Working Document 12

ICES Working Group on the assessment of Celtic Seas Ecoregion, Copenhagen 13 –19 May 2009

Report of the 2008 UWTV Survey on the Aran, Galway Bay and Slyne Head *Nephrops* Grounds

Colm Lordan and Jennifer Doyle
The Marine Institute, Rinville,
Oranmore, Galway, Ireland.

Abstract

The *Nephrops* fishery 'at the back of the Aran Islands' is the mainstay of the Ros a Mhíl fleet. Sustaining this valuable fishery would be at the heart of any management plan for fisheries in the area. In 2008 the seventh in a series of annual UWTV survey was complete and the results of that survey together with a synthesis and analysis of the results is presented. A geostatistical analysis indicates that burrow densities and abundances have fluctuated considerably in space and time. The highest densities occurred in 2004 and the lowest densities in 2008.The 2008 survey shows a decrease in burrow density to the lowest observed. Using the survey directly for assessment and management has been discussed at WKNEPHTV (2007) and at SGNEP (2009).This stock was a focus at the benchmark workshop on *Nephrops* assessment held in Aberdeen WKNEPH, (2009). There appears to a negative relationship between abundance and landings in the autumn and a positive relationship between observed densities and landings the following spring. There is some concern about the stock given the most recent survey abundance observed to date. The time series is short and to date survey estimates have fluctuated across a large dynamic range.

Introduction

The prawn (*Nephrops norvegicus*) are common around the Irish coast occurring in geographically distinct sandy/muddy areas were 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 seventh 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^2 respectively. This report details the results of the surveys to date, look at harvest ratio options and investigates the relationship between survey abundance landings and LPUEs for the stock.

Material and methods

Landings and effort data were obtained from the Department of Communications the Marine and Natural Resources logbook database. Landings and effort for otter trawl vessels where 30% live weight of their monthly (1995-2003) or trip (2003-2008) landings were composed of *Nephrops* were considered as the "*Nephrops* directed fleet".

Stations in Galway Bay and Slyne Head were either randomly picked or selected based on previously completed tows. For the Aran Grounds no prior information was available on the distribution of sediments was available but the boundaries of the fishing grounds were obtained from the fishing industry and through a previous trawl survey in 2001. The initial design in 2002 was based gird of 3*3 miles with 2 random stations selected within each square. This was chosen to obtain the best compromise between statistical need for randomisation and the need for good spatial coverage. In 2003 the survey design for the main area the Aran Grounds changes to a randomised fixed grid 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.

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 2008, poor weather threatened survey progress and although main Aran grid and indicator station at Galway Bay were completed – the Slyne Head grounds were not surveyed.

At each station the UWTV sledge was deployed and once stable on the seabed a 10 minute tow as recorded on DVD. Vessel, calculated layback of the sledge and where possible the USBL position (position of sledge) and depth was logged for the duration of the tow. In 2007 the field of view estimates were confirmed with parallel lazers set at 74cm apart which were visible at the bottom of the screen for most tows.

All recounts were conducted by two trained "burrow identifying" scientists independent of each other on board the RV 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 criteria in the text table below. In addition the numbers of *Nephrops* burrows (multiple burrows in close proximity which appear to be part of a sing 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 made 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.

An "R Quality control tool" developed in-house allowed for survey data to be analysed in terms of data quality in navigation signal, overall tow factors such as speed and visual clarity (Figure 1) and this tool is documented by SGNEPS (ICES, 2009). Figure 2 is an output that depicts counter trends for the survey. Figure 3 and

Figure 4 shows the variability in density between minutes and operators for each station.

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. 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 assuming that the sledge was flat on the seabed (i.e. no sinking). This has been confirmed as a reasonably approximation using lasers in recent years.

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 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 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 a 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

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

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

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.

Results

Landings, effort and LPUE trends 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 2008 and previous years on the Aran Grounds is presented in Figure 6. This shows large interannual 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 observer and expected density estimates confirms that there is good concordance between the observation and model estimates.

The blanked krigged contour plot and posted point density data are shown in Figure 8. The krigged contours correspond very well to the observed data. The results indicate the densities increased from 2002-2004 when very high densities were apparent throughout the ground. Densities subsequently decreased to the lowest levels observed in 2006 but then increased in 2007 to levels observed at the beginning of the survey series. In 2008 the mean density decreased to 0.58 n/m2 the lowest observed in the time series. 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.

The summary statistics from this geostatistical analysis are given in Table 1 and plotted in Figure 9. The 2008 estimate of 515 million burrows is the lowest to date but the estimates have fluctuated fairly widely to date since the survey commenced. The estimation variance of the survey estimates is not presented but is probably relatively low (CVs in the order ~5%). This is based on the observation at WKNEPH09 that the CV in a similar survey in the Irish Sea 2008 was less than 3%.

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 be taken into account (ICES, 2006).

Discussion

In 2009 advice for this *Nephrops* stocks will be updated by WGCSE. The main source of significant new information on this stock comes from the UWTV survey This survey indicates that burrow density in 2008 decreased to 0.58 n/m2 the lowest observed in the time series. In 2008 the length sampling programme was resumed after a break of two years 2006 to 2007 and the indicators of stock status; mean size, sex ratio appear to be stable and recent LPUE has increased.

The methods employed during the Aran UWTV surveys have been documented by WKNEPHTV (ICES, 2007). 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 in 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 estimate 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.

The surveys may be used to look the relationship between relative abundance (assuming constant bias in field of view, occupancy and edge effects) and landings and LPUE. When this is done some interesting correlations are observed. There is a negative relationship between survey abundance and landings in the autumn fishery. There is also a positive relationship between survey abundance and landings the following year.

This may be related to the biology, growth and recruitment dynamics of *Nephrops* on the Aran grounds. Previously, Lordan et al (2005) have examined the life history of *Nephrops* in this area. That study indicated that female *Nephrops* emerge from their burrows in April or early May following the hatching of the eggs that they carried over winter. Maturation of females then occurs in May, June and July and once mature the females spawn and return to their burrows. The landings patterns are linked to this cycle. With landings increasing in the spring as the females emerge and the males become more active. The sex ratio of males in the catches declines to less than 50% in May. Landings and LPUE are at their lowest in August and September. In the autumn a male and immature female dominated fishery (80%) occurs as the males become more active again.

The survey in June is timed towards the end of the main Spring fishery (Figure 10). The burrows represent small *Nephrops* which are establishing burrows for the first time (recruits) and this surviving from previous years. Note these are animals at least 1 year old since individuals hatched in April or early May would be too small to establish visible burrows at this stage. High burrow density in June may reduce autumn emergence because of a need to protect burrows. It is not likely to be an effect on-board selectivity because of large numbers of small *Nephrops* in the catch since there is no evidence of increase discards or indications of a recruiting cohort in years with high survey burrow density. The high burrow density in June may not translate into high landing and LPUEs until the following Spring when the recruits have had a year to grow.

The relationship between survey abundance and LPUEs the following year is not as clear. It will be interesting to see if this relationship will be maintained in the future or is simply an artefact of the short data available. If it is then this could be a useful method to forecast short term stock development and landings. To be effective it

would however require the timing of quota setting to be adjusted slightly to make effective use of the survey.

In conclusion, the trends from the fishery (landings, effort LPUE, mean size etc.) appear to be relatively stable although landings have increased in 2007 and 2008 due to a less restrictive quota. Conversely, the UWTV abundance and mean density estimates should large fluctuations in burrow abundance. The 2008 estimate is the lowest observed to date and is ~60% of the time series average. This coupled with the lack of an effective way of limiting effort or landings from the Aran grounds is a cause for some concern. A new survey point will be available after June which will provide a more up to date prognosis of stock development.

References

ICES 2007. Report of the Working Group on the assessment of Hake, Monkfish and Megrim Stocks on the Southern Shelf (WGHMM). ICES CM 2004/ACFM: 29, pp 800.

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 Ref: LRC, PGCCDBS

ICES 2005. Using UWTV surveys to develop a conceptual ecosystem model of Aran Grounds *Nephrops* population distribution. ICES CM 2005/L:30 Annual Science Conference.

ICES 2009 Report of the Study Group on *Nephrops* Surveys (SGNEPS). ICES CM 2009/LRC: 15, pp 52.

ICES 2009 Report of the Benchmark Workshop on *Nephrops* assessment (WKNEPH). ICES CM XX:XX.in draft.

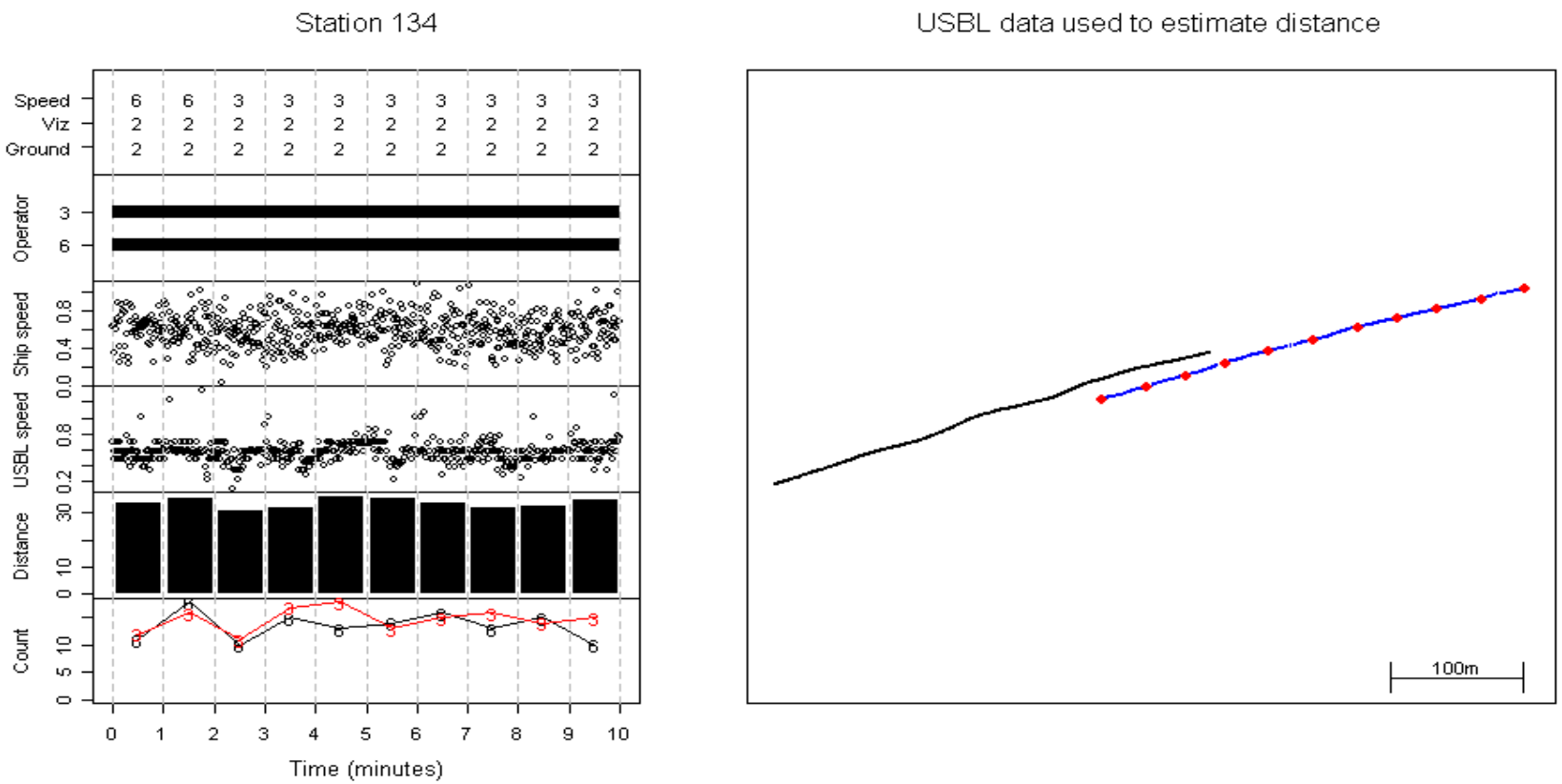

Figure 1.R tool quality control plot of station 134 UWTV Survey of the Aran Grounds FU17 2008.

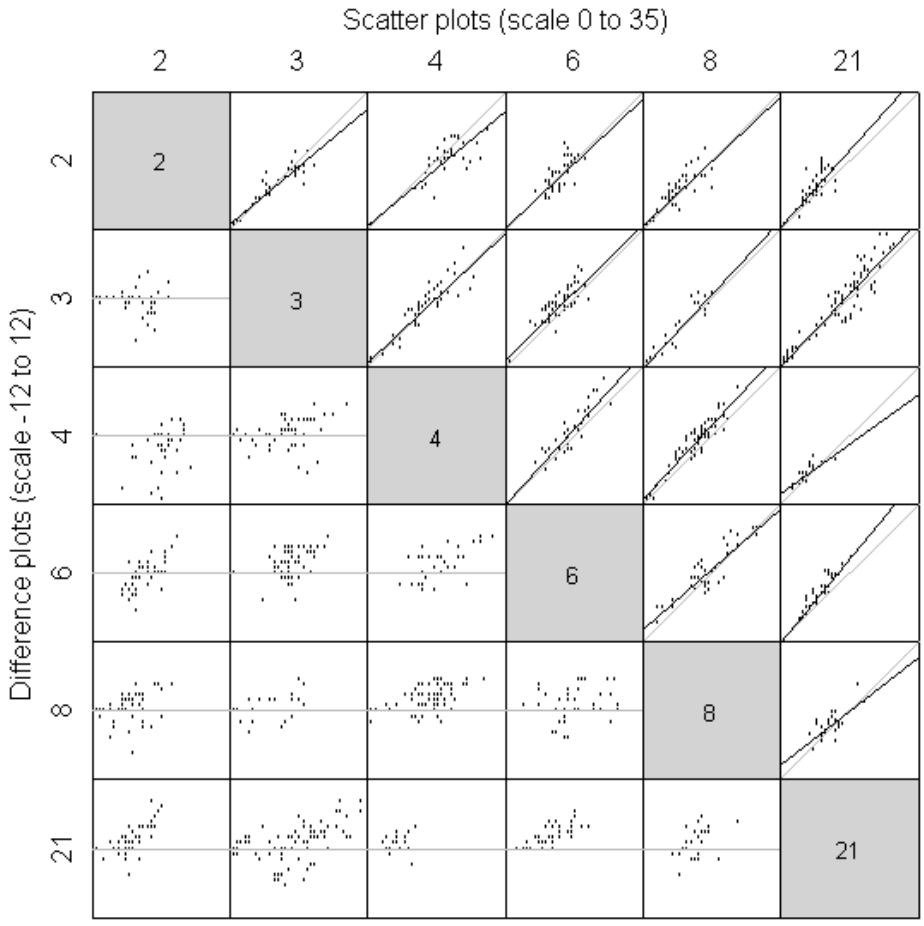

Figure 2.Scatterplot analysis of counter trends during UWTV Survey of the Aran Grounds.

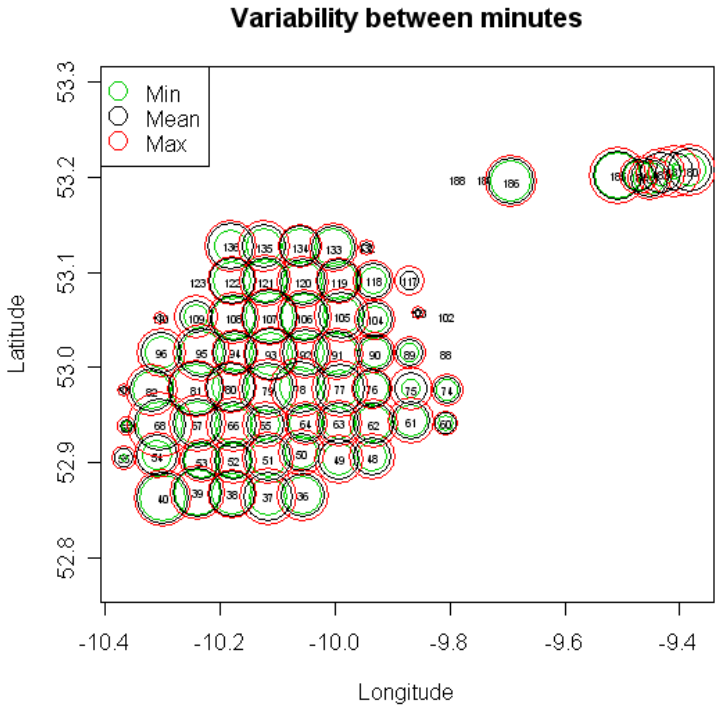

Figure 3. Plot of the variability in density between minutes - Aran Ground UWTV 2008 survey.

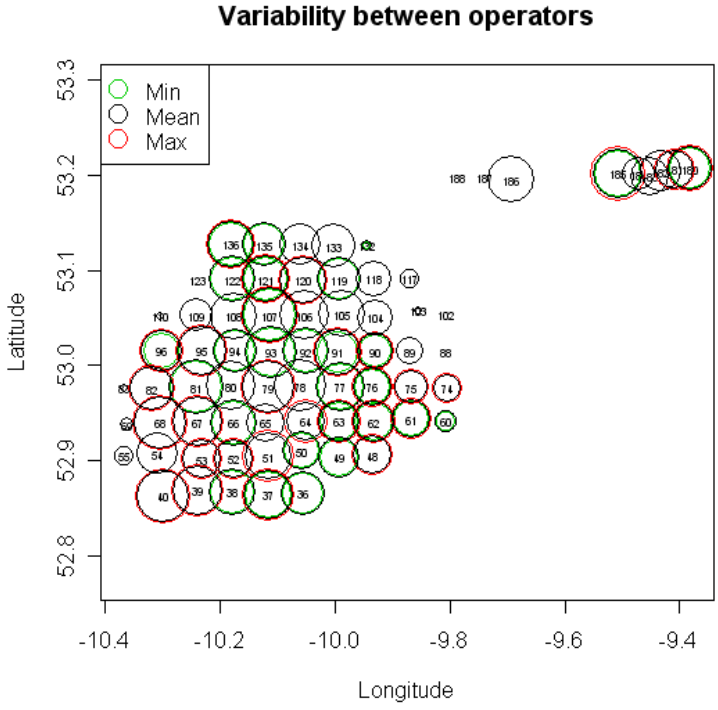

Figure 4. Plot of the variability in density between operators for each station Aran Ground UWTV 2008 survey.

Table 1: Summary geostatistics for the Nephrops UWTV surveys of the Aran Grounds from 2002-2008.

Ground	Year	Number of stations	Mean Density (No./M2)	Domain Area (m2)	Geostatistical abundance estimate (million burrows)
Aran	2002	49	0.81	943	793
	2003	42	0.85	943	825
	2004	64	1.44	937	1408
	2005	70	1.11	931	1089
	2006	67	0.66	932	640
	2007	71	0.88	942	854
	2008	62	0.57	842	515

Table 2: Summary statistics for the Nephrops UWTV surveys of the Galway Bay and Slyne Head grounds from 2002-2008.

Ground	Year	Number of stations	Mean Density (No./M2)*	Area Surveyed (M2)	Burrow count	Standard Deviation	95%CI	CV
Galway Bay	2002	7	1.58	1,299	2,017	0.37	0.34	9%
	2003	3	1.60	591	941	0.29	0.73	11%
	2004	9	0.73	2,312	1,625	0.42	0.32	19%
	2005	4	1.67	661	1,107	0.20	0.32	6%
	2006	3	0.98	540	522	0.27	0.67	16%
	2007	5	1.14	890	992	0.24	0.29	9%
	2008	10	0.42	1,907	859	0.31	0.22	23%
Slyne Grounds	2002	5	0.85	1,216	1,027	0.19	0.23	10%
	2003	0	-	-	-	-	-	-
	2004	3	0.68	827	531	0.27	0.66	23%
	2005	3	0.55	531	294	0.05	0.13	6%
	2006	3	0.41	526	210	0.20	0.49	28%
	2007	4	0.63	838	547	0.31	0.49	24%
	2008	0	-	-	-	-	-	-

*random stratified estimates are given for the Slyne Head and Galway Bay grounds

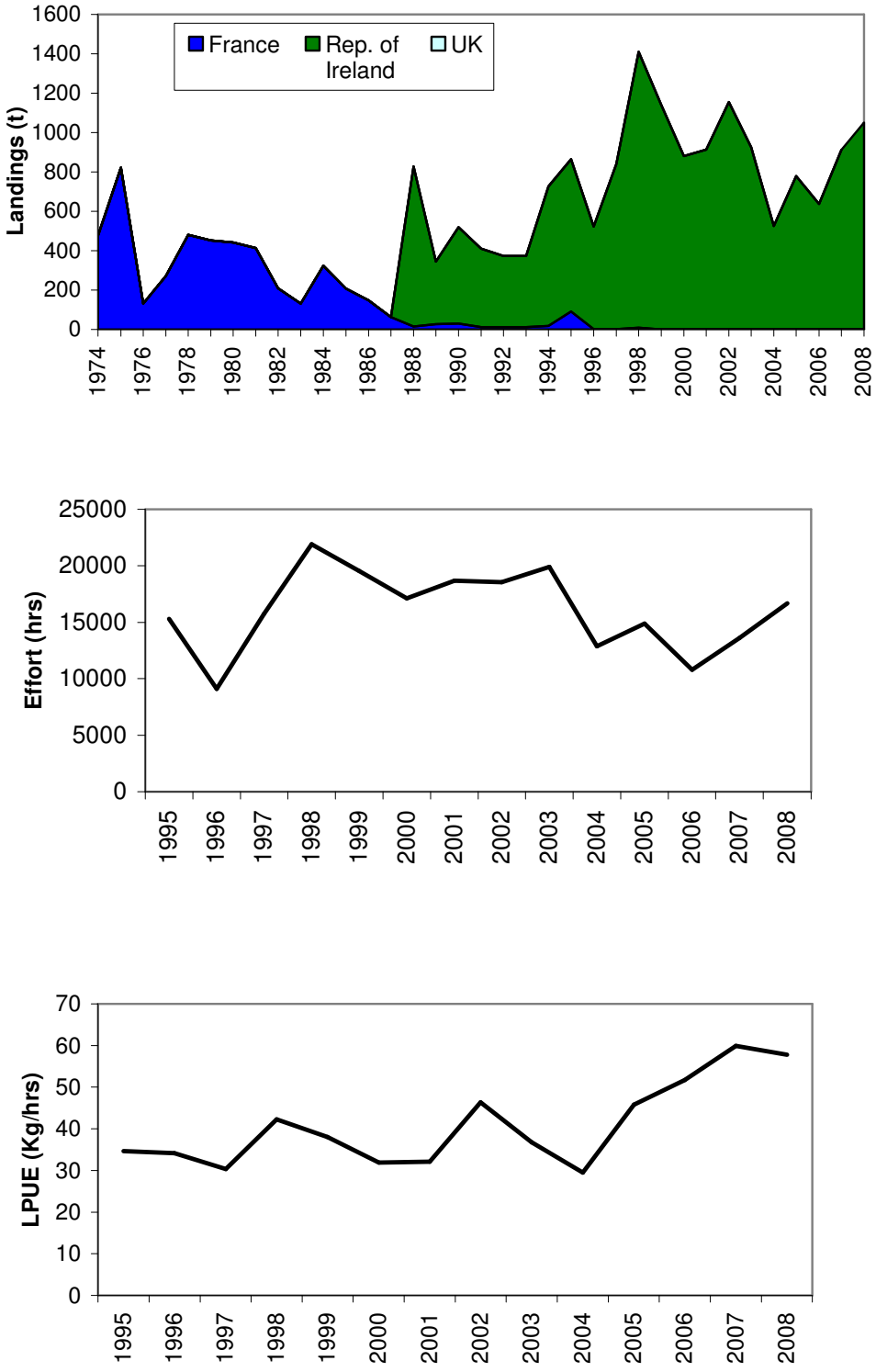

Figure 5: Landings, effort and LPUE trends for the Aran Grounds (FU 17). Note effort and LPUE is for the "*Nephrops* directed fleet" only.

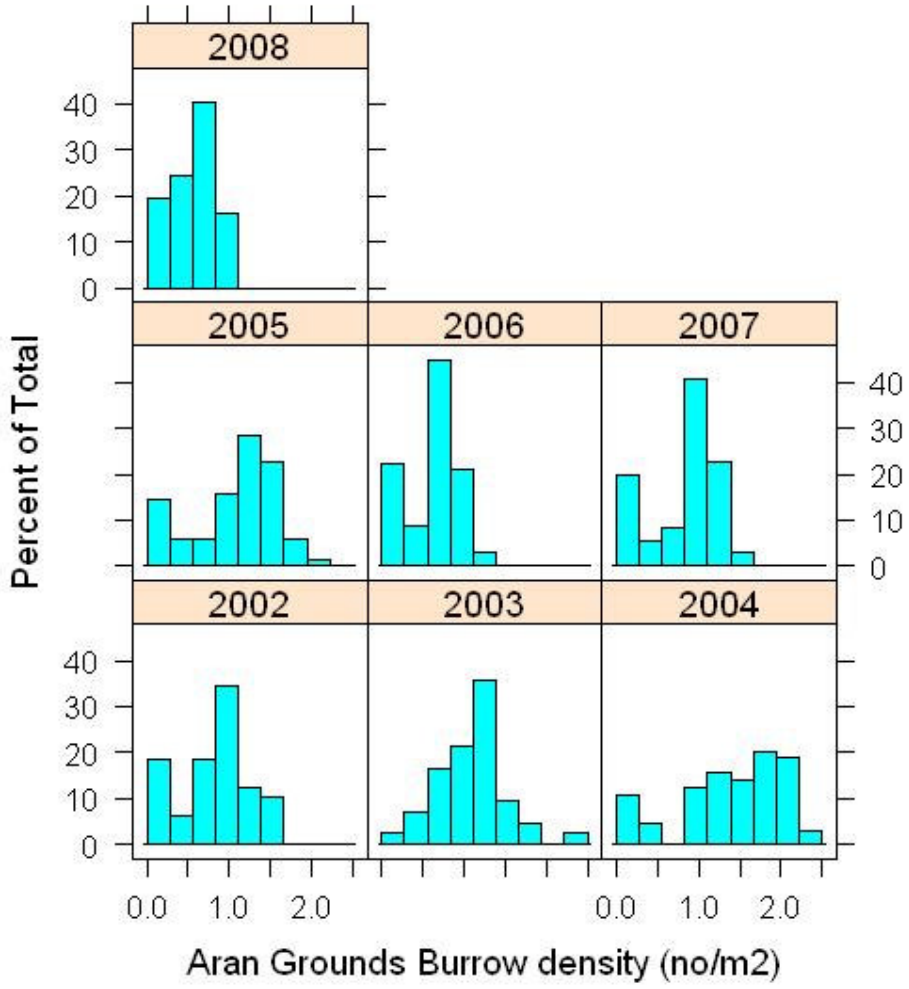

Figure 6: Burrow density distributions for the Aran Grounds by year from 2002-2008.

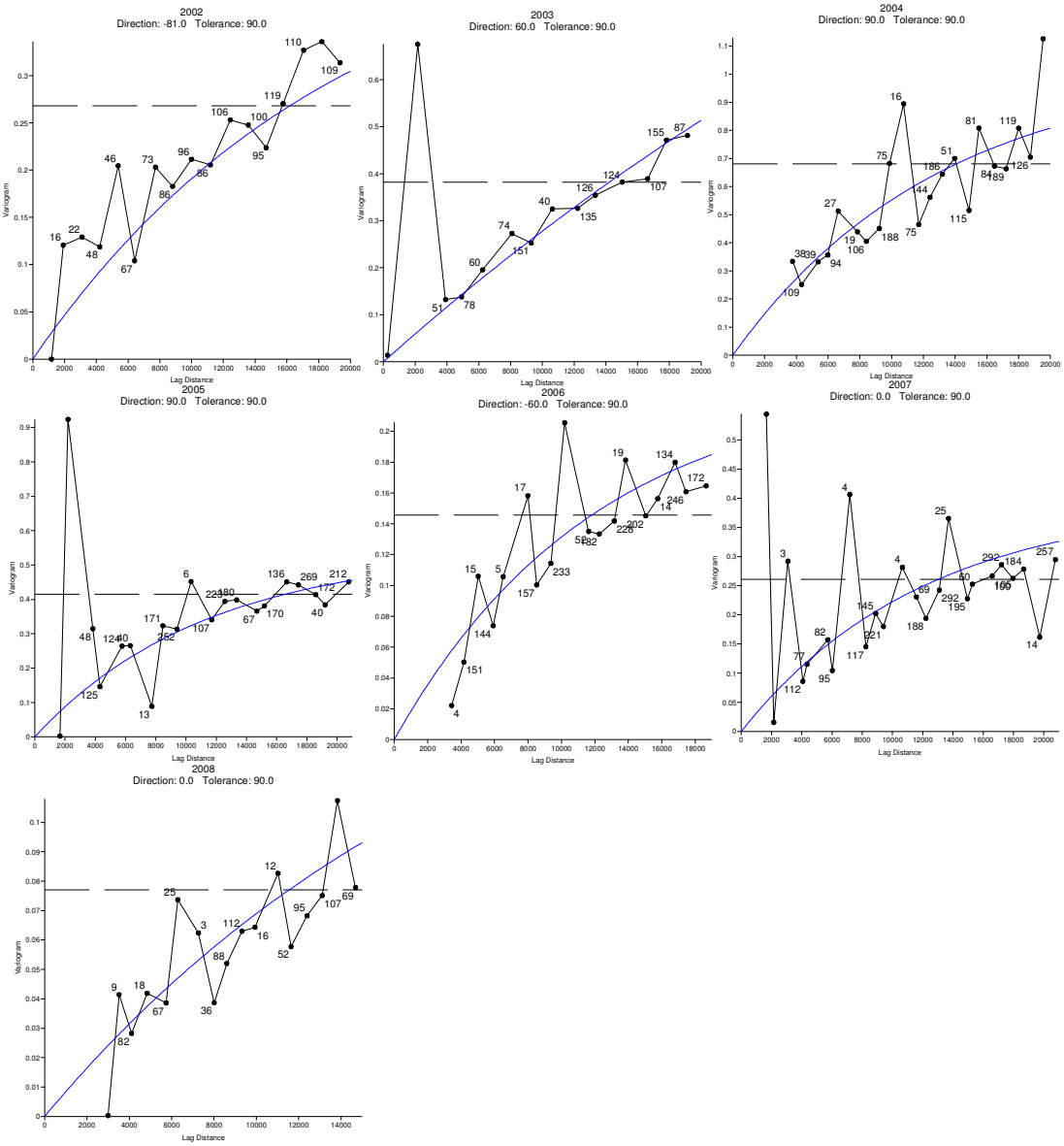

Figure 7: Omnidirectional variogram models used for krigging for the Aran Grounds from 2002-2008.

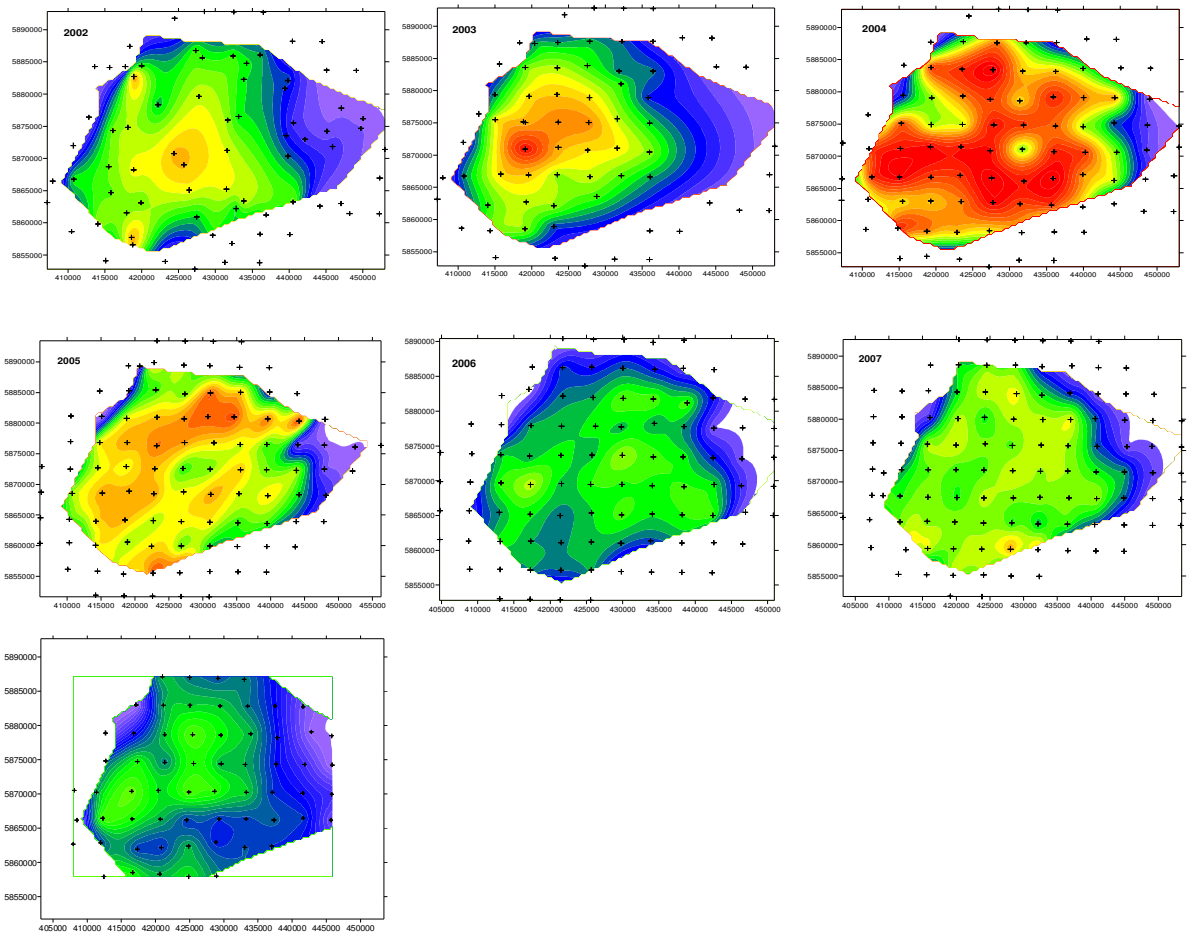

Figure 8: Contour plots of the krigged density estimates for the Aran Grounds from 2002-2008.

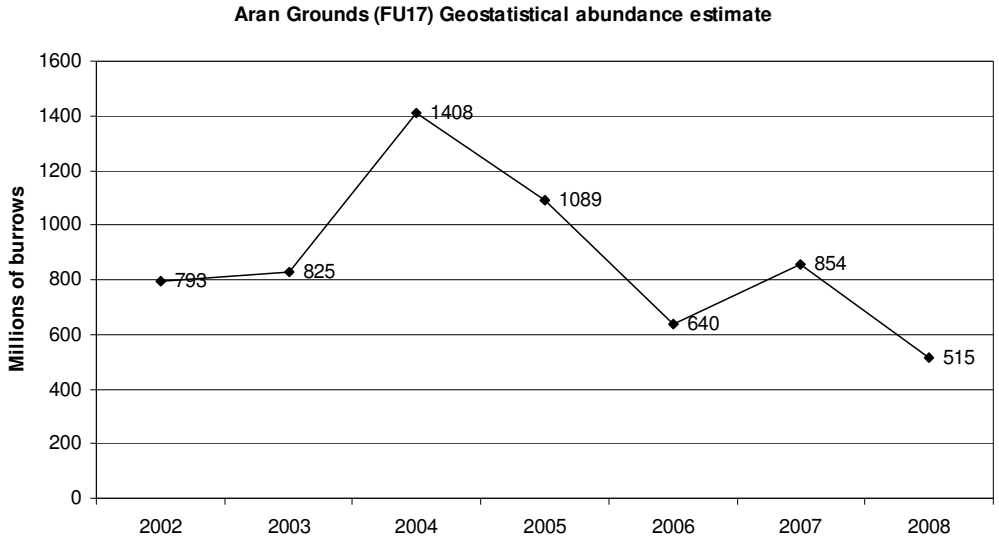

Figure 9: Time series of geostatistical abundance estimates (in millions of burrows) for the Aran Grounds from 2002-2008.

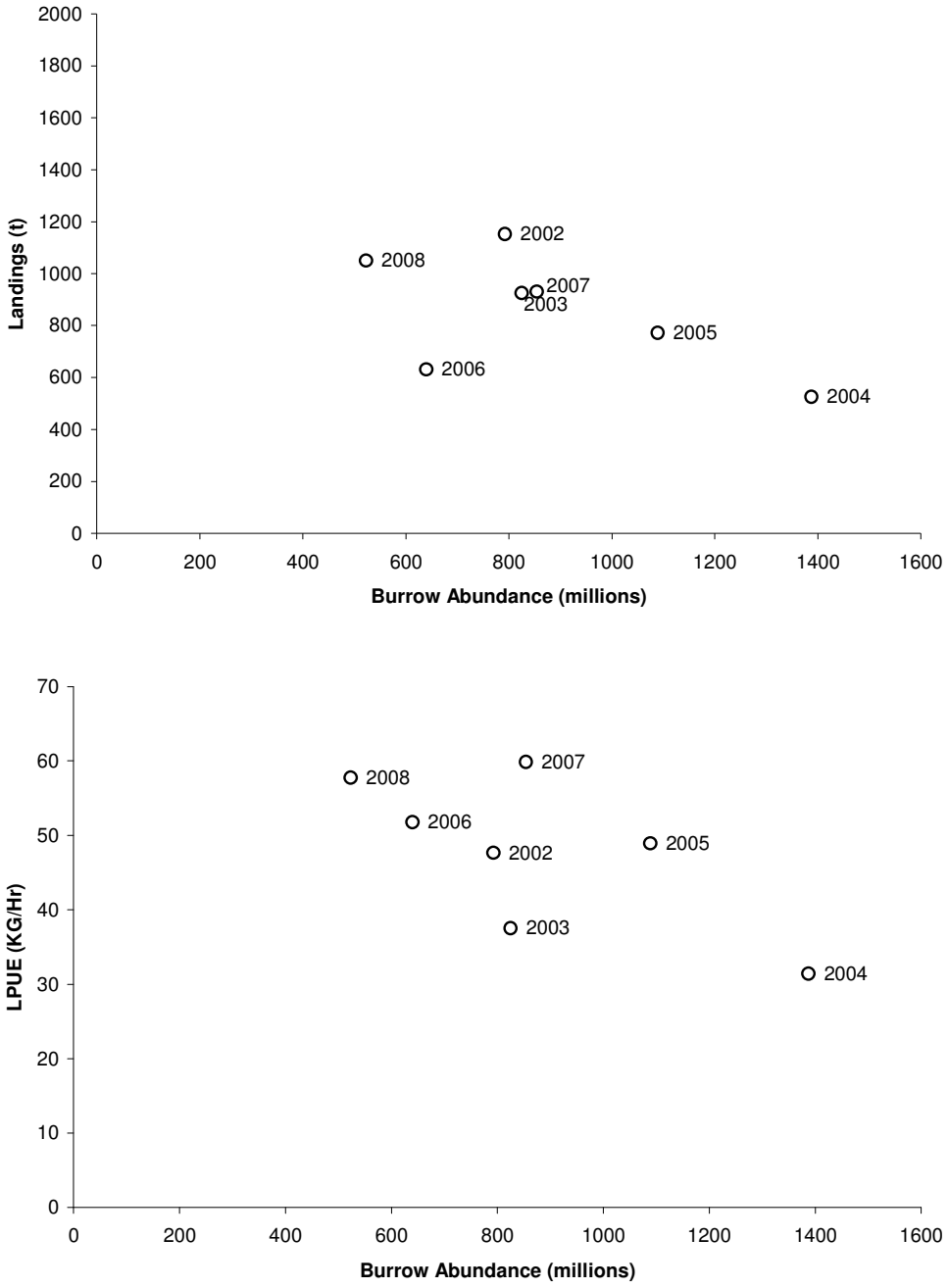

Figure 10: The relationship between landings and LPUE and the abundance estimates from the UWTV surveys on the Aran Grounds.

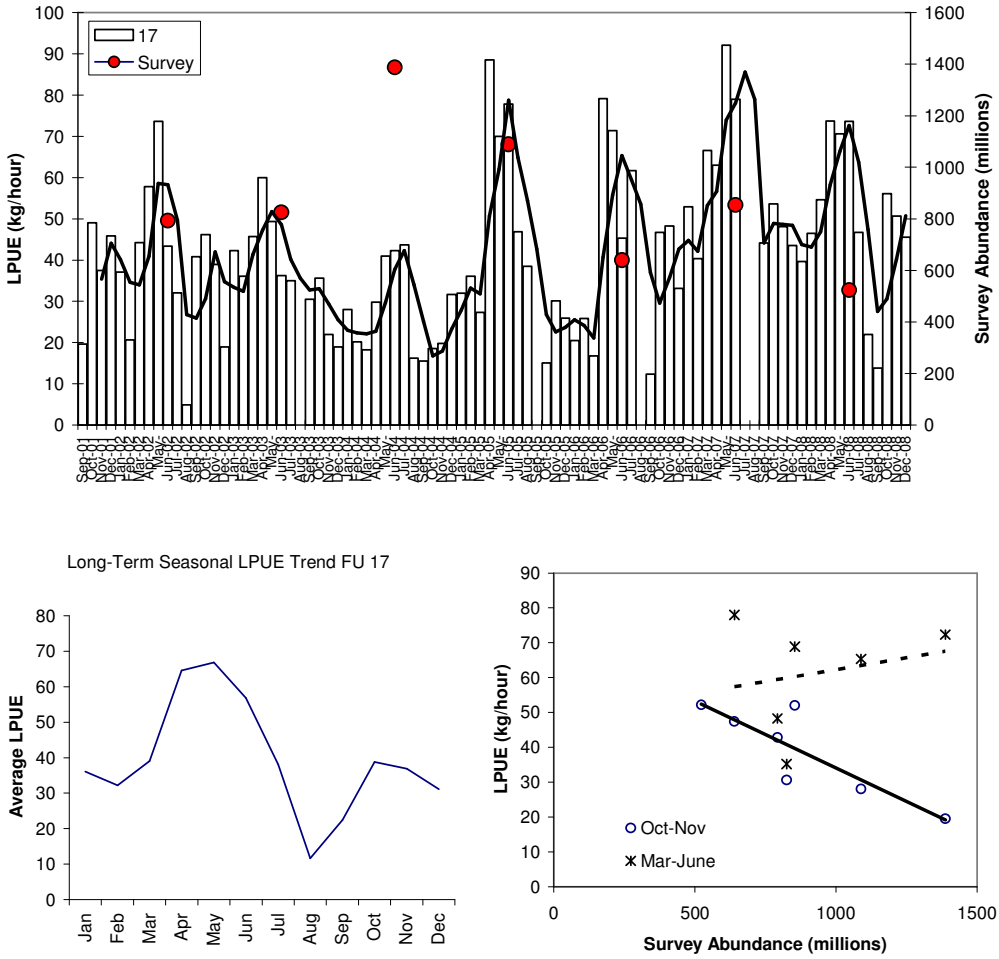

Figure 10: a) The monthly LPUE from FU 17 and survey abundance index b) mean standardised long term (1995-2008) seasonal trend in LPUE for FU 17 and c) the relationship between LPUE's for two time periods and survey abundance estimates.