Porcupine Bank *Nephrops* Grounds (FU16) 2013 UWTV Survey Report and catch options for 2014

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Abstract

This report provides the results of the second underwater television on the 'Porcupine Bank *Nephrops* grounds' ICES assessment area; Functional Unit 16. The survey was multi-disciplinary in nature collecting UWTV, CTD and other ecosystem data. In total 68 UWTV stations were successfully completed in a randomised 6 nautical mile isometric grid covering the full spatial extent of the stock. The mean burrow density observed in 2013, adjusted for edge effect, was 0.106 burrows/m². The final krigged abundance estimate was 768 million burrows with a relative standard error of 4% and an estimated stock area of 7,100km^2. The abundance estimate was 2% lower than in 2012. Landings options at various different fishing mortalities were calculated in line with the recommendations of WKNEPH 2013. Fishing at F_{msy} in 2014 implies a slight increase in the TAC from 1,800 t to 1,850 t. This increase is mainly due to an increase in average mean weight of the landings. The three species of sea-pen found on muddy habitat in Irish waters are *Virgularia mirabilis*, *Funiculina quadrangulari*s and *Pennatula phosphorea* were all observed during the survey. Trawl marks were also observed on over half of the stations surveyed.

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

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Introduction

The prawn (*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 2012 landings worth in excess of € 80 m at first sale. The *Nephrops* fishery on the Porcupine Bank takes place on a large area approximately 7,100 km² of complex muddy habitat between depths of between 330-570m. The fishery typically yields very large individual *Nephrops* that attain very high market prices relative to other fisheries around Ireland. International landings from the fishery peaked in the early 1980s around 4,000 tonnes but have shown a declining trend since then with some fluctuations (ICES, 2013a). The total estimated landings in 2012 were 1,260 t which were likely to be worth in the region of €17.8 m.

In the recent past sustainability of the Porcupine Bank *Nephrops* stock has been a major concern. Consequently a spatio-temporal closed area was developed and proposed by the NWWRAC and implemented between 1st June and 31st July in 2010-2012. In 2013 the fishery was closed from 01st to 31st of May. Since 2011 a functional unit catch limit (actually landings) was in place as part of the TAC regulation (ICES, 2013a). These measures were introduced due to negative trends in the various indicators used to assess the stock and ICES advice for a closure of the fishery in 2009 and 2010. Subsequently the stock situation is known to have improved since 2010 following a good recruitment. The scientific information for this area has also improved with the introduction of a dedicated Irish fisheries-science partnership trawl survey between 2010 and 2012 and the provision of commercial grade data by the Irish industry since 2010 (ICES, 2013b).

Nephrops spend a great deal of time in their burrows and their emergence behaviour is influenced many factors; time of year, light intensity and tidal strength. Underwater television surveys and assessment methodologies have been developed by ICES to provide a fishery independent estimate of stock size, exploitation status and catch advice (ICES, 2009 & 2013b). The first UWTV survey of the Porcupine Bank *Nephrops* grounds (FU16) was carried out in 2012 (Lordan, et al. 2012). That survey was used to provide catch advice for 2013. Subsequently, ICES carried out a benchmark assessment of the Porcupine Bank *Nephrops* stock which concluded that the UWTV survey was a suitable basis to assess and provide management advice (ICES, 2013b).

This was the second UWTV survey of the Porcupine Bank *Nephrops* grounds (FU16). The survey was multi disciplinary in nature and the specific objectives are listed below:

1. To obtain 2013 quality assured estimates of *Nephrops* burrow densities from a randomised isometric grid of UWTV stations at 6 nautical mile spacing over the known spatial and bathymetric distribution of the stock (Figure 1).
2. 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.
3. To collect oceanographic data using a sledge mounted CTD.

This report details the final results of the survey provides catch options for 2014 in line with the recommendations and procedures outlined at the 2013 benchmark (ICES, 2013b).

Material and methods

A randomised isometric gird of stations at 6 nautical mile or 11.1km intervals was planned for the area. The boundary use to delineate the edge of the ground was based on VMS data of fishing activity between 2006-2011 targeting *Nephrops* (shown in Figure 1 and presented Table 1 of Lordan et al. 2012). The grid spacing was determined based on a time constraints of getting the survey completed within a time window of around 5-6 days. This resulted in 69 planned stations. Data on bathymetry and backscatter were also available from the Irish National Seabed Survey and INFOMAR project (http://www.infomar.ie/). The stations ranged from 340-560 m in depth with an average depth of around 440 m (Figure 1).

The operational protocols used were those reviewed by WKNEPHTV 2007 (ICES, 2007) and employed on other UWTV surveys in Irish waters. These protocols 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 from a video cameras with field of view or 'FOV' of 75 cm. Vessel position (DGPS) and position of sledge (using a USBL transponder) were recorded every 1 to 2 seconds. The navigational data was quality controlled using an "r" script developed by the Marine Institute (ICES, 2009b). The USBL navigational data was used to calculate distance over ground or 'DOG' for all of stations.

In line with SGNEPS recommendations all scientists were trained/re-familiarised using training material and footage from the 2012 Porcupine Bank survey, prior to recounting at sea (ICES, 2009b). Once this process had been undertaken, all recounts were conducted by two trained "burrow identifying" 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 standard classification key. The numbers of *Nephrops* burrows complexes (multiple burrows in close proximity which appear to be part of a single complex are only counted once), *Nephrops* activity in and out of burrows were counted by each scientist for each one-minute interval was recorded. Although SGNEPS recommended that verification recounts should be 7 minutes (ICES, 2009b) this was increased to 10 minutes for the Porcupine. This was because at the lower densities observed the relative scale of variation between minutes was higher than typical in other areas. Recounting more minutes resulted in a more stable mean density estimates for each station.

Notes were also recorded each minute on the occurrence of trawl marks, fish species and other species. Abundance categories of sea-pen species were also recorded due to OSPAR Special Request (ICES 2011). Finally, if there was any time during the one-minute where counting was not possible, due to sediment clouds or other reasons, was also estimated so that the time window could be removed from the distance over ground calculations. The "r" quality control tool allowed for individual station data to be analysed in terms of data quality for navigation, overall tow factors such as speed

and visual clarity and consistency in counts (an example is given in Figure 2). Consistency and bias between individual counters was examined using Figure 3. 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 between recounts. Mean density was calculated by dividing the total number of burrow systems by the survey area observed. All recounts were carried out on the footage with a FOV of 75cm. This assumes that the sledge was flat on the seabed (i.e. no sinking). This field of view was confirmed for the majority of tows using lasers during the 2013 survey. The burrow systems in this area are relatively large and occurred at low density making the verification recounts relatively easy. The screen grab image on title page shows a large burrow complex in the centre with three entrances. Figure 4 shows the variability in density between minutes and operators (counters) for each station. These show that the variability between minutes was high reflecting the patchy low density and consistency between counters was very high reflecting the fact that burrow identification was relatively easy.

To account for the spatial co-variance and other spatial structuring a geo-statistical analysis of the mean and variance was carried out using SURFER Version 10.7.972. The mid-points of each UWTV transect were converted to meters using UTM zone 28. Unlike last year the survey achieved close full spatial coverage of the stock area so there was no need to include assumed zero density points in the analysis. As last year an unweighted and unsmoothed omnidirectional variogram was constructed with a lag width of approximately 3.1 km and maximum lag distance of between 79 km. The same logarithmic variogram model was fitted using the SURFER algorithm and used to create krigged grid file of interpolated burrow density. The final part of the process was to limit the calculations to the known extent of the ground using the boundary blanking file. The resulting blanked grid was used to estimate the domain area and total burrow abundance estimate. Krigged estimation variance or CV was carried out using the EVA: Estimation VAriance software (Petitgas and Lafont, 1997). The EVA burrow abundance estimates were extremely close to the Surfer estimate.

In addition a CTD profile was logged for the duration of each tow using a Sea-Bird SBE37. This data will be processed later.

Results

A summary of the univariate statistics and geostatistics on the burrow density estimates are given in Table 1. The mean burrow density observed in 2013, adjusted[1] for edge effect, was 0.106 burrows/m². The range of the observations was relatively high from 0.01-0.23 burrows/m². Most of the salient summary statistics (mean, median, trimmed mean, percentiles etc.) on the observations in 2013 were around 30% lower than in 2012. Histograms of the observed burrow densities observation in 2012 and 2013 for the Porcupine Bank are shown in Figure 5.

[1] Note the "adjusted" density estimates in this report are adjusted by dividing by 1.26 to take account of edge effect over estimation of area viewed during UWTV transects (see Campbell et al 2009).

The final modelled density surfaces in 2012 and 2013 are shown as a heat maps and bubble plots in Figure 6. The scale and spatial pattern of burrow density is relatively consistent in both years. In 2012 a conservative assumption was made about densities declining towards zero towards the south of the area. The 2013 survey with better spatial coverage show that the densities in the middle of the south of the ground and south west do not decline towards zero. The 2013 spatial coverage included a lot of stations very close to the eastern boundary of the ground. These are partly responsible for the ~30% lower mean density estimate observed. The burrow surface fitted for 2012 was actually very consistent with the observations in 2013. The abundance estimate derived from the krigged burrow surfaces (and adjusted for edge effect) was 787 and 768 million burrows in 2012 and 2013 respectively (Table 1). The estimated area of the ground or domain area was 7,108km². The estimation CV on the abundance was around 5% in 2012 and 4% in 2013.

Fishing mortality reference points and mean weight of *Nephrops* in the landings from the Porcupine Bank after WGCSE 2013 are given in Table 2 and Table 3 respectively (ICES, 2013a). Landings options at various different fishing mortalities are calculated in line with the recommendations of WKNEPH 2013 and are shown in Table 4. Fishing at F_{msy} in 2014 implies a slight increase in the TAC from 1,800 t to 1,850 t.

Trawl marks were observed at 56% of surveyed stations and 19% of surveyed stations had trawl marks persisting throughout the 10 minute transect. The distribution and abundance class of the various sea-pen species observed on the UWTV footage is shown in Figure 7. Three sea-pen species occur in the deep mud habitats around the coastal British Isles; *Virgularia mirabilis, Pennatula phosphorea* and *Funiculina quadrangularis* (Hughes, 1998). All three species were observed on footage during the 2013 survey.

Discussion

This was the second systematic UWTV *Nephrops* survey of the Porcupine Bank. The distance from shore (~ 120 nautical miles), exposed nature of the area, the significant water depths involved (330-570m) and relatively large size of the area (>7100km^2) presents significant logistical, technical and survey design challenges. The Marine Institute carries out UWTV surveys in three 10 day pre-planned survey legs. Priority was given to the Porcupine Bank ground whenever a suitable weather window was available during the legs. In 2013 almost full coverage (68/69 planned stations) was achieved across two survey legs. In line with the experience last year; the visibility and footage quality was normally excellent, burrow morphology and size were similar to other areas and the relatively low density meant that burrow identification was relatively easy.

The survey design, with a randomised 6 nautical mile isometric grid, and ground boundary employed were the same as in 2012 (Lordan, et al. 2012). Although the raw burrow density observations from the 2013 grid were around 30% lower than in 2012. Despite this the total abundance estimate remained very similar. This was due to two main reasons, the 2012 survey had more stations in areas with higher burrow density, whereas the 2013 survey had many stations close to the eastern boundary where the densities tend towards zero and the modelled burrow surface for 2012 (when only

partial spatial coverage was achieved) was actually similar to the observations made in 2013. In general, the burrow densities on the Porcupine Bank UWTV survey remain the lowest of any ground which supports an on-going fishery.

An ICES benchmark meeting, WKNEPH 2013, reviewed much of the available data available to assess and provide management advice for Porcupine *Nephrops* (ICES, 2013b). Total catches and landings options for 2014 have been calculated using updated data from WGCSE 2013 in line with the stock annex and recommendations from WKNEPH (ICES, 2013a&b) (Table 4). The resulting landings for 2014 fishing at F_{msy} increase by 50 t to 1,850 t mainly due to an increase in estimated mean weight of the landings. Carrying out annual UWTV surveys to generate catch advice, while challenging, should be continued in the short term given the limited number of UWTV observations to date and evolving knowledge base on the spatial and temporal dynamics of this stock.

In addition to estimating *Nephrops* stock abundance UWTV surveys can be used to monitor the presence of certain benthic fauna (ICES, 2011). Sea-pens and burrowing megafauna communities have been included in the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2010). As noted in 2012 all three species sea-pen species which occur on mud habitat around Ireland were identified on the 2013 footage. The occurrence of *F. quadrangularis* in particular is significant since that species is particularly vulnerable to trawl mortality. *Funiculina quadrangularis* is largely absent from other *Nephrops* grounds around Ireland although there are catches on groundfish surveys in areas where *Nephrops* are not commercially fished (Power and Lordan, 2012). The majority of the Porcupine Bank is fished at least once annually based on the methods described in Gerritsen, et al (2013). The observation that 56% of stations showed some trawl marks is relatively high but broadly consistent with the findings reported in WKNEPH (ICES, 2013b).

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OSPAR, 2010. Background Document for Seapen and Burrowing megafauna communities. OSPAR Commission 2010, London. Publication number: 481/2010

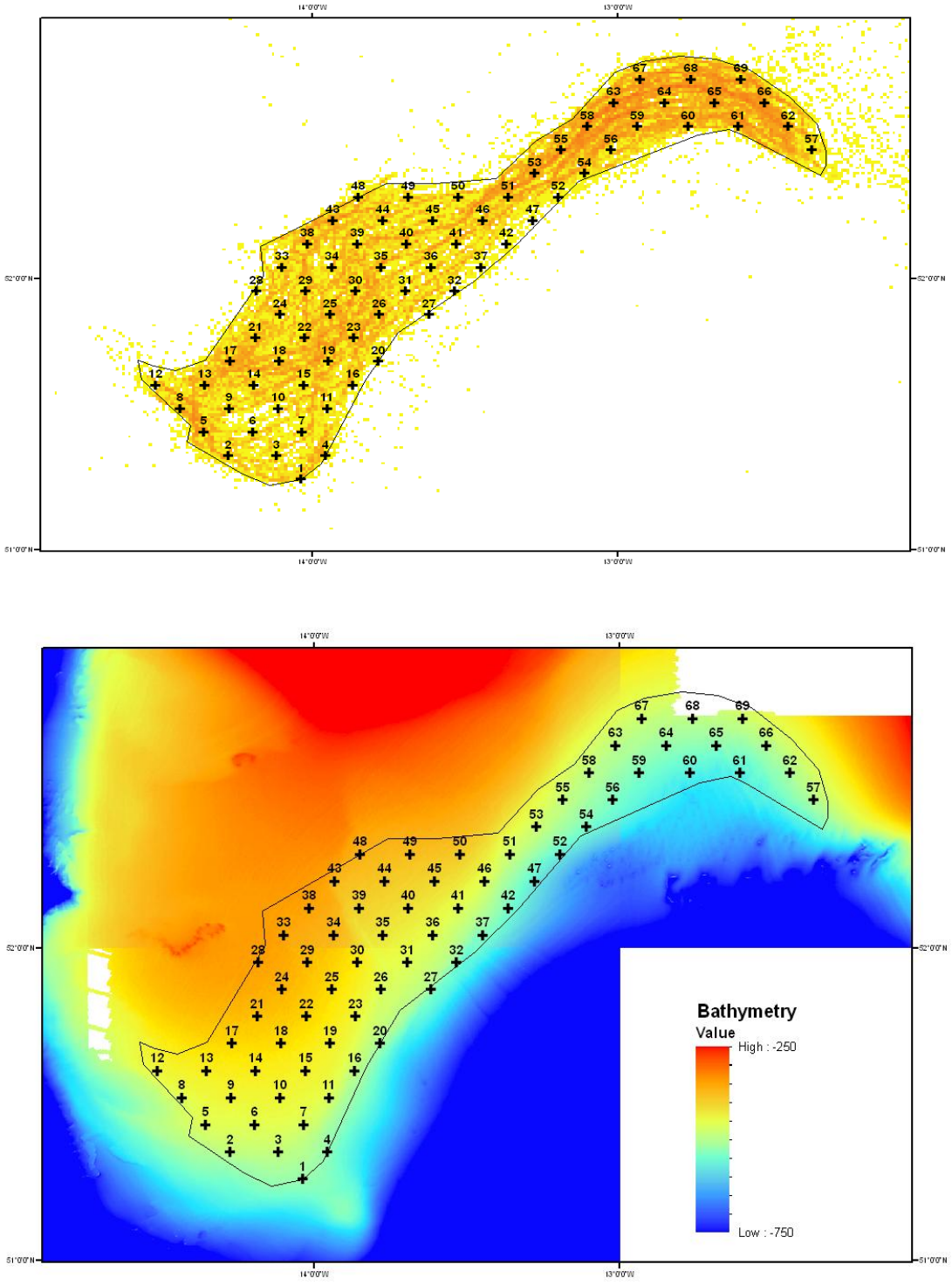

Figure 1: Porcupine Bank 2013 UWTV map of station positions overlaid on a heat map of *Nephrops* directed fishing (top panel) and bathymetry (bottom panel). The black polygon line indicated the ground boundary currently used.

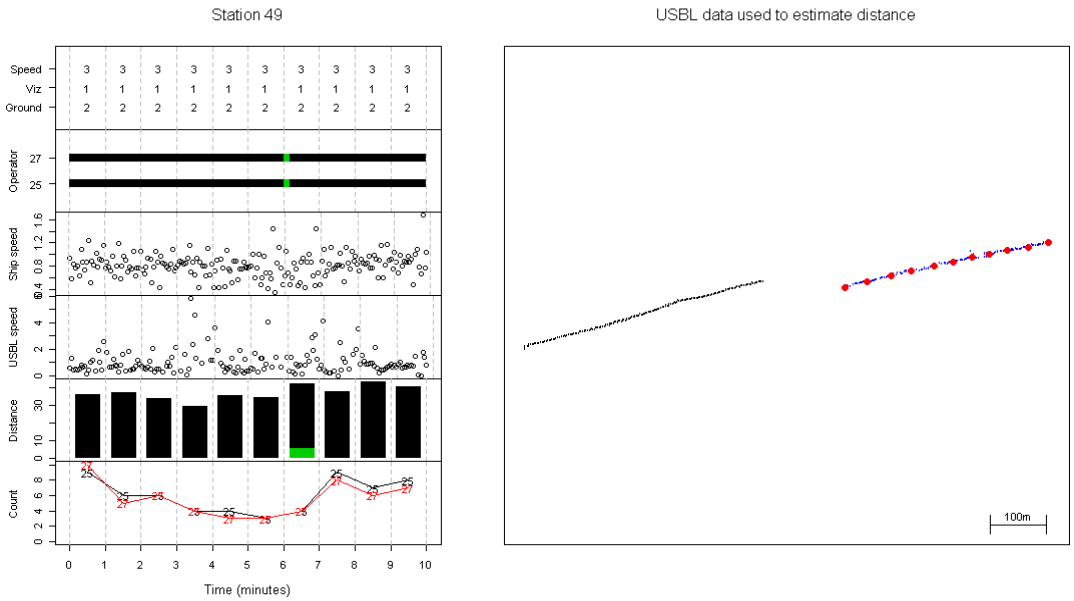

Figure 2: Porcupine Bank 2013 UWTV example quality control plot for the navigational and recount data.

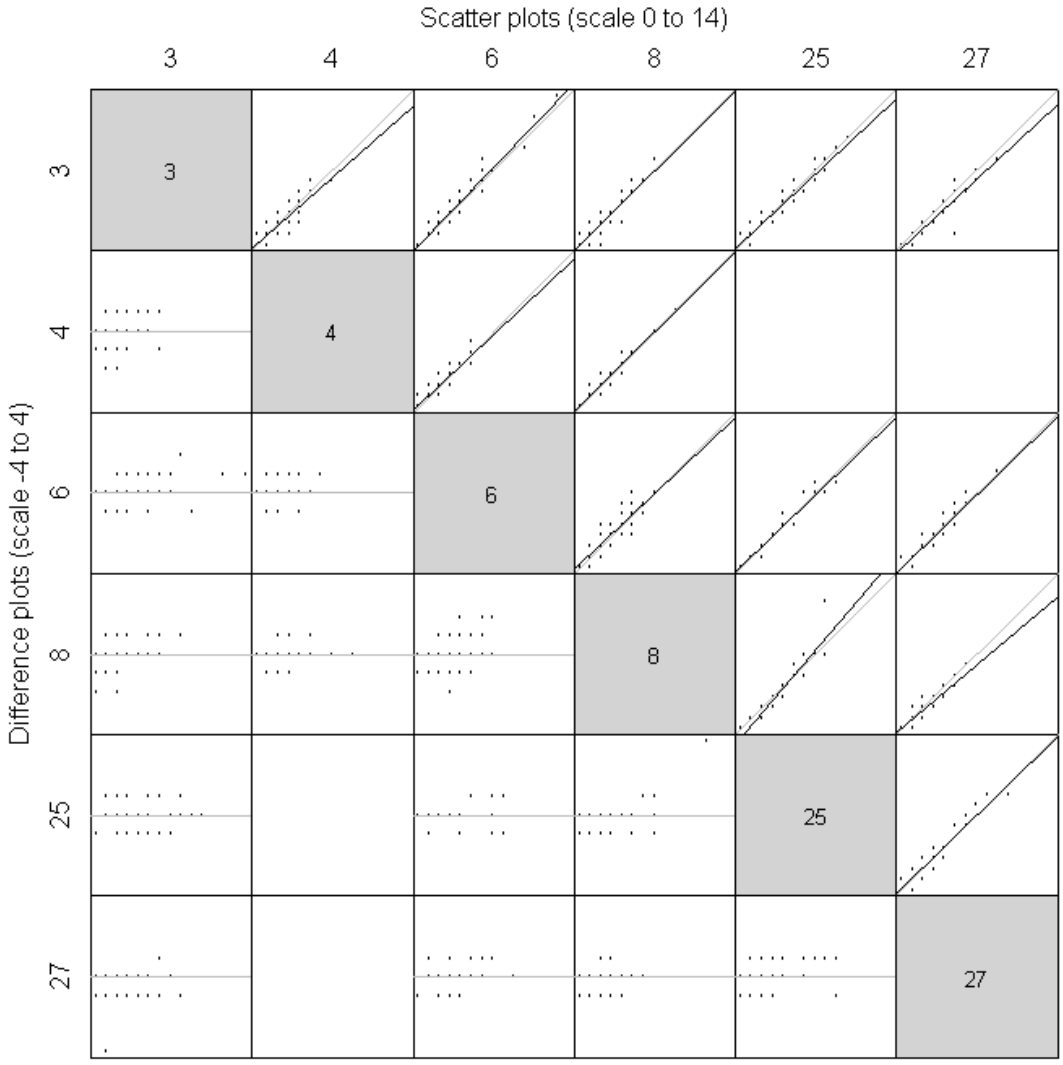

Figure 3: Porcupine Bank 2012 UWTV inter counter comparison plot.

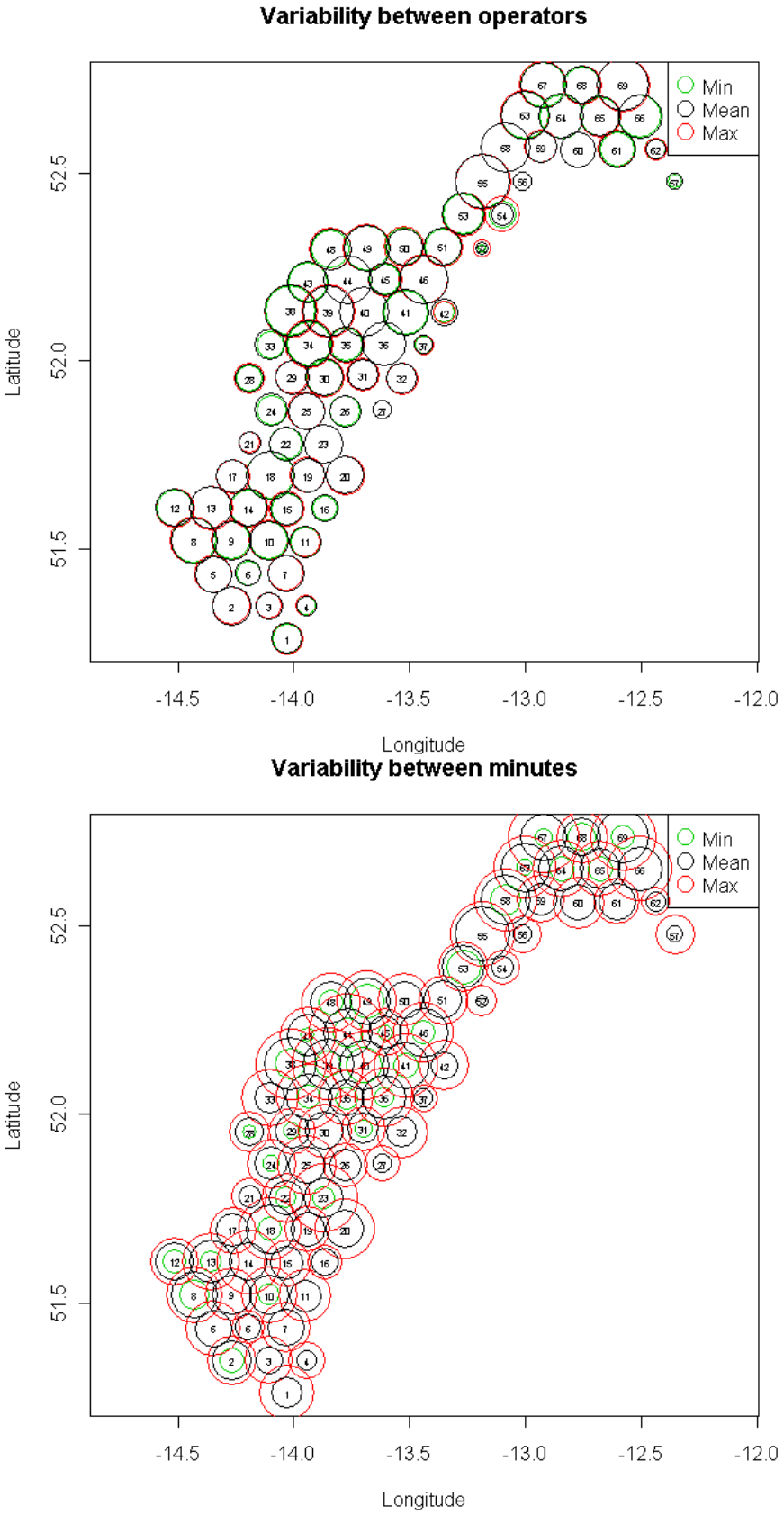

Figure 4: Porcupine Bank 2013 UWTV quality control plot showing variability between counters (top panel) and between minutes (bottom panel) for each UWTV station

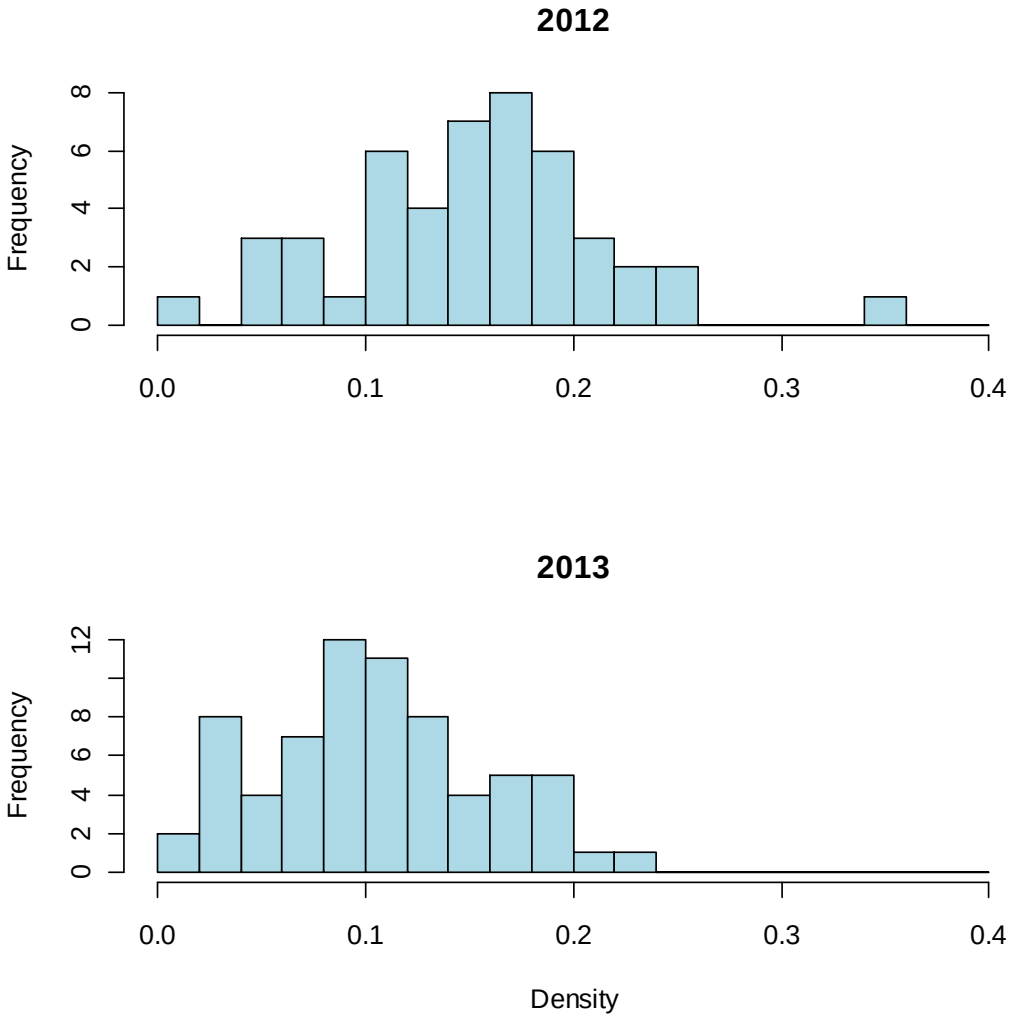

Figure 5: Porcupine Bank 2013 UWTV histogram of observed burrow densities in 2012 and 2013.

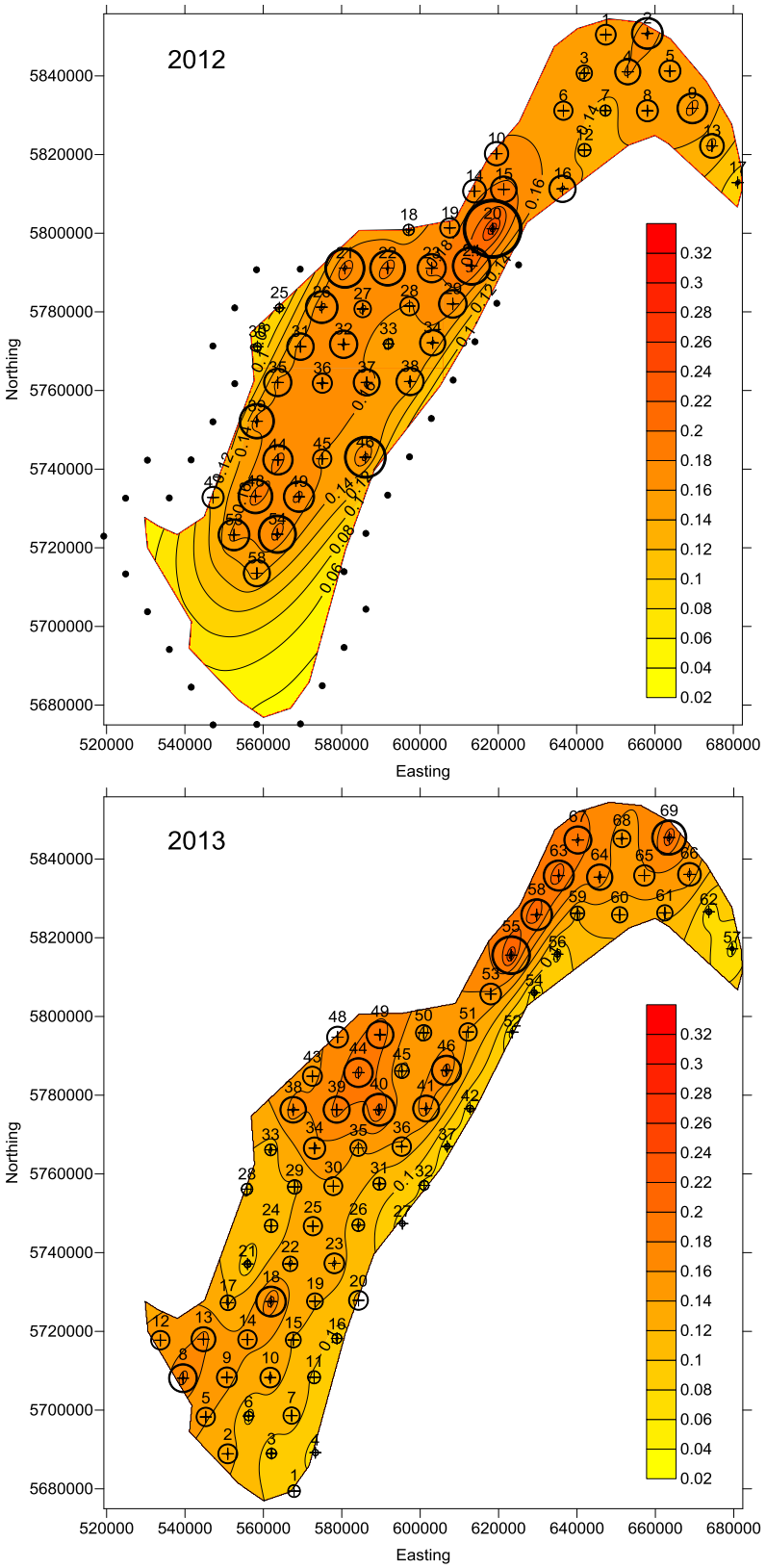

Figure 6: Porcupine Bank UWTV bubble plot of the burrow density observations overlaid on a head map of the krigged burrow density surface for 2012 and 2013. Observed station positions are indicated using a + and assumed zero densities beyond the boundary are shown as black filled circle.

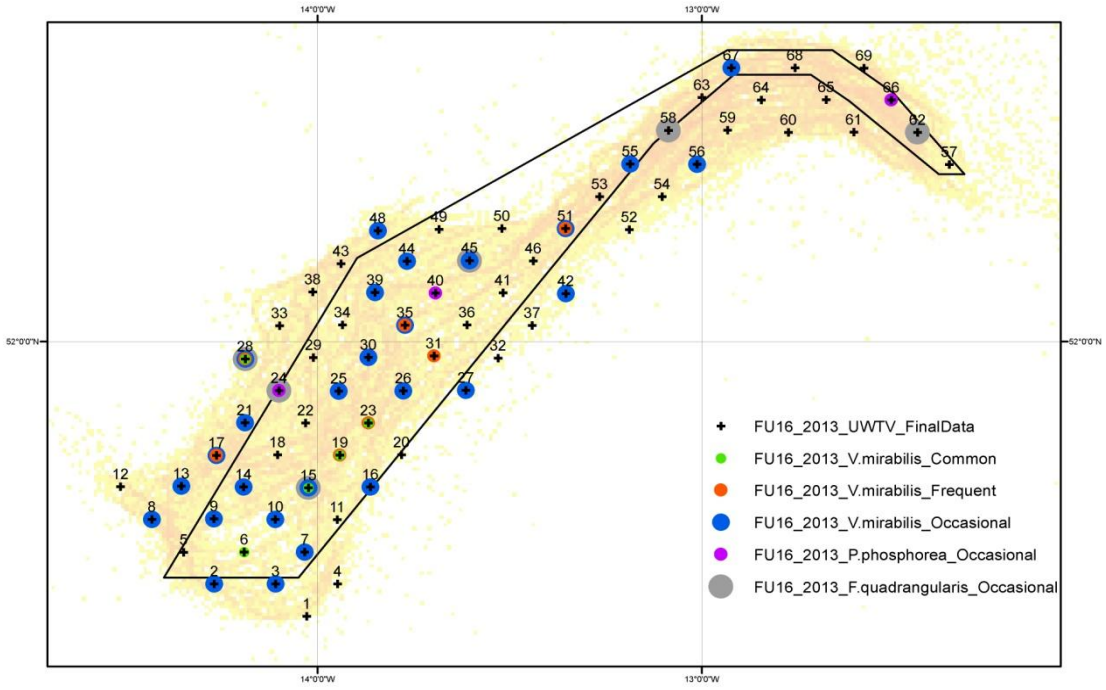

Figure 7: Porcupine Bank UWTV 2013. The distribution and abundance class of sea-pen species observed on the video footage.

Table 1. Summary of univariate statistics and geostatistics for the burrow density estimates (bias corrected) on the Porcupine Bank UWTV survey in 2012 and 2013.

Univariate Statistics	**2012**	**2013**
Number of Observations	47	68
Minimum:	0.014	0.012
25%-tile:	0.113	0.072
Median:	0.158	0.106
75%-tile:	0.187	0.140
Maximum:	0.358	0.233
Midrange:	0.187	0.122
Range:	0.344	0.221
Interquartile Range:	0.074	0.067
Median Abs. Deviation:	0.037	0.034
Mean:	0.151	0.106
Trim Mean (10%):	0.149	0.104
Standard Deviation:	0.063	0.051
Variance:	0.005	0.003
Coef. of Variation:	0.329	0.385
Coef. of Skewness:	0.294	0.198
Geostatistics	**2012**	**2013**
Adjusted abundance estimate (millions)	787	768
Domain area (km^2)	7108	7108
Coef. of Variation	0.049	0.044

Table 2. Porcupine Bank *Nephrops* estimated Per Recruit Reference Points and associated harvest ratios (ICES, 2013).

			Fbar(35-50 mm)		HR	SPR (%)		
		Fmult	M	F	(%)	M	F	T
$F_{0.1}$	M	0.15	0.140	0.034	4.2	39.9	79.3	53.9
	F	0.76	0.709	0.172	12.3	9.7	41.5	21.0
	T	0.19	0.177	0.043	5.0	33.6	75.0	48.4
F_{max}	M	0.28	0.261	0.063	6.6	24.4	66.8	39.5
	F	1.81	1.688	0.410	19.0	4.6	22.6	11.0
	T	0.63	0.588	0.143	11.1	11.5	46.3	23.9
$F_{35\%SpR}$	M	0.19	0.177	0.043	5.0	33.6	75.0	48.4
	F	1	0.933	0.226	14.3	7.6	34.8	17.2
	T	0.35	0.326	0.079	7.7	20.0	61.5	34.8

Table 3. Porcupine Bank *Nephrops* mean weight in the landings time series.

Year	FU16 Mean Weight in Landings (grammes)
1986	46.5
1987	41.4
1988	49.3
1989	46.4
1990	48.7
1991	44.0
1992	42.8
1993	48.3
1994	46.1
1995	44.8
1996	42.2
1997	40.7
1998	43.2
1999	43.8
2000	60.1
2001	49.6
2002	41.5
2003	57.8
2004	65.3
2005	69.8
2006	76.2
2007	71.1
2008	55.9
2009	53.2
2010	65.3
2011	45.8
2012	50.4
Average 2011-2012	**48.1**

Table 4. Porcupine Bank *Nephrops* catch options for 2014.

Outlook for 2014

Basis: F_{2013} = F_{2012} = 3.2%, Bias-corrected survey index (2013) = 768 million; Mean weights in landings (48.1 g, 2011–2012); discard rates by number (0%). Survey bias = 1.26.

Basis	Total Catches*	Landings	Dead Discards**	Surviving Discards**	Harvest Rate
	L+DD+SD	L	DD	SD	for L+DD
F_{MSY} proxy	1848	1848	0	0	5.0%
F_{2013}	1183	1183	0	0	3.2%
$F_{35\%SpR}$	2846	2846	0	0	7.7%
F_{max}	4103	4103	0	0	11.1%

Weights in tonnes.

* Total catches are the landings plus dead and surviving discards.

** Based on negligible discards during observer trips.