Western Irish Sea *Nephrops* Grounds (FU15)

2011 UWTV Survey Report

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Introduction

The Norway lobster, *Nephrops norvegicus*, is exploited throughout its geographic range, from Icelandic waters to the Mediterranean and the Moroccan coast. The western Irish Sea stock (FU15) is by far the most productive of all the *Nephrops* stocks currently fished yielding landings of between 7,000-10,000 tonnes annually from a relatively small geographic area (ICES, 2011). *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 to provide a fishery independent estimate of stock size, exploitation status and catch advice (ICES, 2009 & 2011).

This is the ninth in a time series of UWTV surveys in the western Irish Sea carried out jointly by the Marine Institute, Ireland and the Agri-Food and Biosciences Institute (AFBI), Northern Ireland. The 2011 survey was multi disciplinary in nature; the specific objectives are listed below:

1. To complete randomised fixed survey grid of ~150 UWTV with 3.5 nautical mile (Nmi) spacing stations on the western Irish Sea *Nephrops* ground (FU15).
2. To obtain 2011 quality assured estimates of *Nephrops* burrow distribution and abundance on the western Irish Sea *Nephrops* ground (FU15). These will be compared with those collected previously.
3. To collect ancillary information from the UWTV footage at each station such as the occurrence of sea-pens, other macro benthos and fish species and trawl marks on the seabed.
4. To collect oceanographic data using a sledge mounted CTD.
5. Technology and protocol transfer between Marine Institute and AFBI.

This report details the final UWTV results of the 2011 survey and also documents other data collected during the survey.

Material and methods

The survey design for the western Irish Sea *Nephrops* ground (FU15) is a randomised fixed grid where a point is picked at random and stations are carried out 3.5 nautical miles north-south and east-west. The initial ground perimeter has been established using a combination of integrated logbook VMS data (using the methods described in Gerritsen and Lordan, 2011), BGS sediment maps and previously collected UWTV data and has not been changed since 2003. An adaptive approach is taken whereby stations are continued past the known perimeter of the ground until the burrow densities are zero or very close to zero.

Leg one of the 2011 Irish Sea survey took place on RV. Corystes between 9th to 16th August 2011. This leg covers a proportion of the western Irish Sea (FU15) grid and also then complete coverage of the eastern Irish Sea (FU14). The remaining stations in FU15 were completed on leg two of the survey on the RV. Celtic Voyager between 17th to 26th August 2011. Survey timing was generally standardised to August/September each year and was also timed to take full advantage of the neap tides when visibility is normally better.

The protocols used were those presented and reviewed by WKNEPHTV 2007 (ICES, 2007) and are summarised as follows: 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 an Ixsea USBL transponder onboard RV Celtic Voyager and TrackLink sensor onboard RV Corystes survey) were recorded every 1 to 2 seconds. The navigational data was quality controlled using an "r" script developed by the Marine Institute (ICES, 2009b). In 2011 the USBL navigational data was used to calculate distance over ground for 94% of stations whereas ship data was used for the remaining 6% of stations.

In addition CTD profile was logged for the duration of each tow using a Seabird SBE 19 for stations surveyed by RV. Celtic Voyager. This data will be processed at a later stage. No sediment sampling was carried out in 2011 as the Irish Sea is well sampled through various research programmes and good sediment maps exist for this area.

In line with SGNEPS recommendations all scientists were trained/re-familiarised using training material and validated using reference footage prior to recounting at sea (ICES, 2009). Figure 1 shows individual's counting performance in 2011 against the reference counts 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 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 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 by each scientist for each one-minute interval was recorded. Following the recommendation of SGNEPS the time for verified recounts was 7 minutes (ICES, 2009b).

Notes were also recorded each minute on the occurrence of trawl marks, fish species and other species. Numbers 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, 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 2 and 3). Consistency and bias between individual counters was examined using Figure 4. There is some variability but no obvious bias problems between counters.

The recount data were screened for one minute intervals with any unusually large deviation between recounts. Means of the burrow and *Nephrops* recounts were standardised by dividing by the survey area observed. Either the USBL or estimated sledge lay-back 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 at 75cm assuming 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 2011 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 using SURFER Version 8.02. The spatial structure of the density data was studied through variograms. The mid-points of each UWTV transect were converted to UTMs. 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 approximately 1417m and maximum lag distance of between 53-55 km. A model variogram $\gamma(h)$, was produced with a linear 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: Linear Variogram Model

$$\gamma(h) = Co + S \cdot h$$

Where Co is the unknown nugget effect and S is the unknown slope.
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, variance, standard deviation, coefficient of variation, domain area and total burrow abundance estimate.

Although SURFER was used to estimate the burrow abundance this does not provide the krigged 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 (+/- 0.1 billion burrows).

Results

In 2011, 156 stations were surveyed in western Irish Sea (FU15). The station positions are shown in Figure 5. Of these 86 were carried out on RV Corystes and 70 were carried out on RV Celtic Voyager. A histogram of the observed burrow densities from 2003 to 2011 on the western Irish Sea is presented in Figure 6. Over the time series available the density estimates observed are very similar with modal density of around $1/m^2$. Figure 7 and Figure 8 shows the variability in density between minutes and operators (counters) for each station. These quality control and consistency plots show that the burrow estimates were fairly consistent between minutes and counters. Variability is higher between minutes than counters. Stations close to the boundary tend to show higher minute by minute variability than those in the centre of the ground. Recent trawling activity sometimes impacts on the between minute variability.

The geo-statistical structural analysis is shown in the form of variograms in Figure 9. There is a weak evidence of a sill in some years. A comparison of the observed and expected density estimates – cross validation plots for each year is given in Figure 10. There is good concordance between the observation and model estimates. The blanked and krigged contour plot and posted point density data are shown in Figure 11. The krigged contours correspond well to the observed data. These densities plots show a relatively dynamic situation. Some parts of the ground have consistently higher or lower densities. Densities are consistently lower close to the boundary which implies a well defined and discrete boundary. There tends to be a lower density towards the middle of the ground surrounded by an elongated ring of higher density stations with a SW-NE orientation. The burrow surface plot in 2005 shows quite an unusual pattern with very high observed densities in a band across the middle of the ground. The burrow surface in 2011 was quite consistent with the pattern observed in other years (except 2005) although the burrow densities were generally higher in the southern part of the ground.

The summary statistics from this geo-statistical analysis are given in Table 1 and plotted in Figure 12. The 2011 final abundance estimate of 5.6 billion burrows is very close to that estimated in 2010 and just below the series average. The overall burrow abundance trend is fairly stable (<10% inter annual variation) although the abundance did decline by 17% between 2007 and 2008 (the lowest observed). The CV for 2011 was 2% indicating a very precise survey estimate as observed in previous years.

Sea-pen distribution across the western Irish Sea *Nephrops* grounds is mapped in Figure 13. All sea-pens were identified from the video footage as *Virgularia mirabilis*. Trawl marks were noted at 18% of the stations surveyed and trawl marks present for the entire video transect accounted for 3% of total stations.

Discussion

The Western Irish Sea (FU 15) stock has accounted for >50% of the total landings reported to WGCSE for ICES Sub-area VII (ICES, 2011b) making it singly the most important FU in the TAC management area. This *Nephrops* fishing ground is particularly important to the Irish and Northern Irish demersal fleets. In the last decade it has become by far the most economically important fishery in the Irish Sea. This is a relatively well studied *Nephrops* stock with size information on catches extending back to the 1970s, a trawl survey series since 1994 and larval production surveys in a few years.

Since the benchmark assessment by ICES in 2009 this UWTV survey has become the main input for assessment and calculation of catch options for this stock. Concerns about the accuracy of catch data and unknown and variable growth rates have hampered the development of analytical assessments prior to the benchmark (ICES, 2009). The survey information up to 2010 was used as the main basis for the ICES assessment and 2012 management advice (ICES, 2011a&b). ICES concluded that the *Nephrops* in FU15 was fished at a sustainable rate (ICES, 2011b). The 2011 burrow abundance estimates presented here are not significantly different than last year and will not change the ICES conclusions made in June 2011. Previously ICES have revisited the catch advice for some *Nephrops* stocks where the UWTV survey abundance has changed by more than 15% which is not the case here. The stock remains in a very healthy condition. The abundance observed throughout the short series is well above the MSY B_{trig} (biomass trigger) proposed by ICES of 3.0 billon burrows which was derived from a longer time series of trawl survey data.

Burrow identification in the western Irish Sea is notoriously difficult due to the high underlying burrow densities and sometimes poor visibility. The burrows of *Calocaris macandrae* (a mud burrowing shrimp species) are abundant particularly in the softer muds in the middle of the western Irish Sea grounds. This can lead to confusion with *Nephrops* burrows. However, such allocation errors are minimised due to the training procedures employed during the survey. These include refresher training on classical *Nephrops* burrow signatures and consistency verification with reference count analyses (ICES, 2008 & 2009). The counting performance of the 2011 counters was generally very high with Linn's CCC scores >0.8 for all stations.

An important objective of this UWTV survey is to collect various 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 2008). The CTD data collected will be processed at a later stage. This information is relatively easy to collect and over time will provide a useful data series on oceanographic regime in this region.

The impact of trawling activity on the sea-bed communities' structure and functioning has been raised a potential ecosystem concern (OSPAR, 2010). Sea-pens in particular have been identified as a potential indicator species for benthic habitat health status. OSPAR have sough advice from ICES on the utility of UWTV surveys for collecting data on sea pen status and distributions (ICES, 2011c). The occurrence of sea pens has been noted on this survey since the outset. This is the first year that a systematic quantification and identification of sea-pens to species level was undertaken. Only *Virgilaria mirabilis* was positively identified on the 2011 footage although *Pennatula phosphorea* has been observed in previous years.

The main objectives of the survey were successfully met for the ninth successive year. The UWTV coverage and footage quality was excellent on the western Irish Sea grounds due to survey timing, favourable weather conditions and minimal technical difficulties. The multi-disciplinary nature of the survey means that the information collected is highly relevant for a number of research and advisory applications.

Acknowledgments

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Marine Institute greatly assisted in organising survey logistics. Finally, thanks to the Marine Institute, AFBI and CEFAS staff onboard for their hard work and enthusiasm in making this survey a success.

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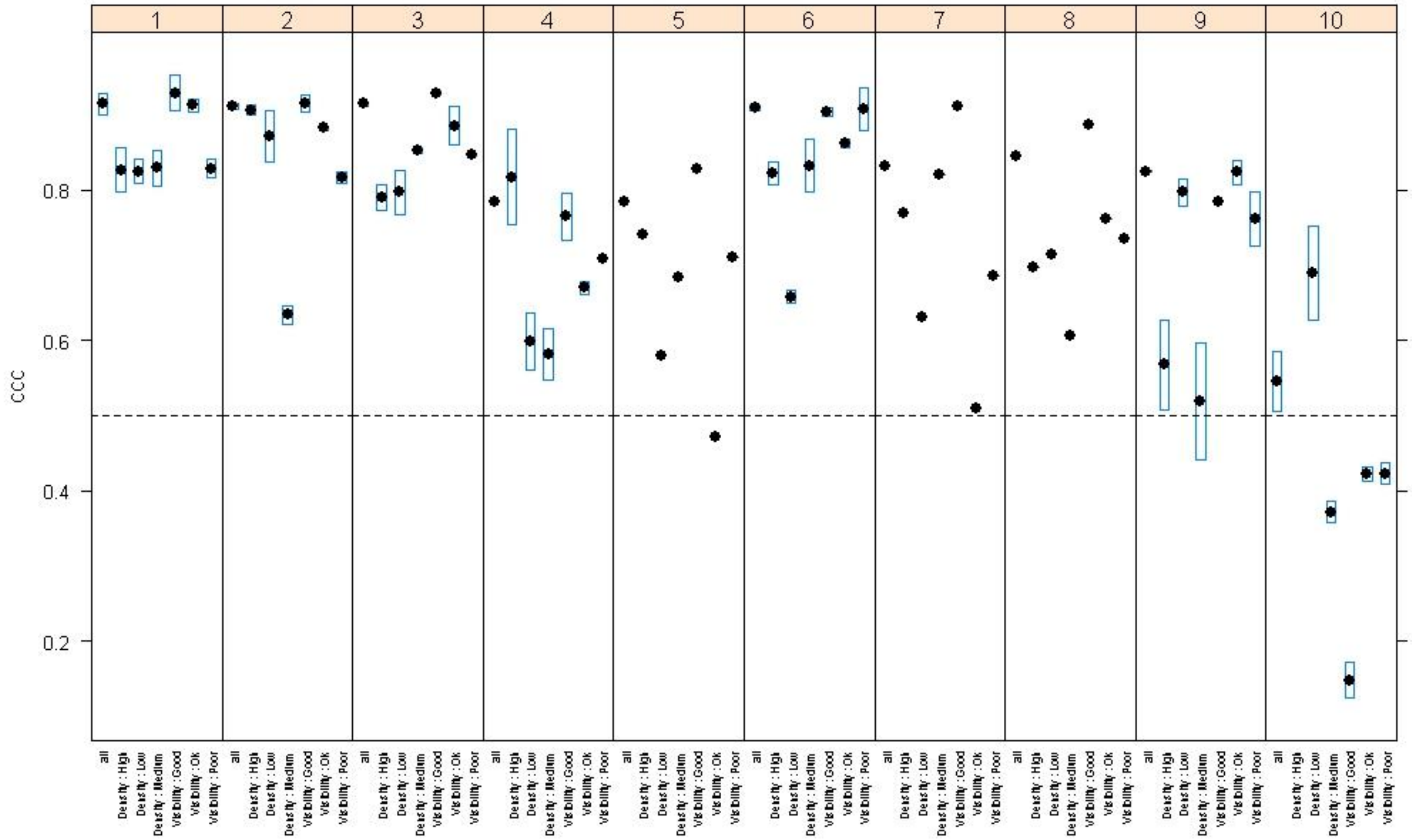

Figure 1: 2011 Counting performance against the reference counts as measured by Linn's CCC for the western Irish Sea ground. Each panel represents an individual. The x-axis (from left to right), all stations pooled, high density, low density, medium density and visibility good.

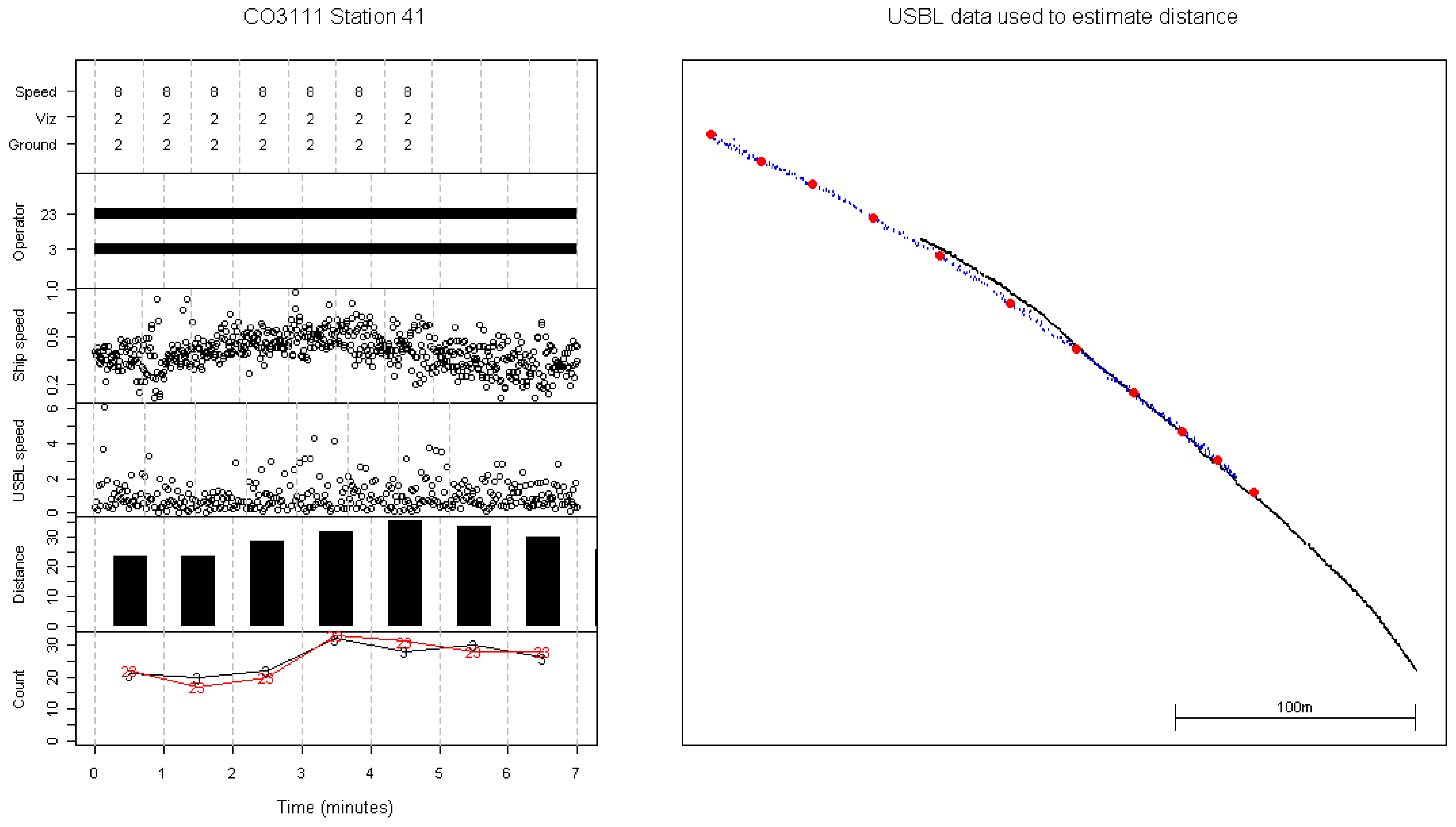

Figure 2: r - tool quality control plot for station 41 of the western Irish Sea grounds (FU15) UWTV (RV Corystes leg) Survey 2011.

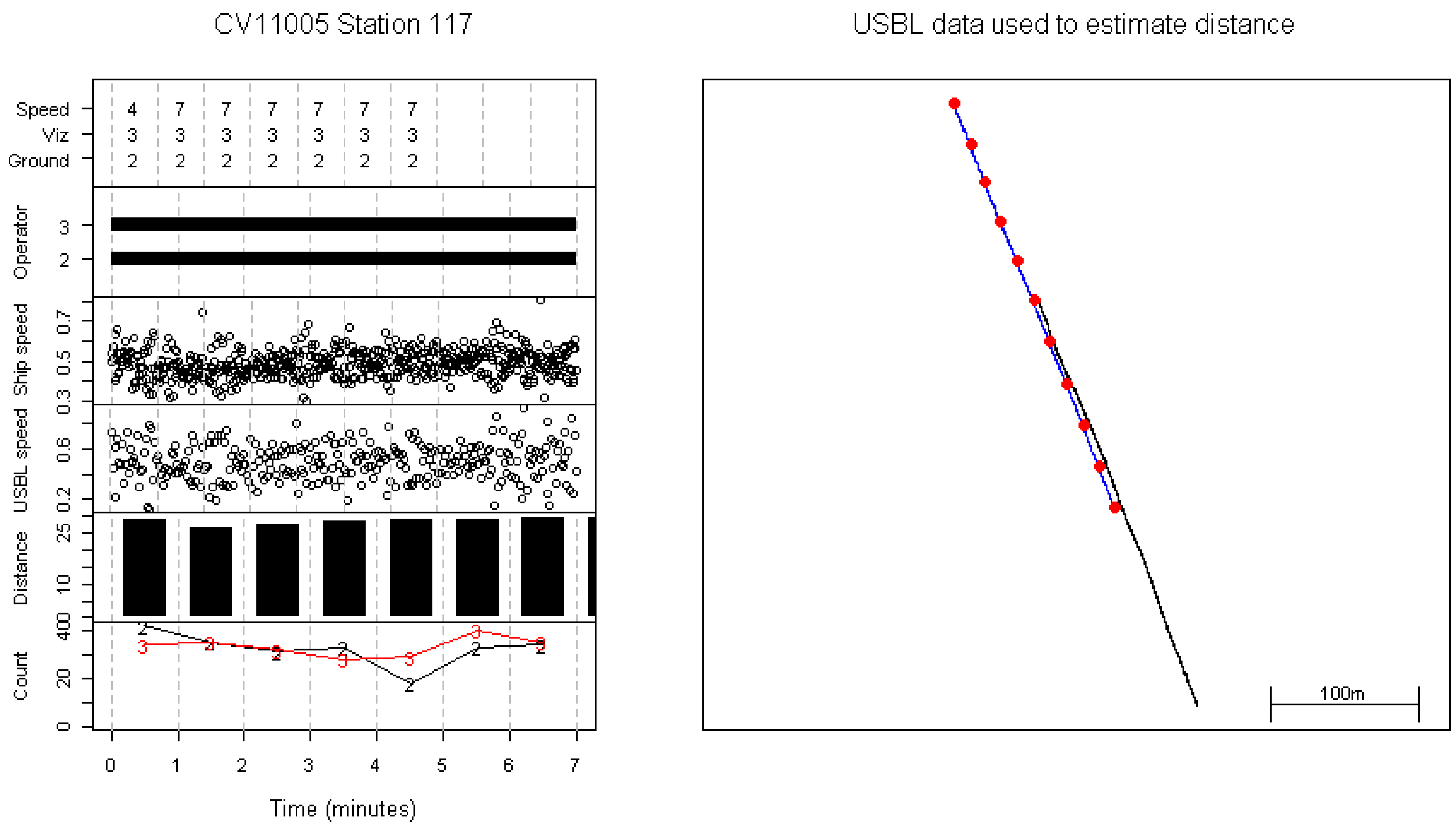

Figure 3: r - tool quality control plot for station 117 of the western Irish Sea grounds (FU15) UWTV Survey (RV Celtic Voyager leg) 2011.

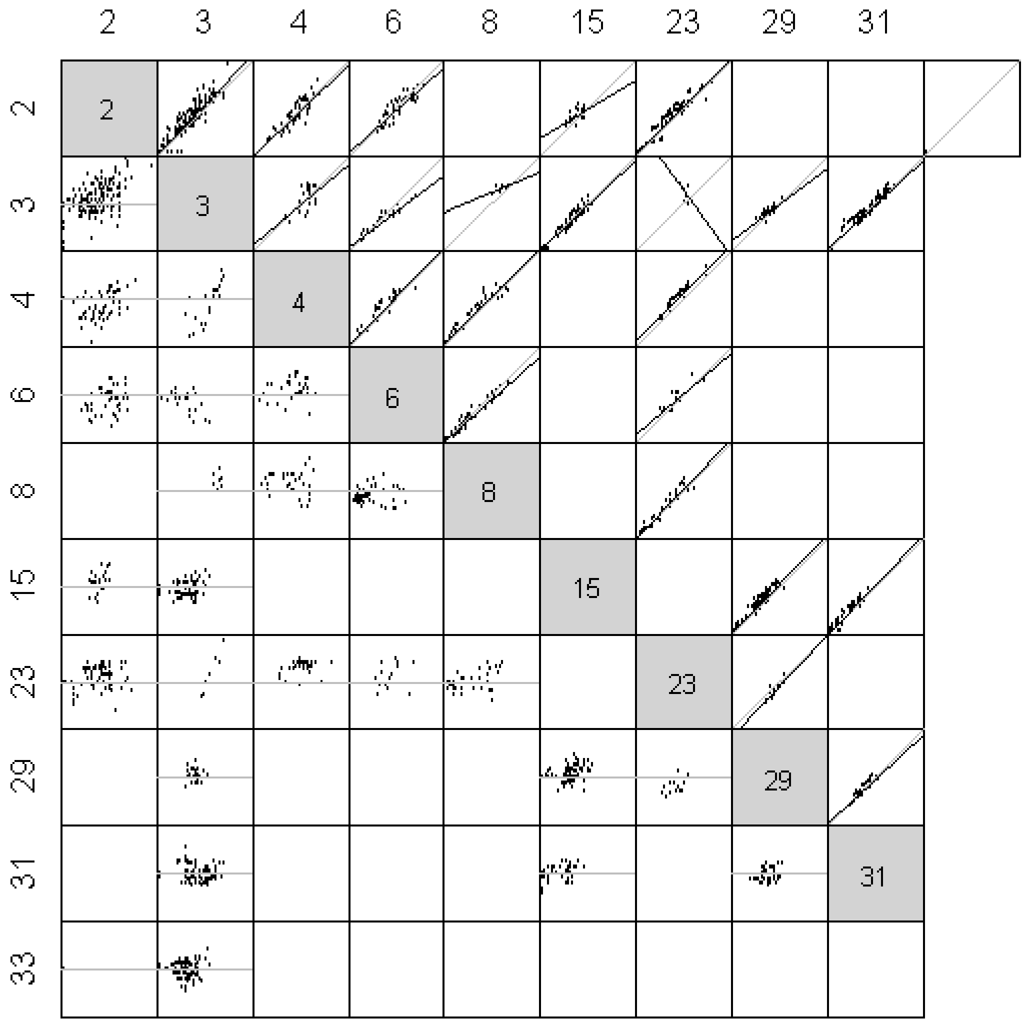

Figure 4 : Scatter plot analysis of counter trends during 2011 UWTV Survey of the western Irish Sea grounds (FU15).

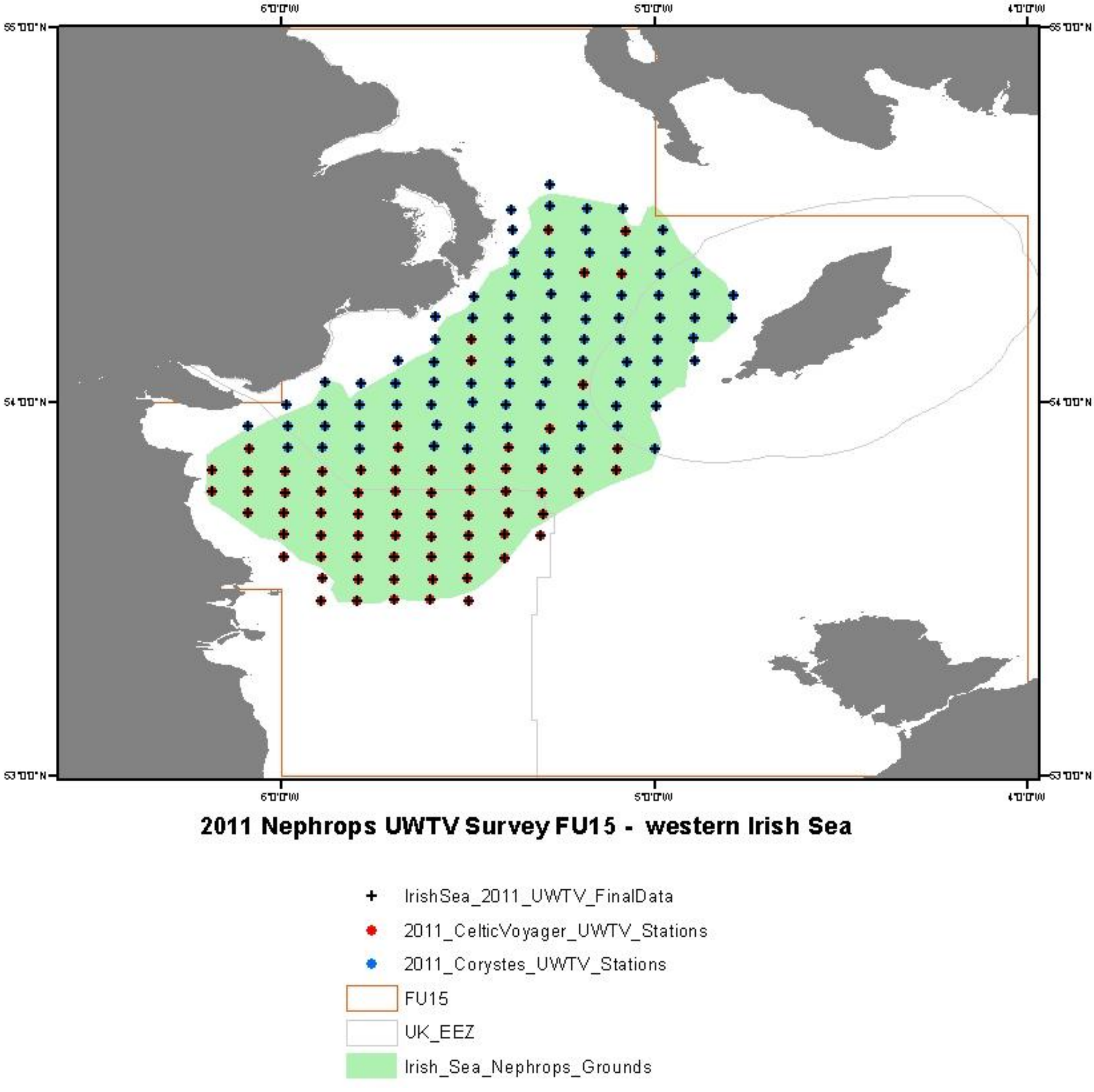

Figure 5: Stations completed on the 2011 UWTV western Irish Sea survey (FU15).

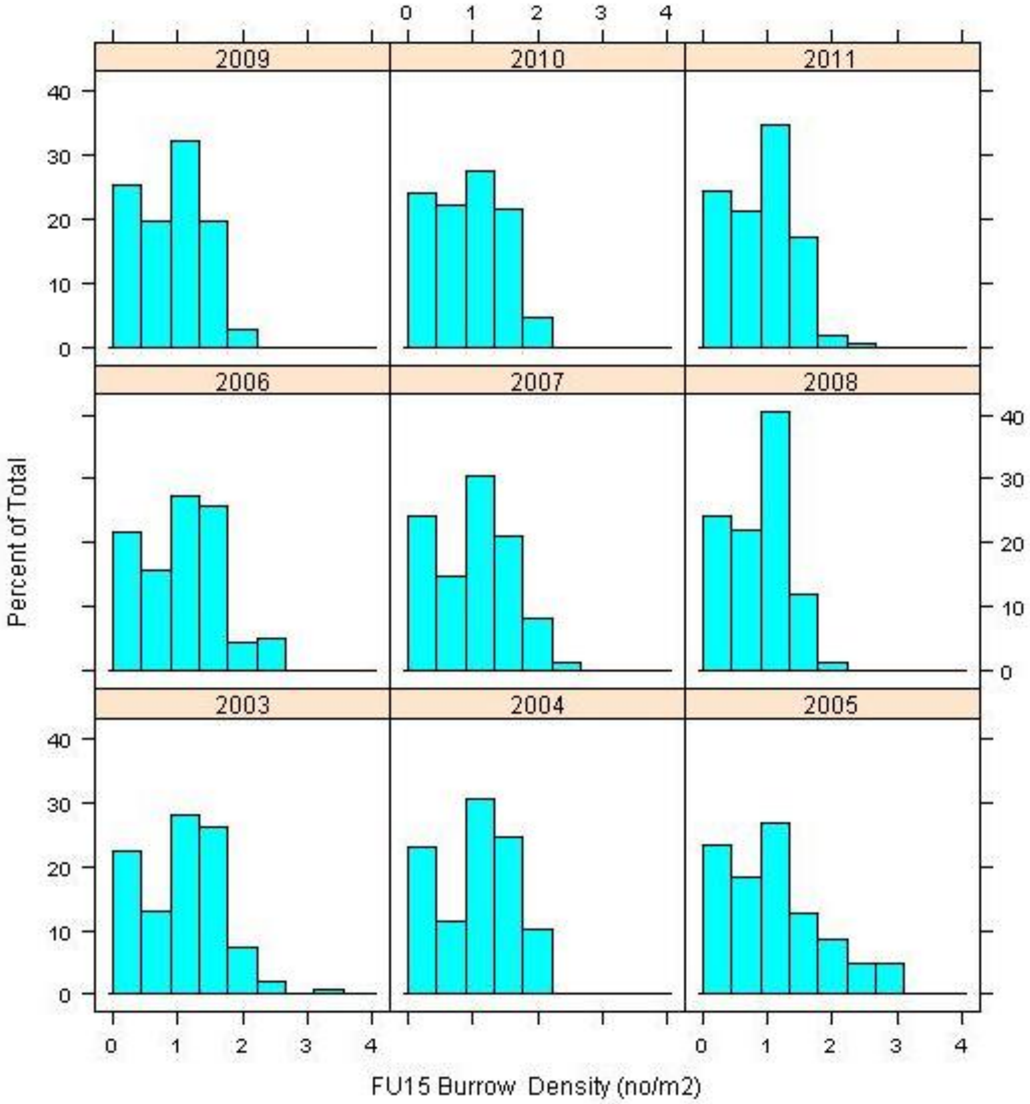

Figure 6: Burrow density distributions for the western Irish Sea (FU15) by year from 2003-2011.

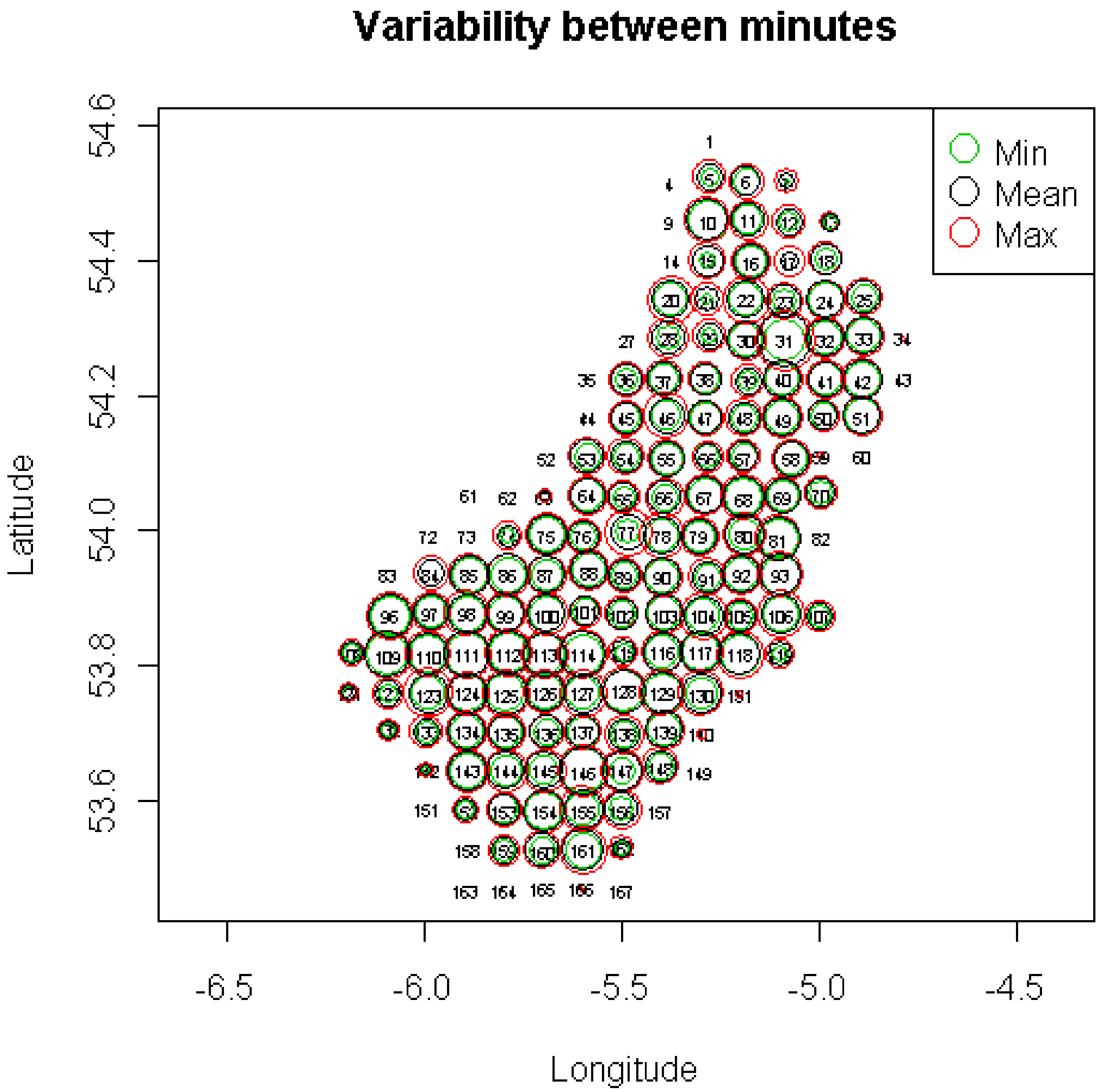

Figure 7 : Plot of the variability in density between minutes for each station during 2011 UWTV Survey of the western Irish Sea grounds (FU15).

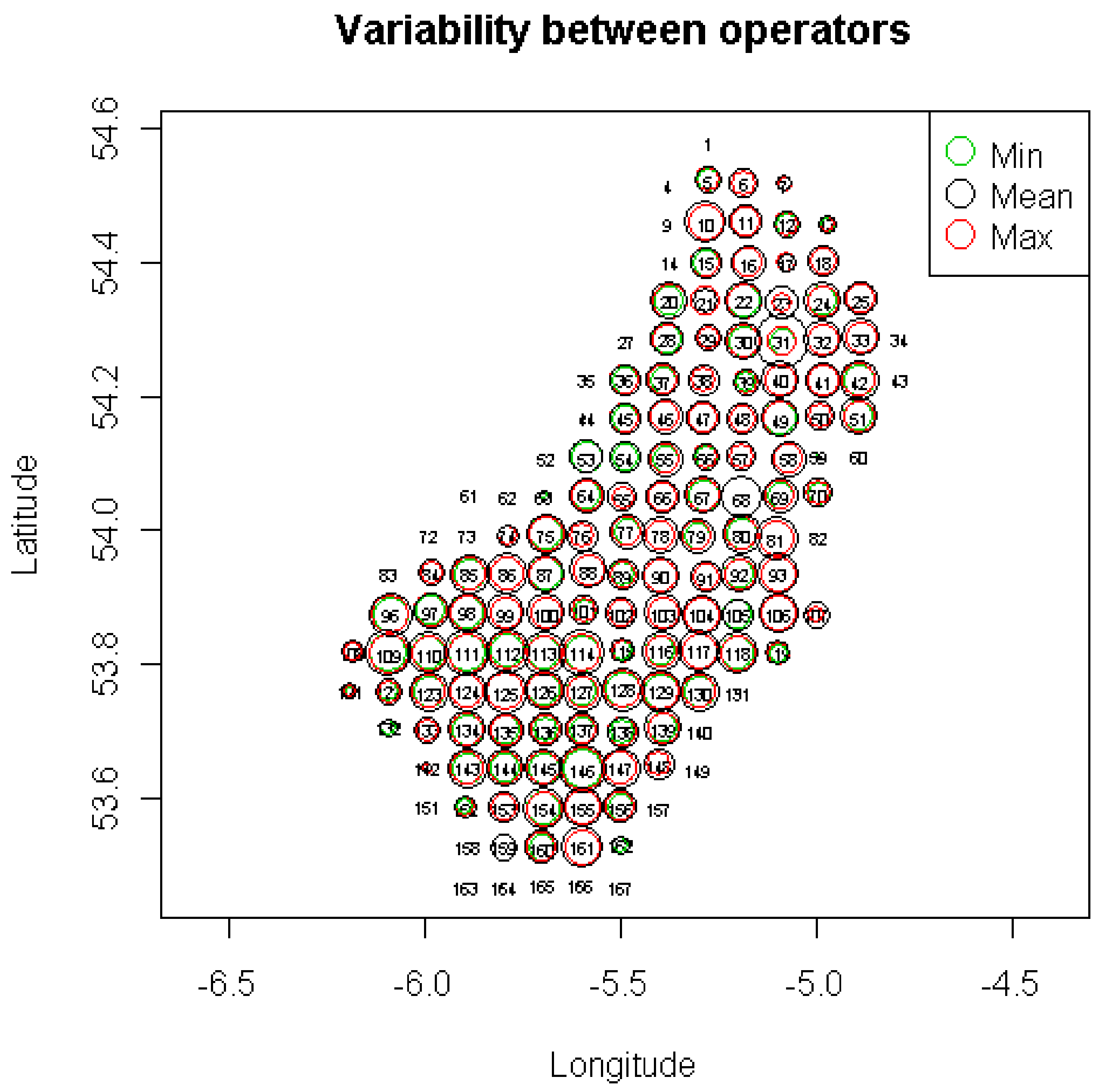

Figure 8: Plot of the variability in density between operators (counters) for each station during 2011 UWTV Survey of the western Irish Sea grounds (FU15).

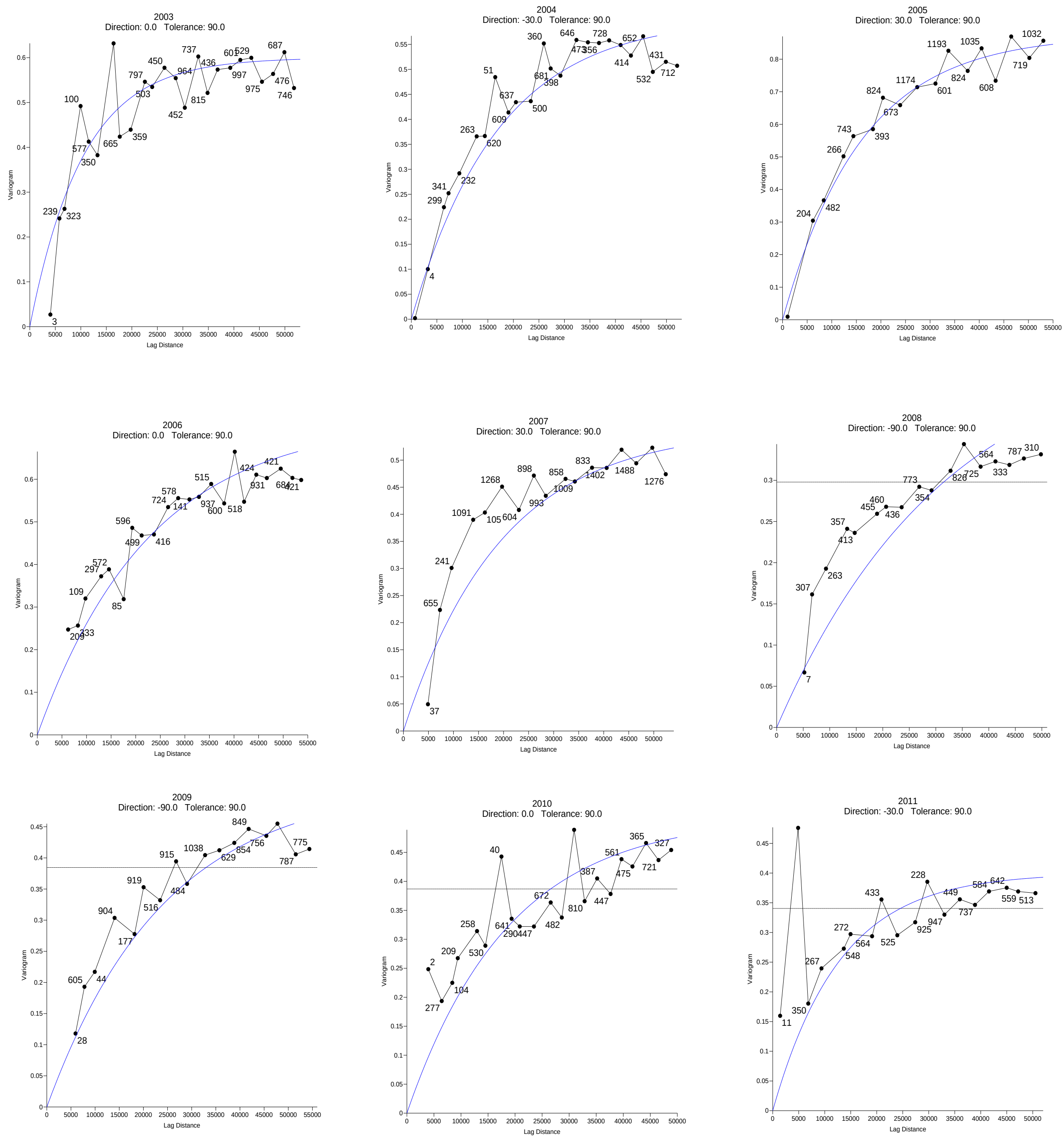

Figure 9: Omnidirectional mean variograms for the western Irish Sea (FU15) by year from 2003-2011.

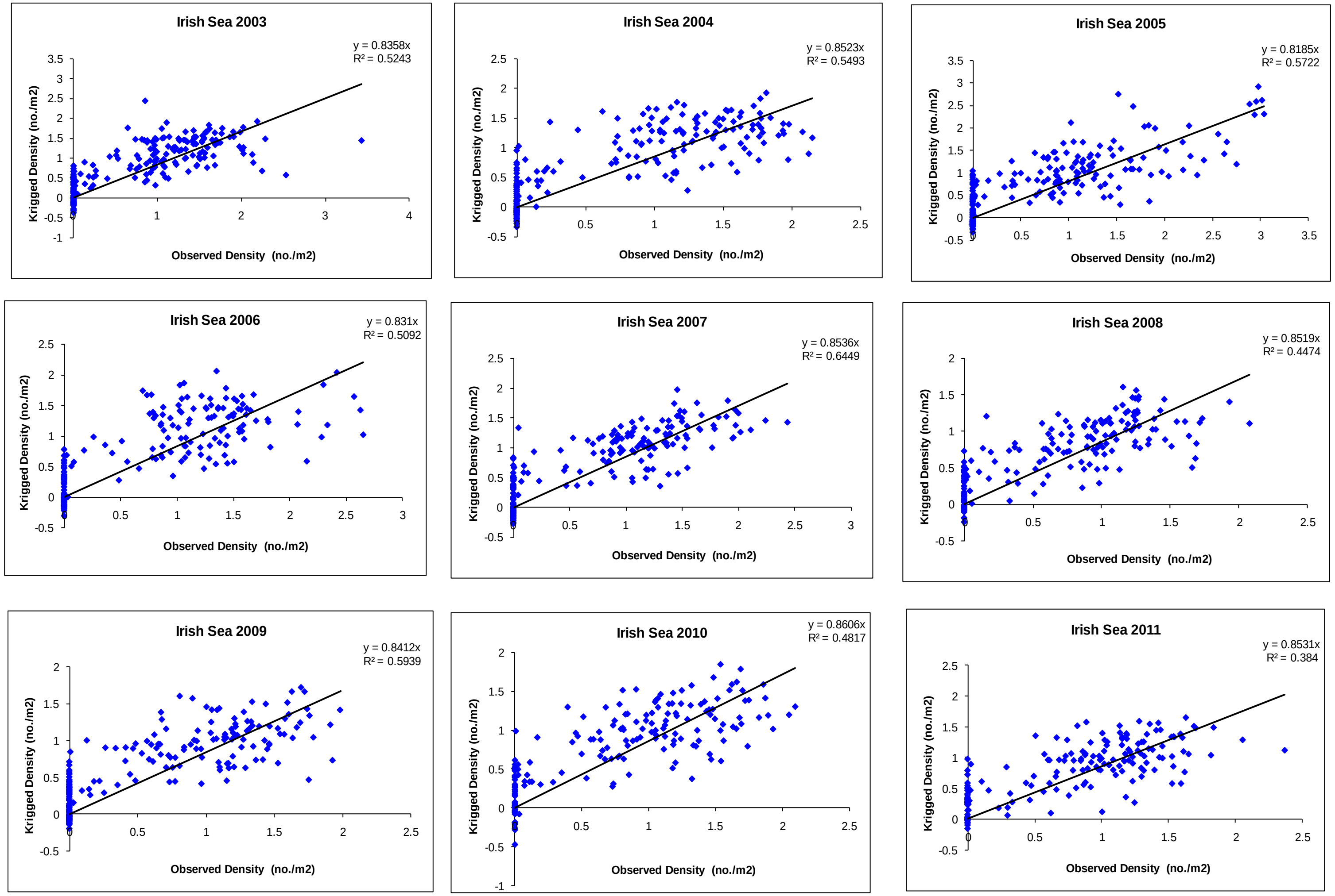

Figure 10: Cross validation plots for the western Irish Sea by year from 2003-2011.

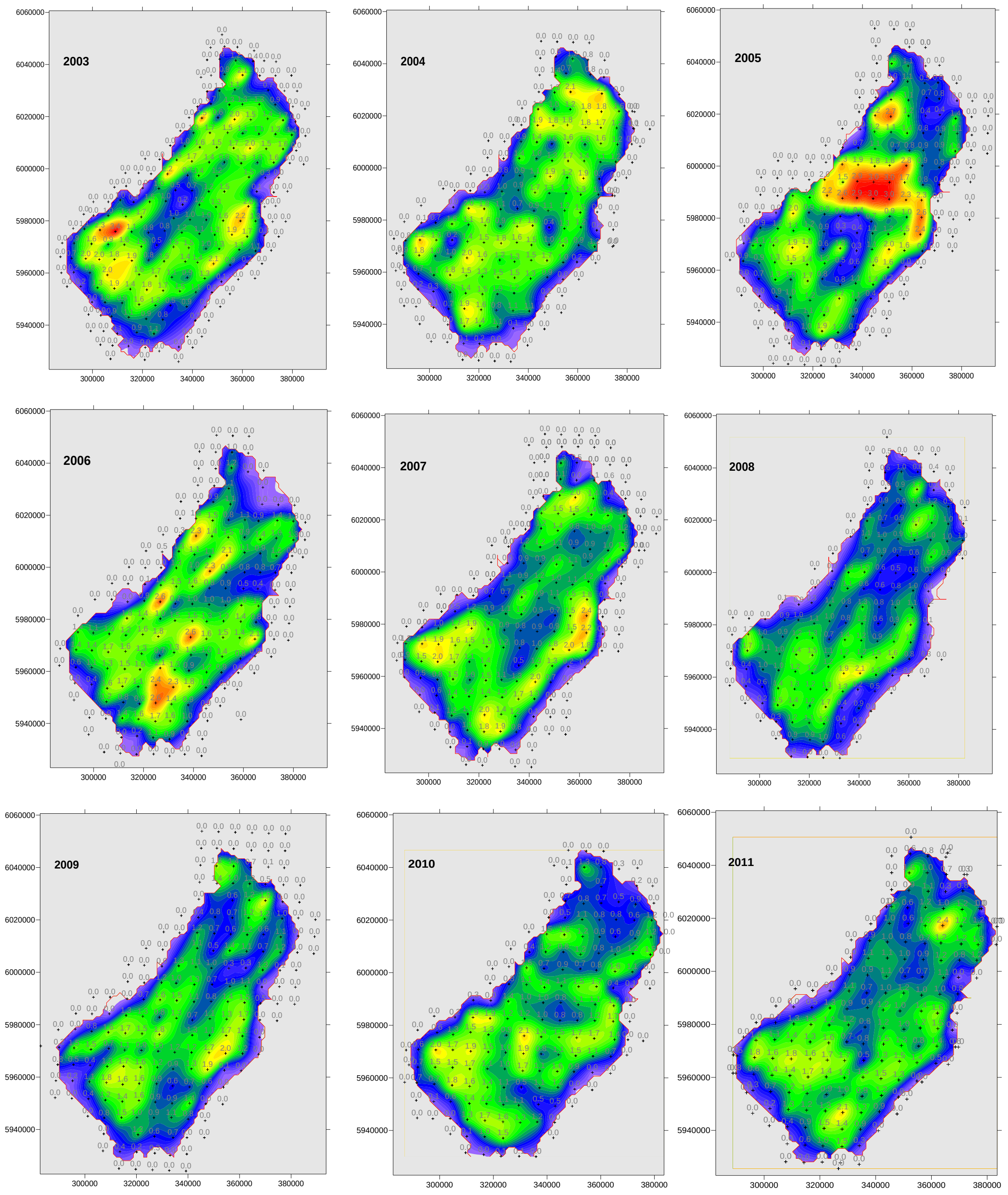

Figure 11: Contour plots of the krigged density estimates of the western Irish Sea (FU15) by year from 2003 -2011.

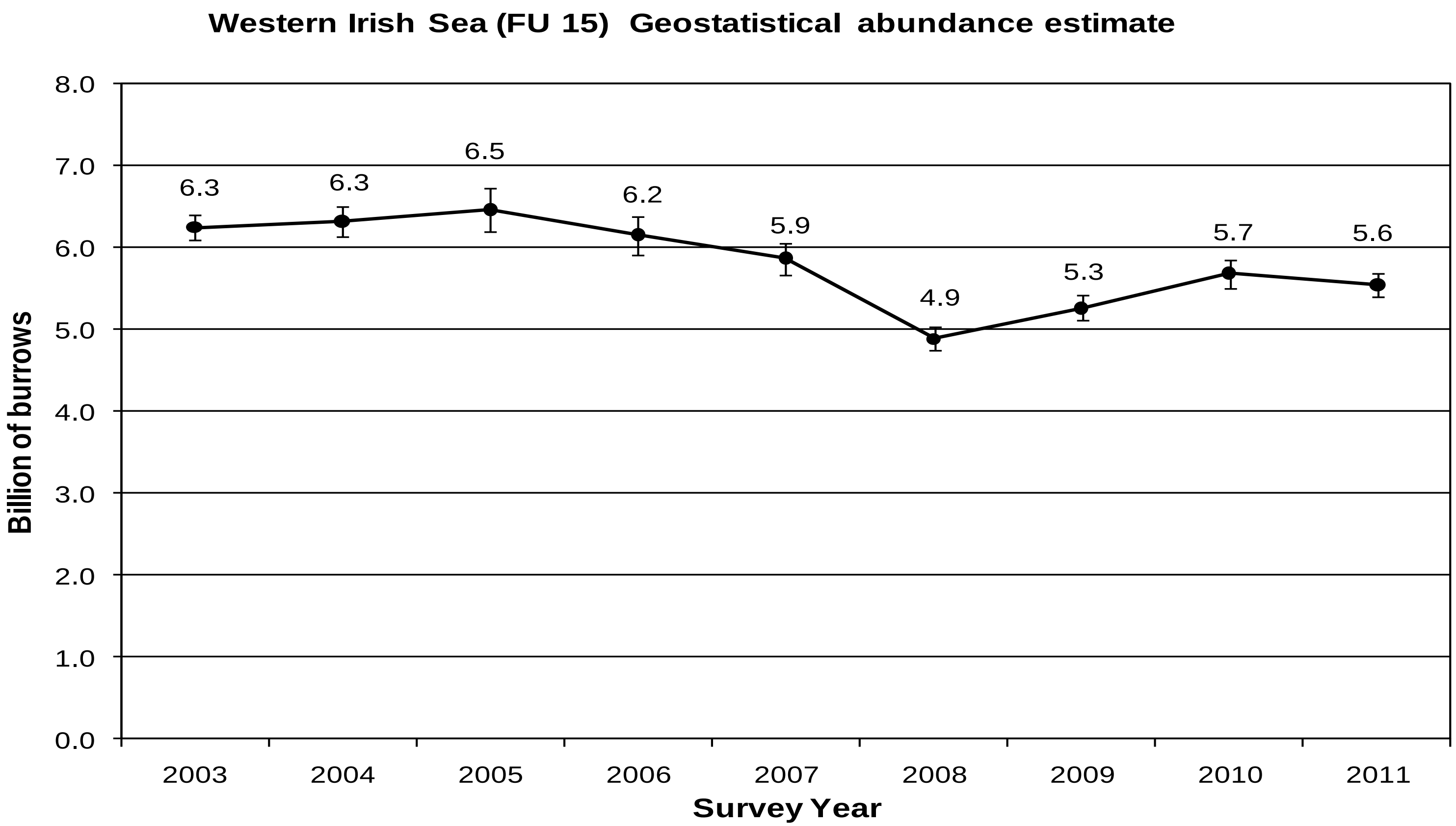

Figure 12: Time series of geo-statistical abundance estimates (in billions of burrows) for the western Irish Sea (FU15) by year from 2003 -2011.

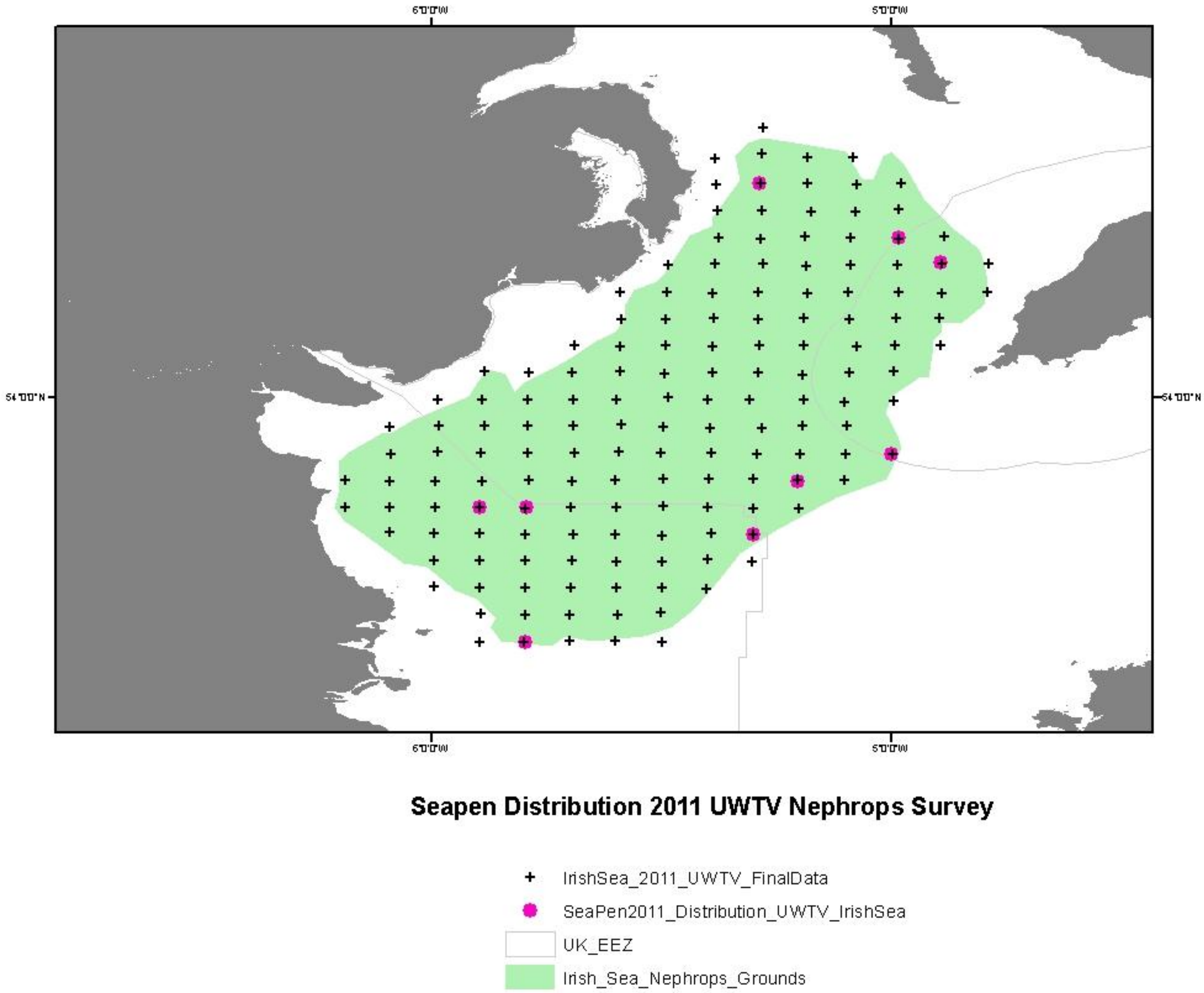

Figure 13: Stations where *Virgilaria mirabilis* was identified during the *Nephrops* UWTV survey for the western Irish Sea (FU15).

FU 15	Year	Number of stations	Mean Density (No./m_2)	Domain Area (km_2)	Geostatistical abundance estimate Estimate	CV on Burrow estimate
Western Irish Sea	2003	160	1.12	5295	6.3	3%
	2004	147	1.13	5310	6.3	3%
	2005	141	1.16	5281	6.5	4%
	2006	138	1.10	5194	6.2	4%
	2007	148	1.06	5285	5.9	3%
	2008	141	0.88	5287	4.9	3%
	2009	142	0.95	5267	5.3	3%
	2010	149	1.02	5307	5.7	3%
	2011	156	1.00	5289	5.6	2%

Table 1: Summary geostatistics for the Nephrops UWTV surveys for the western Irish Sea (FU15) by year from 2003 -2011.