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Report

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Review of Rügen herring larvae survey project

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Summary

A review of the project that collects the German time series of Rügen herring larvae was carried out by members of the project team in Rostock and two external reviewers. This is the report of the external reviewers. The general findings of the review were as follows:

The data set held by the German Institute of Baltic Sea Fisheries on the survey of the Greifswalder Bodden herring larvae is probably the highest temporal and spatially resolved survey of the hatching of Atlantic herring larvae in the world. The time series (from 1988) is of huge potential value, both in terms of providing management advice on the Baltic ecosystem and on investigating and testing hypotheses in the dynamics of fish larvae.

For the last 15 years the main driver for the survey has been the production of the N30 index as an index of the abundance of 0 winter ring herring in ICES Division IIIa and SD 22-24. This has resulted in other potential uses of the data being ignored. There has also been a lack of testing of assumptions and sensitivity analysis of the methods used to construct the N30 index. The approach has been deterministic, without any estimation of precision.

It obvious that this data set can provide information on the early life history dynamics of herring in particular, and temperate marine fish in general. Relatively small adjustments to the goals, resources and research priorities could provide added value in terms of scientific output into the primary literature, especially in the fields of mainstream marine ecology and population dynamics.

1. Introduction

At the request of the Institute of Baltic Sea Fisheries, a review of the German Rügen herring larval survey (RHLS) project took place on the 13th to 17th November 2006. Two external reviewers were invited to join and lead the review of the project and the time series of surveys. The objective of the review was:

"To review the logistics of the survey, the scientific value of the time series, the potential use of the surveys in both assessments and fisheries science and the potential development and utilisation of the surveys in the future."

The review was held in an informal manner with the RHLS project manager, current research scientists, the director and deputy director of the Baltic Sea Fisheries Institute all taking part. This report represents the opinions of the two external reviewers.

The current aim of the RHLS project is to develop and continue the time series of ichthyoplankton surveys in the spring and summer in the Greifswalder Bodden. The survey time series contains data from 1988 to the present (19 years), although the initial series began in 1977. The methods were slightly changed between 1992 and 1994. The time series consists of weekly sampling from mid to late March to early July of the abundance and lengths of herring larvae and physical information (from 1992 onwards) of the water column at each station.

The review particapnts were:
External Reviewers
Dr Mark Dickey-Collas (IMARES, The Netherlands)
Dr Richard DM Nash (IMR, Norway)
Internal Participants (Institut für Ostseefischerei)
Dr Birgitt Klenz
Dipl.-Biol. Ulrich Berth
Dipl.-Math. Rainer Oeberst
Dr Tomas Gröhsler
Dr Christopher Zimmermann
Dr Cornelius Hammer.

2. Review Process

The review was designed to address the role of the survey in the framework of providing both management advice and research outputs (see agenda in annex 1). The agenda was drawn up by the external reviewers and the scientists at the Baltic Sea Fisheries Institute involved in the project. The first day was spent investigating the background of the survey. A brief review of the ecology of western Baltic Sea herring, spawning sites and behaviour, previous surveys and the local oceanography was carried out. This was followed by an explanation of the utility of the current abundance index provided by the survey for the stock assessment of herring in the western Baltic Sea (Division IIIa and Subdivisions 22-24). On the second day, the review considered the logistics of the survey (with trips to the research vessel *Clupea* and the ichthyoplankton sorting laboratory), how the data were collected and stored and the use of the data. The current methods used for the analysis and provision of indices were also investigated. The third day of the review was an informal workshop on the further development of the survey and its role into the next decade. The review report was written on the fourth day, which was then presented on the final day.

3. Issues raised on the management and scientific output of the project

3.1 Background knowledge

The first reported studies concerning the Rügen spring spawning herring larvae were in 1937 to 1939 (see Biester 1989). Prior to this period, in the 1920s Baltic Sea herring were dominated by autumn spawners, of which there are numerous earlier studies (see Biester 1989 for references). The earlier studies on the Rügen herring indicated that the Greifswalder Bodden, Strelasund and the coast of the Usedom Island were the main spawning grounds. There is obviously a wealth of information on larvae distributions in the area covering the period up to 1931, however, much of this will concern autumn spawning herring. Studies in the Greifswalder Bodden were undertaken sporadically in the period 1958 to 1961. In 1977 surveys that resembled the current survey design (weekly sampling from March/April to July each year) were started (see Biester 1989). Biester (1989) also refers to a number of ICES CM documents that give results on larvae distributions for the period around 1977 and later. There is also reference to a number of documents in German concerning the distribution of herring larvae in the area. In May and July 1981 some studies to the west of Rügen Island were initiated and the waters to the east of Rügen were included in the survey from 1984/85. These additional survey sites allowed a comparison of distributions and abundances along the coast compared with the Greifswalder Bodden.

At the start of the survey in Greifswalder Bodden a Bongo net with either 200 or 316 and 500µm mesh netting was used in a double oblique haul (see Brielmann & Biester 1979). Larvae were measured to the 0.5 mm below. The assumption or observation was that the larvae 'grew in waves' therefore it was possible to identify modes in the larvae length frequencies and these could be used to track and estimate growth rates of larvae in the area (see Brielmann & Biester 1979). The instantaneous mortality rates were also estimated from the readily identifiable modes in the length frequencies. Brielmann & Biester (1979) mention that the herring spawn on the macrophytes in the bay.

In Brielmann's (1989) paper there is only mention of the 200 or 315µm mesh suggesting that it was the data from this net only that was used for any subsequent analyses. However, this point needs to be clarified. The data from 1977 to 1987 were used to estimate the numbers of surviving herring larvae (see Brielmann 1984) and then correlated with the numbers of 0-wr herring in the VPA. Interestingly there was also a correlation between the mean abundance of Calanoidea in June and the abundance of surviving larvae. This suggests there may be a link between larvae survival and prey availability.

The earlier raw data (1977 to 1987) are not available; therefore the present time series covering weekly sampling between March/April and July each year (maximum of 11 surveys per year) are only available. These data consist of larvae abundances and length frequencies, and from 1992 onward, surface and bottom temperature, salinity and dissolved oxygen saturation by station and survey.

Throughout the review, it became clear to us that there is a large amount of data available from other sources that have yet to be considered in this project.

3.2 Logistics of surveys

The review considered the logistics and resource requirements to carry out the survey. Both the vessel (R.V. Clupea) and the ichthyoplankton laboratory were thought to be suitable to execute the survey. In particular, the ichthyoplankton laboratory was thought to be of a very high standard (in terms of functionality and health and safety). The use of bongo nets was considered appropriate. We felt that the CTD may need to be updated, as the project manager suggested that taking physical oceanographic samples took a disproportionate time at each sampling station. With 35 stations, and approximately 30 minutes steaming time and 15 minutes to sample, the grid could be covered in 26 hours. However, for every 10 hours of sampling 1½ hours of steaming is required (as the vessel needs to moor over night), this would add 4½ to the survey time. So the active survey period in perfect weather should be 30½ hours, in other words 3 working days.

The reviewers were surprised by the time taken to process a sample in the ichthyoplankton laboratory. In other institutes a sample takes on average 2-2½ hours to prepare and process. In this project an average of 4½ hours are taken per sample. Only one of the bongo net catches is processed per trawl. Those in the project suggested that this longer period was caused by the need to measure all the larvae in the sample to ensure that all the larger larvae (required for the N30 index) were measured. Note that samples with more than 1000 larvae are sub-sampled into 3 x approximately 200 larvae and then these are raised to the whole catch. Whilst extremely high catches of herring larvae occur in all herring ichthyoplankton surveys, an average abundance of larvae of 5 per m^2 estimated from a 70 m^3 sampled volume, in 7 m depth suggests a sample of 50 larvae. Maps of abundance of herring larvae from the Greifswalder Bodden time series show 4-5 extremely high catches per year, whereas the remaining samples were lower. We think that time should be taken to further investigate the processing of the samples and the logistics of working up the samples and estimating length. The cost benefit of taking 4½ hours to process a sample should be carefully considered.

3.3 Retention/dispersion

Retention and dispersal mechanisms in ichthyoplankton and specifically the larvae of pelagic species has been an active research field in the international community for the last 25 years (see Iles & Sinclair 1982 etc). The subject is becoming “hot” again (see ICES SGRESP and the new workshops from that group).

The current survey design utilises 35 stations (spread across 15 sub-areas) within Greifswalder Bodden. There are no stations outside the bay. The survey design has the premise that this is a retention area and there is little or no leakage out of the area, at least of larvae less than 30 mm. Part of the logic for sampling only in the bay is that this is the major spawning area for this stock, however, this does not really refer to evidence of retention of larvae. There is evidence that water enters the bay from the north-west through the channel and must therefore exit to the east across the relatively broad entrance to the bay. There is a sill to the bay which may make flows relatively complex. However, to date there are no available data on flow rates or current patterns in the area to evaluate the potential for passive drift out of the bay. Anecdotal evidence suggests that the abundance of larvae outside the bay may be low and there is little evidence (cursory visual examination) of the larvae length data to suggest there is aggregation of larger larvae at the entrance of the bay.

There is a need for empirical evidence on whether there is retention of larvae in the bay or whether emigration can and does occur.

3.4 Hatching

The reviewers felt that understanding the dynamics of hatching was an important element of the scientific output from the time series. It is also required to understand the processes behind the production of time series indices. The survey series covers 19 years (1988-2006), with weekly estimates of hatching in the Greifswalder Bodden. This is an amazing data set, and nowhere else in the world does such a series of data exist for Atlantic herring. However, these data appear underutilised. The methods used to create the N30, and the principal interest in the older larvae, has lead to a reduction in research activity on hatching. Importantly, the assumption that the larvae hatch in cohorts has never been tested. The apparent cohorts seen in the length frequencies may be an artefact of sampling.

The clumping of all of each week's survey to the mid date of that week may mask and in fact create the impression of weekly cohorts. Other methods are required to analyse and investigate the dynamics of hatching of herring in the Greifswalder Bodden. Ichthyoplankton surveys in the Irish Sea and off the Iberian peninsula have used general additive modelling (GAMs) to describe the spatial and temporal variability in egg or larvae production. This method does not require clumping either spatially or temporally, and thus the dynamics of hatching can be investigated (within the constraints of the degrees of freedom). This method can also allow for the inclusion of salinity into the model as suggested by the project manager.

3.5 Growth

In all studies of the ecology of larvae and in the production of the N30 index, an understanding and estimation of growth is required. In the N30 method growth is estimated from modal progression analysis. Currently, a combined length frequency for a complete survey (lasting 5 days) is constructed. This contains larvae that have newly hatched over the period of the survey and older larvae. With growth rates at this time ranging from approximately 0.3 to 0.5 mm d^{-1} a larva at the beginning of the survey could be 1.5 to 2.5 mm longer at the end of that week's survey i.e. one to two 1mm length bins larger than if sampled at the beginning of the survey. This can have an effect on the perceived modes in the combined length frequencies and affect the estimation of growth rates. This temporal clumping has already been mentioned in the hatching section above.

The estimation of growth rate is dependent on being able to identify modes in the length frequencies. This is currently done using DOS programs (NORMSEP and FISAT) and requires subjective input from the operator to identify the modes. In general only four modes are identified in the length frequencies with the subjective confidence in modes decreasing rapidly with increasing mode number.

The growth rate of larvae estimated from the modal progression analysis was compared with estimates from a small pilot study using otolith micro-increments (Oeberst & Klenz 2003). This study suggested that the growth rates from the modal progression were within expected values.

Early growth rates from the modal progression analysis are acceptable, however, there are problems using this technique for older larvae due to the inability to identify modes in the older and longer larvae. There is also a potential of avoidance by the larger larvae, or even emigration out of the area (see retention above) leading to an under-representation in the samples. The effects of these problems on the estimated growth rates are an unknown. Studies that consider the growth of larvae using micro-increment analysis of the otoliths of larvae must take account of the inability to detect primary increments in the otoliths of slow growing herring larvae (<0.4mm per day; see Fox *et al.*, 2003).

3.6 Habitat

The hatching and the dynamics of the herring in the Greifswalder Bodden are inherently linked to the habitat. A survey that covers the spawning of north-east Atlantic herring on macrophytes, must account for the habitat as a whole. In other words, that habitat is important. The presence of Eider ducks, the mixture of spawning on sea grass and brown algae, the impact of salinity events and the overall productivity of the system are all important. The proposed laying of pipelines also increases the need to understand and map the habitat as a whole.

Surveys of the coverage and variably of macrophytes would provide vital extra information to link to the hatching of larvae and the dynamics of the Greifswalder Bodden. This appears not to have been considered since the 1970s. The annual input of carbon into the system by the spawning of herring should also be assessed. Under the ecosystem approach to fisheries management, the EU habitats directive and the EC revision of the data collection regulation to include pressure and state indicators the need for research on this aspect of the Greifswalder Bodden system must be considered important.

3.7 N30 (includes mortality)

The N30 was the primary product of the Greifswalder Bodden herring time series throughout the last 15 years. The N30 is an index of a projected abundance of larvae at 30mm in length from the whole hatching season.

The mortality rates of herring larvae within Greifswalder Bodden are estimated from the reduction in abundance of 'hatching cohorts' of larvae between successive surveys. The method is dependent on being able to successfully identify 'cohorts' in the length frequencies and track them through time (surveys, see hatching above). The method utilises the number of days between the median dates of the surveys for the elapsed time. A matrix of mortality rates for each year is made up for each survey and each 'cohort'.

As mentioned previously, only the first four 'cohorts' are followed therefore, the estimated mortality rates of the smaller larvae are used to project the abundances forward to 30mm length. The numbers of larger larvae (>20mm) in the survey are very low, necessitating the use of this technique rather than simply raising the numbers of 30mm larvae caught. The forward projection to 30mm is necessary for all larvae <30mm, including very small larvae, in the last survey as there are no further estimates of mortality. In all cases the growth rates from the earlier modal progressions are used in the estimate of growth rate and hence time to 30mm length.

The estimate of the number of larvae that were spawned in the Greifswalder Bodden, surviving to 30 mm, is reliant on the survey covering the whole distribution of the larvae. The estimate is also reliant on the estimates of natural mortality and growth rate. At present there is the assumption that the mortality trajectory of the cohort continues as the larvae get older and longer, similarly the growth trajectory does not differ with time.

3.8 Data storage and analysis

The data for the whole project are stored in different ways; the primary station data in dbase, the raised larvae length frequencies in excel spreadsheets, the raising methods on paper and the CTD profiles as text files. This makes data accessibility poor, and until all the data are combined into a well structured data base, analysis and modelling will be slow, awkward and problematic.

Many of the assumptions in the current analysis have not been sensitivity tested, and the precision of many of the estimates are unknown. The majority of the analyses to date has been focused on estimating the N30 index.

4. Links to assessment/purpose of survey

The surveys on herring larvae in the Greifswalder Bodden and around Rügen were originally designed to investigate the distribution and frequency of herring larvae of the Rügen herring stock (see Brielmann & Biester 1979). During the course of this research 'peaks' in larvae abundance were identified, growth rates estimated (in degree days) and mortalities estimated. Subsequently, the data were used to estimate the numbers of larvae that achieved 30mm and correlations undertaken with the estimates of 0-wr for the herring stock in ICES sub-divisions 22 and 24 (Brielmann 1984, 1989).

4.1 Survey relationship to Baltic production and IIIa herring

The assumption is that the majority of the spring spawning herring that constitute the IIIa, subdivision 22-24 stock spawn in the vicinity of Greifswalder Bodden. Therefore the abundance of larvae in the area is a reflection of the IIIa SD 22-24 stock dynamics. Investigations suggested that the larvae abundance was independent of the Spawning Stock Biomass or numbers due to the very restricted spawning area and variable mortality rates of eggs through a number of density-dependent effects e.g. low oxygen levels due to thick egg mat layers. The numbers of larvae, especially when projected forward to at least 30mm length were thought to be indicative of the year class strength i.e. numbers of 0-wr fish in the stock. Whilst a large portion of the stock in this management area spawns in the Greifswalder Bodden there is a significant amount of spawning elsewhere around the area.

4.2 The N30 and the 0-wr index

The larvae abundance deriving from spawning in Greifswalder Bodden has been projected forward to the abundance of larvae at 30mm (Müller & Klenz 1994) and this is called the N30 index. The correlations have then been made with the 0-wr abundance estimates from the acoustic surveys and the equivalent 0-wr estimates from the VPA. In the case of the acoustic surveys the fish in October have a mean length of approximately 90mm. This is in essence 3 months later than the time period of the N30 index. To use the N30 index for a 0-wr index is to assume the natural mortality does not vary between years. This is most probably not realistic since predator/prey and feeding conditions vary interannually, therefore, some provision should be made to adjust the N30 to reflect the relative abundance of the older fish.

The N30 index does not perform well as a tuning fleet for 0 group herring in the stock assessment because the correlation is heavily driven by three extreme years classes, when both the N30 and the numbers of 0wr fish from the VPA were high. However if these are removed, there is no correlation between the remaining two series i.e. the explanatory strength when the N30 is low, is very poor. Also there are no intermediate N30 values in the series, as also found by Brielmann (1989) with the old series and the error bars are such that there is very little signal in the index values. A similar situation in the modern series means that the current N30 series does not agree with the recent trends in the catch. However, this does not mean that the N30 is incorrect, merely that the signals are noisy and may be different between the time series.

4.3 The value of time series

The time series, 1988 to present, is an extremely valuable data set with quantitative estimates of the abundance of larvae at length, at approximately weekly intervals for a period of approximately 11 weeks each year. Since 1992 this data set has been augmented with physical data covering temperature, salinity and oxygen saturation. The time series allows, amongst other things, one to examine intra- and inter-annual variability in; spatial variability in hatching success, growth rates, mortality rates and ecology of the young stages of spring spawning herring. The sampling frequency is high enough to allow relatively complex analytical tools to be used to examine controlling processes in detail. The time series also provides a good basis for raising a number of hypotheses that can be tested on both spawning dynamics and general life history dynamic models. The time series also provides a sound basis for input into understanding the dynamics of the herring in this area and providing meaningful insight as to the management and potential vulnerability of this stock to e.g. anthropogenic influences.

5. Conclusions of the review

The data set held by the German Institute of Baltic Sea Fisheries on the survey of the Greifswalder Bodden herring larvae is probably the highest temporal and spatially resolved survey of the hatching of Atlantic herring larvae in the world. The time series (from 1988) is of huge potential value, both in terms of providing management advice on the Baltic ecosystem and on investigating and testing hypotheses in the dynamics of fish larvae.

For the last 15 years the main driver for the survey has been the production of the N30 index. This has resulted in other potential uses of the data being ignored. There has also been a lack of testing of assumptions and sensitivity analysis of the methods used to construct the N30 index. The approach has been deterministic, without any estimation of precision.

It obvious that this data set can provide information on the early life history dynamics of herring in particular, and temperate marine fish in general. Relatively small adjustments to the goals, resources and research priorities could provide added value in terms of scientific output into the primary literature, especially in the fields of mainstream marine ecology and population dynamics.

6. Recommendations

6.1 Literature review

A literature review to be carried out on western Baltic spring spawning herring, and autumn spawning herring in the western Baltic Sea with particular emphasis on reproduction, spawning, the dynamics and ecology of the larvae and the coastal spawning habitats used for spawning. This should include PhDs theses, grey literature, ICES contributions and published literature in both German and English over the last 150 years.

6.2 Data storage and management

All data must be stored and linked in a database. Raising procedures must be automated and made transparent.

6.3 Reanalysis of spatial variability

An analysis be carried on the sub-areas of the Greifswalder Bodden so that the spatial variability is better understood and minimised through sub-area allocations.

6.4 Testing of assumptions, sensitivity and precision.

The approach used in the analysis should be changed, so that the assumptions inherent in the methods are always challenged and sensitivity testing considered the norm to each analysis. Estimates of precision should also be produced where possible.

6.5 Laboratory processing be assessed

That the cost benefit of counting all larvae in large samples, measuring large numbers of larvae in sub-samples and measuring all larvae in smaller samples be fully investigate and tested by investigating the CVs of the estimates. Folsum splitters should be purchased and their use incorporated into the protocols. An investigation into the use of a larger mesh on one of the rings of the Bongo net should be initiated, to see if larger larvae are caught without the newly hatched larvae, thus reducing the processing time.

6.6 The N30 index

In the short term, the determination of the N30, and perhaps an N20, be maintained once the spatial variability in estimates has been minimised. However an alternative mode fitting package, which is less subjective, should be investigated and used to estimate the size of 'cohorts'. Some indication of precision should also be included with the estimates. The N30 is a novel approach developed by this laboratory. The sole aim of the ichthyoplankton survey should not be the production of an index for assessment.

6.7 Consider as an ecosystem survey

Develop a framework of research that allows the current survey time series to be considered an ecosystem survey, along the lines of the other ICES ecosystem surveys (see PGNAPES).

6.8 Follow up review

A one day review be held in 2½ years to follow progress on the project.

6.9 Research priorities

That the following be considered as important research needs:

i. The hatching dynamics of larvae. *Suitable for an MSc or PhD project with a linked university. Propose that GAMs be investigated as a tool.*

ii. The potential loss of larvae out of the Greifswalder Bodden. *Needs either additional sampling locations and/or work with oceanographers.*

iii. The growth of herring larvae. *Carefully consider methods that can be used, including primary-increment otolith analysis of older surviving larvae. A modelling approach, rather than purely empirical approach may also help. Working with survivors opens up the research area of*

non-random survival and cohort success, but care must be taken in the light of the findings of Fox et al. (2003)..

iv. Habitat and utilisation of potential spawning areas in the Greifswalder Bodden. *Methods are investigated to quantify the spatial coverage and variability in macrophyte abundance.*

v. Variability in larval mortality. *Once the basic assumptions have been tested about hatching, growth, retention and spatial variability, investigate the between year, and between cohort variability in larval mortality, using the empirical estimates only.*

vi. Spawning dynamics of herring in the western Baltic. *A study of the fecundity and behavioural aspects of spawning, with additional investigations of egg density and egg survival.*

vii. Attempt to retrieve the data from the earlier survey (1977- 1987).

viii. Assess the relative importance of the herring production in the Greifswalder Bodden relative to the rest of the IIIa herring stock.

6.10 Presentations

That abstracts for oral presentations be submitted on the dynamics of hatching of herring in the Greifswalder Bodden to the NAFO/PICES/ICES symposium "Reproductive and Recruitment Processes of Exploited Marine Fish Stocks" Lisbon October 2007 and to the ICES/Globec symposium "Linking Herring" Galway August 2008 on the use and limitations of the N30 approach.

6.11 Outputs

The following descriptive working titles are suggestions for peer reviewed publications:

1. Literature review of the reproductive dynamics and larval ecology of western Baltic spring spawning herring.

2. Spatial characteristics of the hatching of herring in the Greifswalder Bodden, the influence of salinity and temperature.

3. Year and cohort effect in growth of herring larvae in the Greifswalder Bodden.

4. Year and cohort effect in mortality of herring larvae in the Greifswalder Bodden.

5. Early life history dynamics in spring spawning herring; a case study of western Baltic herring.

6. Relationship between macrophyte abundance and the hatching of herring in the Greifswalder Bodden.

7. The importance of herring spawning for the transfer of carbon into the Greifswalder Bodden.

8. Drift and retention of herring larvae in the Greifswalder Bodden, a major hatching ground for western Baltic spring spawning herring.

7. References

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Annex 1- Agenda of the Review

Review of Rügen herring larvae surveys
Rostock 13-17th November 2006

External Reviewers:
Dr Mark Dickey-Collas (IMARES, The Netherlands)
Dr Richard DM Nash (IMR, Norway).

Internal Participants:
Dr Birgitt Klenz
Ulrich Berth (part time)
Rainer Oeberst, (part time)
Dr Tomas Gröhsler (part time)
Dr Christopher Zimmermann (part time)

Objective: To review the logistics of the survey, the scientific value of the time series, the potential use of the surveys in both assessments and fisheries science and the potential development and utilisation of the surveys in the future.

Monday 13th November

09:30 Welcome and Introductions
09:45 Agreement of work plan and agenda, followed by initial discussions with personnel responsible for the larvae surveys, data archives etc.
10:30 Review historical information on IIIa and SD 22-24 herring biology and ecology.
13:30 Review of the history of the larvae surveys and relevant background literature
16:00 Discussion on why the survey has not been incorporated into the stock assessment as requested by working documents submitted to HAWG.

Tuesday 14th November

09:30 Logistics of the survey: audit of resource requirements (manpower, ship time, research activities and analysis, data storage) *including short presentation on current methods.*
13:30 Review of actual time series data:
i) Numbers
ii) Larvae characteristics
iii) Physical data

Wednesday 15th November

09:30 Group workshop on the potential utilisation of the time series and future format of the survey (with presentations and discussions)
16:30 Future development of the survey (from 2007), with an evaluation of logistics and cost implications

Thursday 16th November

09:30 Future development of the survey cont'd
13:00 External Reviewers write the report

Friday17th November

09:30 Presentation of the Report by Mark Dickey-Collas and Richard Nash
11:30 Review ends.

Drs. E. Jagtman

Signature: _____

Date: 22 November 2006