

## Update on the 2009 UWTV Survey of the Aran, Galway Bay and Slyne Head *Nephrops* Grounds

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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 Irish *Nephrops* fishery is extremely valuable with landings in recent years worth around € 30 m at first sale supporting an important indigenous processing industry. The *Nephrops* fishery 'at the back of the Aran Islands' can be considered the mainstay of the Ros a Mhíl fleet. 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 to enable sustainable management of the resources are urgently required.

This is the eight data point in a time series of UWTV surveys on the 'Aran grounds'. The survey covers three distinct mud patches; the Aran Ground, Galway Bay and Slyne Head. These have approximate areas of 940, 41 and 26 km<sup>2</sup> respectively. In 2009 this survey was used to develop catch options for the stock using a bias corrected survey estimate as an absolute measure of stock size and recent discard rates and mean weight to forecast catch (ICES, 2009a). This report details the results of the 2009 survey and updates the catch option table using the most recent survey estimate.

### Material and methods

Stations in Galway Bay and Slyne Head were either randomly picked or selected based on previously completed tows. A randomised fixed grid design is used for the Aran grounds where a point is picked at random and stations are carried out at a fixed distance north-south and east-west. The distance between stations varied somewhat but is currently 2.25 nautical miles. An adaptive approach is taken where by stations are continued past the known perimeter of the ground until the burrow densities are close to zero. The boundary used to delineate the edge of the ground was based on information from the fishing industry and has not been changed since 2002.

Survey timing was generally standardised to June each year. 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, poor weather and technical problems meant that coverage was poor compared with the other years. In 2009 all three *Nephrops* grounds were surveyed successfully in June.

At each station the UWTV sledge was deployed and once stable on the seabed a 10 minute tow was recorded onto DVD. Vessel position (DGPS) and position of sledge (using a USBL transponder) were recorded every 1 second. The navigational data was quality controlled using an “r” script developed by the Marine Institute (ICES, 2009b). In addition depth was logged for the duration of the tow.

In line with SGNEPS recommendations all scientist were trained/re-familiarised using training material, validated and reference footage prior to recounting at sea (ICES, 2009). 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 the classification. In addition 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* in and *Nephrops* out of burrows counted by each scientist for each one-minute interval was recorded. Notes were also recorded on the occurrence of trawl marks, fish species and other species during the one-minute interval. Finally, if any there was any time during the one-minute where counting was not possible this 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 (Figure 1). There was a problem with the navigational information for the ship in 2009 but this does not effect the distance over ground calculations which were based on USBL navigational information. Consistency and bias between individual counters was examined using Figure 2. Figure 3 and Figure 4 shows the variability in density between minutes and operators (counters) for each station.

The main change in protocol this year relates to the amount of time recounted. Following the recommendation of SGNEPS the time for verified recounts was reduced from 10 to 7 minutes (ICES, 2009b). The survey data for years prior to 2009 has not been updated although work is underway to recount footage

The resultant recount data were screened for one minute intervals with an unusually large deviation between recounts. Means of the burrow and *Nephrops* recounts were standardised by dividing by the survey area observed. The USBL data were used to calculate distance over ground of the sledge. The field of view of the camera at the bottom of the screen was estimated assuming that the sledge was flat on the seabed (i.e. no sinking). ). This field of view was confirmed for all of tows using lasers during the 2009 survey

To account for the spatial co-variance and other spatial structuring a geo-statistical analysis of the data was also carried out using SURFER Version 8.02 for stations within the main fishing area the Aran Grounds for all years. The spatial structure of the density data was studied through variograms. Initial the mid-points of each UWTV transect were converted to UTM's. In addition to the survey stations various boundary positions were included in the analysis. The assumption at these boundary positions was that the *Nephrops* abundance was zero. These stations were outside the known distribution of *Nephrops* or suitable sediment and were approximately equidistant to the spacing within the main grid each year. An unweighted and unsmoothed omnidirectional variogram was constructed with a lag width of between

1-1.4 and maximum lag distance of between 19-20 km. A model variogram  $\gamma(h)$ , was produced with a nugget component and an exponential component (Equation 8). Model fitting was via the SURFER algorithm using the variogram estimation option. Various other experimental variograms and model setting were examined before the final model choice was made.

*Equation 8: Exponential Variogram Model*

$$\gamma(h) = C[1 - e^{-h}]$$

Where C is the scale for the structural component of the variogram and h is the anisotrophically.

The resulting annual variograms were used to create krigged grid files and the resulting cross-validation data were plotted. If the results looked reasonable then surface plots of the grids were made using a standardised scale. The final part of the process was to limit the calculation to the known extent of the ground using a boundary blanking file. The resulting blanked grid was used to estimate the mean, domain area and total burrow abundance estimate.

Although SURFER was used to estimate the burrow abundance this does not provide the kriged estimation variance or CV. This was carried out using the EVA: Estimation VARIance software (Petitgas and Lafont, 1997). The EVA burrow abundance estimates were all extremely close to the Surfer estimate ( $\pm 30$  million burrows) with the exception of 2004 when the spatial coverage was poor.

## Results

Landings, effort and LPUE trends for FU17 are given in Figure 5. These indicate that landings increased throughout the 1990s with some fluctuations peaking in 1999 at  $>1,400$  t since then there has been a general decline in landings with an increase in 2008 on 2007 figure by 14% to 1050 t. This is fourth time in the series that landings have been in excess of 1000 t from this FU. Effort in the “*Nephrops* directed fleet” shows a declining trend since 1998 and LPUE has remained fairly stable over the time series and both have increased in 2008.

A histogram of the observed burrow densities for 2009 and previous years on the Aran Grounds is presented in Figure 6. This shows large inter-annual variation in modal burrow densities.

The geostatistical structural analysis is shown in the form of variograms in Figure 7. There are a few outliers apparent but they appear have little leverage on the variogram models observed. With the exception of 2006 a nugget is apparent in most years. There is weak evidence of a sill at around 12km in some years but it is not clear and the logarithmic model used does not have a sill. A comparison of the observed and expected density estimates confirms that there is good concordance between the observation and model estimates.

The blanked kriged contour plot and posted point density data are shown in Figure 8. The kriged contours correspond very well to the observed data. The results indicate

the 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 rather and there is a notable trend towards lower densities towards the east. On the south western boundary there are indications of high densities close to the boundary. In this area there is a sharp transition from mud to rocky substrate and work is underway to define this boundary more accurately.

The summary statistics from this geostatistical analysis are given in Table 1 and plotted in Figure 9. The 2009 estimate of 718 million burrows is a 39% increase on the lowest to date in 2008. The estimates have fluctuated widely since the survey commenced. The estimation variance of the survey as calculated by EVA is relatively low (CVs in the order <5%). The 2009 estimate is below the mean of the series but given the fluctuations observed to date it is difficult to conclude how significant that is.

The survey abundance is compared with landings and LPUE data for the *Nephrops* directed fleet in Figure 10. This indicates a slightly negative relationship between survey abundance and landings. However, this may not be statistically significant. A more detailed investigation was then carried out to examine the relationship between burrow abundance and monthly landings and LPUE. The fishery can be characterised by two main periods; the autumn fishery and the fishery in the subsequent spring. There is a weak relationship between survey abundance and LPUEs (Figure 11). The results also suggest that there is a negative relationship between survey abundance in June and LPUE in the autumn and a positive relationship with the fishery in the subsequent spring. The results are based on few data points and the landings are based on logbook data which may not reflect true levels of catch since discards and misreporting have not been taken into account (ICES, 2006).

## Discussion

The UWTV survey series for the Aran Grounds was first developed in 2002 and has become the main source of fishery independent information on this stock. Sampling of the fishery has been sporadic although normal sampling resumed in 2008 and fishery dependent data a subject to some quality concerns (ICES, 2009c). The methods employed during the Aran UWTV surveys have recently been discussed and well documented by WKNEPHTV, WKNEPHBID and SGNEPS (ICES, 2007, 2008 and 2009b). The uncertainty estimates in the survey were examined initially using EVA during WKNEPH 2009 and updated for all years here. This analysis indicates that the survey method (randomised grid and geostatistical estimation of abundance) does estimate the abundance very precisely compared with other approaches.

For this particular survey occupancy and edge effects become critical when using the survey as an absolute abundance estimate. WKNEPH 2009 estimated the cumulative over estimation bias to be in the order of 1.3. Occupancy is assumed to be one *Nephrops* per burrow. The fishing intensity on the Aran Grounds is high with trawls sweeping several times the area of the ground annually. Given the high intensity of trawling it is likely that unoccupied burrows are filled in quickly. The edge effect bias is more difficult to quantify. This has been estimated by WKNEPH 2009 by double counting footage, once counting all complexes then counting only those that remain within the field of view when passing off the bottom of the screen. The

difference between these counts are the edge burrows and half of these are together with those that remain on the screen are used to estimate the bias.

It is worth noting that there is no positive correlation between survey abundance estimates and landings or LPUE (if anything there is a negative one Figure 10). In previous WDs to WGCSE this has been explored by looking at survey abundance and lagged LPUEs.

The WKNEPH reported developed a methodology for developing catch options based directly on the surveys (ICES, 2009a). In addition, WKNEPH developed a methodology for estimating long term fishing mortality reference points. The lack of sampling data meant that stock specific reference points could not be developed for FU17. The methodology was used by WGCSE to develop a catch option table according to the stock annex (ICES, 2009c). Table 2 is an updated catch option table for FU17 using the 2009 survey estimate. None of the other inputs have been changed.

In conclusion, the survey estimates themselves are precisely estimated given the relatively homogeneous distribution of burrow density and the modelling of spatial structuring. Large fluctuations in burrow abundance have been observed in this short time series but landings and LPUE trends are not well correlated with these. The 2009 survey is a statistically significant 39% increase compared with 2008. Ultimately there still remains a degree of subjectivity in the production of UWTV abundance estimates. In the provision of catch options based on the bias corrected absolute survey estimates additional uncertainties related to the bias correction factor, mean weight in the landings and the discard rates also arise.

## References

- ICES 2007. Report of the Workshop on the use of UWTV surveys for determining abundance in *Nephrops* stocks throughout European waters (WKNEPHTV). ICES CM: 2007/ACFM: 14
- ICES 2008. Report of the Workshop and training course on *Nephrops* burrow identification (WKNEPHBID). ICES CM 2008/LRC:03.
- ICES, 2009a Report of the Benchmark Workshop on *Nephrops* assessment (WKNEPH). ICES CM 2009/ACOM:33.
- ICES 2009b Report of the Study Group on *Nephrops* Surveys (SGNEPS). ICES CM 2009/LRC: 15, pp 52.
- ICES 2009c Report of the Working Group on the Celtic Seas Region (WGCSE) ICES CM 2009/ACOM:09.
- Petitgas and Lafont, 1997. EVA (Estimation VAriance). A geostatistical software on IBM-PC for structure characterization and variance computation. Version 2.

**Table 1:** Summary geostatistics for the *Nephrops* UWTV surveys of the Aran Grounds from 2002-2009.

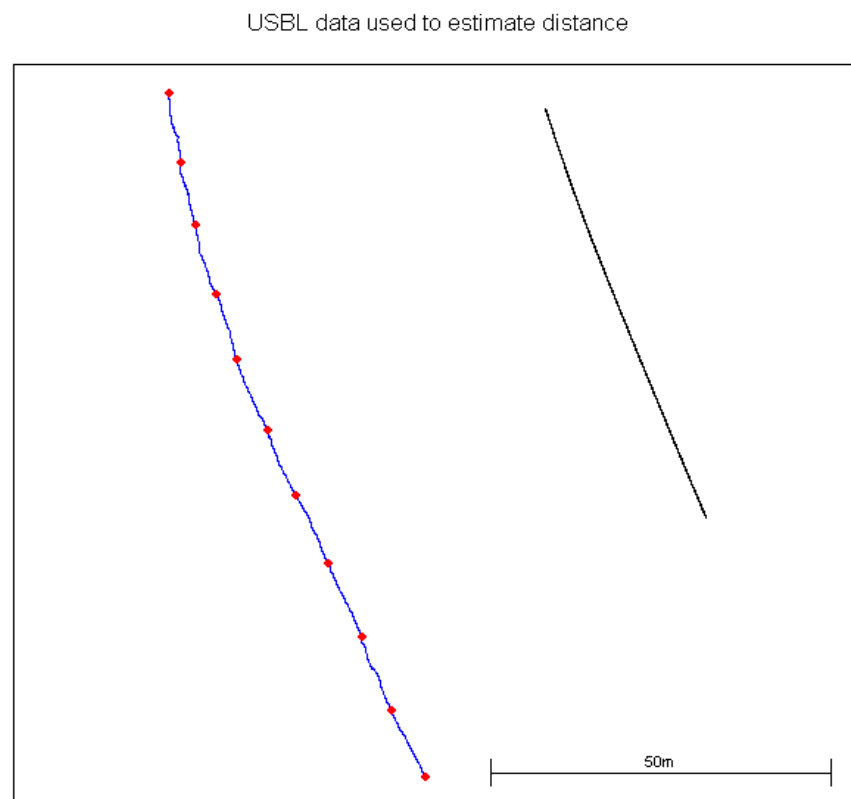
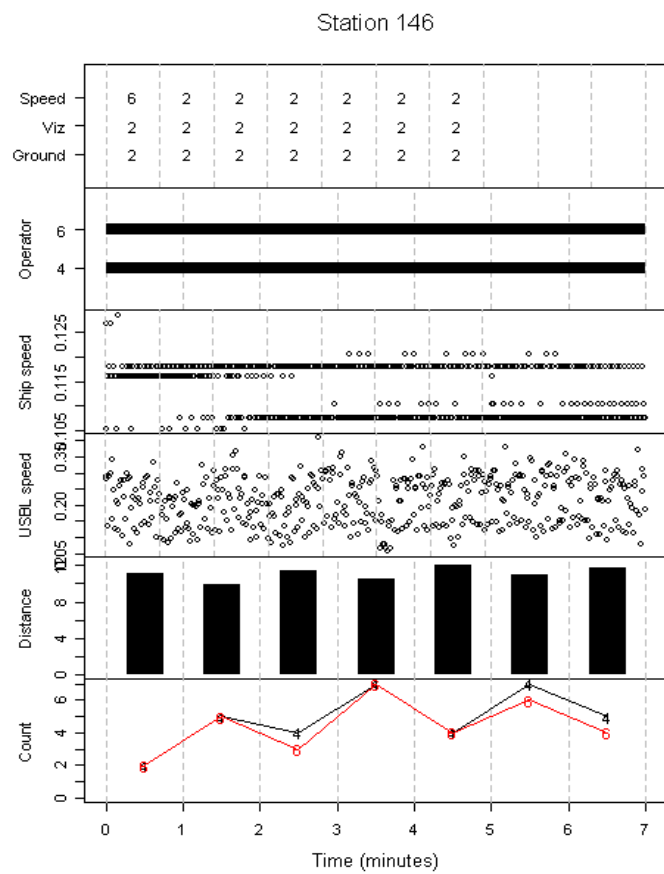
Ground	Year	Number of stations	Mean Density (No./M2)	Estimation Standard Deviation	Domain Area (m2)	Geostatistical abundance estimate (million burrows)	CV on Burrow estimate
Aran	2002	49	0.81	0.02	943	793	2%
	2003	42	0.85	0.06	943	825	5%
	2004	64	1.44	0.04	937	1408	3%
	2005	70	1.11	0.04	931	1089	3%
	2006	67	0.66	0.02	932	640	3%
	2007	71	0.88	0.02	942	854	3%
	2008	62	0.57	0.02	842	515	3%
	2009	79	0.73	0.02	940	718	2%

**Table 2:** Summary statistics for the *Nephrops* UWTV surveys of the Galway Bay and Slyne Head grounds from 2002-2009.

Ground	Year	Number of stations	Area Surveyed (M <sup>2</sup> )	Burrow count	Mean Density (No./M <sup>2</sup> )	Var	Standard Deviation	Standard Error	t-value	95%CI	CV <sub>lid</sub> (Relative SE)
Galway Bay	2002	7	1,299	2,017	1.58	0.14	0.37	0.14	2.45	0.34	8.8%
	2003	3	591	941	1.60	0.09	0.29	0.17	4.30	0.73	10.6%
	2004	9	2,312	1,625	0.73	0.18	0.42	0.14	2.31	0.32	19.4%
	2005	4	661	1,107	1.67	0.04	0.20	0.10	3.18	0.32	6.0%
	2006	3	522	522	1.01	0.06	0.25	0.15	4.30	0.63	14.5%
	2007	5	890	992	1.14	0.06	0.24	0.11	2.78	0.29	9.3%
	2008	10	1,907	859	0.42	0.10	0.31	0.10	2.26	0.22	23.4%
	2009	8	1,207	1,116	0.93	0.03	0.16	0.06	2.36	0.14	6.2%
Slyne Grounds	2002	5	1,216	1,027	0.85	0.04	0.19	0.08	2.78	0.23	9.9%
	2003	-	-	-	-	-	-	-	-	-	-
	2004	3	827	531	0.68	0.07	0.27	0.15	4.30	0.66	22.7%
	2005	3	531	294	0.55	0.00	0.05	0.03	4.30	0.13	5.6%
	2006	3	526	210	0.41	0.04	0.20	0.11	4.30	0.49	28.1%
	2007	4	841	547	0.63	0.10	0.31	0.15	3.18	0.49	24.6%
	2008	-	-	-	-	-	-	-	-	-	-
	2009	6	531	144	0.40	0.05	0.22	0.09	2.57	0.23	22.5%

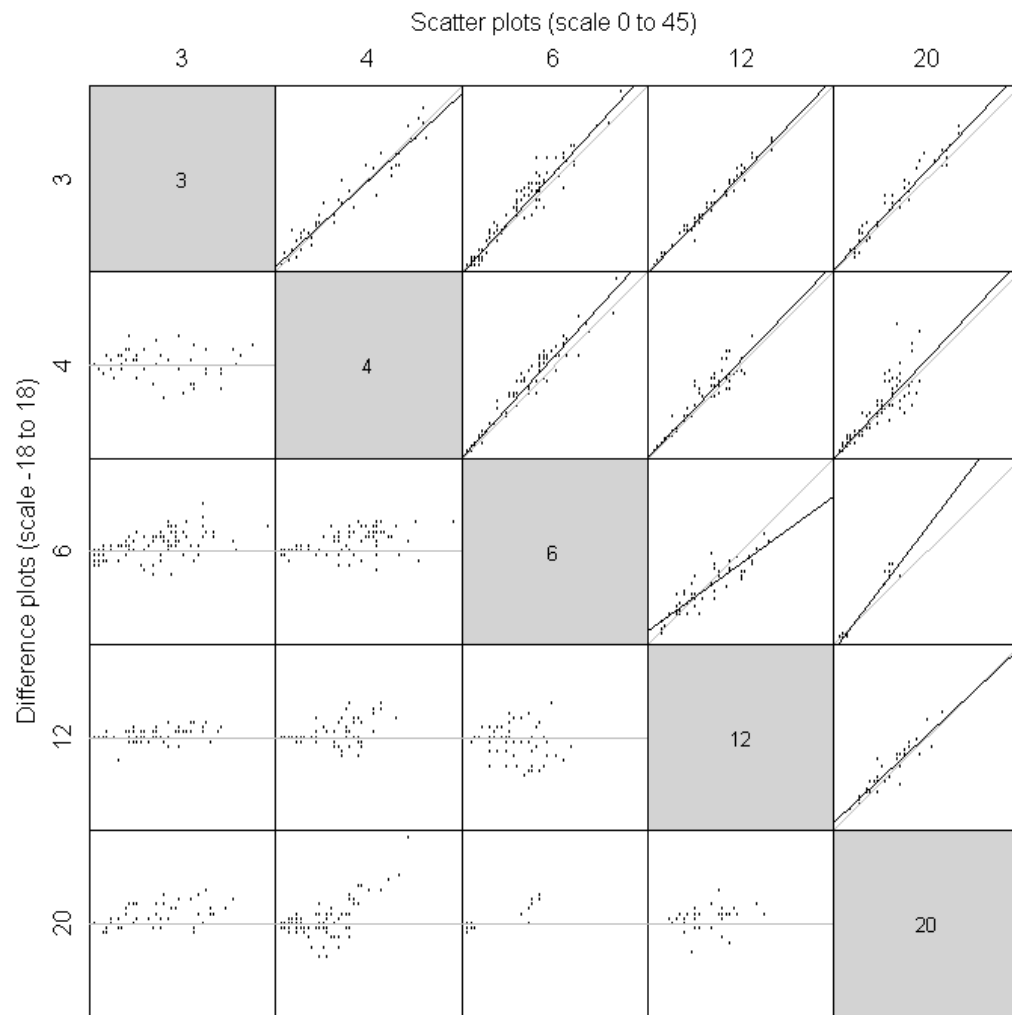
**Table3:** Updated management option table for FU17 with 2009 survey estimate included.

			Implied fishery	
	Harvest rate	Survey Index (millions)	Retained number (millions)	Landings (tonnes)
	0%	552	0	0
	2%	"	8	176
	4%	"	16	352
	6%	"	23	528
F <sub>0.1</sub> for other Nephrops stocks is in this range	8%	"	31	704
	10%	"	39	880
F Current	11.9%	"	47	1,050
	12%	"	47	1,055
F <sub>max</sub> for other Nephrops stocks is in this range	13%	"	51	1,143
	14%	"	55	1,231
	15%	"	58	1,319
	16%	"	62	1,407
	17%	"	66	1,495
			Basis	
Landings Mean Weight (KG)		0.0226	Sampling 2008	
Survey Overestimate Bias		1.30	WKNEPH 2009	
Survey Numbers (Millions)		718	UWTV Survey 2009	
Prop. Retained by the Fishery		0.71	Sampling 2008	

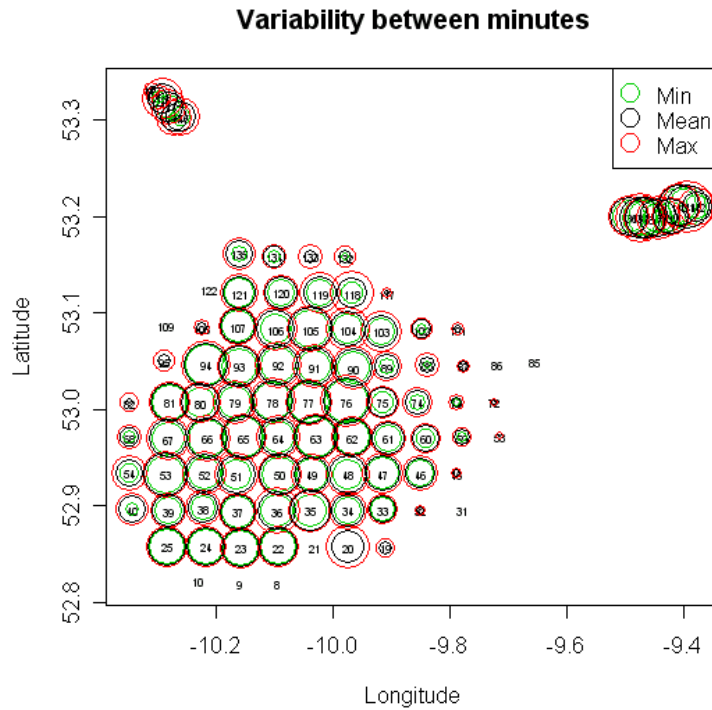


**Figure 1.R** tool quality control plot of station 146 UWTV Survey Aran Grounds FU17 2009.

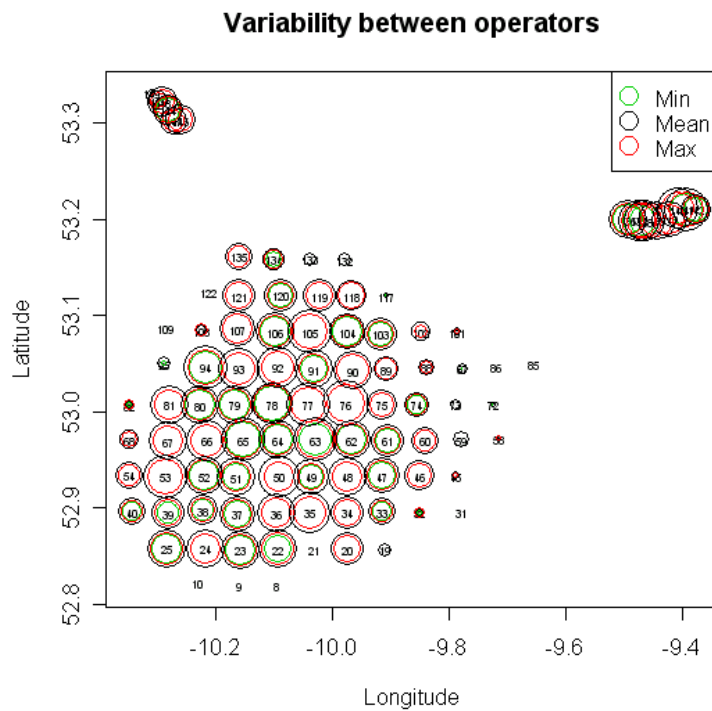




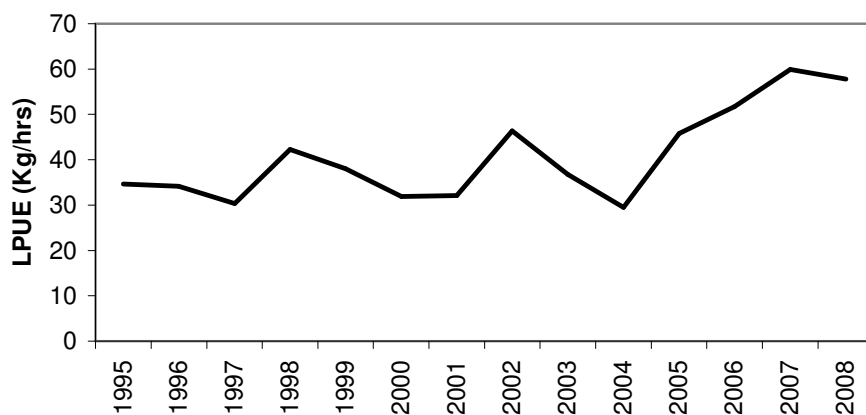
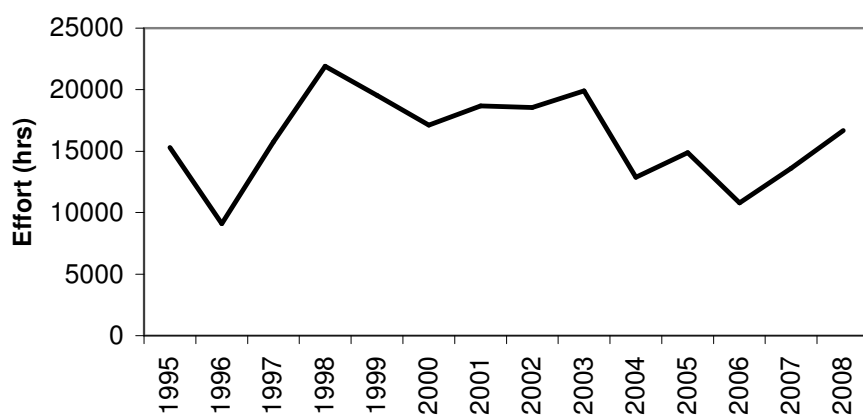
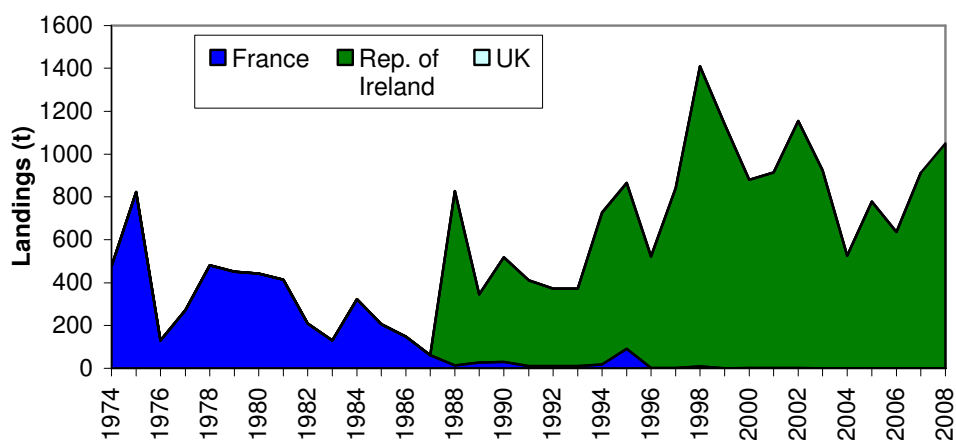
**Figure 2.**Scatterplot analysis of counter trends during 2009 survey of the Aran Grounds.



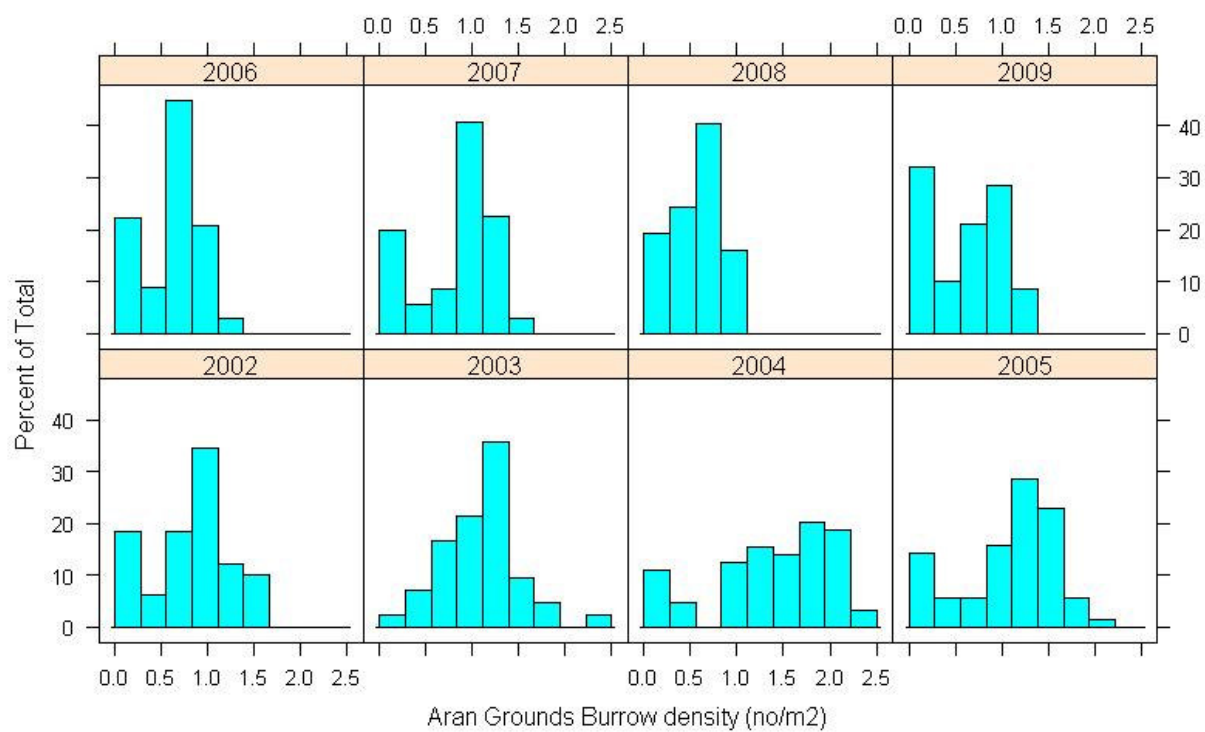
**Figure 3.** Plot of the variability in density between minutes - Aran Ground UWTV 2009 survey.



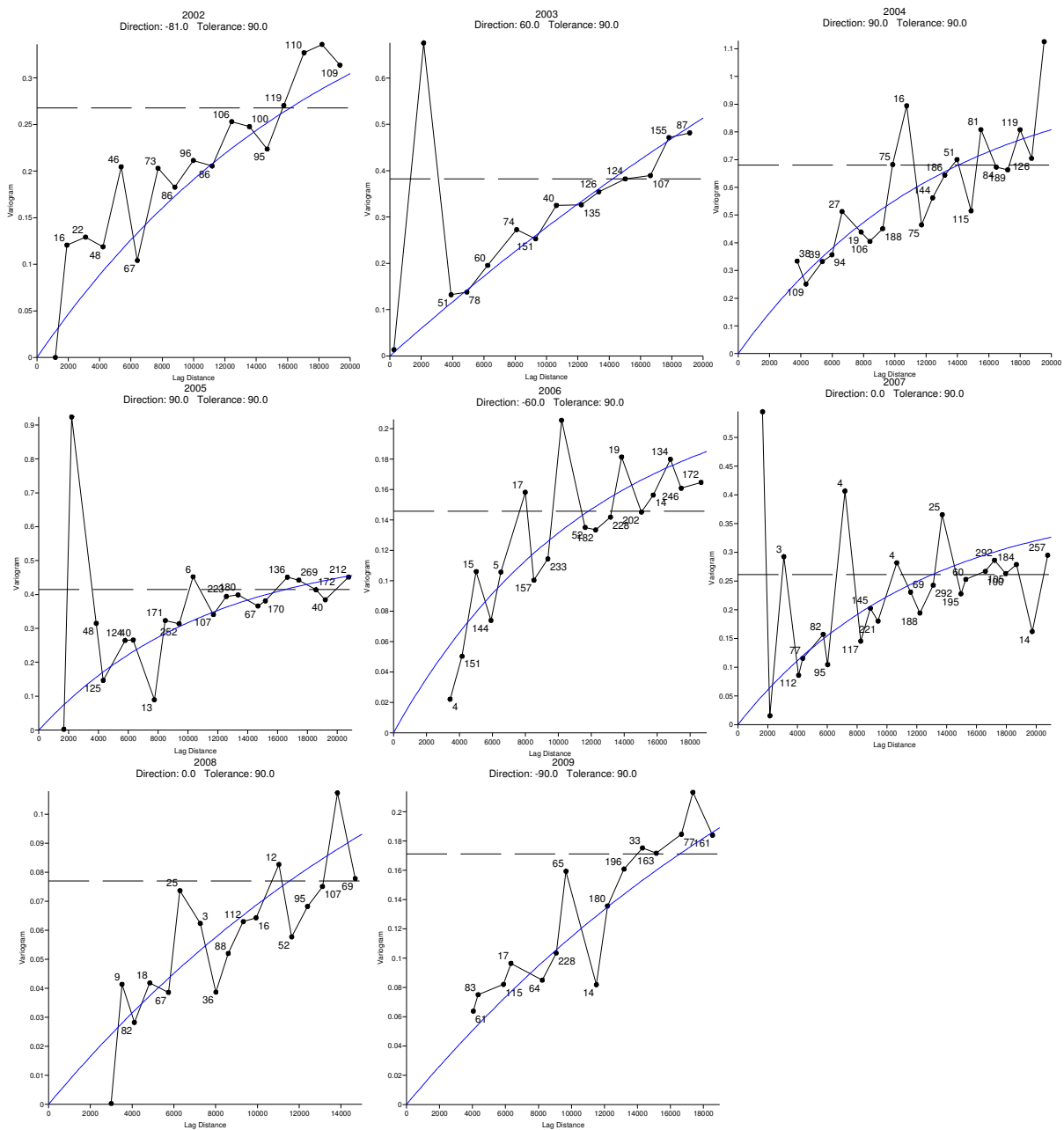
**Figure 4.** Plot of the variability in density between operators for each station Aran Ground UWTV 2009 survey.



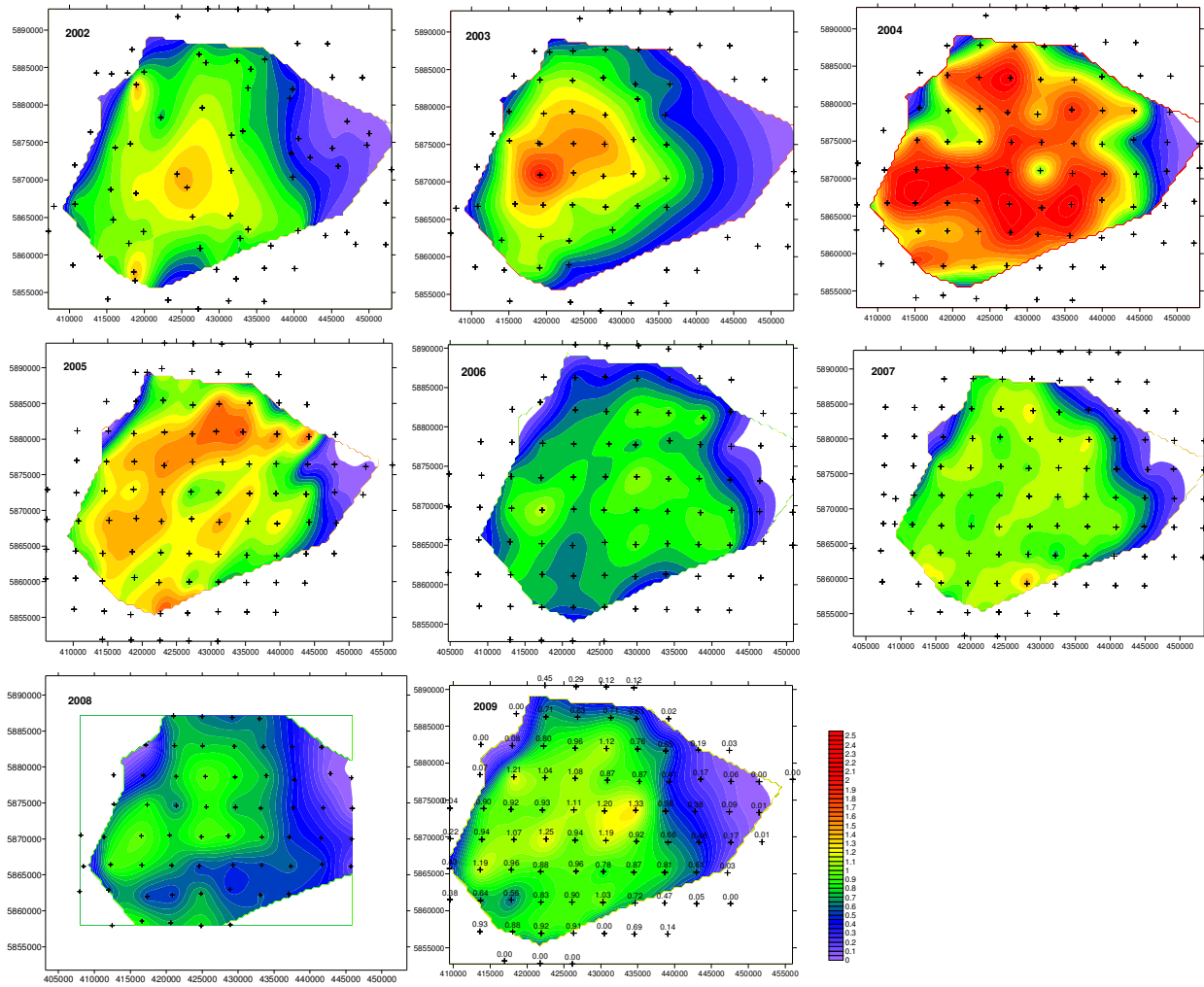
**Figure 5:** Landings, effort and LPUE trends for the Aran Grounds (FU 17). Note effort and LPUE is for the “*Nephrops* directed fleet” only.



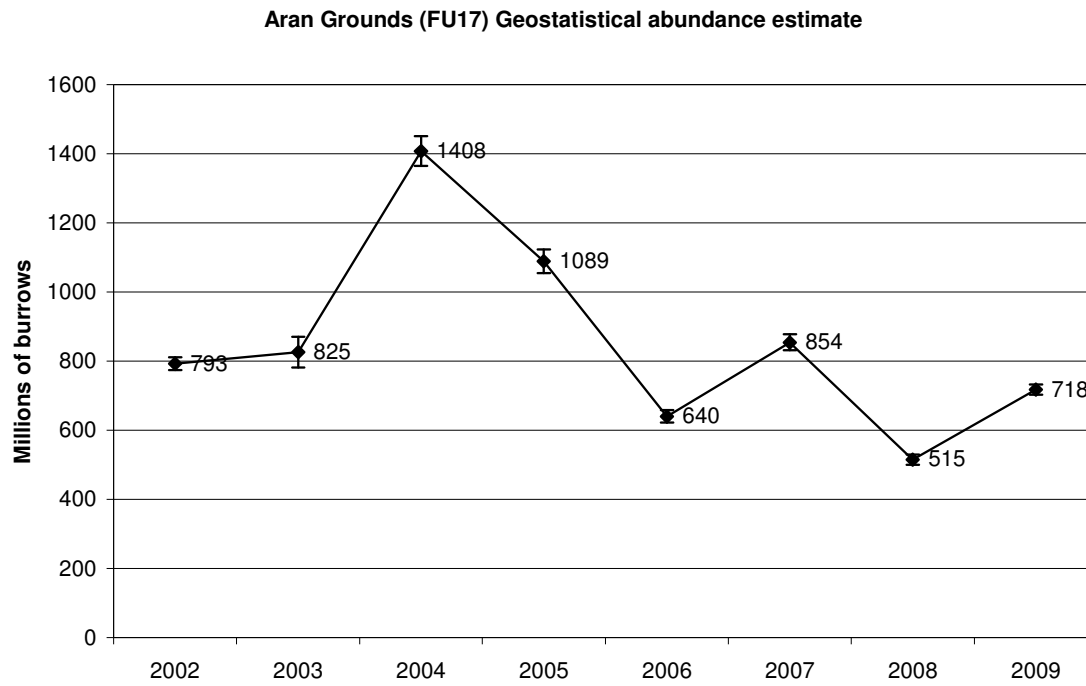
**Figure 6:** Burrow density distributions for the Aran Grounds by year from 2002-2009.



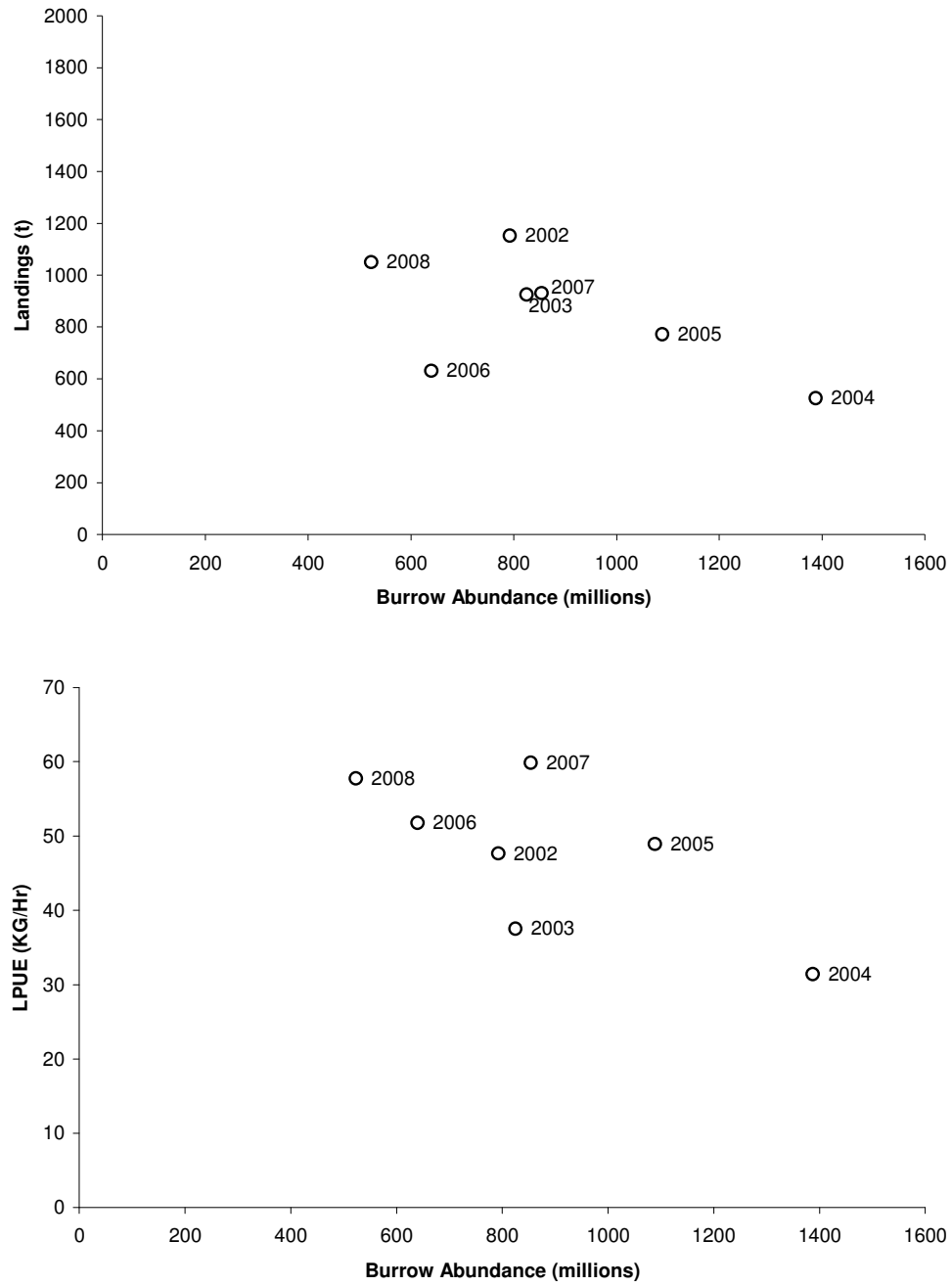
**Figure 7:** Omnidirectional variogram models used for kriging for the Aran Grounds from 2002-2009.



**Figure 8:** Contour plots of the kriged density estimates for the Aran Grounds from 2002-2009.



**Figure 9:** Time series of geostatistical abundance estimates (in millions of burrows) for the Aran Grounds from 2002-2009.



**Figure 10:** The relationship between landings and LPUE and the abundance estimates from the UWTV surveys on the Aran Grounds.