	Galway Bay	6	0.55	12%	78.966	43.2	67.1	19.4
2012	Galway Bay	4	0.64	10%	78.966	50.9	76.9	24.9
2013	Galway Bay	5	0.37	10%	78.966	29.6	52.0	7.2
2014	Galway Bay	3	0.50	6%	78.966	39.8	60.6	19.0
2015	Galway Bay	5	0.71	15%	78.966	55.8	88.8	22.8
2002	Slyne Head	5	0.76	8%	39.146	29.8	38.9	20.7
2003*	Slyne Head	0	0.65	0%	39.146	25.3	38.1	12.4
2004	Slyne Head	3	0.53	10%	39.146	20.8	37.4	4.2
2005	Slyne Head	3	0.44	1%	39.146	17.4	18.6	16.2
2006	Slyne Head	3	0.30	9%	39.146	11.8	26.3	-2.6
2007	Slyne Head	4	0.51	12%	39.146	19.8	34.3	5.3
2008*	Slyne Head	0	0.41	0%	39.146	16.0	26.7	5.2
2009	Slyne Head	6	0.31	7%	39.146	12.2	19.2	5.1
2010	Slyne Head	7	0.73	4%	39.146	28.7	32.3	25.1
2011	Slyne Head	7	0.51	5%	39.146	20.0	25.1	14.8
2012	Slyne Head	3	0.52	2%	39.146	20.5	23.3	17.7
2013	Slyne Head	4	0.54	10%	39.146	21.1	33.8	8.3
2014	Slyne Head	4	0.28	6%	39.146	11.0	18.8	3.2
2015	Slyne Head	5	0.50	4%	39.146	19.6	24.0	15.2

* mean density estimated

Table 5: FU17 Aran grounds: Inputs to management option table. Landings, discards, and removals by number, proportion retained, absolute UWTV survey abundance and 95% confidence intervals estimated harvest rate, and landings and discards mean weights.

Year	Landings in Number (millions)	Total discards in Number (millions)*	Removals in Number (millions)	Prop Removals Retained	UWTV abundance estimate (millions)	95% Confidence Interval	Harvest Ratio	Landings (t)	Total discards (t)*	Mean Weight in landings (gr)	Mean Weight in discards (gr)
2001	48.7	25.4	67.8	0.72				912			
2002	54.5	17.7	67.8	0.80	1070	69	6.3%	1152	192	21.2	10.8
2003	44.1	18.3	57.8	0.76	1246	186	4.6%	933	183	21.2	10.0
2004	29	11.4	37.6	0.77	1410	113	2.7%	525	112	18.1	9.9
2005	42.4	19.7	57.2	0.74	1092	56	5.2%	778	182	18.4	9.2
2006	na	na	49.5*	na	627	60	7.9%	636	na	na	na
2007	na	na	57.3*	na	920	52	6.2%	913	na	na	na
2008	48.2	22.1	64.7	0.74	541	31	12.0%	1057	248	21.9	11.2
2009	24.9	9.5	32.0	0.78	696	29	4.6%	626	129	25.1	13.6
2010	37.3	15.2	48.8	0.77	879	38	5.6%	939	224	25.2	14.7
2011	31.9	8.5	38.4	0.83	672	39	5.7%	659	92	20.6	10.8
2012	61.1	8.3	67.3	0.91	468	36	14.4%	1246	86	20.4	10.4
2013	60.0	12.0	69.0	0.87	441	46	15.7%	1295	129	21.6	10.7
2014	33.9	5.0	37.7	0.90	383	37	9.8%	766	48	22.6	9.6
2015					556	50					
Avg 12-14				0.89			13.3%		Avg 08-14	22.5	11.6

Table 6: FU17 Aran grounds: Short-term management option table giving catch options for 2016 using the 2015 UWTV survey estimate.

Variable	Value	Source	Notes
Stock abundance	556 million individuals	ICES (2015a)	UWTV survey 2015
Mean weight in landings	22.5 g	ICES (2015a)	Average 2008-2014
Mean weight in discards	11.6 g	ICES (2015a)	Average 2008-2014
Discard proportion	13.9%	ICES (2015a)	Average (proportion by number) 2012-2014
Discard survival rate	25%	ICES (2015a)	Only applies in scenarios where discarding is allowed
Dead discard rate	10.8%	ICES (2015a)	Average 2012-2014 (proportion by number). Calculated as dead discards divided by dead removals (landings + dead discards). Only applies in scenarios where discarding is allowed.

Catch options assuming zero discards

Basis	Total catch	Wanted catch*	Unwanted catch*	Harvest rate**
MSY approach (F_{MSY} proxy)	991	915	76	8.5%
Fmax	1900	1754	145	16.3%
F35%SPR	1422	1313	109	12.2%
Fcurrent (2012-2014)	1548	1430	118	13.3%

* "Wanted" and "unwanted" catch are used to describe *Nephrops* that would be landed and discarded in the absence of the EU landing obligation based on discard rates estimates for average (2012-2014).
** Calculated for dead removals and applied to total catch.

Catch options assuming discarding allowed

Basis	Total Catches	Dead removals	Landings	Dead discards	Surviving discards	Harvest rate*
	L+DD+SD	L+DD	L	DD	SD	for L+DD
MSY Approach (F_{MSY} proxy) assuming recent discard rate	1026	1006	948	59	20	8.5%
MSY Approach (F_{MSY} proxy) assuming 7% discard rate in weight**	1031	1013	958	54	18	8.5%

* calculated for dead removals.