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## Report of the Workshop and training course on *Nephrops* burrow identification (WKNEPHBID)

25-29 February 2008

Belfast, Northern Ireland, UK



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International Council for  
the Exploration of the Sea

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## Executive summary

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WKNEPHBID was convened to address some of the sources of uncertainty in *Nephrops* burrow counting identified by WKNEPHTV (ICES 2007). The group focussed on three main areas,

1. the training of personnel unfamiliar with the complexities of burrow counting.
2. the development of training and reference material.
3. the production of reference counts for standardisation of counter performance.

Footage from four main *Nephrops* grounds was available (Farn Deep, Fladen Ground, Western Irish Sea and the Kattegat), each with distinct characteristics and problems in interpretation. After plenary viewing of the footage which helped consolidate a common consensus on burrow complex identification, experienced counters went through the footage with less experienced counters in small groups to further demonstrate the application of burrow identification criteria and assist with general training.

The construction of training material was commenced and is to comprise, for each area, a general description of *Nephrops* burrow identification, characteristics of common burrowing species likely to be confused with *Nephrops* and still shots of burrow types. Annotated video footage is also being produced in which burrow complexes are highlighted as they pass through the field of view. Training material is to be completed before the 2008 round of TV surveys.

Reference counts were made for three functional units, FU6, FU7 and FU15 (Farn Deep, Fladen Ground, Western Irish Sea) and are now considered the standard against which the relative performance of counters is to be measured. The footage selected for these reference counts covers the range of visibility, *Nephrops* density and species complexes likely to be encountered in each area. Prior to a survey, individual counters will read the reference material and then obtain a calibration coefficient which will be used to standardise their counts.

## 1 WKNEPHBID Terms of Reference

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A **Workshop and training course on *Nephrops* burrow identification** [WKNEPHBID] (Chair: Ewen Bell, UK) will be established and take place in Belfast, Northern Ireland, UK, from 25–29 February 2008 to:

- a) for each survey area develop a reference set of video runs or images that can be used for training and consistency evaluations;
- b) produce other reference material for training e.g. keys;
- c) agree a common protocol for the counting of burrow complexes to be adopted (taking into account findings of WKNEPHTV (2007) and the further analyses on historical count data);
- d) develop a framework to make formal calibrations between counters (in-house) and ring tests (between labs) (e.g. the UK NMBAQC system <http://www.nmbaqcs.org>) using video material on DVD shared between the relevant laboratories;
- e) training existing and new burrows counters using newly developed material;
- f) develop a common data exchange format of burrow counts to facilitate inter-laboratory comparisons of counting performance;
- g) consider methodologies to objective describe tow quality rather than the current rather subjective descriptions.

## 2 Introduction

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Over the last 20 years, assessments for *Nephrops* stocks have become increasingly reliant upon UWTV as a source of fishery independent measures of stock status. WKNEPHTV (ICES, 2007) undertook a detailed review of the various surveys currently in operation within the ICES community (and beyond), the report listing the survey designs, operating procedures and counting protocols operated in each survey. WKNEPHTV also tabled the sources of potential uncertainty and bias in each stage of surveying, counting and subsequent assessment. This Group was convened to follow up on a number of these sources of uncertainty and to begin the process of improved standardisation between the various laboratories.

*Nephrops* stocks are divided into Functional Units for the purposes of assessment, the locations of which are shown in figure 2.1. Regular TV surveys are now scheduled in 15 FUs with more intermittent data available from 8 further areas.

The Group was tasked with the production of two main outputs, reference video sets (and accompanying reference counts) and training manuals. As this was the initial attempt to produce this sort of standardised information for *Nephrops* stocks, the Group focussed on the three stocks with the longest history of TV surveys, the Irish Sea (FU15), Fladen Grounds (FU 7) and the Farn Deep (FU 6). Video footage from the Kattegat (FU 4) was also made available to the Group and training material developed.

The group consisted of a significant proportion of beginners to *Nephrops* burrow counting as well as more experienced scientists.

The first day took presentations covering the use of computer-based burrow recognition, statistical properties of inter-counting performance and inter-laboratory

variation in benthic discrimination. The final presentation covered the properties of *Nephrops* burrows and features of burrows from other species likely to be encountered on *Nephrops* grounds. A revised key for burrow identification is given in Annex 5.

Day two introduced the reference video sets to the group. There are fundamental differences in water clarity, *Nephrops* abundance and species composition in the three focus areas (FU 15, FU 7 and FU 6) and Kattegat (FU 4).

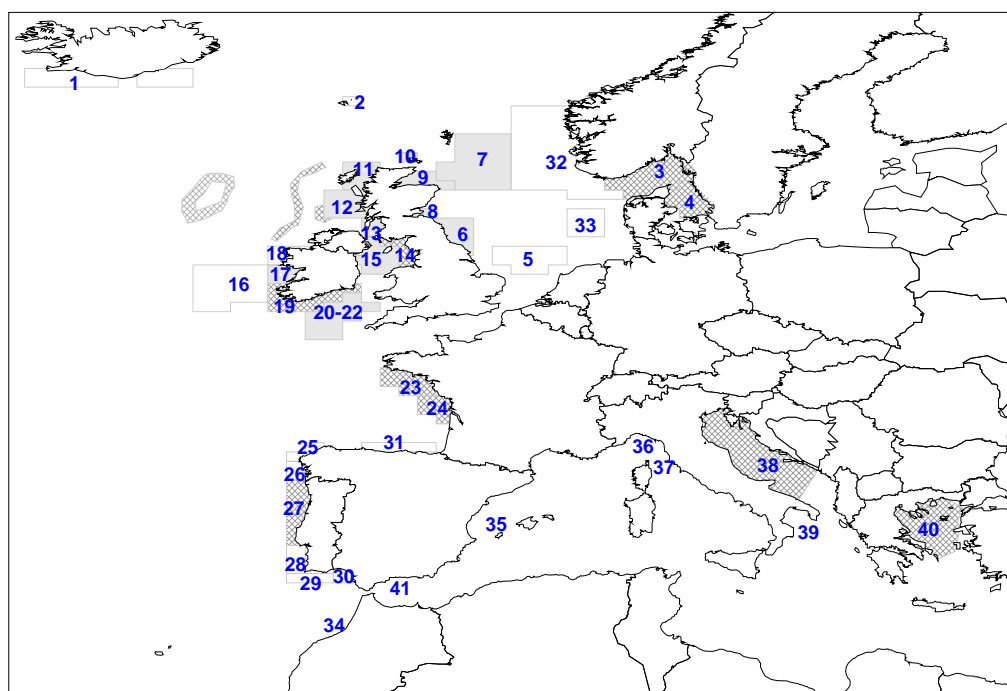


Figure 2.1: *Nephrops* stocks (Functional Units) European waters taken from WKNEPHTV, ICES 2007. Areas in grey have regular UWTV surveys; hatched areas have intermittent data and/or propose to commence more regular UWTV surveys. Regular UWTV surveys are now in progress for FUs 4 and 14.

### 3 Presentations & working papers

#### 3.1 Automatic detection, identification and counting of bottom characteristics – the case of deepwater *Nephrops* fishing grounds in Portuguese waters

IPIMAR and IST-IT (Institute of Telecommunications, Lisbon) started collaborative work in 2006 on the use of image analysis techniques to arrive at a computer-based procedure to assist scientists in counting of benthic organisms.

Sample footages were taken off the Portuguese south coast, in Norway lobster fishing grounds at 450/500 metres depth. A Kongsberg Maritime OE1324 monochrome SIT low-light, high-intensity (2e-4 lux) camera was used in association with a recording and powering unit. Both devices were attached to the top part of a survey bottom trawl, with the camera hanging from the headline pointing down in the towing direction at an angle of 45°. A single light of 75W was mounted parallel to the camera axis.

In a first approach, attention was drawn to the identification of lobsters appearing in the camera's field of view. For that purpose, three different features mimicking a human visual attention model (intensity, shape and motion) were selected and combined as a single salient map for lobster detection (Correia *et al.*, 2007).

Preliminary results based on the analysis of a small a number of video samples pointed to a 90% success (identification) rate, with some occurrence of false positives. Subsequent work introduced a further level of complexity by addressing the identification of two more classes of objects, Norway lobster's burrows and 'others' (the latter aiming at identifying gear impact marks). For this purpose a number of supplementary image characteristics were used to arrive at the identification of the additional classes of objects (Lau *et al.*, 2007; Lau *et al.*, 2008a, submitted). As a result of the preliminary testing, all lobsters could be correctly identified, while the success rate of burrows identification did not surpass 72%. The latter figure owes much to the difficulty in detecting the candidate regions (due to noise and poor image resolution) prior to applying the feature extraction step. Notice that in order to evaluate the automatic results, the selected video samples had to be manually classified in advance. Finally, a latter manuscript considered a further image feature and started to include the temporal aspect in the analysis (notably for region tracking and to discard temporally spurious regions), which is of key importance to a proper detection and counting of the different classes of objects (Lau *et al.*, 2008b, submitted). These improvements increased the rate of positive burrow identification to near 90%. Furthermore, the methodology herein reported was also implemented in software including a user-friendly interface (I<sup>2</sup>N<sup>2</sup> – IT- IPIMAR *Nephrops Norvegicus*) (Lau *et al.*, 2008b, submitted).

Meanwhile, taking advantage of the existing footages, Fonseca *et al.* (2008, submitted) have carried out a first, although preliminary, quantification of *Nephrops* burrow density in Portuguese waters, based on visual counting. Area determination was achieved by superimposing a measuring grid (the 'Canadian grid') over single frames. Density averaged 2.1 burrows (entrances not burrow complexes) per square metre. However, that figure may be revised, considering that burrow structures in deep waters contrast significantly with those in shallow waters. As such, an adequate counting protocol needs still to be implemented to take into account the depth factor (certainly related to sediment nature).

### **3.2 Inter-observer Variability as a Source of Uncertainty in *Nephrops* Burrow Estimates: a case study from the Western Irish Sea**

The Western Irish Sea *Nephrops* fishery is the most valuable fishery in Northern Ireland and is intensively fished by Northern Irish and Irish vessels. Stock assessments of the *Nephrops* fishery have been carried out collectively by the Agri-Food and Biosciences Institute (AFBI formerly The Science Service of the Department of Agriculture and Rural Development for Northern Ireland) and the Marine Institute (MI, Republic of Ireland). In 2003 a joint North-South collaboration in the use of UWTV surveys as a method of annual fishery-independent stock assessment commenced. Minute-by-minute tow data were analysed for two UWTV surveys conducted in 2007. *Nephrops* burrow counts for each tow were recorded by two observers working independently. Data from 125 tows were recorded and 115 tows were suitable for analysis. Each observer only analysed footage once; there were no repeat measurements. It was therefore possible to assess only the between observer variability, that is reproducibility, and does not address the within observer variability, that is repeatability. Reproducibility was evaluated using Lin's concordance correlation coefficient (CCC), which is suitable for datasets with a minimum of 10 observations and Poisson distributed data, such as burrow counts. The drawbacks of using other methods such as Pearson's correlation coefficient, t-tests and ANOVAs, coefficient of variation or intraclass correlation coefficient are well documented. The Lin's CCC value and 95% confidence interval were used to



determine if disagreement, poor agreement or acceptable agreement existed between observers. Scatter and difference graphs were also used to further evaluate the level of agreement. Observer expertise in identifying and counting burrows and physical tow conditions were also assessed against the level of agreement.

#### **4 Overview of Nephrops TV surveys & recent modifications**

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Survey design and counting protocol for both Ireland (surveyed by Marine Institute and AFBI) and Scotland (surveyed by FRS Aberdeen) had not changed since the WKNEPHTV report.

The counting protocol of CEFAS (responsible for the English UWTV surveys) has now changed to counting in 1-minute blocks (as in Scottish and Irish surveys). The use of HD camera was also explored and although due to technical problems did not achieve the results hoped for CEFAS will continue to develop its usage. In addition, CEFAS plans to have a new sledge built for the survey in autumn 2008 which will necessitate the creation of a new set of reference tows.

##### **Surveys in ICES Division IIIa - The Danish Survey in Kattegat 2007**

During 2006 and 2007 a Danish underwater TV survey was begun aiming at establishing a routine under water TV survey for *Nephrops* in IIIa.

This survey is to a very large extent based on the experience from the TV surveys conducted by the fisheries research institutes in UK and Ireland. 2006 and 2007 can be considered as a trial period, where most of the actual cruise time was spent on mounting and testing the technical equipment to be used in the underwater survey. The last survey in the trial period (October 2007) was successful and has provided useful data for assessing density and also a basis for continuation of this survey.

At present Sweden is planning to establish a similar survey. However, eventually it is the intention that the Danish and Swedish surveys will complement each other in the coverage of all *Nephrops* grounds in IIIa.

##### **Species identification of burrows in Kattegat**

The general density of all burrow openings in the surveyed area in Kattegat seems to be of similar magnitude as in the eastern North Sea and in the Irish Sea. However, it seems that the species composition differs from those seen in the North Sea and Irish Sea, but as the burrow making species have not yet been subject to special investigations, it is not yet possible to identify all the 'holes' in the sea bed.

The shape of the entrances to *Nephrops* burrows are in most cases easily identified, however, due to the soft consistence of the mud in this area, it appeared as if the burrow entrances in many cases were steeper (vertical) than observed elsewhere. Such entrances show less pronounced V-shape (sickle shape) than normally seen.

Entrances of *Calocaris macandreae* burrows are very common and could in some case be confused with the smaller *Nephrops* 'holes'. Openings of other burrow making crustaceans belonging to Thalassinidea have already been identified. These species are the following: *Upogebia stellata*, *Callianassa subteranea*, *Jaxea nocturna*. It is highly probable that the bivalve *Thracia convexa* is responsible for some of the frequently seen pair of holes very close to each other. Openings belonging to the Echiurid species *Maxmuelleria lankestri* and *Thalassena thalassum* have also been identified on the videos.

Since the depth range on the *Nephrops* grounds in the Kattegat is of the order 30-50 m, most of the light sensitive burrowing animals are more likely to be active on the sea bed during night. Therefore, in order to obtain improved qualitative information on the species it was recommended, that on all the TV survey areas in Kattegat replicas of selected tows should be made during night. Furthermore, it was also suggested that some 'anchor dredge' samples of the mud bottom be taken to provide better information on the more common burrowing species.

## 5 Creation of reference sets (ToR a)

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### 5.1 Reference counts

Because of the number of different fisheries currently surveyed and the resources involved in producing these reference sets it was decided to initially prepare and review the reference sets of three distinct fisheries regularly surveyed by three different institutes. The three areas and surveys chosen with different characteristics were the Fladen (surveyed by FRS; typically low to medium densities with large burrow entrances); Western Irish Sea (surveyed by Ireland and Northern Ireland; typically high densities of small burrows and often in turbid conditions); Farn Deep (surveyed by England; with typically low to medium densities; range of different burrow sizes; smaller field of view and steeper camera angle).

It was decided that a reference set would comprise of 10 runs of 5 minutes covering the range of usable video footage encountered on a typical survey. The range needed to cover clear to murky video; high to low densities; and if available a mix of *Nephrops* and other species burrows. Each institute collated video footage from their archives and burnt them onto DVD with each run comprising a separate chapter.

The most experienced counters from each of the three institutes – FRS (Scotland), Marine Institute (Ireland) and Cefas (England) were used to create the reference counts for each set. There are few differences between the counting protocols employed each institute (section 8) but any that might have influenced counts were resolved prior to the creation of the reference counts. As is standard practice for all the three surveys, *Nephrops* burrow counts were recorded for each minute of each run.

Each counter reviewed all the footage in isolation and only once all the reference sets had been reviewed were the results compared. The counts for the Fladen and Farn Deep were compared and where differences between the counters reached a set threshold the footage for that minute was re-examined and a consensus between the three counters was reached for that particular minute. For the Fladen and Farn Deep footage (FU 7 and 6 respectively) the acceptance criterion was as follows:

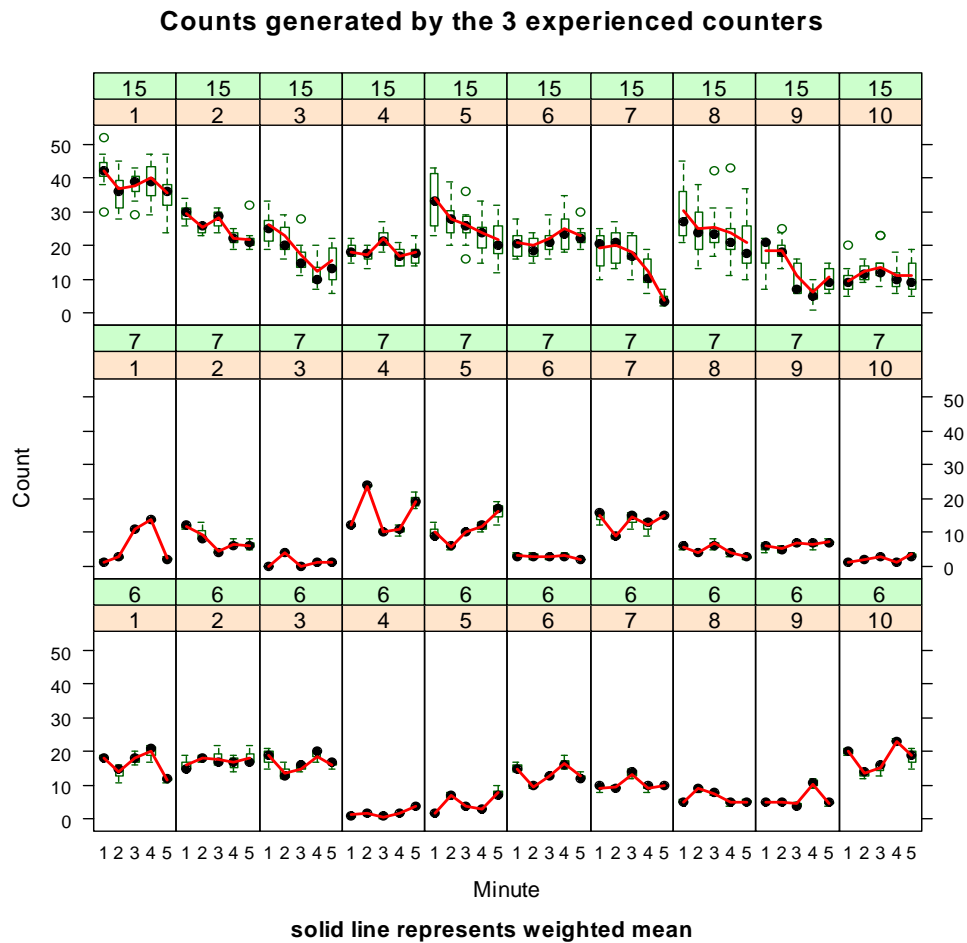
For a reference count of greater than 20 burrows per minute, counts more than 10% different from the weighted mean were deemed unacceptable. For counts between 15 and 20 the criteria used was 20% and for 8 or less it was 40%. For all average counts of 1 or less it was decided there needed to be exact consensus.

The criterion traditionally used for the Western Irish Sea (FU15) is to recount minutes where a difference of more than 7 burrows occurs. There was, however, insufficient time to complete the consensus exercise for this FU due to the complexity of reading the footage from this area. Instead, the footage for this FU was reviewed multiple times either at the workshop or back at the laboratories and the count used for each individual was the arithmetic mean of the counts for each minute of each station.

The reference count for each area was taken as a weighted average of the three counters with the local expert for each area having twice the weight of the other counters; i.e. for the Fladen grounds, the counts of the Scottish expert had twice the weight of the English and Irish experts. Consensus counts (FU 6 and 7) and mean counts (FU15) by minute, FU and run are shown in figure 5.1 and the reference counts by run and functional unit are given in table 5.1.

**Table 5.1 Reference count by run (10 x 5 minute run per FU) and functional unit.**

Run	FU		
	6	7	15
1	82.50	31.00	192.44
2	86.75	38.00	127.04
3	82.00	6.00	94.47
4	9.75	76.25	92.45
5	23.75	53.75	134.00
6	67.25	14.25	111.04
7	50.75	65.50	73.62
8	32.00	23.00	125.17
9	29.50	31.75	64.91
10	91.25	10.50	57.54



**Figure 5.1: Consensus (FU 6&7) or individual mean (FU15) counts by minute, FU and run with the weighted average "reference" count.**

Lin's Concordance Correlation Coefficient (CCC) (Lin, 1989) measures the ability of counters to exactly reproduce each others counts on a scale of 1 to -1 where 1 is perfect concordance (i.e. a pairwise plot will have all points lying along the 1:1 line. A value of -1 would be generated by all points lying on the -1:1 line and a value of 0 indicates no correspondence at all. The robustness of this measure is obviously a function of the number of data points and with only 5 points per individual run it was likely that there would be a large degree of scatter. The CCC was calculated for all pairwise combinations of non-consensus runs for each FU (Figure 5.2), and for FU 15 we were able to test whether the CCC was different when comparing counts within an individual ("self") as opposed to comparing counts between counters ("other"). The CCC values were considerably higher in FU 6 and 7, reflecting the easier reading conditions of these areas.

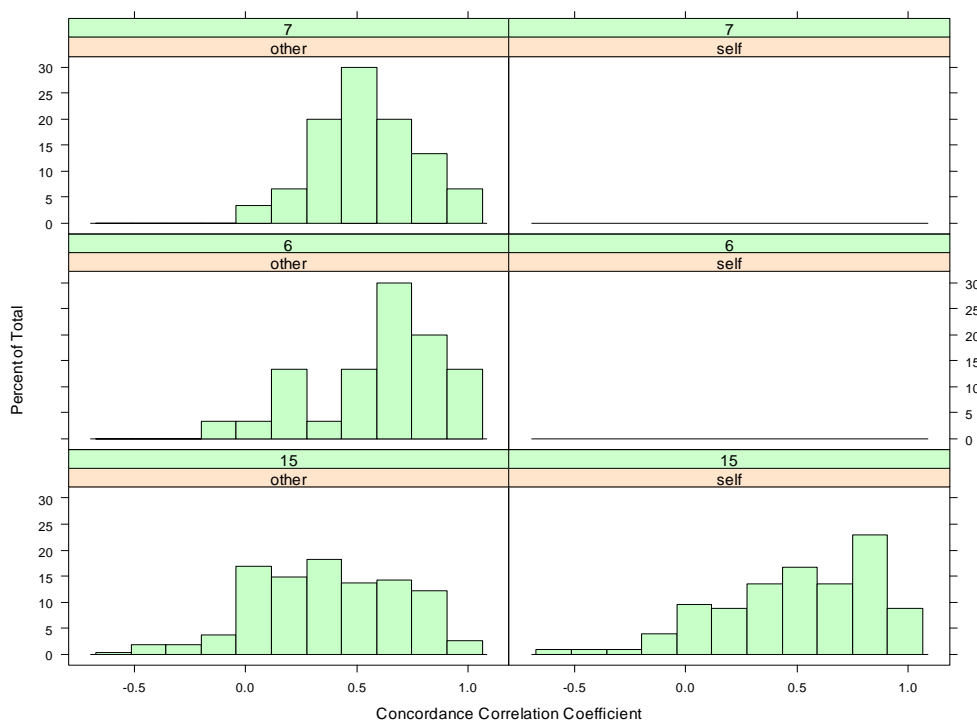


Figure 5.2: Histograms of Lin's Concordance Correlation Coefficient for each pairwise combination of recounts. "Self" is all intra-counter pairings; "other" is all inter-counter pairings.

Table 5.1. Median values of CCC by FU and inter-counter pairings ("other") or intra-counter pairings ("self").

FU	OTHER	SELF
6	0.73	
7	0.53	
15	0.37	0.55

For very low counts (i.e. <5 per minute), small differences (i.e. 1 or 2) in counting have a substantial effect upon the CCC values. Figure 5.3 shows the CCC values against the mean burrow density ( $N$  per minute), by FU and inter/intra counter pairings. Very low mean densities only occurred in FUs 6 & 7 where there are fewest pairings but there does not seem to be a systematic decline in CCC values with burrow density.

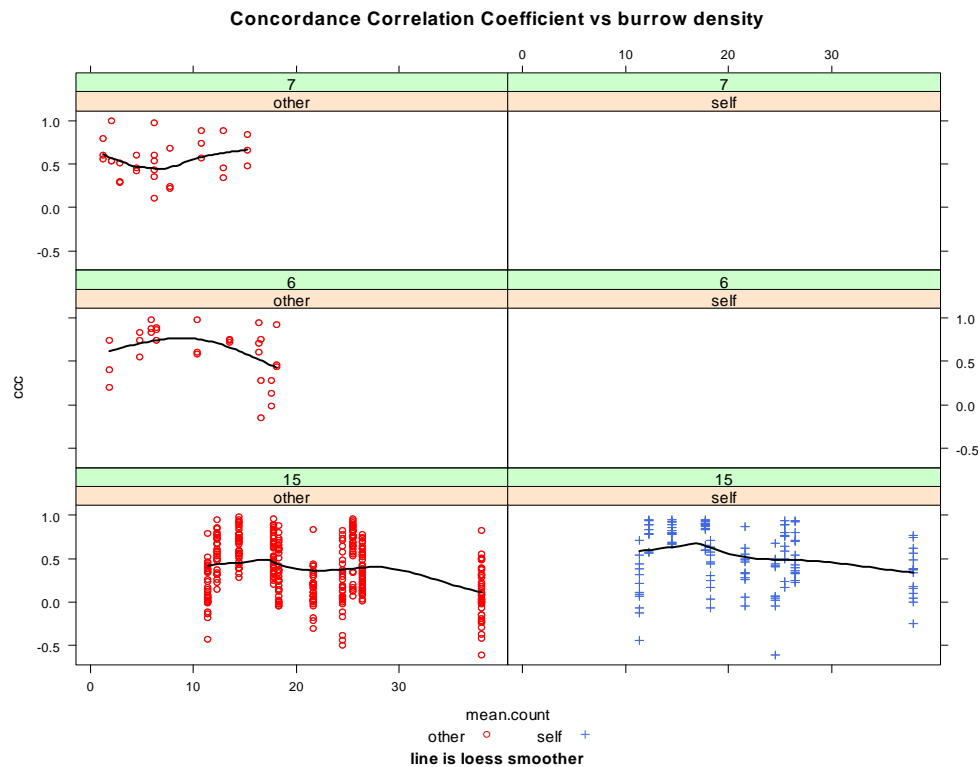


Figure 5.3: Lin's Concordance Correlation Coefficient vs. mean burrow density (N per minute) for the three Functional Units, split by inter-counter pairings ("other") and intra-counter pairings ("self").

This exercise has demonstrated that some conditions encountered on UWTV surveys pose considerable challenges to burrow counting and that even experienced counters will not reach exactly the same conclusions.

The existing criterion used for deciding when additional recounts are required per run (i.e. 10% differences between counters, or > 7 burrow count difference) may be enhanced by using the CCC scores. Further work is required to determine the effect upon uncertainty in the final abundance estimates, but using a criterion based upon CCC for the at-sea counts may reduce the number of recounts required by being less prescriptive. Visual inspection of the stations with poor CCCs should indicate whether individual minutes should be recounted or whether the whole track needs recounting. Modelling studies should be used to explore the relationship between CCC criterion, recounting probabilities and final burrow density estimates in order to find the optimum levels.

Further reference sets will be developed through the coming year, and a set for the Kattegat and Skagerrak and will be available by the end of May.

## 5.2 Determination of Calibration Coefficients

The reference counts are to be used to construct calibration coefficients for each individual counter. Each counter participating in a survey should first run through the training material and then read the reference set prior to any counting. If an individual counter reads the reference set and comes up with counts that are 10% higher than the reference counts, their calibration coefficient is 0.9 and this is then applied to their subsequent counts for the survey.

FU specific calibration coefficients are to be calculated as follows:

- 1 ) Total up the individual's burrow counts over the 5 minutes for each run.
- 2 ) Divide (1) by the corresponding reference count to produce a run-specific ratio.
- 3 ) Take the mean of (2) – this is the individual's calibration coefficient for that particular FU.

## 6 Training Existing and New Burrow Counters

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**Objectives:** Training needs for *Nephrops* television survey counters had been identified for staff from different institutes. The objective of the sessions was to familiarize novice participants with burrow type, to learn what to count and how to count using the newly developed material from different geographical areas under different tow conditions.

Training Groups consisting of novice and intermediate skilled observers were divided into groups based on geographical areas of interest.

- Irish Sea Group: low visibility, Irish Sea typical fauna and traces
- Kattegat: *Nephrops*, typical fauna and traces, good visibility
- Clear/Deep Water Group: *Nephrops* and other burrowing fauna, clearer waters more typical of deep waters

Training groups were lead through typical video sections with cycles of reviewing and counting by a highly experienced observer (expert).

### 6.1 Irish Sea Group

The group comprised of participants from Ireland (MI and AFBI) and Scotland (FRS). Footage from the Irish Sea resembles footage seen on West of Scotland grounds such as the Clyde.

Recorded video footage from the Marine Institute Irish Sea Underwater TV survey was examined. This footage was made up of recordings from a variety of survey stations, and contained stations with varying burrow density, sledge speed and visibility. It was decided to commence with “easy” footage and, as trainees became more confident, proceed on to footage of increasing difficulty (e.g. greater density, poorer visibility, etc.). Initially, footage was examined either frame-by-frame or in a stop/start fashion with an experienced counter highlighting *Nephrops* and non-*Nephrops* burrows both in real-time and on paused frames. Questions and comments were invited from the trainees on any area where they felt unsure or unconfident. Having reviewed the footage slowly with an experienced counter, the footage was replayed on a minute-by-minute basis allowing both experienced and inexperienced delegates to count the *Nephrops* burrows on-screen. After each minute, counts were compared. If there were large differences between experienced counters and inexperienced counters, the footage was replayed frame-by-frame and all participants discussed the features seen on screen.

The results/conclusions of the group were:

- Trainee confidence increased remarkably throughout the session.
- As the session progressed, trainee burrow counts became more comparable to those of experienced counters. However, decreasing visibility, higher density and faster sledge speed each had a marked effect on inter-counter variability.

- Continued difficulties were experienced in distinguishing small *Nephrops* burrows from those of other species.
- There were also continued difficulties in identifying *Nephrops* burrow complexes amongst those of other burrowing species, particularly in high density areas.
- All trainees expressed difficulties in burrow counting at “live speed”. Trainees expressed the feeling that greater confidence in their counts could be achieved by replaying difficult sections of footage at a slower speed. However, this results in more time being taken to count a station and may lead to “over-analysis” of the footage.
- It was noted that after a break of one hour for lunch, inter-counter variability increased remarkably. However, after approximately ten minutes of counting, variability had once again decreased.

## 6.2 Kattegat

The group comprised of participants from the Denmark and Sweden. The expert took the participants through a number of videos from different ground types within the area surveyed by a Danish research vessel. The videos had different densities of *Nephrops* and confounding species (other burrowers with similar traces). Visibility was uniformly good. Initially videos were reviewed for accuracy of identification of *Nephrops* and identification of confounding species. A series of counts were then carried out by the group on a cross-section of the videos representing the above-mentioned differences. Following training, there was good agreement for all but the low density grounds where small *Nephrops* were present. Here confounding species made it difficult to be sure of the identification of anything other than larger burrows. It was agreed that more ground-truthing of this area needs to take place, both by trawling at the times of peak emergence of *Nephrops* and by trawling and dredge sampling for identification of other species. The participants all found the training to be constructive having increased their accuracy and repeatability.

## 6.3 Clear/Deep Water Group

The group comprised of participants from Portugal, Spain, Greece and Ireland with grounds characterized by deeper clearer waters, with low to medium *Nephrops* density. Participants were primarily beginners, starting video assessment or with a future interest in video assessment. The training material was from the North Sea, generally characterized by lower burrower densities in clear conditions. The expert pointed out the general conditions for going through the material – what and what not to count (features) and how to count (time intervals, count-through line on the screen). Four sections of video were reviewed from the Fladen Ground and the Farn Deeps. For the first video the expert ran the material pointing out and discussing various features. Each section of video was broken down into 5 1-minute count periods. For each section:

- the group counted each 1 minute section with a short pause between minutes;
- after the 5 minutes, counts were compared (including the expert counts);
- the expert reviewed the video slowly with the participants and features seen on screen were discussed;
- the counting exercise was repeated and counts compared again.



Of the four videos, three represented good tow conditions and the fourth was of low visibility to give the participants an idea of how conditions can be unfavourable (high floc concentration in the water column). The group showed good progress from high, over-estimating, variable counts to much closer to the expert with consistency between their counts. Video 4 (poor visibility) was more problematic for the participants. The following table shows the mean percentage difference in counts between the expert and trainee counters and is indicative of the progress. For Videos 1 to 3 there was a decrease in the difference with the expert from 75% to 20-25% with a corresponding decrease in variability. The data for Video 4 was less conclusive because of the poor visibility, with the high floc content not only obscuring the seabed but also making focusing on the seabed difficult. The participants were almost all novices, progressed well, but would further benefit with extended training through the data sets, which will be made available through the workshop.

Mean and standard deviation of percentage differences of novice observers from expert observer from first and second counting runs on 4 video clips.

		VIDEO 1	VIDEO 2	VIDEO 3	VIDEO 4
<b>Run 1</b>	<b>Mean</b>	<b>75.59</b>	<b>37.16</b>	<b>35.24</b>	<b>19.32</b>
Run 1	SD	53.11	11.37	25.70	17.65
<b>Run 2</b>	<b>Mean</b>	<b>27.29</b>	<b>20.75</b>	<b>26.97</b>	<b>33.00</b>
Run 2	SD	15.46	12.84	19.19	27.96

## 7 Training manuals (ToR b)

The Group was shown a draft of the training manual being created by CEFAS. This consists of a Power-point presentation of instructions for what and how to count along with photographic guides to the identification of *Nephrops* burrows and other burrowing species likely to be encountered. Accompanying this there are a number of video clips with a written commentary detailing the burrow complexes seen and reasons for these identifications.

During discussions and presentations regarding training for workers newly engaged in working with *Nephrops* it was agreed that it would be valuable to have short clips of footage from the underwater TV surveys with some form of annotation and/or audio commentary talking the trainee through what they were seeing on screen. However as audio commentary could prove to be distracting and perhaps incapable of maintaining pace with the moving footage, annotation was the favoured option. Annotation would also have the benefit of highlighting and identifying the burrow complexes directly to the viewer on screen. With this in mind suitable methods of annotating video clips were investigated.

A free high performance video editing program (DebugMode WAX™ 2.0e) that can be downloaded from <http://www.debugmode.com/wax/> was obtained and tested for its suitability in annotating and highlighting *Nephrops* burrows. The program can read various formats, however during the course of the workshop only the Microsoft Audio Video Interleave (AVI) format was tested.

Once an AVI video clip of 1 minute of footage was loaded into the program a basic drawing function was overlaid onto the clip via the 'drag and drop' interface. An oval shape was then drawn and reshaped over a burrow complex. A 'keyframing' mode was then used which allowed the shape to be moved and reshaped, on a frame by frame basis if necessary. In most instances it was perfectly acceptable to have only

two key frames (frames with the shape in it) with over a dozen or more frames between them as a 'smooth' setting, within the 'keyframing' mode, interpolated the shape location between the two key frames to produce a shape that maintained its position in real time around the burrow complex, as it moved down the screen. This shape could then be made invisible via a checkbox and moved to another area of the screen and reshaped to cover another complex before making it visible once more and repeating the process of adding key frames as above. This was then repeated for the duration of the clip before being rendered back into an AVI file complete with all the burrows highlighted. It was noted that there was minor image degradation and slight pixelation of the rendered clip, however the end result was very encouraging and it would seem that this program is suitable for the requirements of annotating *Nephrops* underwater TV footage for the purposes of producing training material.

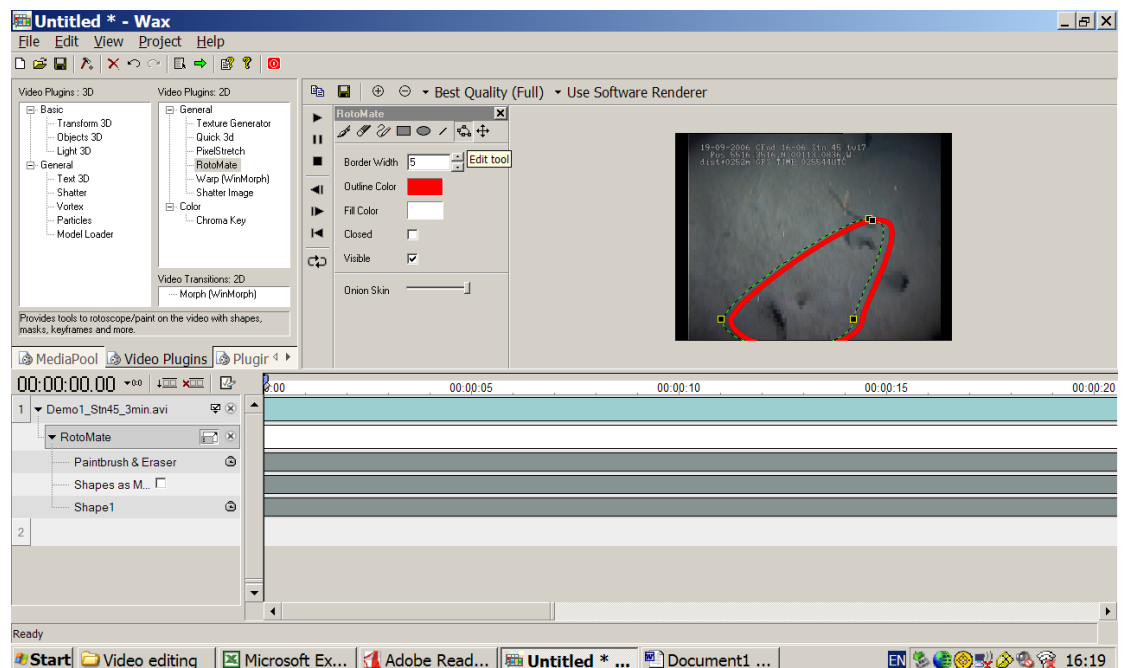


Figure 7.1: Screen shot of The WAX™ program showing a burrow complex being highlighted.

A user-guide to WAX was created during the meeting and is in Annex 6.

## 8 Common protocol

The protocols used by Ireland, Scotland, Northern Ireland and England (only countries for which UWTV surveys are routinely conducted for assessment purposes so far) for counting are largely the same. Counts are performed mostly at sea, in isolation with counts recorded in 1 minute blocks. Complete standardisation of protocols would be the ideal in terms of reducing the influence of individual subjectivity; however such changes may impact upon the absolute level of counts and therefore create a discontinuity in the time series. Most of the video footage has been retained and therefore it would be technically possible to re-do all the historic counting under a new protocol but the demands upon staff time would be utterly impractical and expensive. Where a change to a time series is inevitable due to a change in gear, improved harmonisation of counting protocols may be prudent (cross-calibration exercise).

Currently there are three differences in counting protocol:

### 1) Screen position

Burrow complexes are identified and recorded when they pass a specified line horizontal line on the screen. For Scotland and Ireland this line is the bottom of the screen, whilst for England this line is 2cm up from the bottom on a standardised 24" (24 inches on the diagonal, standard 4:3 aspect ratio) CRT monitor (make etc). The reason for this is the calibration exercise undertaken at sea for the visible track width puts the measured line at this 2cm level. With the advent of a new sledge the screen-width calibration methodology may also change and a move towards a common protocol of counting at the bottom of the screen is possible.

### 2) Monitor size

A range of monitor sizes from 14" to 24" CRT are currently used by the various laboratories, and LCD monitors are not used. Monitor displays do not always utilise all the available image and require individual setting and calibration. Small monitors tend to have a sharper image because the dots comprising the screen are closer, the disadvantage being that small burrows become more difficult to observe. Larger screens have the potential to make small burrows more visible but their image is less well defined and the distance the eyes must scan to cover the image is greater. These factors are all affected by the distance from the screen at which the viewers place themselves. No exercise has been undertaken to determine whether there is an optimum screen size and as consistency is the key then no standardisation of monitor size is recommended. Screen size may prove to be an influential factor during ring testing (see section 8) and therefore research into the effect of screen size on counting performance is recommended before any ring tests commence. Calibration data sets should include some footage of a calibration grid/measure so that the field of view on the various monitors can be adjusted correctly.

### 3) "Corner" burrows

When a burrow passes the "counting line" at the corner of the screen it is assessed to be either in or out of view based upon the main shadow of the burrow intersecting the corner. If only the delta crosses the corner then the burrow is not counted as being in view. The protocol of Scotland and Ireland states that a burrow is to be counted as in once provided that at least 50% of the burrow entrance is on-screen (50% rule). England assess the burrow to be in if any of the burrow entrance is on-screen (1% rule). The Group considered that the 50% rule was open to more subjection than then 1% rule, particularly when encountering high-densities of small burrows. Uncertainty regarding the extent of a burrow which is visible in the corner is not to be confused with uncertainty regarding whether the burrow actually passes through the corner – the counter must be certain that the burrow was visible. Exercises in determining a) whether significant differences in counts occur between the 50% and 1% rules and b) what the implication for "edge effects" might be are recommended before any decision is made.

## 9 Data Exchange and Ring Tests

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### 9.1 Ring Tests

It is proposed that formal Ring Tests are set-up between laboratories to ensure the continued harmonisation of counting standards. Such ring tests are distinct from the

use of the reference data sets. The purpose of creating and exchange reference video sets and counts is to create an index of counting performance for individual counters which is then used to standardise the counts before use in stock assessment. These reference sets and accompanying training material will be of most use to the laboratory performing the corresponding UWTV survey, but with the development of UWTV surveys in new areas these reference sets may be transferable to areas with similar visibility/species complexes. **It is proposed that each laboratory holds a complete set of reference sets and therefore as each new reference set is generated it is distributed to the *Nephrops* coordinator at each laboratory.**

Ring Tests are proposed to effect greater harmonisation of counting standards between the laboratories (thus hopefully reducing the potential for creep in individual's calibration measures). Given the high level of variability in terms of visibility and species complexes between the various sea areas, the Group proposes to have 4 separate Ring Test groups, allocated according to their characteristics (depths, burrows characteristics, species composition...). The following areas were considered:

- 1 ) Irish Sea and West of Scotland;
- 2 ) North Sea, and Aran Grounds;
- 3 ) Kattegat, Skagerrak and Celtic Sea;
- 4 ) deep, clear water grounds (Rockall shelf-edge, Spain, Portugal, Greece and Italy).

The format of each Ring Test would be that the countries involved in each area would exchange video footage to comprise 10 sections of 5 minutes, covering a range of visibility, *Nephrops* density and species complexity and tests should be coordinated every three years.

The Group proposes that the first Ring Test will take place in the 4<sup>th</sup> quarter of 2009 for groups 1 and 2. A coordinator would be identified at the nearest Assessment Working Group/*Nephrops* study group meeting whose task would be to ensure effective exchange of ring test video sets, ensuring the relevant training manual was available to all parties and to collate the resulting data. The decision as to whether a formal re-training meeting is required would be taken after analysis of the data is complete.

## 9.2 Data exchange

As the usage of the reference sets and training sets develops it is desirable to analyse the effects of training upon counting performance across all areas. To this effect it is proposed that an exchange of counts is initiated. The purpose of these shared data is solely for the analysis of relative counting performance and the data would remain the property of the contributing laboratory.

The exchange format is flat format text files with column headings. Two files are required, one specifying the station details, the other specifying the counts made for each minute of each station by each recorder. A third file may also be created where data allow giving supplementary information regarding the length of time the seabed is visible (per minute), the presence or absence of trawl marks, presence or absence of other burrowing organisms and additional comments.

### Count file

FU, CRUISE, DATE\_READ, TIME\_READ, STATION, COUNTER\_CODE, MINUTE, COUNT

**Station file – by minute**

FU, CRUISE, LAT, LON, DATE\_TOW, TIME, DISTANCE\_COVERED, FIELD\_OF\_VIEW

**Supplementary file**

FU, CRUISE, STATION, MINUTE, VISIBLE\_TIME, TRAWL\_MARKS, OTHER\_BURROWS, COMMENTS.

## 10 Tow Quality

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Measures of tow quality currently in use are simple qualitative statements (i.e. “poor”, “good” etc) made by individual counters. These perceptions of quality are based on a composite of the visibility and/or technical issues and are subject to both inter-personal differences and temporal trends introduced by consecutive low/high visibility tows.

Objective measures of tow quality in terms of turbidity and lifting/sinking of the sledge are relatively easily addressed through the addition of a turbidity sensor and altimeter to the sledge. Scotland use an altimeter as a standard piece of equipment on each tow and England has recently tested the utility of two turbidity sensors. Ireland has also tested turbidity sensor on the Aran 2007 survey. There are, of course increasing technical difficulties with the addition of each new piece of equipment. Self-powering and logging devices make no additional demands upon the power/data bandwidth of the towing umbilical but require regular downloading and re-powering on deck and are subject to total data loss in the event of a failure. Attachment of additional equipment can also affect the performance of the sledge; marine sensors are often heavy and bulky resulting in increased sinking and increasing the complexity of deployment.

The speed (absolute and variance thereof) and distance covered during a tow also contribute to tow quality. Fast ground speeds makes reading the tow more difficult particularly in low-visibility and/or high density areas and the resolution of the cameras currently used is such that slowing down the replay speed does not help. The effect of higher tow-speeds will not be uniform across all runs, those with good visibility, low *Nephrops* density and few burrowing species can take a higher tow speed with no loss of counting and therefore an objective measure remains somewhat arbitrary. The use of slow-motion (high-frame rate) cameras would help resolve such resolution problems as the users could replay at slow speed without losing resolution, indeed slow-motion cameras may be of more utility than high-definition (high pixel-density) cameras for UWTV surveys. Variation in sledge speed i.e. stop/start motions cause problems with visibility in that the sledge often creates a cloud of sediment when it stops and it can then be difficult to tell exactly when the sledge has started moving again. The coefficient of variation (CV) of sledge speed could be determined through the use of a flow-metre on the sledge (assuming that tidal currents did not significantly change during the tow). Data presented to WKNEPHTV showed that mean and variance per tow had generally stabilised after around 5 minutes, therefore provided that the sledge has covered at least half the required distance within the full 10 minutes of the run, variation in the distance covered should not significantly affect the result. Reducing the variability of distance covered per run could be effected by changing the recording protocol from one of fixed time to fixed distance as measured by either a odometer wheel (Scottish sledge) or DGPS dynamic positioning (English sledge).

One component of tow quality and uncertainty also considered was that of species misidentification. In areas where the visibility is good and the most abundant

burrowing species is *Nephrops*, errors of burrow identification are likely to be low. As the species complexity increases and the density of all burrows increases then the potential for misidentification increases. One potential metric of quantifying the likelihood for misidentification would be the ratio of *Nephrops* burrow entrances to total number of burrow entrances. The reality of creating such an index would be a daunting task, especially in areas such as the Irish Sea where the ground is riddled with burrow entrances (so called “Swiss Cheese” or “cheesy” ground. Visually counting all burrow entrances in this environment would swallow huge resources in terms of personnel hours and is therefore completely impractical. It may however be possible to modify the burrow identification software developed in Portugal (see section 3) to count all burrow entrances, potentially also discriminating small/large entrances. This would still leave an unresolved issue of the number of *Nephrops* burrow entrances as opposed to the number of burrow complexes (the recorded metric), but as a first step the Group recommends that this approach is tested for feasibility.

Further field work is still required to reduce the uncertainty regarding the species identification of burrows, particularly those burrows likely to be confused with those of small *Nephrops*. Given the depths of most of the *Nephrops* grounds this will need to be undertaken using either traditional gears (dredge/beam trawls) or more innovative use of landers/ROVs.

## 11 Recommendations

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Underwater TV surveys for *Nephrops* are gaining momentum and rapidly becoming the standard tool for direct stock assessment of these internationally exploited stocks. It would also appear that UWTV surveys are destined to be covered under the umbrella of the EU Data Collection Regulations (DCR) which require that such activities be internationally coordinated. The Group therefore recommends that ICES should set up a formal and permanent group to oversee the coordination and continued standardisation of these surveys.

This Group has made strong advances in the standardisation of counting protocols and the training of counters but there remain other areas of uncertainty which require dedicated investigation. Edge-effects, that is the counting of burrows which lie mostly beyond the directly observed track, are a significant source of both bias and uncertainty. Earlier work (Marrs *et al.* 1996, Smith *et al.* 2003, Morello *et al.* 2007) and modelling simulation exercises (ICES 2000, ICES 2007, Cambell *et al.* 2008 in prep) have demonstrated their potential magnitude but the Group recommends that a work be undertaken to directly estimate their influence, preferably before the proposed *Nephrops* Benchmark group meets.

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## Annex 2: Agenda

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### Monday

- 13:00–13:20 Set-up, introductions Ewen Bell, CEFAS, chair WKNEPHBID, Richard Briggs, AFBI, local host
- 14:00–17:00 Presentations
- Annika Mitchell, FAFB, AFBI  
 Paulo Fonseca, INRB-IPIMAR  
 Matt Service, FAFB, AFBI  
 Jim Atkinson, UMBSM  
 discussion of general counting protocol,  
 benthos,  
 format of record sheets  
 training manual format etc.

### Tuesday

- 09:00–11:00 Irish Video, Jennifer Doyle, Marine Institute
- 14:00–16:00 English Video, Jon Elson, CEFAS
- 16:00 Kattegat Video, Bo Andersen, DIFRES

### Wednesday

- 09:00–11:00 Scottish Video, Adrian Weetman, FRS Aberdeen
- 13:30–17:00 Production of Training Material
- 13:30 – 17:00 *Generate the baseline calibration counts (Jennifer, Adrian & Jon)*
- 17:30 Reception with Minister

### Thursday

- 09:00–12:30 Continuation of training material production
- 09:00–12:30 Calibration system trials
- 13:00–17:30 Report writing

### Friday

- 09:00–13:00 Report adoption

### Annex 3: WKNEPHBID terms of reference for the next meeting

This workshop was proposed as a one-off meeting and no further meetings are proposed before the proposed *Nephrops* Benchmark group meets.

### Annex 4: Recommendations

RECOMMENDATION	ACTION
The Group recommends that a permanent formal body be set-up to coordinate development of the various UWTV surveys for <i>Nephrops</i> similar to that for trawl surveys. This body could be the driving force for addressing the uncertainties listed in WKNEPHTV (2007) section 6.10, overall uncertainty table.	ICES/Resource Management Committee/Living Resources Committee
The Group recommends that a group is convened to specifically address edge effects in burrow density estimation (as detailed in WKNEPHTV (2007) section 6.10, overall uncertainty table.	ICES ACOM
Each national laboratory to produce a set of reference counts for their survey areas.	<i>Nephrops</i> experts within each laboratory
Each national laboratory holds a complete set of reference sets and therefore as each new reference set is generated it is distributed to the <i>Nephrops</i> coordinator at each laboratory.	<i>Nephrops</i> experts within each laboratory
Each national laboratory to develop a training manual for their surveys areas using such software identification packages as DebugMode WAX™ 2.0e.	<i>Nephrops</i> experts within each laboratory
Each national laboratory to produce a SOP – common protocol for counting taking into account the equipment systems used.	<i>Nephrops</i> experts within each laboratory
The Group proposes that the first Ring Test will take place in the 4th quarter of 2009 for groups 1 and 2. A coordinator would be identified at the nearest Assessment Working Group/ <i>Nephrops</i> study group meeting whose task would be to ensure effective exchange of ring test video sets, ensuring the relevant training manual was available to all parties and to collate the resulting data.	<i>Nephrops</i> experts within each laboratory
Each national laboratory investigate measures to quantify tow quality such as Turbidity meters.	<i>Nephrops</i> experts within each laboratory
The Group proposes that the burrow identification software developed in Portugal should be tested to count all burrow entrances, potentially also discriminating small/large entrances.	Paulo Fonesca, IPIMAR in conjunction with <i>Nephrops</i> experts within each laboratory

## **Annex 5: Criteria for burrow recognition and burrow identification key**

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The key which follows is a revision of that in Marrs et al. (1996) and uses surface features to identify the originator of a given burrow observed using UWTV, where possible to species level. This may be relatively straightforward; some burrows have species-specific features which, if visible, make their identity unmistakable. Fortunately, the larger *Nephrops* burrows are within this category. Often, however, the situation is more difficult, particularly when the overall burrow density is high, several burrow-dwelling species are common on the ground, and some of these have burrows that can be confused with those of smaller *Nephrops*. The burrows of a range of species are described in Marrs et al. (1996).

With experience, the observer is able to recognize the burrows of many species with a fair degree of confidence. There will, however, always be areas of uncertainty, for example, burrows which do not fully conform to the expectation for a given species, burrow recognition features which are disrupted by the passage of fishing gear, a high burrow density making it difficult to differentiate between adjacent burrows, etc. For some burrows, the features which are species-specific are only seen in a proportion of the burrows of that species, for example, a particular type of excavation or feeding trace which is only visible after recent burrow maintenance or feeding activity. For other burrows, the configuration of openings may suggest a genus, but further information is needed before identification can be taken further.

Ground-truthing by various methods will improve accuracy of burrow recognition. These include:

- 1) Identification of species seen to be associated with burrows when using UWTV.
- 2) Examination of trawl catches from the area, identifying those species which are known from the literature to be facultative or obligate burrowers.
- 3) Examination of the burrowing fauna taken from the area by grab, box core, anchor dredge or hydraulic dredge.
- 4) Investigation of faunal records for area, noting burrow-dwelling species.
- 5) Consideration of grain size preference, geographical and depth range information for given species as indicated in the literature.
- 6) In those few cases where it is possible, direct observation by SCUBA diving. The diver is able to discriminate a level of detail beyond that possible from analysis of videotape. Further techniques available to the diver are suction sampling and resin casting. The former may extract the burrower, the latter enable detailed description of the burrow and accurate identification of the burrower (either from burrow structure or entrapment in the resin). Large burrows may be probed by hand and the occupant extracted.

The following key to burrow recognition using surface features visible at the scale of UWTV observation is therefore intended as a guide. With faunal or floral identification, accurate identification is virtually assured if the specimen is under direct examination. It is often much more difficult if a species is sighted but not captured. It is the same for burrows: with a resin cast of the burrow under

examination, identification is relatively straightforward; identification by observation of burrow surface features alone is, in many cases, difficult and sometimes impossible. The key is a reasonable working tool which can be updated and refined as more information on burrow morphology is acquired.

The key includes burrowers from a wide range of particulate substrata (sands, muddy sands, sandy muds, muds, muddy gravel), from the eulittoral of beaches and lagoons to deep water in the Mediterranean and coastal NE Atlantic. Some of the species included do not occur on *Nephrops* grounds, others occur there only rarely. *Nephrops*, however, has a wide depth distribution (4-800m) and constructs burrows in muddy sands, sandy muds and muds. The depth and substratum preferences of many of the species listed in the key are not well defined and vary geographically. Thus, for many species, overlap with *Nephrops* on some grounds and in some areas cannot be excluded on the basis of perceived habitat preferences. Thus, in the central Adriatic, the *Squilla* mantis grounds are principally on inshore muddy sands and the *Nephrops* grounds are further offshore on soft muds. There is, however, a zone of sandy mud between these grounds where both species occur. Therefore, substratum type has not been used as a dichotomous character in the key. The key does, however, include notes on substratum preference (based on habitat records in literature and personal observations).

Because many burrow-dwelling species are found both in the NE Atlantic and Mediterranean, geographical range has not been used as a dichotomous character. The key does, however, include notes on geographical range. Water depth is given in general terms only, since for many species there is a paucity of data and since there appears to be wide geographical variation for some species.

The diameter of burrow openings has been used as a dividing character in the key. This also should be used with some caution, as with the distance between openings of a given burrow, since these features will vary with the size/age of the burrower. Whether the burrow is vertical or oblique/horizontal is a useful dividing character. This difference can be determined from UWTV, even when the camera is mounted to give an oblique forwards view. Some care has to be exercised, however, since for several species, some openings are of vertical shafts while others in the same system are the openings of oblique tunnels.

Whether or not the openings of a given burrow form a characteristic cluster is also a useful criterion. Again, there will usually be some members of the population whose burrows do not conform to the usual pattern, perhaps because of the stage of burrow development, or because of collapse of some openings, etc., so some care has to be exercised when interpreting burrow clusters. The shape of openings is also instructive, as is the presence of tracks and trails, pellets or mounds of ejecta, excavatory scours and feeding traces (e.g. proboscis marks) - features which betray the identity of the occupant.

Some burrows are identified by more than one route in the key, e.g. callianassids and echinurans, since several, differently-keyed characteristics are diagnostic.

Some species occupy burrows constructed by others, e.g. various polychaetes, bivalves, shrimps, squat lobsters and fish. These may co-exist with the burrow-constructing species (endoecism) or may occupy burrows that have been vacated by the original occupant. Also complex burrows arise from the interconnected burrows of several species. All of this adds to interpretational complexity.

Marrs et al. (1996) was made available to all WKNEPHBID participants, together with a PowerPoint presentation of burrow characteristics and burrowing species.

**Recognition and enumeration of *Nephrops* burrows as evidenced from surface features**

- 1) At least one burrow opening is usually distinctly crescentic in shape. Where the angle of view permits sight of the tunnel beyond this opening, the angle of descent is usually shallow.
- 2) There is often evidence of expelled sediment, usually in a broad delta-like 'fan' at the burrow opening, and scrapes and tracks made by the chelipeds and pereopods are often apparent. These features and a clean, uncollapsed burrow opening suggests current occupancy (collapsed or partially collapsed burrows are unlikely to be occupied and should be ignored). However, beware if there has been recent passage of a trawl – displaced sediment may have spilled into occupied burrows and may yet to be cleared by the occupant. An occupied burrow may have both collapsed and functional openings.
- 3) Secondary openings may be similarly crescentic but are often more circular and with a steeper connecting tunnel/shaft.
- 4) Look for clusters of openings that appear to be related (i.e. interconnected) and count these as individual burrows (= burrow systems). Simple burrows are linear. More complex burrows are T-shaped with three openings and may be further elaborated. Look for configurations of openings that appear to converge on a central region. Openings/tunnels that are orientated in a different direction are likely to belong to a separate burrow.
- 5) Some burrow systems are complex conjunctions of the tunnels of an adult and one or more juveniles. Such burrows should be counted as a single burrow.
- 6) Burrows may have different morphologies on grounds that have different characteristics (sediment type, density of *Nephrops* and other burrowers, depth, area, etc.). For example, on some deep Aegean grounds *Nephrops* burrows appear to be more complex than on shallower Mediterranean grounds. Also, in soft sediments burrows often appear to make steeper angles with the plane of the sediment surface than burrows from coarse grounds. Grounds where hydrographic conditions concentrate larvae/postlarvae are often characterised by small *Nephrops* at high density amongst a high density of burrows of other species such as *Calocaris macandreae*: the type of sediment present in such areas depends on local hydrography and differs geographically. Burrow openings on recently trawled grounds may appear atypical. Get your eye in for the characteristics of *Nephrops* burrows on the ground being counted. Take particular care on high density grounds and in conditions of poor visibility.
- 7) For a given ground, get familiar with the burrows of species that can be confused with those of *Nephrops* so that misallocation errors are reduced. Where possible, on difficult grounds it useful to observe the ground at the time of peak emergence of *Nephrops*. This will improve confidence in correct allocation of burrow identity. Unfortunately, some of the species

whose burrows may be confused with those of *Nephrops* rarely or never emerge under normal conditions.

- 8) On high density grounds several *Nephrops* burrows are often visible at the same time: take care to differentiate between them by considering directions of tunnels, sizes and shapes of openings, etc.
- 9) Some grounds are characterised by burrows of very small *Nephrops*. If these animals are smaller than those caught in the fishery, or used for biomass determinations, should they be enumerated?

Make use of training material and regularly check performance.

#### Key to identity of sea bed burrows in NE Atlantic and Mediterranean waters using surface features

- |   |   |
|---|---|
| 1. Burrow opening(s) < 5mm in diameter.   | probably macrofaunal polychaetes, etc: not covered in key |
| Burrow opening(s) > 5mm in diameter.  | 2   |
| <hr/>   |   |
| 2. Burrow descending vertically or near vertically.   | 3   |
| Burrow descending at shallow angle, becoming near-horizontal.   | 20  |
| <hr/>   |   |
| 3. Surface opening(s) > 2cm in diameter.  | 4   |
| Surface opening(s) < 2cm in diameter.   | 6   |
| <hr/>   |   |
| 4. Large opening (up to 20cm at plane of mud surface) to deep (up to 1m) shaft; sometimes an oblique side tunnel opening to surface adjacent to shaft; smaller burrows of other species may surround shaft and connect with it; usually a conspicuous mound of excavated sediment at shaft opening. In muddy sediments (either fine or coarse) over wide depth range in NE Atlantic & Mediterranean | <i>Cepola rubescens</i>                                   |
| Burrow with one or two openings, without conspicuous mound(s) of excavated sediment at opening(s)   | 5   |
| <hr/>   |   |
| 5. Either a single circular opening to a burrow which is often dilated just below plane of sediment surface (this is usually the modified burrow of another species), or two equal-sized, circular openings at either end of a steep U-shaped burrow (may also be the modified burrow of another species). Inshore muddy substrata in NE Atlantic & Mediterranean                                   | <i>Gobius niger</i>                                       |
| Burrow with two circular openings (which may be up to 1m apart and 50mm or more in diameter), one of which is larger than the other. Mediterranean, in muddy sands and sandy muds.  | <i>Squilla mantis</i>                                     |
- NB: There are a number of other burrow-dwelling stomatopods in NE Atlantic and Mediterranean waters, some occurring on deep muddy grounds. All are smaller than *S. mantis*: little is known of their burrows but they may well be similar to those of *S. mantis* in structure, though smaller.

6.	Only one burrow opening apparent	7
	Clearly more than one burrow opening	11
7.	No obvious burrow lining.	8
	Obvious lining, i.e. a dwelling tube.	cerianthid or polychaete
8.	No burrow-associated trace visible on sediment surface; burrow not in mound.	identity unconfirmed
	Burrow-associated trace visible on sediment surface and/or burrow opening at apex of mound.	9
9.	Burrow in apex of mound of sediment ejecta.	10
	Spoke-like traces, either spatulate in shape, or bifid distally, extending from burrow; may radiate through 360°; usually in flat sediment, occasionally associated with mounds.	echiuran
<p>NB: The proboscides responsible for the traces may be seen and aid identification, e.g.</p> <p><i>Maxmuelleria lankesteri</i> (NE Atlantic) - large, green, spatulate proboscis</p> <p><i>Maxmuelleria gigas</i> (Mediterranean) - large, greenish-grey, spatulate proboscis</p> <p><i>Bonellia viridis</i> (NE Atlantic &amp; Mediterranean) - large, green, bifid proboscis</p> <p><i>Bonellia minor</i> (Mediterranean, possibly global) - small, green, bifid proboscis</p> <p><i>Amalosoma eddystonense</i> (NE Atlantic) - large greenish-grey bifid proboscis</p> <p><i>Thalassema thalasseum</i> (NE Atlantic &amp; Med.) - small, pink or cream, undivided, very extensible proboscis</p> <p><i>Maxmuelleria</i> spp. appear to be confined to fine sediments; the other species are reported from both fine and coarse sediments.</p> <p>There are other species recorded for the area, e.g. several <i>Maxmuelleria</i> spp. about which little is known. There are almost certainly new species awaiting description - <i>Ochetostoma azoricum</i> (large, olive green, spatulate proboscis) was first described from the Azores in 1996. Its burrows are similar to those of <i>M. lankesteri</i>. See also 10.</p>		
10.	Small (usually < 10cm diameter) mound; sediment often reduced (grey); hole at apex of mound often blocked.	possible exhalant shaft of callianassid (see 18)
	Large (> 10cm diameter, often >30cm) mound; sediment reduced only in areas of most recent ejecta	possible exhalant shaft of echiurans – <i>Maxmuelleria lankesteri</i> (NE Atlantic), <i>M. gigas</i> (Mediterranean) or <i>Thalassema thalasseum</i> (both areas) - smaller mound than <i>Maxmuelleria</i> spp., often granular (faecal pellets)



NB: Little is known of echiuran burrow morphologies. Most have two openings, but these may be widely spaced and the connection between them is not apparent. See also 9.

11. Closely-spaced (< 5cm) paired openings.	bivalve siphon holes e.g. <i>Thracia convexa</i> , <i>Solecurtus</i> spp.
Openings not in closely-spaced pairs.	12
12. Openings (3 or more) grouped into discrete clusters or loosely paired.	13
Openings not grouped into discrete clusters.	19
13. Some or all openings narrowed to form chimneys and therefore small and often inconspicuous; often 2 or 3 openings per burrow, but can be more.	upogebiids
<ul style="list-style-type: none"> <li>• <i>Upogebia stellata</i> (eulittoral &amp; sublittoral muddy sediments; NE Atlantic &amp; Mediterranean)</li> <li>• <i>Upogebia deltaura</i> (NE Atlantic - usually coarse sediments with admixture of mud; Mediterranean - deep water muds, but there is evidence that the Mediterranean entity is a different species)</li> <li>• <i>Upogebia pusilla</i> (eulittoral and shallow sublittoral, muds &amp; muddy sands; often lagoonal; NE Atlantic &amp; Mediterranean)</li> <li>• <i>Upogebia tipica</i> (shallow sublittoral; muddy sands; Mediterranean)</li> <li>• <i>Upogebia mediterranea</i> (shallow sublittoral, in coarse sediment beside <i>Posidonia</i> beds; Mediterranean)</li> <li>• <i>Gebiacantha talismani</i> (deep water muds; Mediterranean)</li> <li>• Burrow descriptions are more detailed for some species than others.</li> </ul>	
Burrow openings are not narrowed to form chimneys and therefore conspicuous; usually more than three openings per burrow.	14
14. Openings wider than long (slit-like); may be very numerous; northern N Atlantic	<i>Maera loveni</i>
Openings circular in cross section.	15
15. Openings often in threes or multiples of three; sublittoral muds, wide depth range; NE Atlantic and Mediterranean.	<i>Calocaris macandreae</i>
Openings may be paired or occur in clusters, but without a regular pattern of threes.	16
16. Obvious lining present, usually projecting above sediment plane; a 2-opening dwelling tube.	<i>Chaetopterus variopedatus</i>
No obvious lining present.	17

17. Ring of openings (usually 4-7) in a shallow depression, around a central cone with a hole at its apex; occur in pairs, each ca 20cm in diameter. Inshore muddy sands, sandy muds and muds, NE Atlantic & Mediterranean. Another similar burrow seen in deep Mediterranean waters consists of a single ring of ca 10 holes without a central cone or hole burrower identities
- unknown; possibly enteropneusts
- Openings do not form a ring.
- 18
- 
18. Burrow, in muddy sediments, over wide depth range, consists of one or more deep inhalant shafts (up to 2cm in diameter), often with funnel-like openings, associated with one or more small mounds marking the sites of exhalant shafts. These mounds may have an apical hole, but this is often blocked by loose, pelletized sediment. Burrows in sandy muds and muddy sands have more inhalant shafts than in soft muds. NE Atlantic and Mediterranean.
- Callianassa subterranea*
- Burrow, usually in sandy sediments and shallow water, consists of several narrow (< 1cm), inhalant and exhalant shafts, the former may have funnel-like openings, the latter may be set in mounds, but in a high energy environment these features may be obscured by wave and current action. Dramatic mound and valley topography may occur in low energy environments. Burrows may occur at high density.
- other callianassids
- *Callianassa tyrrhena* (eulittoral & shallow sublittoral; NE Atlantic & Med.)
  - *Callianassa truncata* (shallow sublittoral; Mediterranean)
  - *Callianassa candida* (shallow sublittoral; Mediterranean)
  - *Callianassa acanthura* (shallow sublittoral; Mediterranean)
  - *Calliax punica* (shallow sublittoral; Mediterranean)
  - *Calliax lobata* (known only from sublittoral canyon type locality; Med.)
  - *Gourretia denticulata* (probably coarse grounds, habitat uncertain; Med.)
  - Little is known of the burrow morphologies of most of these species.
- 
19. Burrow consists of two, widely-spaced (sometimes > 1m) holes, one in a large mound and the other (which may have spatulate traces radiating from it) in flat sediment; relationship between holes difficult to determine.
- Maxmuelleria lankesteri*  
(NE Atlantic) or *M. gigas*  
(Mediterranean)
- NB: *Thalassema thalasseum* may have a similar burrow morphology in some sediments, but there is little information. The animal is much smaller than *Maxmuelleria* spp. and the burrow features are correspondingly smaller. NE Atlantic and Mediterranean.**
- Various-spaced holes in sediment for which interconnections may be inferred by their configuration or by observation of sediment plumes displaced by water currents within burrow (e.g. by diver or by passage of TV sledge).
- various burrows whose occupants have yet to be determined.
-

20. Distance between connected main openings usually > 50cm	21
Distance between connected main openings usually < 50cm	23
<hr/>	
21. Crescentic, often large (> 10cm diameter) openings (commonly 2 or 3, sometimes more); spoil heaps around some or all of openings; tracks, if visible, include elongate (claw marks) and styliform (footprints) indentations radiating from burrow openings. In muds, sandy muds and muddy sands; wide depth range, NE Atlantic & Mediterranean. Crescentic openings, usually < 5cm diameter; either curved scrapes or crenate ejecta mounds at one or more openings.	<i>Nephrops norvegicus</i>  22
<hr/>	
22. Distinctive, curved scrapes at one or more burrow openings; commonly 2 or 3 burrow openings, but may be numerous; no closed (backfilled) openings. Muds, sandy muds and muddy sands: wide depth range; NE Atlantic & Mediterranean.	<i>Goneplax rhomboide</i>
<p>NB: Other crabs construct burrows in appropriate environments, e.g. <i>Carcinus maenas</i> (NE Atlantic inshore muds when no other cover present), <i>Monodaeus couchi</i> (sublittoral muds when no other cover present, including deep water muds in the Mediterranean; also occurs in NE Atlantic), <i>Brachynotus gemmellari</i> (inshore muddy sands; Mediterranean). <i>Geryon trispinosus</i> (=G. tridens) constructs large burrows in deep water muddy sediments: there is a large elongate scour at the burrow opening. Little is known about burrow structure, but most appear to be simple, shallowly-shelving tunnels with a single opening.</p> <p>Distinctive crenate ejecta mounds beside one or more burrow openings (which may be numerous); at least two openings per burrow are open, others are closed (backfilled) - a distinctive diagnostic feature; some openings are of obliquely descending tunnels, others are of vertical shafts. In muds (usually fine-grained) over wide depth range; NE Atlantic &amp; Mediterranean</p>	
<hr/>	
23. Distance between burrow's main openings usually 30-50cm.	24
Distance between burrow's main openings usually < 30cm	26
<hr/>	
24. Burrow usually has 2 or 3 openings, sometimes more; openings usually small and crescentic, sometimes with elongate depression beside opening; tunnel junctions at 60o - may be deduced from angle of tunnels at openings. Usually fine mud grounds; northern N Atlantic	<i>Lumpenus lampretaeformis</i>
Simple burrow (apparently), probably with two openings.	25

25. Small (<3cm) openings; in fine mud substrata;  
NE Atlantic & Mediterranean

possibly *Myxine*  
*Glutinosus*

Relatively large (> 3cm) openings.

Possibly *Gaidropsarus*  
*biscayensis* (= *Antonogadus*  
*megalogynodon*) or  
*Ophidion* spp.  
Mediterranean)

**NB: A number of elongate fish are implicated as facultative or obligate burrowers. Almost nothing is known of their burrows or burrowing behaviour. At the present state of knowledge, it is impossible to identify such burrows by surface features alone. It is necessary to see the fish entering, leaving or within a burrow opening. Even then, care has to be exercised since the burrow may be that of another species.**

- 
26. Burrow usually has 2 or 3 openings, either  
crescentic or circular in appearance; may be  
small pellets of ejected sediment at one or  
more openings. In mud, sandy mud & muddy  
sand; NE Atlantic & Mediterranean.

*Lesueurigobius friesii*

**NB: other small fish, e.g. *Enchelyopus cimbrius* (N Atlantic), may produce burrows of similar structure, but very little is known about them (there is some information for NW Atlantic specimens but they occur on different grounds) –NE Atlantic *E. cimbrius* is often seen in hollows in the mud and some have been observed to swim into burrows when disturbed. Presumably burrow size will vary with fish size. *Zosterisessor* (= *Gobius*) *ophiocephalus* constructs burrows in Mediterranean lagoons, amongst *Zostera*, but does not occur on *Nephtrops* grounds.**

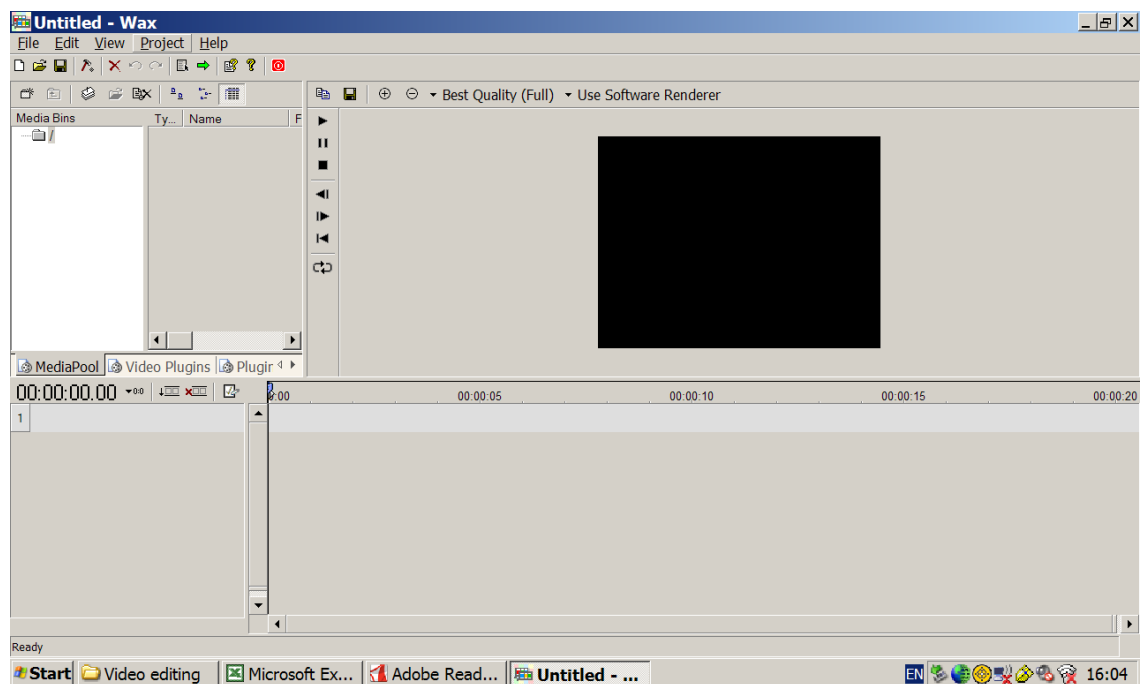
Burrow often with 2 or 3 small openings,  
sometimes more, crescentic or circular in  
appearance; elongate scours may be visible  
at one or more openings, also small spoil heaps.

*Alpheus glaber*

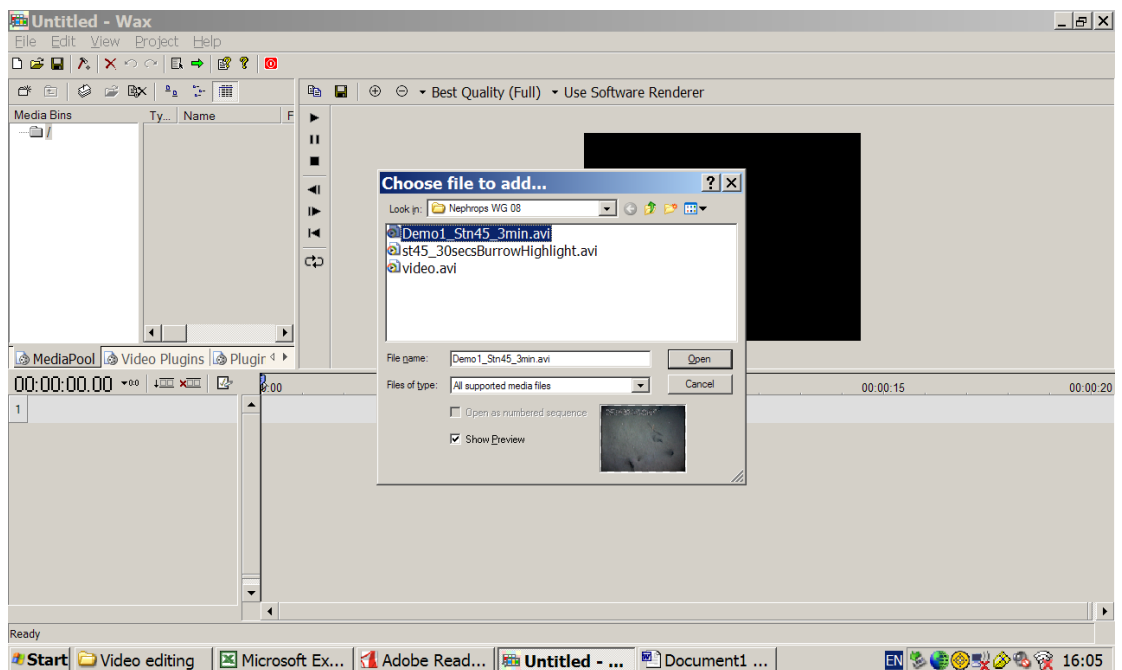
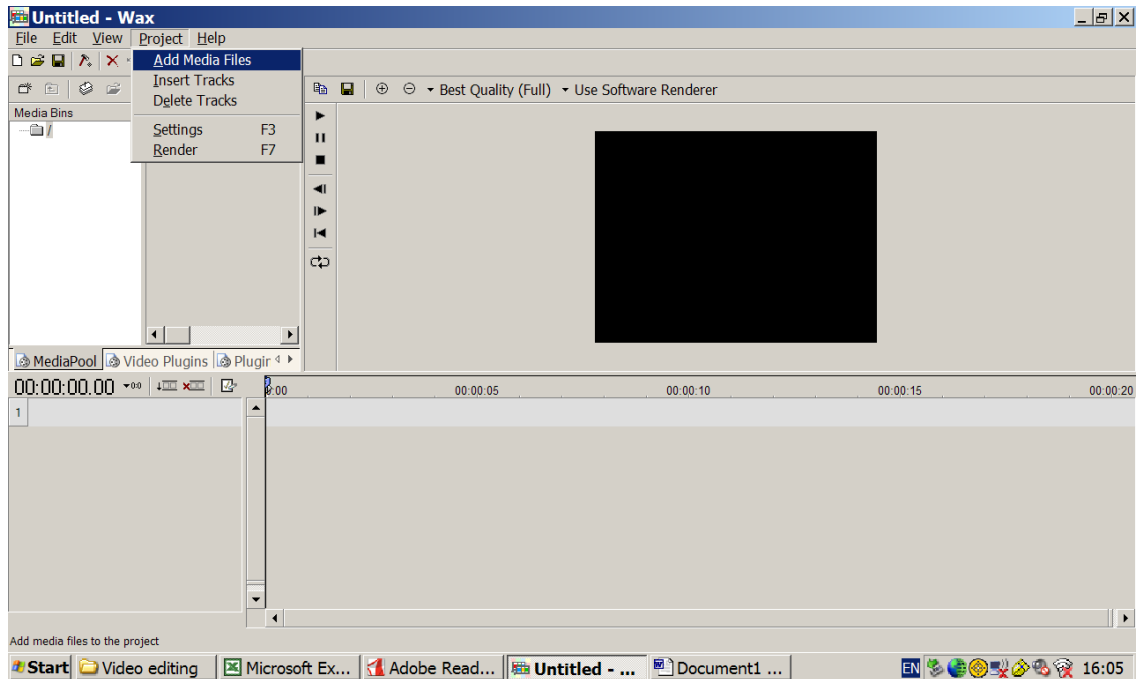
**NB: Other Caridea may construct similar burrows: there is little information at present. Some carideans cohabit in the burrows of other species, e.g. *Processa novaei holthuisi* in the burrows of *Callinassa subterranea* and *Maxmuelleria lankesteri* and *Athanas amazone* in the burrows of *Squilla mantis*.**

## **Annex 6: User Guide for using DebugMode Wax™ 2.0e to annotate Nephrops UWTv footage.**

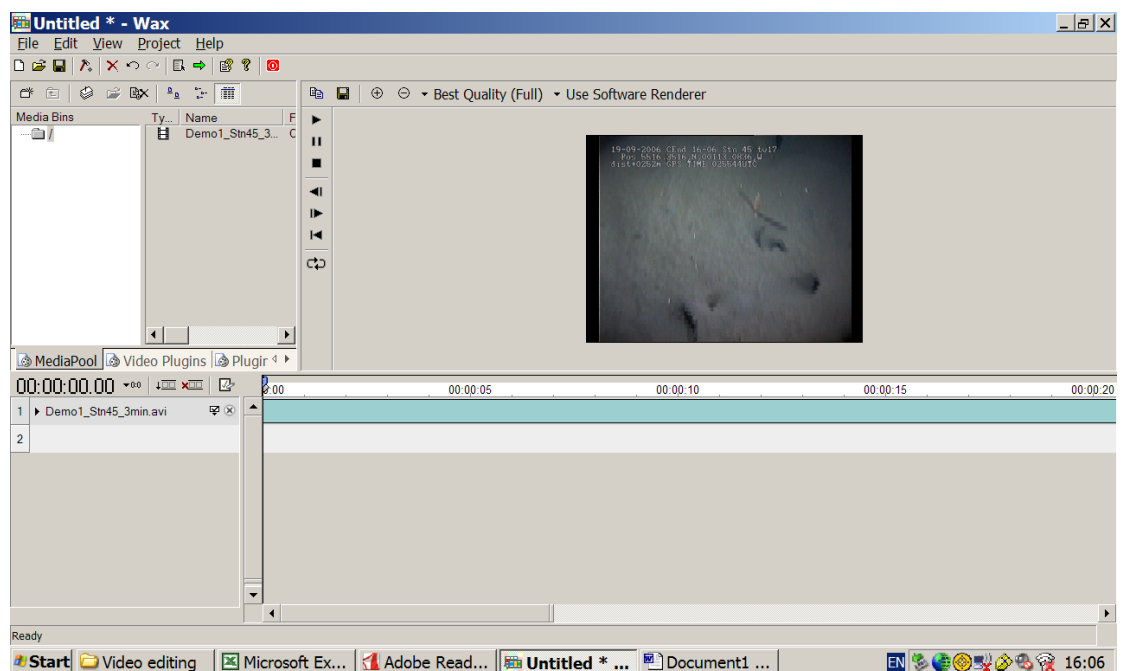
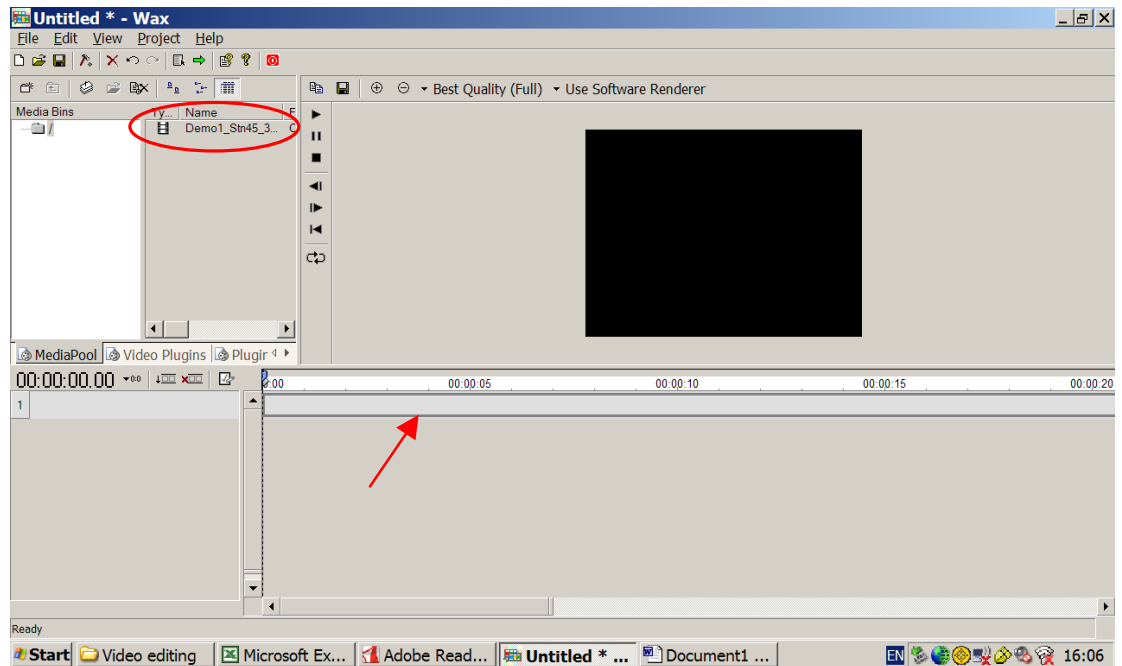
Whilst the Wax 2.0 program supports a variety of formats only the Microsoft AVI type has been used during the compilation of this guide. Therefore any problems with regards to opening other video file formats are not covered. Also this is currently a working draft and may not be a fully comprehensive set of instructions. Any comments and questions would be gratefully received for steps, which may not be clear, described sufficiently or even completely absent.



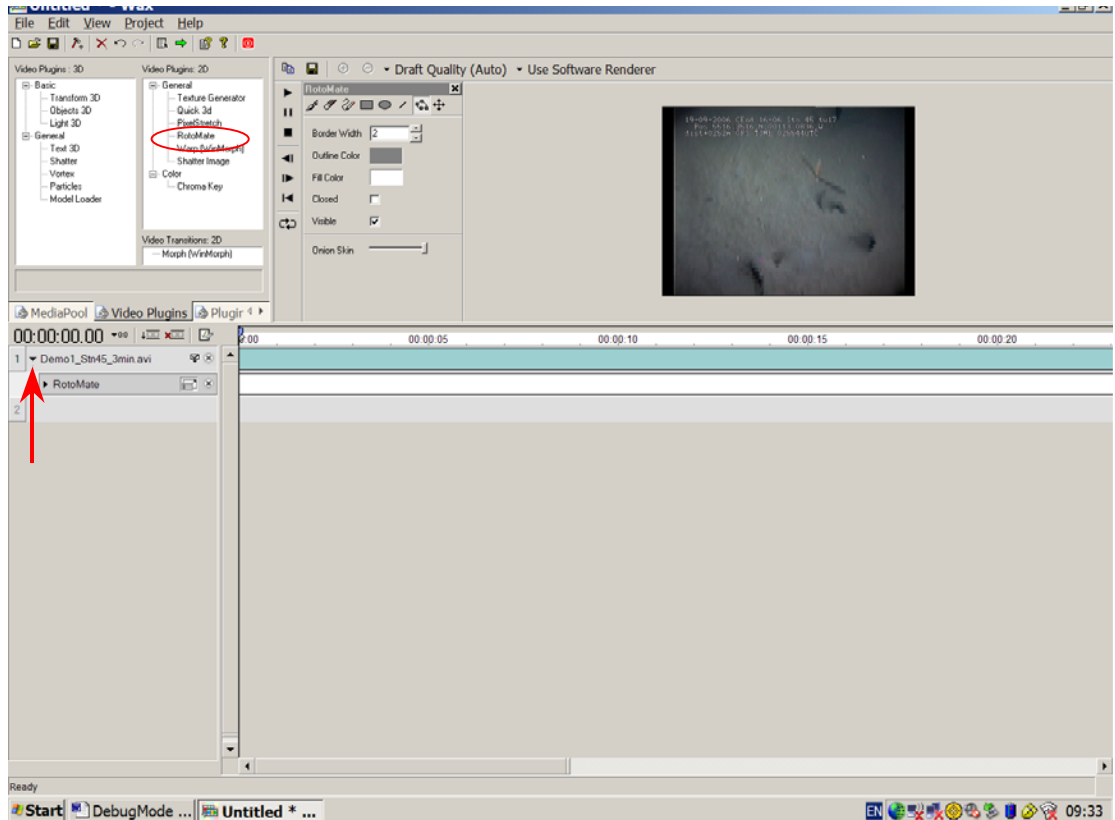
- 1) Start the program and you should view a screen similar to above.



- 2) In the main toolbar select 'Project >Add Media files' and navigate to the folder containing the video clip you wish to edit.

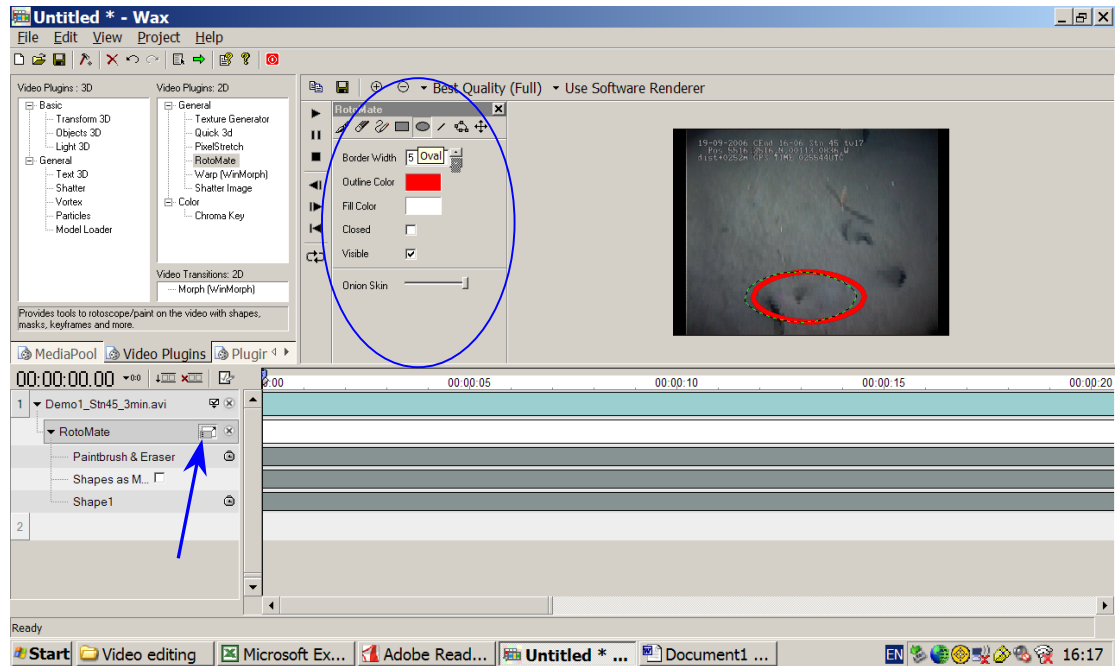


- 3) The clip will appear in the top left hand window (highlighted with red circle), under the 'MediaPool' tab. Click and drag using the left mouse button and drop the video clip onto the empty 'timeline' (highlighted with red arrow). The Video clip will then display in the black window at the top right hand area of the screen.

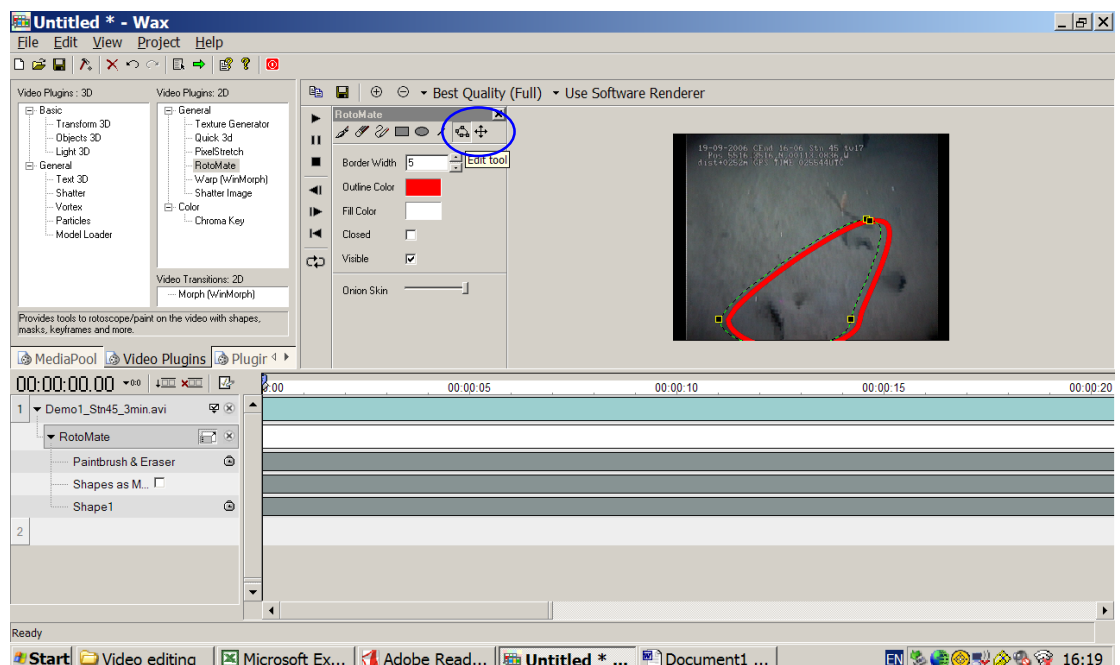


- 4) To edit the video with annotation and shapes use the 'RotoMate' Plugin (highlighted with red circle), which can be found under the 'Video Plugins' tab. As with the video clip click and drag using the left mouse button and drop it onto the video clip timeline (the blue/green bar). (It may be necessary to expand the program tree to display the RotoMate Plugin, by clicking on the arrow icon next to the clip name (Red arrow)).

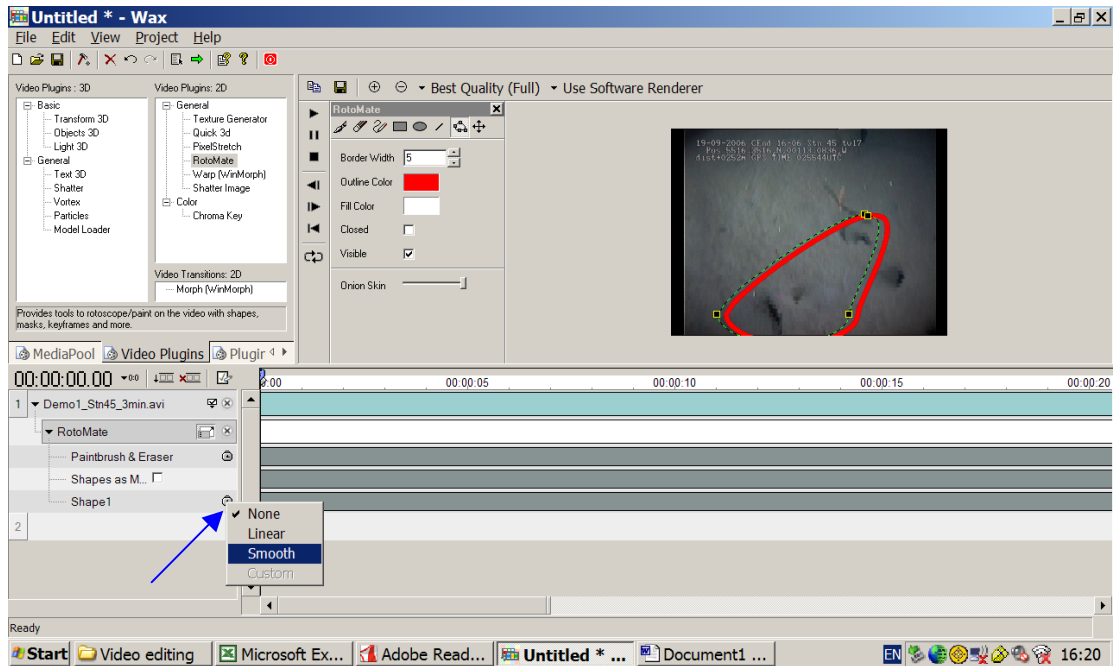




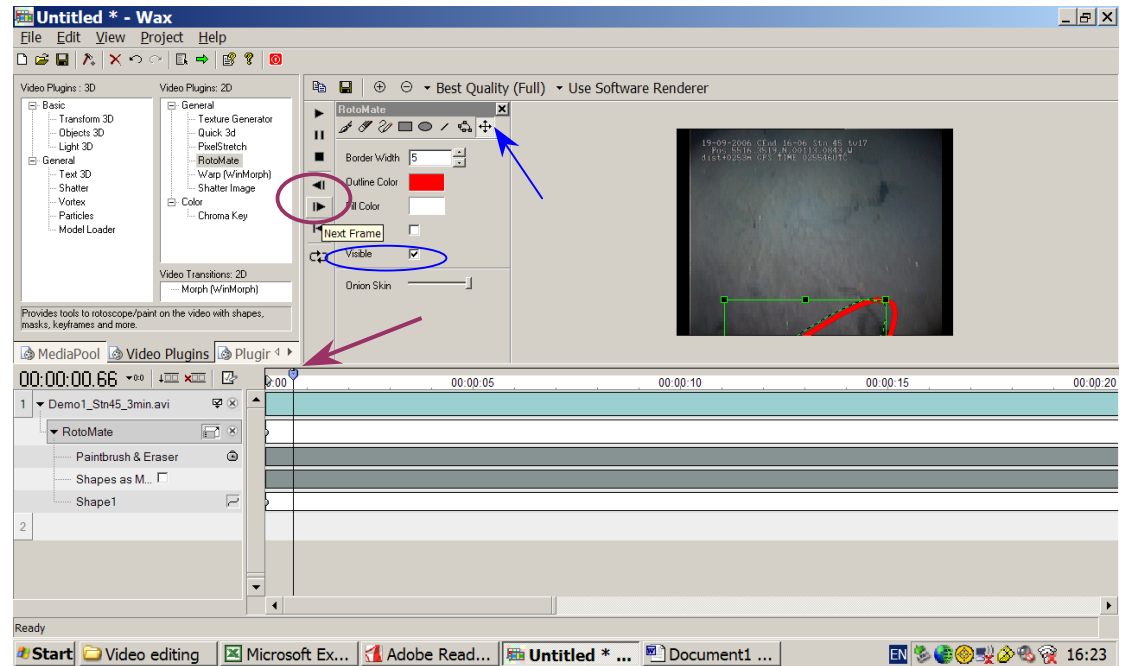
- 5) Click on the RotoMate Plugin setup icon (highlighted by blue arrow) to bring up the editor toolbar next to the video preview pane (highlighted with blue circle). You can now select the Oval and choose the colour and thickness you want before clicking on the video preview pane to draw the shape.



- 6) Using the edit buttons (highlighted with blue circle) you can reshape and move the shape you had drawn in the previous step to cover the extent of any burrow complexes.

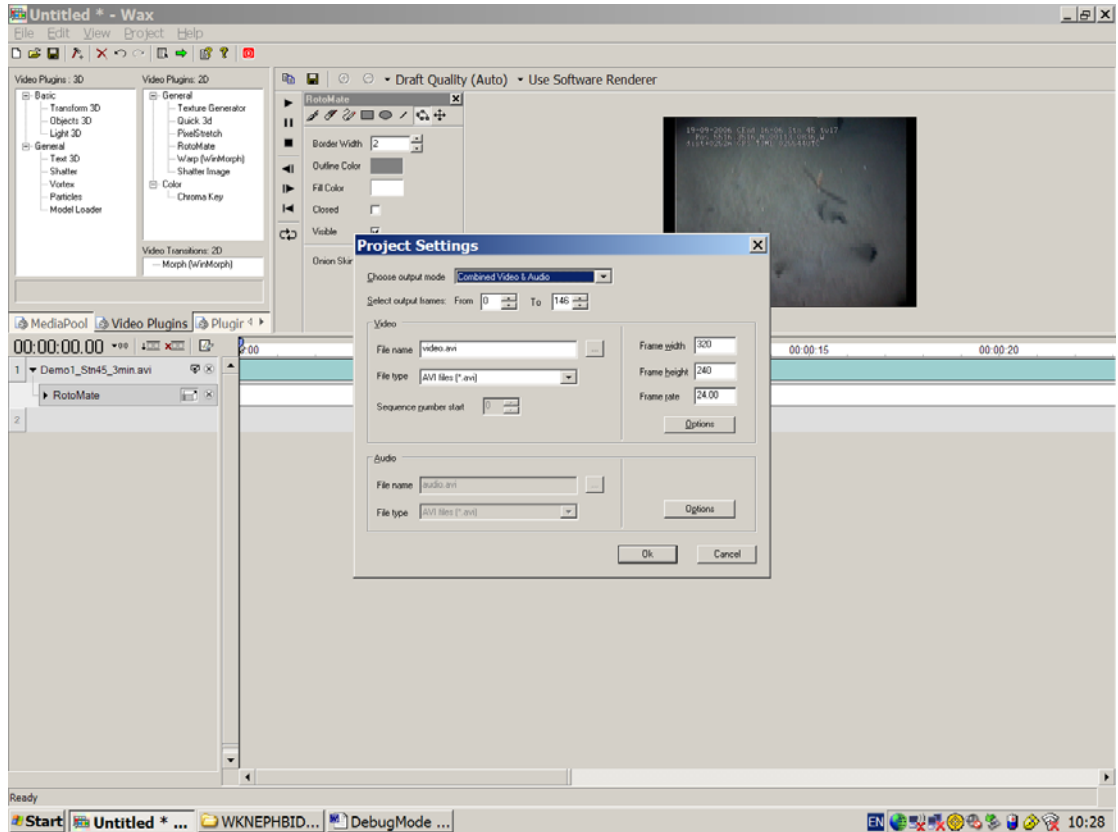


- 7) The shape you have drawn will now be visible, and of the same size and shape, in the same part of the screen throughout the whole of the clip. This is not at all appropriate for highlighting numerous complexes throughout a clip. To make it visible only in selected areas of the clip it is necessary to use the 'Keyframing' mode. To do this for the shape you have drawn simply click on the clock icon next to the shape name under the Rotomate program tree, in the bottom left of the screen (highlighted by a blue arrow), and select 'Smooth'.



8) To make the shape follow the burrow down the screen as the video is played advance the video by several frames (Highlighted by purple circle, Alternatively click and drag the blue icon at the top of the timeline to advance the video frame more freely (highlighted by purple arrow). Once the video clip has been advanced by the desired number of frames select the Edit tool (highlighted by blue arrow) to move the shape into position over the burrow complex. You can also reshape the shape if necessary. Repeat this step until the burrow moves off the screen, ensuring that whilst the shape is in position over the burrow the visible box is checked (highlighted with blue circle). Once the shape has reached the bottom of the screen, and the burrow complex is almost off the screen, you can advance one screen and then **uncheck the visible box**. Now advance the screen until another burrow complex is encountered and move the shape into position over the new complex and reshape etc as required. Once the shape is in position, check the visible box and repeat the above steps to move the shape with the burrow complex etc and continue until all of the complexes in the clip have been highlighted.

You will now notice that there are small grey circles in the timeline pane. These represent events for the shape, called 'Keyframes', such as movement, reshaping and visibility. As the Smooth option was selected in a previous step the program will interpolate the shape between these 'Keyframes' which will result in a smooth moving shape that follows the burrow complex down the screen before disappearing and then reappearing around another complex further into the clip when the video is played. If the shape does not disappear and migrates from the bottom of the screen up to the new burrow complex you will need to play around with the visibility check box properties for each 'keyframe'.



- 9) Once you have finished with the clip you can render it back into a complete AVI file for playback in standard media software such as Windows media player. First Select 'Project > Settings' from the main toolbar and click on the '...' icon next to the file name to choose the name you want to give the saved file and the location you would like it to be saved. There are various other options available in this menu such as file type. Once you are happy with the settings click 'Ok' and then select 'Project > Render'. A progress bar will appear as the rendering process takes place. Once completed the file can be found in the folder you specified in the project settings window.