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Report of the 2007 UWTV Survey on the Aran, Galway Bay and Slyne Head *Nephrops* Grounds

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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 2007 the sixth in a series of annual UWTV survey was complete and the results of that survey together with a synthesis and analysis of the results. 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 the 2006.The 2007 survey shows an increase in burrow density. Using the survey directly for assessment and management is not yet possible. However, 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. The relationship between abundance and landings is not as clear. There is no serious concern about the stock given the recent survey abundance.

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 sixth 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 (2003-2007) 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 chose 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.

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.

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).

To account for the spatial co-variance and other spatial structuring a geo-statistical analysis of the mean and variance 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.

Length frequency distribution of the catches 2002-2005 were obtained from Marine Institute sampling programmes. Unsorted *Nephrops* catch were obtained from the Aran Grounds and a discard ogive was used to decompose the catches into landed and discarded components. No port sampling took place in 2006 and 2007 due to lack of co-operation with scientific sampling by the fishing industry. Length-frequency data for 2006 and 2007 were obtained from a beam-trawl during the UWTV survey in June.

Results

Landings, effort and LPUE trends are given in Figure 1. 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 2007 by 46%. The landings pattern is similar as for other years. Effort in the "*Nephrops* directed fleet" show as declining trend since 1998 and LPUE has remained fairly stable over the time series and both have increased in 2007.

A histogram of the observed burrow densities for 2007 and previous years on the Aran Grounds is presented in Figure 2.

The geostatistical structural analysis is shown in the form of variograms in Figure 3. 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 for each year is given in Figure 4. There is good concordance between the observation and model estimates though there may be some underestimation

The blanked krigged contour plot and posted point density data are shown in Figure 5. 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 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 2002 survey was based on a random design but geographically stratified to achieve reasonable coverage. In 2003 the survey was cut short due to technical problems and the eastern part of the ground was not covered. In 2004 the survey in June was again cut short due to extremely poor weather conditions but about a month later in late July additional stations were completed to achieve better coverage of the grid.

The summary statistics from this geostatistical analysis are given in Table 1. The geostatistical coefficient of variation estimate ranges between 35-51%.

The survey abundance is compared with landings and effort data for the *Nephrops* directed fleet in Figure 5. 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 6). The results also suggest that there is a negative relationship between survey abundance in June and landings in the autumn and a positive relationship with the fishery in the subsequent spring (Figure 7). 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).

Length frequency distributions are shown in Figure 8. These are shown to see if there is any indication of strong recruitment to the stock which might corroborate the survey results. Despite the inclusion of discards in these data there is no indication of strong recruitment from the length frequency data. The length frequency data for females caught during the 2006 survey are similar to those observed in previous years, yet in 2007 the length frequency data is quite smaller. The 2006 - 2007 length frequency distributions of males is substantially smaller than those obtained from annual commercial samples in previous years.

Discussion

The time series of available data with which to assess this stock is short. Previously an assessment has not been possible for this stock but several assessment options have been explored. In 2008 advice for *Nephrops* stocks will be updated. The main source of significant new information on this stock comes from the UWTV survey since no sampling took place in 2006 and 2007 due to withdrawal of co-operation with sampling programmes by the fishing industry. This survey indicates that burrow density in 2007 increased to that observed at the start of the time series.

The methods employed during the Aran UWTV surveys have recently been discussed and documented by WKNEPHTV (ICES, 2007). The workshop also considered the major uncertainties and assumptions in translating UWTV survey data to abundance or biomass. The conclusion was that there is a continuum in terms of how surveys are used. Using the survey as a relative index to tune some assessment model is the least demanding since assumptions and bias (provided they are stay reasonably constant over time) are handled as catchability term. Using the survey as absolute estimator of biomass is the most rigorous in terms of data requirements since the assumptions and biases need to be accounted for or minimised to obtain an accurate result. Give the problems with commercial data it is not yet possible to have a full calibrated assessment for this stock therefore the survey can only be used as an absolute abundance estimate in terms of number of burrows visible.

For this particular survey field of view, occupancy and edge effects become critical when using the survey as an absolute abundance estimate. Whilst it is not possible to quantify these it is possible to estimate the relative scale of the problem. Variation in the field of view is not known since it is not straightforward to quantify. If anything it may lead to an over-estimation of burrow abundance by up to 30%. This bias may be weather dependent with overestimation more significant in poor weather conditions. Similarly the edge effect has not been estimated or corrected for may lead to an over-estimation bias in abundance by between 25-34%. Occupancy also and important unknown and in this survey the assumption is that all those burrow counted are occupied by a single *Nephrops*.

Simulations have shown that applying a 20% harvest ratio to *Nehrops* stocks looks sustainable in the long-term (ICES, 2007). However, these simulations assume perfect implementation of the survey and the catch. In the Aran Grounds this is not the case therefore it would be premature to continue with the harvest ratio approach discussed last year for this stock (ICES, 2006).

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 7). 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 (Figure 8). 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 stock trends from the fishery (landings and LPUE) appear to be stable although these have increased in 2007 due to a less restrictive quota. The relative UWTV survey index of burrow abundance has increased in 2007 from the lowest level observed in 2006 since the series commenced in 2002. It is premature to have catch advice based on the survey although it may have some explanatory power when it comes to seasonal landings and LPUEs. Sampling of landings and discards stopped in 2006 and 2007 due to non co-operation by the fishing industry and this will severely hamper attempts to have an adequate assessment for this stock short to medium term. However, the sampling programme has been initiated in 2008 due to new co-operation. Currently there is no serious concern about the stock status since burrow densities are still very high a new survey point will be available after June which will provide a more up to date prognosis.

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. Draft.

Lordan C., Fitzpatrick, F and Nolan, G. 2005 Using UWTV surveys to construct a conceptual ecosystem model of *Nephrops* on the Aran grounds. ICES, CM XX:XX.

Table 1: Summary geostatistics for the Nephrops UWTV surveys of the Aran Grounds from 2002-2007.

Ground	Year	Number of stations	Number of boundary points	Mean Density (No./M2)	Var	Standard Deviation	CVgeo (%)	Domain Area (m2)	Raised abundance estimate (million burrows)
Aran	2002	49	27	0.81	0.14	0.37	46%	943	793
Aran	2003	42	27	0.85	0.19	0.43	51%	943	825
Aran	2004	64	26	1.44	0.27	0.52	36%	937	1408
Aran	2005	70	28	1.11	0.15	0.39	35%	931	1089
Aran	2006	67	26	0.66	0.07	0.26	39%	932	640
Aran	2007	71	35	0.88	0.10	0.32	37%	942	854

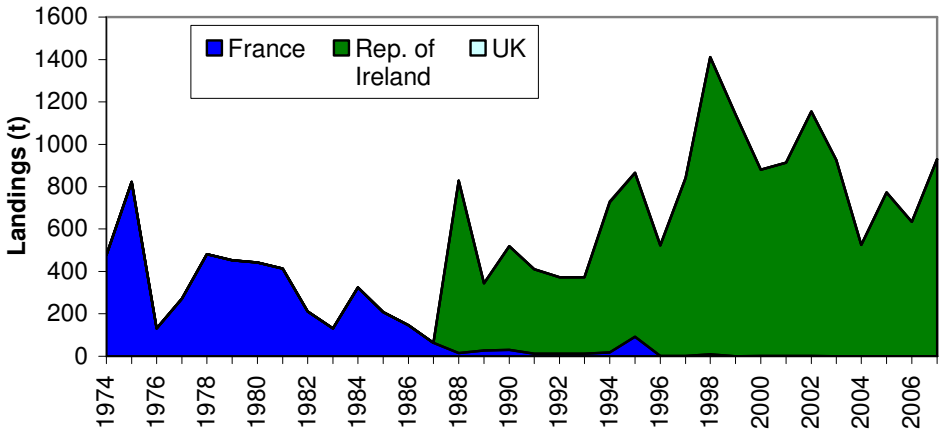


Figure 1: Landings, effort and LPUE trends for the Aran Grounds (FU 17). Note effort and LPUE is for the "*Nephrops* directed fleet" only.

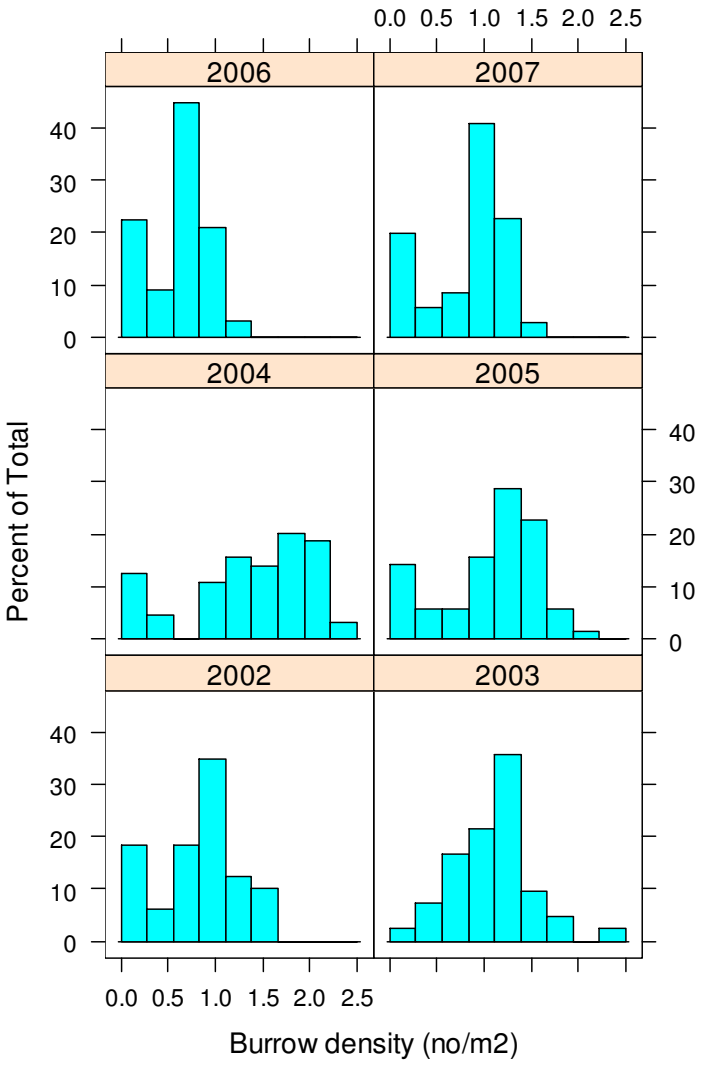


Figure 2: Burrow density distributions for the Aran Grounds by year from 2002-2007.

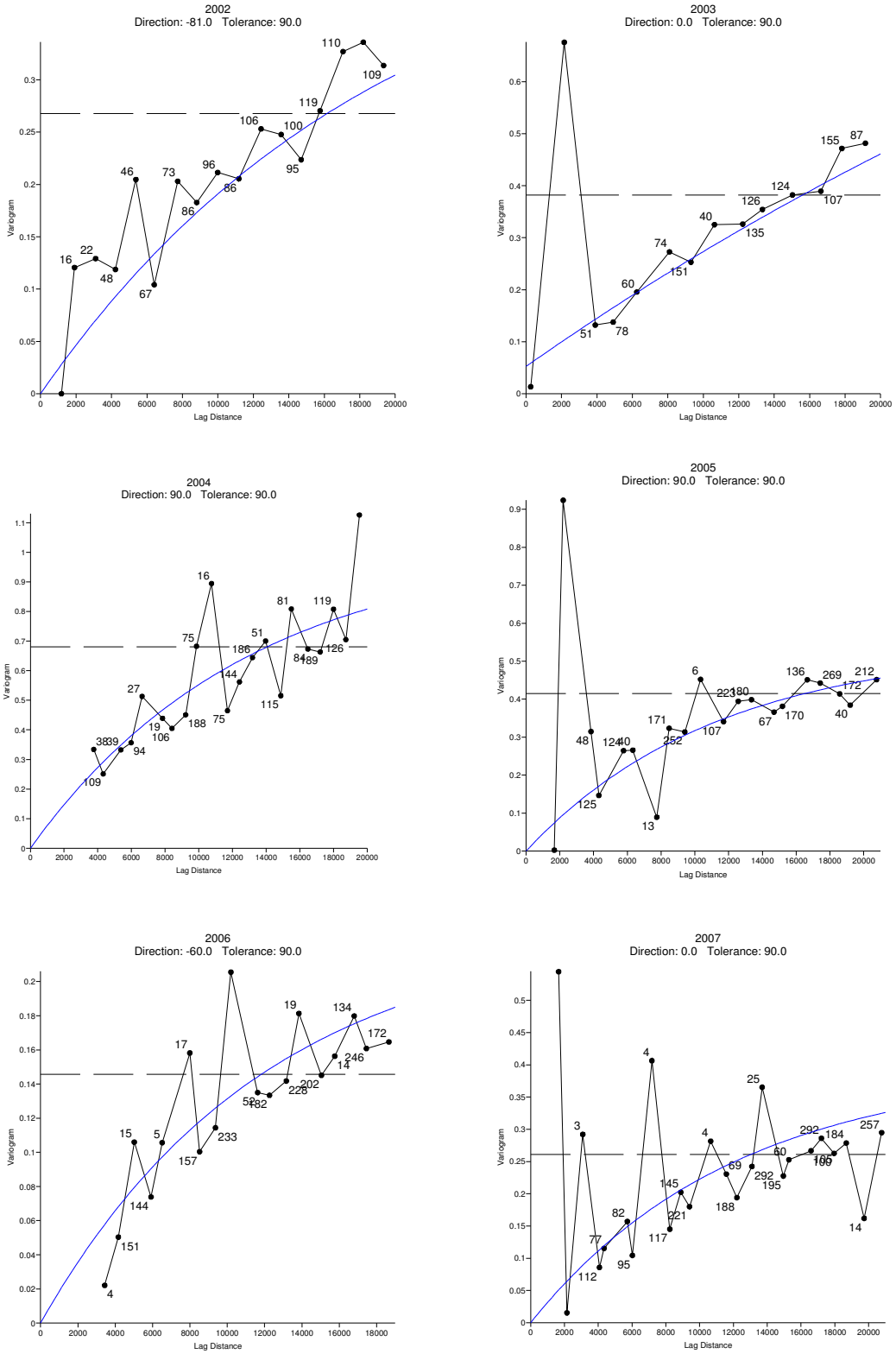


Figure 3: Omnidriectional mean variograms for the Aran Grounds by year from 2002-2007.

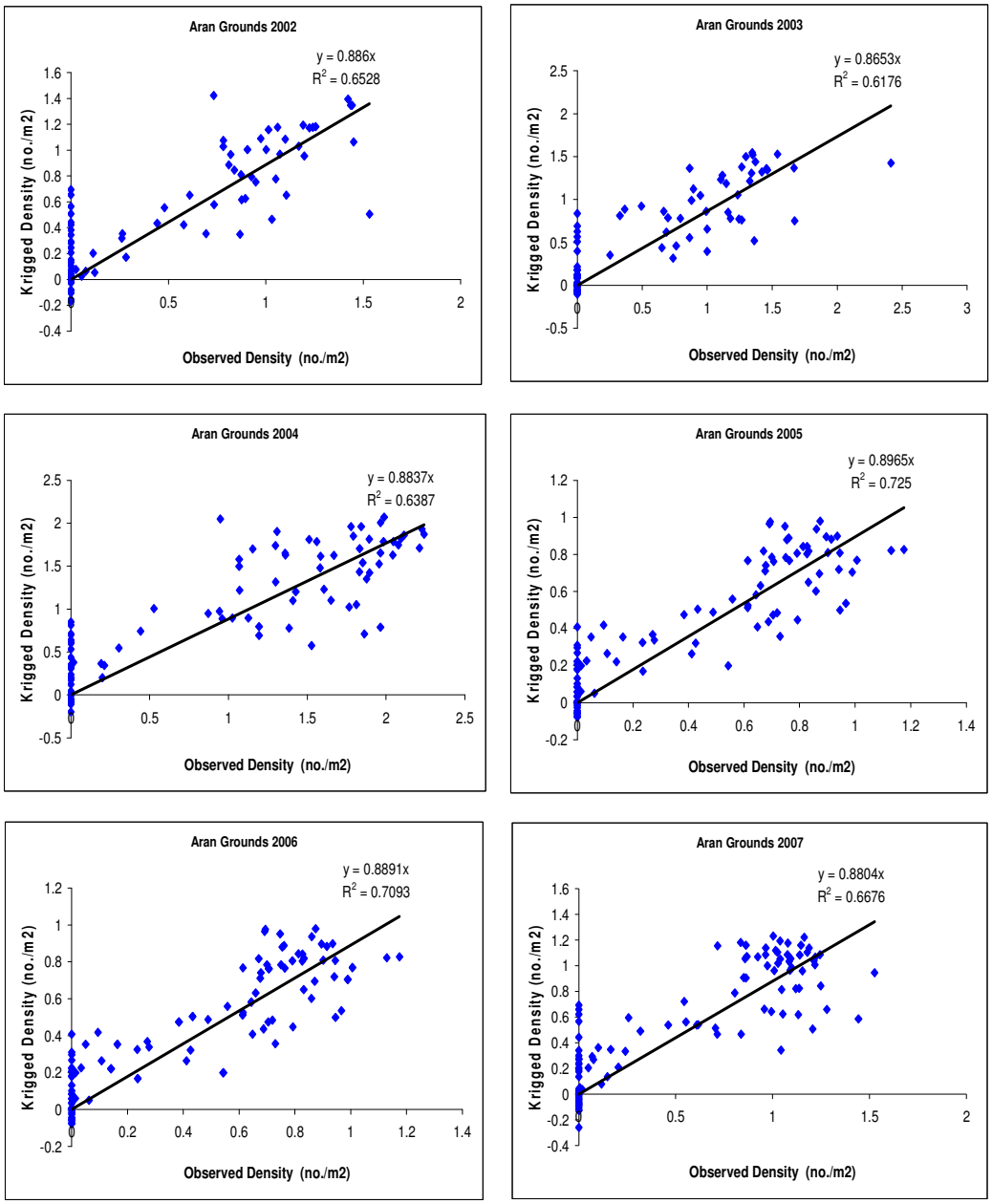


Figure 4: Cross validation plots for the Aran Grounds by year from 2002-2007.

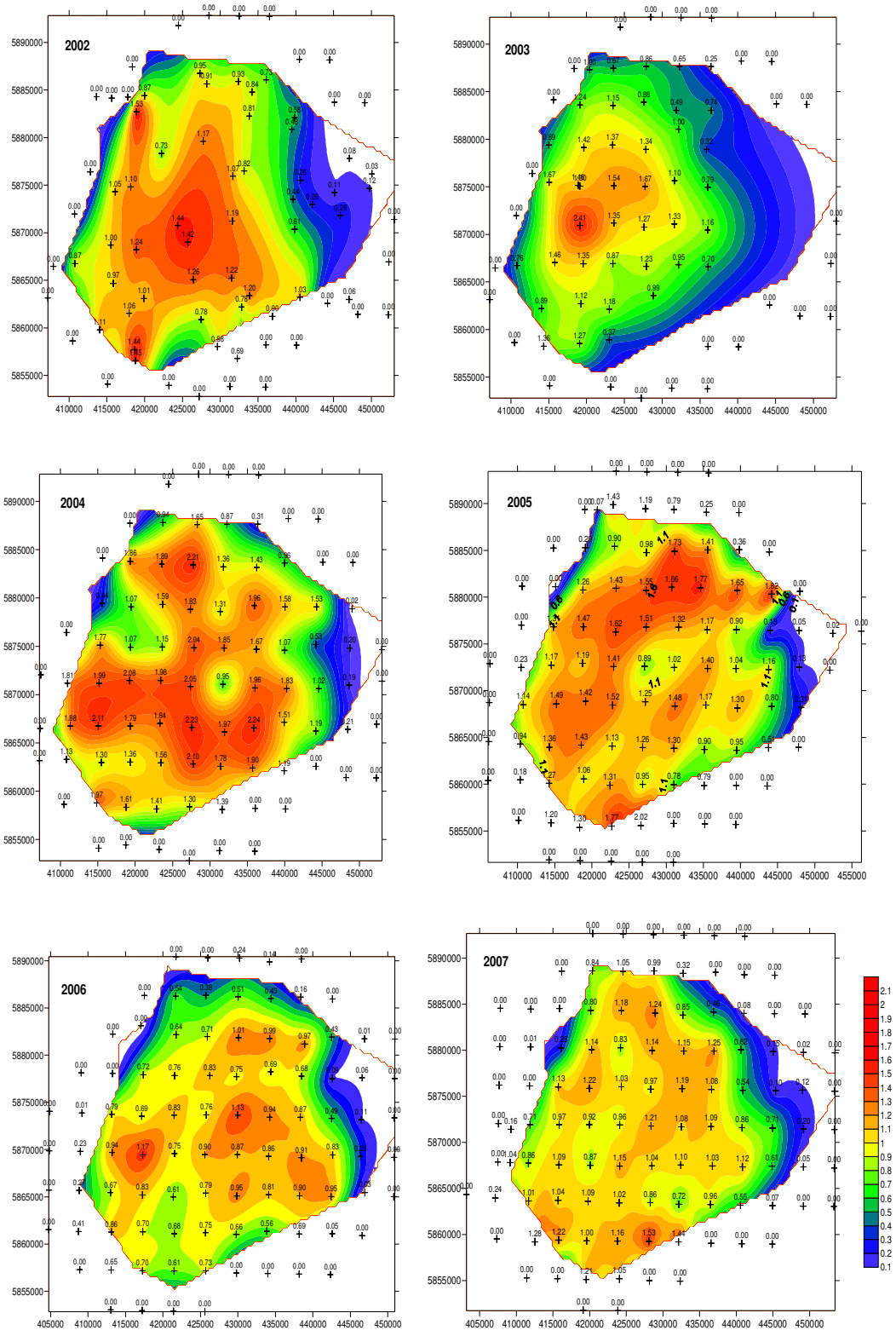
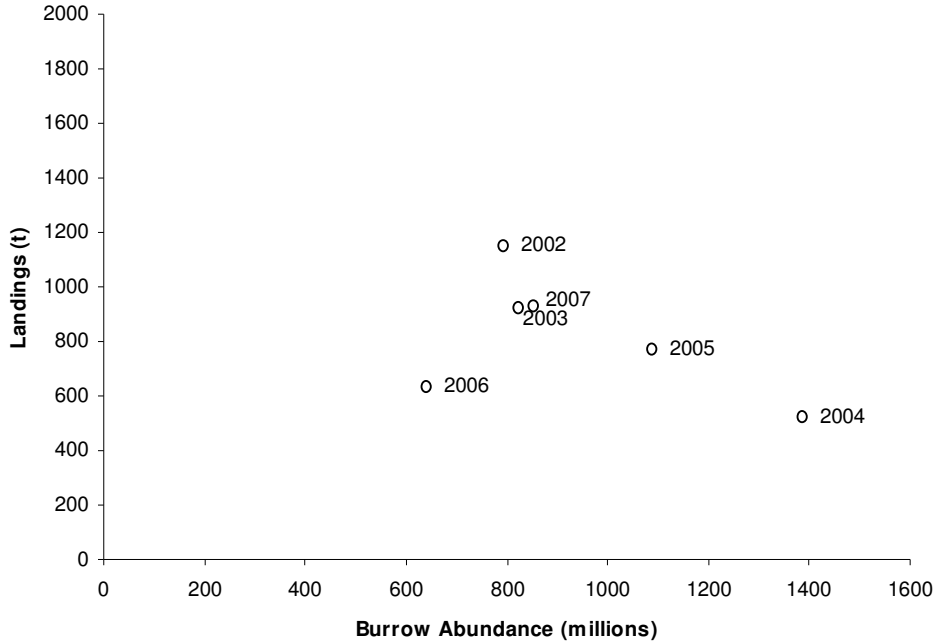


Figure 5: Contour plots of the krigged density estimates for the Aran Grounds from 2002-2007.



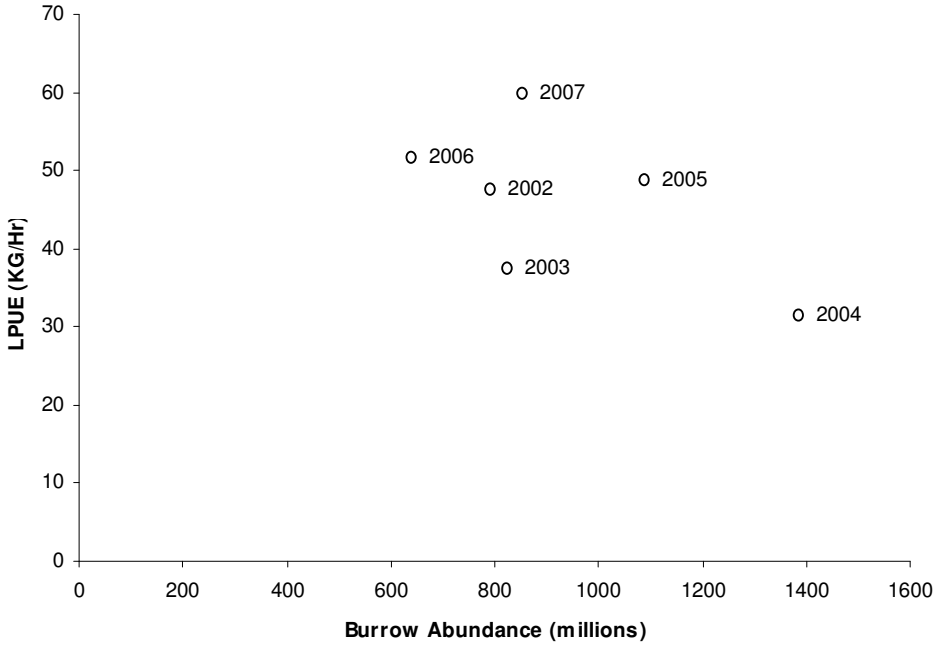


Figure 5: The relationship between landings and LPUE and the abundance estimates from the UWTV surveys on the Aran Grounds.

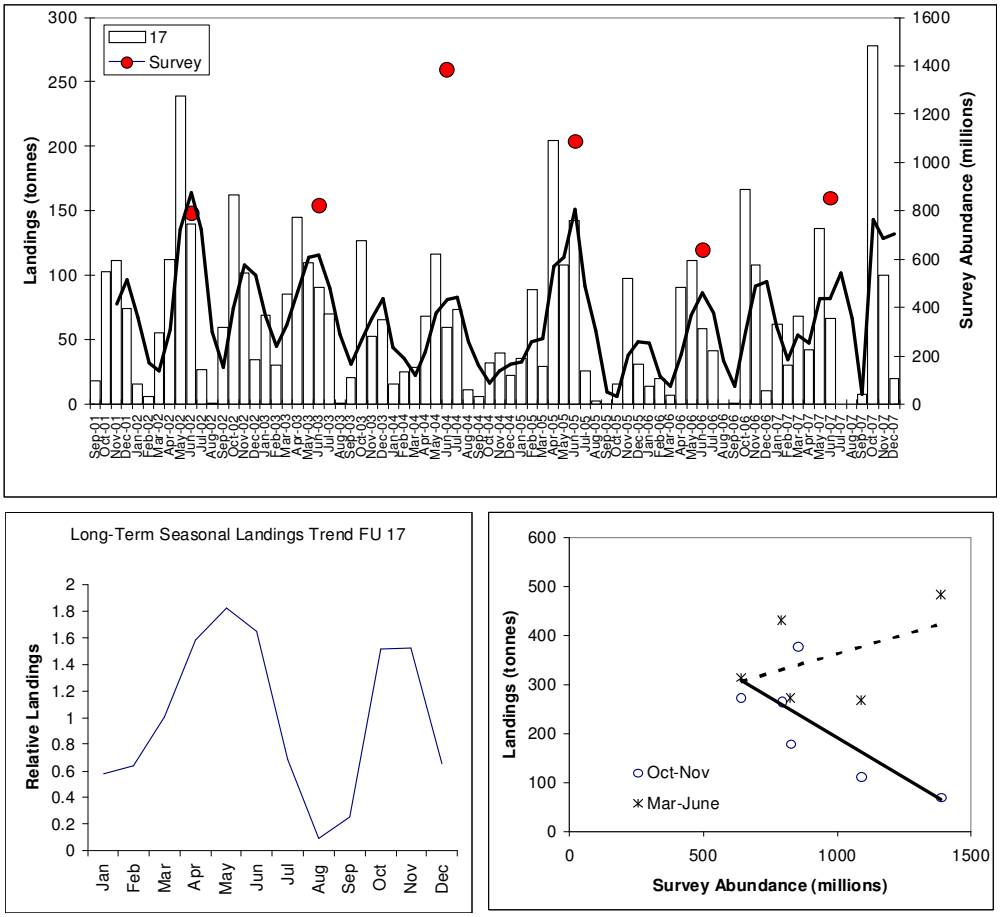


Figure 6: a) The monthly landings from FU 17 and survey abundance index b) mean standardised long term (1995-2007) seasonal trend in landings for FU 17 and c) the relationship between landings for two time periods and survey abundance estimates.

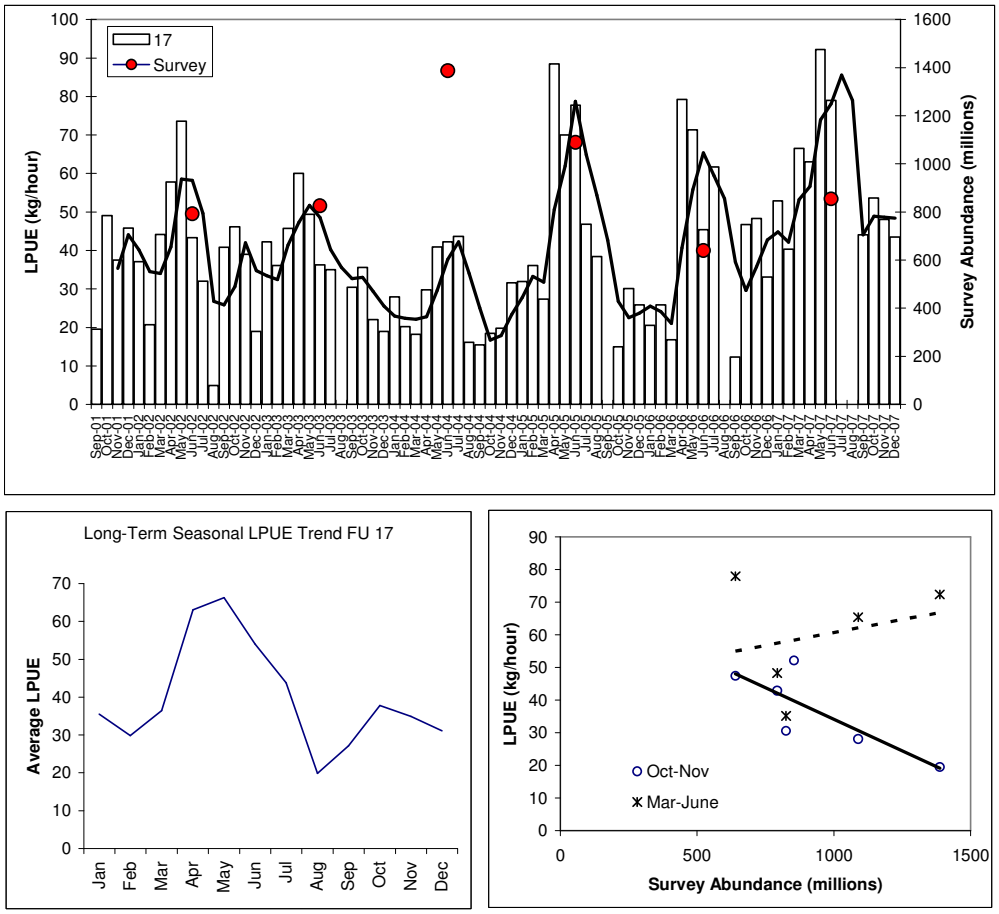


Figure 7: a) The monthly LPUE from FU 17 and survey abundance index b) mean standardised long term (1995-2007) seasonal trend in LPUE for FU 17 and c) the relationship between landings for two time periods and survey abundance estimates.

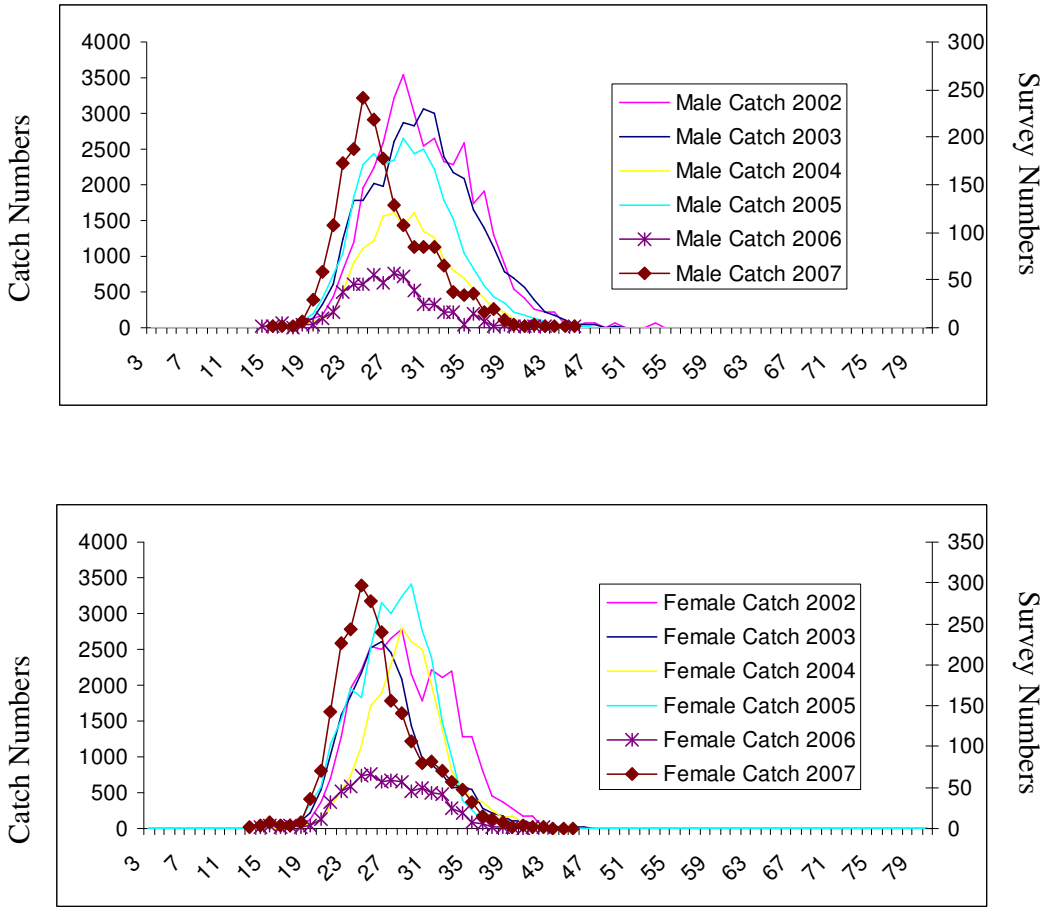


Figure 8: Annual length frequency distributions for male and female *Nephrops* catch from the commercial fishery on Aran Grounds 2002-2005 and survey data for 2006 - 2007.