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SCICOM STEERING GROUP ON ECOSYSTEM SURVEYS SCIENCE AND TECHNOLOGY

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First Interim Report of the Working Group on Atlantic Fish Larvae and Egg Surveys (WGALES)

1–5 December 2014

San Sebastian, Spain

ICES CIEM

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Contents

Executive summary

The Working Group on Atlantic Fish Larvae and Egg Surveys (WGALES) met, for the first time, in San Sebastian, Spain from 1–5 December 2014. The meeting was attended by 27 participants from 12 countries (representing 18 different institutes).

The first day the meeting dealt with general WGALES work, including the ToRs relating to various issues of standardization, calibration, data quality and storage of data from international herring larvae surveys (Section 7).

Days 2–4 were scheduled for the presentations and discussions on two theme session "Current ichthyoplankton surveys in the Atlantic and Mediterranean" (Section 3) and "Recent developments in egg and larval mortality studies" (Section 4). In the first session 26 presentations were presented on different ichthyoplankton surveys from the Norwegian Sea, North Sea, Baltic, Atlantic and Mediterranean. There is great effort shown on survey sampling, but most surveys target only one species, and these are mostly pelagic species. Standardization in methods between institutes has progressed substantially. It recommended that surveys and methods involved should be regularly evaluated and updated. Ichthyoplankton surveys are becoming more multidisciplinary, but this also puts pressure on survey time allocation. Image analyse methodologies have proven to be very relevant in identification and it is used by several institutes. Investment in taxonomic expertise has been somewhat neglected recently, but this expertise is pertinent to get correct identifications. Genetic techniques, which have become cheaper, also help in taxonomic identification. Combining of methods for population biomass estimations (e.g. acoustics and egg surveys) was shown to be valuable. Moreover, the need to combine also efforts among surveying, modelling and assessment researchers was felt important for future workshops or meetings.

In the second session, 14 presentations were presented. Studies were presented focusing on modelling, field and laboratory studies and methods to estimate mortality. Alternative analytical approaches were discussed to overcome the potential weaknesses of the more classic methods. It was pointed out that dedicated experiments should be carried out in order to assess mortality of eggs and larvae more adequately.

The last day dealt with the discussion of the ICES egg and larval database, recommendations from the workshop on clupeoid larvae identification, and recommendations for ichthyoplankton SISPs.

Participants are willing to upload various ichthyoplankton survey datasets to the ICES egg and larval database however; some institutes also have to comply with national regulations on data availability. A workshop is recommended to get all scientists acquainted with input format and prepare the various datasets for upload into the ICES egg and larval database. At the workshop it will also be decided which output reports and products should be available from the database.

WGALES recognizes the need for international workshops on identification and staging of fish eggs and larvae.

All participants agreed that the WGALES group and meeting was a much-needed instrument to be able to exchange methods and techniques and discuss various topics between ichthyoplankton survey experts. This meeting only dealt with the egg and larval part of ichthyoplankton surveys. WGALES recognizes that the adult part of the ichthyoplankton surveys is just as important as the egg and larval part. At the next

meeting in 2016, the topic for the theme session will include studies on adult reproduction necessary for ichthyoplankton surveys.

1 Administrative details

Working Group name	
The Working Group on Atlantic Fish Larvae and Egg Surveys (WGALES)	
Year of Appointment	
2013	
Reporting year within current cycle (1, 2 or 3)	
2	
Chair(s)	
Cindy van Damme, The Netherlands	
Maria Manuel Angélico, Portugal	
Meeting venue	
San Sebastian, Spain	
Meeting dates	
1 – 5 December 2014	

2 Terms of References

The terms of reference for the meeting were:

a) Present current ichthyoplankton surveys in the light of their original purposes, with respect to design, estimation methods and challenges (including their potential as ecosystem surveys);

b) Present current understanding and future research needs of natural mortality of fish eggs and larvae in order to improve accuracy and precision of egg production and larvae abundance estimates of the ichthyoplankton surveys;

c) Prepare a template for the ICES ichthyoplankton survey protocols;

d) Receive and act upon ToRs from Working Groups within the umbrella of ichthyoplankton surveys e.g. IBTSWG, WGACEGG, WGIPS, WGMEGS, and WGEGGS2.

Extra terms of reference from other groups were:

Herring Assessment WG

HAWG recommends that the data and protocols associated with the MIK survey and output data are investigated in conjunction with the appropriate experts from IBTSWG, WGALES and WGISDAA (where it would form an ideal case study). The specific points to investigate are: (a) Historical development of the survey gears and methods, (b) Standardization of current gears and sampling protocols, (c) Calibration and intercomparison of existing gear types, (d) Data storage both at the co-ordinator and ICES level, (e) Data analysis and generation of indices for use in stock assessment and scientific research.

WK on the IDentification of CLUPeoid larvae

1) Based on the low agreements during the workshop, it is clear that the identification of clupeoid larvae is difficult and identification should be improved. WKIDCLUP therefore recommends that workshops on fish larvae identification are held regularly (every 5 years) to exchange knowledge and to increase agreement on sample processing and identification of fish larvae. Especially when conducting ecosystem wide surveys it is important to standardize methods and larvae identification.

2) WKIDCLUP recommends to investigate the effect of the low agreement in clupeoid larval identification on the herring assessment.

3) Experienced persons showed a much higher agreement in species identification compared to less experienced. WKIDCLUP recommends that institutes ensure the continuity of staff for fish larvae identification to increase the quality of larval identification in survey samples.

Working Group on Improving use of Survey Data for Assessment and Advice

Survey planning groups should refer problems with design or index calculation to WGISDAA.

WK of SSGESST expert groups chairs

The survey expert groups need to develop an implementation plan for the development of the survey protocols (See Section 4.8 in the 2013 WKESST report).

The extra terms of reference were addressed during the meeting and the replies were also reported on the ICES website.

2.1 Work plan

Year 1	If necessary WGALES will meet by correspondence to act upon urgent Tor's from ichthyoplankton survey groups (ToR d).
Year 2	WGALES will organize a meeting to address ToR's a, b, c and d.
Year 3	If necessary WGALES will meet by correspondence to act upon urgent Tor's from ichthyoplankton survey groups (ToR d).

2.2 Adoption of the agenda

The adopted agenda addressed all terms of reference and can be found in Annex 2.

3 Current ichthyoplankton surveys in the Atlantic and Mediterranean (ToR a)

In this session, 26 presentations were presented. A short summary of the session can be found below. Abstracts of the presentations can be found in Annex 6 and extensive summaries of the discussions resulting from the presentations can be found in Annex 7.

Session 1 was dedicated to general presentations on the ichthyoplankton surveys conducted in many regions of the Atlantic and Mediterranean. The participants appreciated the effort showed on survey sampling coverage by all surveys presented, but it

was also pointed out that with a few exceptions the surveys target only one species. In addition, the great majority of the surveys presented are directed at pelagic fish species and very few are centred on more coastal species.

The detail given in surveying allowed the recognition that standardization in methods between institutes has progressed substantially. Despite this fact some surveys need improvement, this was especially considered important for the IBTS-MIK surveys including also in this case developments in laboratory processing and data analyses. It was suggested that surveys and all methods involved should be regularly evaluated and updated; in addition, quality data control and adequacy for each objective should be preserved.

It came across clearly from the presentations and discussions that the ichthyoplankton surveys are becoming more multidisciplinary by including for instance regular sampling for hydrology, zooplankton and top predators census. However, the current demands to fulfil MSFD requirements also put pressure on survey time allocation. While welcoming the ecosystem survey approach, the coordinators of surveys, directed at population size and structure estimation, call to attention that the main objectives of the surveys cannot be disrupted. In addition, vessel size and working on a 24h schedule may limit extra sampling. Finally, all extra samples and data have to be processed, a task that often is not considered when human resources are allocated to survey data and sample processing.

Image analyse methodologies have proven to be very relevant in phyto- and zooplankton taxonomic analyses and its utilization is consequently being conducted by several institutes either on board or in the laboratory. Nonetheless, investment in taxonomic expertise, which has been somewhat neglected recently, should be kept to high standards in order to maintain correct classification. Genetic techniques, which have become cheaper, may also help in taxonomic identification.

Combination of methods for achieving population biomass estimations (e.g. acoustics and EPM estimations presented for mackerel) was retained as valuable and its development looks pertinent. Moreover, the need to combine also efforts among surveying, modelling and assessment researchers was felt important for future workshops or meetings.

4   Recent developments in egg and larval mortality studies (ToR b)

In this session, 14 presentations were presented. A short summary of the session can be found below. Abstracts of the presentations can be found in Annex 8 and extensive summaries of the discussions resulting from the presentations can be found in Annex 9.

Session 2 addressed issues related to egg and larvae mortality. Presentations were made on sources of mortality, ways of assessing mortality, data analyses and limitations in results of egg production methods caused by incorrect or biased mortality estimates. Alternative analytical approaches were discussed to overcome the potential weaknesses of the more classic methods. The participants pointed out that dedicated experiments (at sea and in the laboratory) should be carried out in order to assess mortality of fish eggs and larvae more adequately. Also, modelling approaches including parameterization of egg, larvae and adults physiologic rates as well as hydrodynamics and other habitat description aspects should be looked at and incorporated in the analyses. In particular, the vertical dimension in the egg and larvae distributions have not gained enough attention yet.

5   Template of ICES ichthyoplankton surveys protocols (ToR c and WKESST recommendation)

The general guidelines for the SISP were discussed. WGALES was asked by WKESST to provide guidelines specific for ichthyoplankton surveys.

General guidelines from SISP

- Background
- Comprehensive set of objectives
- Survey sampling design
- Observation methodology
- Protocol for sampling gear and instrumentation
- Protocol for collecting biological samples
- Caveats
- Analysis
- Reporting Results
- Survey summary sheet

WGALES recommends including:

1) Background

- Objectives
- Some notes on the historic of surveys (and method) and institutions (countries) involved
- Target species and deliverables from survey (indices and its application)

2) Surveying

- Area and period of survey
- Sampling
  - Egg, larvae
  - Adults
  - Hydrology
  - Other (e.g. birds and mammals)
  - Gear and operation, design (pros and cons) and sampling at sea (e.g. subsampling, fish measurements, etc.), sample preservation

3) Laboratorial processing

- Egg, larvae (procedures for sorting, counting, identification, measurements, etc. equipment used); description of identification keys and scales of development for stages (including photos or schemes)
- Adults (procedures for weighting, counting oocytes, histology, etc. equipment used); description of stages for maturation, atresia, oocyte development, POFS degeneration, measurements for fecundity, age reading, etc. (including photos or schemes)

4) Analyses of data

- Egg, larvae

- Adults, including markers and estimators (e.g. POFs, which cohorts), formulas, statistical approaches and parameter definition for particular functions, variance estimation, strata definition, software, etc. (pros and cons)

5) Products

- Indices and its usage (which groups use the info and to what end)

- Reports produced and where are they stored, periodicity (what to include in the report)

- Data update and storage

6 ICES egg and larval database

During the meeting, a presentation on the ICES egg and larval database was presented (see Section 3). In this presentation, the development and current status of the ICES database was discussed. On Friday morning, a discussion on the ICES database with Carlos Pinto from the data center was held to clarify questions from WGALES and prepare a list of requests for the ICES egg and larval database.

It was decided that WGALES should be the official WG which all requests concerning the actual database should be directed to by individual WG's, institutes or scientists.

Most WGALES participants are interested and willing to contribute and incorporate their ichthyoplankton survey data into the ICES database. Some institutes are restricted by national regulations to upload data. Not everyone is familiar with the database format. WGALES therefore recommends organising a workshop of 3 days for implementing datasets and database products. During this meeting, participants will be instructed in the database format and be given the possibility during the workshop to conform the format of their own datasets to the ICES format and give their dataset in the correct format to the ICES Data Center to be uploaded. The second part of the workshop should be devoted to discussion on possible output and products to be generated from the ICES egg and larval database.

A request was given to the data center to create an extra field in the ICES egg and larval database (From Finlay on behalf of WGMEGS). Of some countries multiple institutes are participating in the same survey. Currently it is only possible to enter country, but it should also be possible to enter institute and/or laboratory into the database.

Apart from the above request, WGALES is in agreement with current input and output format. However, during the 3 day workshop there should be the possibility for participants to suggest changes for the input and output format. The definitive formats should be agreed upon in the workshop.

During the WGALES meeting participants offered the below list of datasets that can be included into the ICES egg and larval database:

- Cefas Irish Sea survey data (Need to check for permission to upload data)

- Northern Ireland dataset, it is unclear at the moment which dataset it is, Carlos Pinto from the data center should check with Steven Beggs

It should be possible to update and correct data in the database and thus resubmit data. However, this should only be possible at certain times and a clear protocol on timing

of updating of the survey data should be prepared. This can be discussed during the 3-day workshop but survey working groups should also advise on this. There should at least be a certain time period prior to the assessment where resubmission of the data in not possible. In addition, a log of the corrections to the database should be kept in order to allow recalculation of indices from the data.

WGALES would like the possibility to publish of data which is finalized and keeping preliminary data protected, but accessible to survey and assessment groups. Survey groups should have the possibility to upload preliminary data but can decide if they want to upload preliminary data.

7 Herring larvae surveys (ToR d and extra recommendations from HAWG)

The HAWG recommendation was addressed and discussed during the current/recent WGALES meeting in San Sebastian. The working group (WGALES) concluded on the points raised by HAWG as follows:

a. and b. Historical development of survey gears and methods and their standardization

The historical development of survey gears and methods is currently being investigated by the survey coordinator and participants. Standardization of the survey gear, in particular of the net fabric and mesh size is currently underway which will lead to a unified mesh size for all participants. The effect on larvae catchability by the utilization of shorter than standard bridles (5 m opposed to 10 m) by some survey participants still needs to be investigated (see also c.)

Another issue was the treatment of samples immediately after completion of a haul. Some participants stored the samples in formalin immediately after catch and consequently analysed preserved larvae while others sort and analyse fresh samples. However, sorting of fresh, unpreserved samples may have an effect on the results of length measurements since larvae tend to shrink significantly in warm laboratory conditions. Large discrepancies in length frequencies of larvae caught in the same rectangles, by different participants employing the different sample treatments (pre-served vs. unpreserved), are probably caused by these differences in sample processing. In order to reduce the differential effect of shrinkage on larvae measurements it was therefore suggested that all survey participants should transfer their samples, immediately after catch, in to buffered formalin. For those participants who are not able to apply formalin fixation for safety reasons it is imperative to keep the samples and sorted larvae in cool conditions, at least until the completion of the herring larvae measurements. Laboratory temperature conditions should be kept as close as possible to the ambient temperature conditions that the larvae were caught i.e. between 5 and 8° C.

c. Calibration and intercomparison of existing gear types

There are a number of different sampling gear setups (mesh size, filtering area and bridle lengths) which need to be included in reanalyses of the historical data and the present data. To understand the dynamics and contributions of the various herring stock components to the MIK index it is necessary to investigate the catchability of each net. WGALES discussed these issues and concluded that comparative sampling with existing MIK net types should be undertaken. WGALES suggested that this should be undertaken using a dedicated survey, on one vessel, immediately after the 1st quarter IBTS when all targeted length classes of herring larvae are still abundant. Comparative

tows should be undertaken in a suitable area with all the various MIK types that are currently in use.

d. Data storage at coordinator and ICES level

Currently, MIK data are stored at ICES and with the MIK survey coordinator, at TISF in the old Excel format. The Excel format was set up many years ago by the first survey coordinator at DTU Aqua, Denmark. The data are currently being quality checked in two (or more steps). In the first step only data back to 2000 are checked and subsequently corrected if possible or flagged appropriately. These quality checks are a necessary perquisite for all the analysis to be performed with respect to issues describe in the following paragraph (e.). Once this is done, the data will be converted into the ICES egg and larva database format and uploaded to ICES.

e. Data analysis and generation of indices for use in stock assessment and scientific research

With the increasing importance of the Downs component in total North Sea herring SSB it became apparent that the current algorithm for calculating the MIK herring larvae index became more likely to produce biased results. This was particularly true for the 2014 MIK survey when large numbers of small herring larvae originating from the Downs component resulted in an extraordinarily high MIK index. Part of this biased result originated from the undersized mesh utilized by some participants particularly in the southern survey area where Downs larvae are most abundant. How-ever, the major problem with these small larvae stems from the index calculation algorithm itself. The current algorithm deals with the small larvae as follows:

It is assumed that small Downs larvae are only abundant south of 54 °N. Consequently, only for stations south of that latitude, an exception rule is implemented. The mean larval length for each of those stations is calculated, and if that value is < 20 mm all data from that station is excluded from the index calculation.

In 2014, this rule lead to the exclusion of 37 stations from the index calculation but also, and more importantly because of that all or nothing rule, to the inclusion of a number of stations with high or very high abundances of small larvae, where either the mean length was > 20 mm or the station was north of 54 N. These stations contributed to almost 40% of the total index.

Another issue was raised with the presentation drift patterns of larvae originating from several spawning sites around the British Isles. It became apparent that in 2014, herring larvae that were found in the northern North Sea during the MIK survey most likely originated from the west of Scotland spawning sites. This phenomenon is to be further investigated in WKWEST (western herring stocks Benchmark for 2015).

These issues clearly underscore the need for a determination of the contributions by individual stock components to the MIK index.

In the future, and with the increasing importance of the Downs Component for the North Sea herring stocks, it is also desirable to initiate another MIK survey for those larvae to obtain an O ring index for this component and thus a recruitment index for the whole North Sea complex. This is important since the NS Autumn spawning herring is assessed as one stock, not as separate components.

8   Survey design (Extra recommendation from WGISDAA)

The recommendation of WGISDAA was discussed during the meeting. It was explained what the role of WGISDAA is and how they might be able to help with survey

design problems. WGMEGS has currently asked WGISDAA to help with changes in the survey needed because of the expansion of the spawning area and period of mackerel.

9 Clupeid larvae identification (Extra recommendations from WKIDCLUP)

WGALES discussed the WKIDCLUP recommendations and concluded on those as follows:

1) WGALES concluded that not only the identification of clupeoid larvae could be improved, but also identification of other fish larvae as well as fish eggs is important if e.g. dynamics in fish recruitment or identification of principal spawning areas shall be further investigated. WGALES therefore not only supports WKIDCLUP's recommendation to carry out that workshop every 5 years but also recommends that workshops for fish egg and larvae identification should be carried out on a regular basis. For fish eggs, WGALES recommends that next year's WKFATHOM meeting is extended by one day that will be dedicated to fish eggs other than those of mackerel and horse mackerel.

2) WGALES discussed the possible effect of the low agreement on herring assessment. However, most of its impacts may only be fully addressed and analysed by the respective assessment group HAWG. Those investigations should be done by survey, where the specific probabilities of misidentification have to be evaluated. In a first step, a ring ID test between the respective survey participants should be carried out.

3) WGALES concluded that in order to improve and maintain fish egg and larvae ID quality, all institutes carrying out those kinds of surveys should make sure that only fully competent staff is sent on those surveys.

10 Next meetings

Next meeting of WGALES will be held in Thessaloniki, Greece, from 17–21 October 2016. (Annex 3).

The Workshop on the ICES Egg and Larval Database (WKIELD) will meet in Copenhagen, Denmark, from 27–29 April 2015 (Annex 4).

Annex 1: List of participants

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Annex 2: Agenda

Monday 1st December

13:00	General WGALES
14:00	lunch
14:30	Subgroup herring larvae
17:00	End of day

Tuesday 2nd December

9:00   Opening workshop, appointing rapporteurs for the various session (parts)
        Maria Manuel Angélico and Cindy van Damme

9:30   Introductory presentation about WGALES
        Cindy van Damme

        Start session 1: Egg and larval surveys

9:50   Ichthyoplankton surveys in the Baltic
        Bastian Huwer

10:10   Ichthyoplankton surveys in the Bornholm Basin, the Gdańsk Deep, and
        the Gotland Basin
        Andrei Makarcuks

10:30   Multidisciplinary sampling during the French IBTS in the English Channel and North Sea
        Christophe Loots

10:50   MIK surveys
        Matthias Kloppmann

11:40   An overview of the UK (Northern Ireland) Methot–Isaacs–Kidd Survey
        (NIMIK)
        Steven Beggs/Richard Nash

12:00   Sardine ichthyoplankton in the western English Channel and Celtic Sea.
        Steve Milligan

12:20   Using the 1st Quarter IBTS MIK sampling for determining the distribution
        of spawning in winter, from egg distributions: the MIKeyM nets
        Richard Nash

12:40   Can the standard ICES coordinated IBTS-MIK survey provide reliable
        data on herring recruitment and spawning locations in the North Sea?
        Cindy van Damme

14:20   The Ruegen herring larvae survey": Is a single-bay monitoring suitable for
        a reliable recruitment forecast in the western Baltic Sea?
        Patrick Polte

14:40   The Irish herring larvae survey
        Steven Beggs/Richard Nash

15:00   Project CRAMER: Ecology of hake recruitment in the Northwest Spanish
        Iberian coast (ICES Subdivision VIIIc west)
        Paula Alvarez

15:20   BIOMAN: Anchovy DEPM surveys in the Bay of Biscay from 1987 to 2014
         Maria Santos

16:00   The Atlantic Iberian sardine DEPM surveys: 1988 – 2014
         Maria Manuel Angélico

16:20   The southern horse mackerel DEPM
         Maria Manuel Angélico

16:40   GoC anchovy DEPM
         Maria Paz Jimenez/Paz Díaz

Wednesday 3rd December

9:00   Plankton sampling during spring acoustic surveys PELAGO (IPMA) and
         PELACUS (IEO)
         Maria Manuel Angélico

9:20   Ichthyoplankton sampling and processing during the PELGAS Ifremer
         survey in the Bay of Biscay.
         Martin Huret

9:40   Relations between eggs and larvae of *Engraulis encrasicolus* and biotic and
         abiotic variables in the southwestern Adriatic Sea
         Sara Malavolti/Claudio

10:00   Ichthyoplankton around a potential nuclear new build at Sizewell in Suf-
         folk Steve Milligan

10:20   The Norwegian spring survey on the distribution of fish eggs and larvae
         in the northern North Sea – sampling strategy and bottlenecks
         Hannes Höffle

10:40   Developments in Total Annual Egg Production estimates for the North-
         east Atlantic Mackerel Egg Survey 1992 – 2013
         Finlay Burns

11:20   On the way towards using hydroacousticmultifrequency techniques to as-
         sess Northeast Atlantic mackerel (*Scomber scombrus*)
         Jens Ulleweit

11:40   Clupeid larval fish surveys in the NE Baltic Sea
         Timo Arula

12:00   Implementing routine larval surveys in the North Sea: progresses and per-
         spectives

         Marta Moyano

12:20   Fine scale distribution and temporal variability in plaice (*Pleuronectes
         platessa*) and cod (*Gadus morhua*) eggs during the 2000 Irish Sea ichthy-
         oplankton surveys.
         Richard Nash

         Discussion Session 1

Start session 2: Recent advances in egg and larval mortality studies

14:20   A real-time PCR assay to estimate invertebrate and fish predation on anchovy eggs in the Bay of Biscay
Aitor Albaina

14:40   Using laboratory ecophysiological studies to improve individual-based models of North Sea larval herring foraging and growth
Marta Moyano

15:00   A Bayesian hierarchical model for estimating daily egg production and mortality rates
Leire Ibaibarriaga

15:40   Egg mortality and egg production estimates for Atlanto-Iberian sardine (1988–2014) using an external mortality model
Paz Díaz

16:00   Mortality in anchovy eggs
Maria Paz Jimenez/Paz Díaz

16:20   Characteristics of juvenile survivors reveal spatio-temporal differences in early life stage survival of Baltic cod
Bastian Huwer

16:40   Calculations of mortality rates of sprat eggs
Andrei Makarchouk

Thursday 4th December

9:00   ICES larval and egg database
Carlos Pinto/Cindy van Damme

9:20   Drivers and stressors of herring early life stage mortality in inshore spawning areas of the western Baltic Sea
Patrick Polte

9:40   Linking short-term physiological responses to longer-term climate impacts: a case study using Atlantic herring early life stages
Marta Moyano

10:00   Can microzooplankton support the growth and survival of Atlantic herring larvae in wintertime?
Franziska Bils

10:40   Effect of temperature and development on mortality rates of a riverine fish species (Chondrostomanasus): comparison of laboratory and field results. Larval mortality in the Danube river
Hubert Keckeis

11:00   First steps towards an integrative modelling approach of fish larvae habitat. An application to Downs herring larvae
Christophe Loots

11:20   Upwelling at the Senegalese coast: A suitable spawning area of small pelagic fish
Maik Tiedemann

11:40   Egg mortality rates, an exploration of specific and spatial variability: are we making any progress and is it really necessary to have a precise estimate?
Richard Nash

12:00   **Discussion session 2**

14:20   Breakout in groups: groups of 4–5 persons: Questions: main conclusion and future perspective for session 1, main conclusion and future perspective for session 2, topic for next WGALES meeting

16:20   Discussion of break out groups

20:00   WGALES Dinner

Friday 5th December

10:00   Eggs and larvae database, WKIDCLUP recommendations, Survey Protocols for Ichthyoplankton surveys

11:00   WGALES recommendations, ToR's for next meeting, Election of new chair

12:00   Report writing

13:00   Finish meeting

Annex 3: WGALES multi annual terms of reference

2012/MA2/SSGESST17 The **Working Group on Atlantic Fish Larvae and Eggs Surveys (WGALES)**, chaired by Maria Manuel Angélico, Portugal, and Richard D.M. Nash*, Norway, will meet in Thessaloniki, Greece 17–21 October 2016, to work on ToRs and generate deliverables as listed in the Table below.

WGALES will report on the activities of 2015 and 2016 (the second year) by 1 December 2016 to SCICOM

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2013	Correspondence	Intersessional	Interim report by 5 January 2015 May 2013 to SSGESST (SSGIEOM)	Group is planning to meet face to face in 2nd year – see below.
Year 2014	1–5 December	San Sebastian, Spain	Interim report by 5 January 2015 to SSGIEOM	Cindy Van Damme to be replaced by Richard Nash from next meeting of WGALES
Year 2016	17–21 October	Thessaloniki, Greece	Final report by 1 December 2016 to SSGIEOM, SCICOM	

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Present current ichthyoplankton surveys in the light of their original purposes, with respect to design, estimation methods and challenges (including their potential as ecosystem surveys);	The activities of WGALES are vital for the delivery of state-of-the-art ichthyoplankton surveys, ensuring high standards and incorporating new techniques and developments for the future. WGALES will lead to the cross fertilization of ideas, methodologies, developments and standardization of ichthyoplankton surveys in the ICES area. Hence providing a platform from which to improve the assessments based on the ichthyoplankton surveys. WGALES	5.1, 5.2	2nd year	Report in 2016

		fits into the ICES science plan Sections 5.1 and 5.2.			
b	Present current understanding and future research needs for integrating ichthyoplankton data and methodologies into methodologies for assessing population sizes	Ichthyoplankton surveys are often part of a larger and more encompassing set of studies which are aimed at determining population size e.g. Egg Production Methodologies. There is a need to review the various aspects of such research, as a complete study, to ensure the correct data are collected and there is a general understanding of how all the parts fit together to ensure complete and relatively precise estimates of stock size are realized.	5.1, 5.2	2nd year	Report with review of methodologies and potential 'pitfalls' for undertaking multidisciplinary estimations of stock size which involve the use of icthyoplankton surveys, and needs for future research for a bettter integration of fish egg and larvae data.
c	Receive and act upon ToRs from Working Groups within the umbrella of ichthyoplankton surveys e.g. IBTSWG, WGACEGG, WGIPS, WGMEGGS, WGEGGS2.	The activities of WGALES are vital for the delivery of state-of-the-art ichthyoplankton surveys, ensuring high standards and incorporating new techniques and developments for the future. WGALES will lead to the cross fertilization of ideas, methodologies, developments and standardization of ichthyoplankton surveys in the ICES area. Hence providing a platform from which to improve the assessments based on the ichthyoplankton surveys.	5.1, 5.2	3 years, if necessary WGALES can react by correspondence on urgent ToR's from other ichthyoplankton surveys groups in 2013 and 2015. During the meeting in 2014 ToR's from ichthyoplankoton survey groups from 2013 and 2014 will be addressed and reported on.	Report in 2016.

Summary of the Work Plan

Year 1	If necessary WGALES will meet by correspondence to act upon urgent Tor's from ichthyoplankton survey groups (ToR c).
Year 2	WGALES will organize a meeting to address ToR's a,b, and c.
Year 3	If necessary WGALES will meet by correspondence to act upon urgent Tor's from ichthyoplankton survey groups (ToR c).

Supporting information

Priority	The activities of WGALES are vital for the delivery of state-of-the-art ichthyoplankton surveys, ensuring high standards and incorporating new techniques and developments for the future. WGALES will lead to the cross fertilization of ideas, methodologies, developments and standardization of ichthyoplankton surveys in the ICES area. Hence providing a platform from which to improve the assessments based on the ichthyoplankton surveys. WGALES fits into the ICES science plan Sections 5.1 and 5.2.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required is ICES secretariat support for reports.
Participants	The Group will be attended by members of ICES groups, WGMEGS, WGEGGS2, WGIPS, IBTSWG, WGACEGG and guests carrying out ichthyoplankton surveys in the non-ICES areas.
Secretariat facilities	ICES secretariat support for reports.
Financial	DCF funding is required to support the attendance of the meetings.
Linkages to ACOM and groups under ACOM	There are linkages with the advisory committees through the individual ichthyoplankton surveys groups. Through the review and standardization of the ichthyoplankton surveys the quality of the data for the assessments is ensured.
Linkages to other committees or groups	SCICOM and there is a very close working relationship with the all the groups of ichthyoplankton surveys, WGMEGS, WGEGGS2, WGIPS, IBTSWG, WGACEGG and their assessment groups, WGWIDE, HAWG, WGHANSA.
Linkages to other organizations	No formal linkages.

Annex 4: WKIELD terms of reference for the next meeting

The **Workshop on the ICES Egg and Larval Database** (WKIELD), chaired by Cindy van Damme, the Netherlands, and Carlos Pinto, Denmark, will meet in Copenhagen, Denmark, 27–29 April 2015 to:

a) Review and finalize the input and output format of the ICES egg and larval database;

b) Instruct ichthyoplankton survey participants in the format of the database and prepare their datasets for uploading to the ICES egg and larval database;

c) Prepare a list of output products and reports needed from the ICES egg and larval database.

WKIELD will report by 22 May 2015 to the attention of WGALES, WGMEGS, WGEGGS2, WGIPS, IBTSWG and WGACEGG.

Supporting Information

Priority	The ICES egg and larval database will ensure and standardize ichthyoplankton survey data. Through the standardization and review process before uploading the data to the database the quality of the ichthyoplankton data for the assessment groups is ensured.
	Scientists involved or in charge of various ichthyoplankton surveys are willing to store the datasets of their survey into the ICES egg and larval database. This workshop will allow scientists to reformat and upload their data into the ICES database.
	The workshop will result in an agreed standard format for reports and products from the ICES egg and larval database for use in assessments and other scientific needs.
Scientific justification	Term of Reference a)
	Several ICES coordinated and non-ICES coordinated ichthyoplanton surveys are carried out in the Northeast Atlantic. The ICES egg and larval database should give the possibility of all ichthyoplankton survey dataset carried out in the ICES areas to be uploaded to the ICES egg and larval database.
	Term of Reference b)
	Scientists involved or in charge of various ichthyoplankton surveys are willing to store the datasets of their survey into the ICES egg and larval database. Not all of these scientists are familiar with the format of the database. This workshop will allow scientists to bring their datasets and reformat these to be able to upload the data into the ICES database.
	Term of Reference c)
	The workshop will prepare an overview of output products needed for assessments and/or scientific advice from the ichthyoplankton surveys datasets.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	10–20 scientists have indicated interest to participate in this workshop. The workshop will be attended by members of ICES groups, WGMEGS, WGEGGS2, WGIPS, IBTSWG, WGACEGG and guests carrying out ichthyoplankton surveys in the (non-)ICES areas.
Secretariat facilities	Meeting room facilities at the ICES secretariat and support with finalizing of the report.

Financial	No financial implications.
Linkages to advisory committees	There are linkages with the advisory committees through the individual ichthyoplankton surveys groups. Through the review and standardization of the ichthyoplankton surveys data the quality of the data for the assessments is ensured. Assesment groups using ichthyoplankton survey data have indicated they want to use the data from the ICES egg and larval database directly for use in their assessments.
Linkages to other committees or groups	SCICOM and there is a very close working relationship with the all the groups of ichthyoplankton surveys, WGMEGS, WGEGGS2, WGIPS, IBTSWG, WGACEGG and their assessment groups, WGWIDE, HAWG, WGHANSA.
Linkages to other organizations	No formal linkages.

Annex 5: Recommendations

Recommendation	Adressed to
1. WGALES recommends the follwing fields are added to the ICES egg and larval database; Netnumber, cruise number, minimum and mximum depth sampled and institute. It should also be possible to add the metadata descriptions of the individual surveys to the database. The database should allow for uploading preliminary data, but these should be kept protected until finalized. The database should have the possibility to resubmit data and keep a log of the resubmissions.	DIG, ICES datacenter
2. WGALES recommends to include specific topics relating to ichthyoplankton surveys in the SISP's of these surveys (see Section 4 for details).	SSGIEOM
3. WGALES recognizes the need for international workshop for identification and staging of fish eggs and larvae. These workshops should not only deal with the target species of the surveys, but include other species in order to develop the surveys in to more ecosystem monitoring. Such workshops should be held regularly, e.g. every 5 years.	WGMEGS, WGEGGS2, WGACEGG, IBTSWG, WGIPS, WKFATHOM
4. WGALES recommends that the WKFATHOM egg identification and staging workshop in 2015 should be extended with an extra day for identification of other species besides the target species mackerel and horse mackerel.	WKFATHOM, WGMEGS
5. WGALES discussed the possible effect of the low agreement on herring assessment, but recognizes that the impact of this may only be fully addressed and analysed by the assessment group HAWG. Those investigations should be done by survey, where the specific probabilities of misidentification have to be evaluated. In a first step, a ring ID test between the respective survey participants should be carried out.	HAWG
6. WGALES concluded that in order to improve and maintain fish egg and larvae ID quality, all institutes carrying out those kind of surveys should make sure that only fully competent staff is sent on those surveys.	WGMEGS, WGEGGS2, WGACEGG, IBTSWG, WGIPS
7. IBTS participants should consider an intercomparison of all types of MIK currently in use, in order to investigate the catchability for the different length classes of herring larvae	IBTSWG, HAWG
8. With the increased contribution of the Downs component in the North Sea the current IBTS0 index is not indicative of recruitment for the whole stock. This is due to the survey occurring too close to hatching time for this component. Therefore, a second MIK survey, in April, should be considered.. Such a survey should not necessarily cover the entire North Sea, rather, only the southern and eastern sections of the North Sea.	IBTSWG, HAWG
9. WGALES recommends that MIK data are uploaded to ICES egg and larvae database after quality checks are carried out, and errors corrected or flagged accordingly.	IBTSWG
10. WGALES recommends that the algorithms of MIK index calculation are revised, acknowledging the different stock components, and incorporate the extensive length data that are available. The revision will necessitate a recalculation of the time-series of MIK indices for use in the North Sea herring assessment.	WGISDAA, HAWG

Annex 6: Abstracts of session 1 Egg and larval surveys

Bastian Huwer

Ichthyoplankton surveys in the Baltic

*DTU Aqua, GEOMAR Kiel, NMFRI Gdynia, IHF Hamburg University, TI-OSF Rostock, BIOR Latvi*a

This talk will present a >25 year time-series of ichthyoplankton surveys in the Baltic. The main focus area is the Bornholm Basin, as this is the most important spawning ground for the Eastern Baltic cod stock as well as an important spawning ground for Baltic sprat. The talk will provide a historic overview about the development of the surveys from the mid-1980s to present times and will present examples of various process-oriented studies related to the surveys, including e.g. estimates of egg production, investigations of egg and larval mortality due to hydrographic conditions and predation, and analyses of larval condition and growth.

Andrei Makarchouk

Ichthyoplankton surveys in the Bornholm Basin, the Gdańsk Deep, and the Gotland Basin

Regular ichthyoplankton sampling has been being carried out by our institute since 1970s. Regions covered included the Bornholm Basin, the Gdańsk Deep, and the Gotland Basin, but in the 1990s investigated area was restricted mainly to the Gotland Basin. Three to five surveys were executed each year in the period from March to August. Samples were collected at the positions of the hydrological stations or after trawling in the main. The regular grid of ichthyoplankton stations was introduced in the early 1990s. The samples were collected with ichthyoplankton net IKS-80, which had the mouth opening 0.5 m² and mesh size 500 μm. This net was operated vertically (from bottom or 140 m depth to the water surface), and towed on water surface during 10 minutes at a speed of ca. 2 knots.

We try to avoid the influence of differences in the positions of stations by calculating the mean weighted numbers of eggs and larvae drawing the isolines in Surfer program and calculating total number of them in the region with the Volume function.

Christophe Loots

Multidisciplinary sampling during the French IBTS in the English Channel and North Sea

Since 2006, an ecosystemic sampling is performed during the French IBTS on board of the RV 'Thalassa' in the English Channel and Southern North Sea. This sampling encompasses hydrobiological measurements using CTD and Niskin bottles as well as phytoplanktonic, mesozooplanktonic and ichthyoplanktonic sampling. For zooplankton and fish larvae, classical nets like WP2 and MIK are used. A multi net is used for vertical sampling of fish larvae. To collect fish eggs, a continuous sampling is performed using the CUFES and a new net called the Mikey net has been deployed since 2012. These samples are used for different research purposes including trophic web studies, spatio-temporal distribution and habitat modelling of plankton and spawning grounds. Studies dedicated to nutrition, growth and physiological condition of fish

larvae and in particular, of Downs herring larvae are also based on these collected samples. The French IBTS allows to have an overview of the planktonic ecosystem in the English Channel and southern North Sea during the winter period, which remains poorly, studied whereas it precludes the spring planktonic bloom.

Matthias Kloppmann

Fish larvae survey during the International Bottom Trawl Survey (IBTS)

Thünen-Institute of Sea fisheries

The MIK survey provides an abundance index for large herring larvae (around and > 20 mm SL) that is used in the assessment as a recruitment index for North Sea herring. It takes place during first quarter IBTS with Germany, Denmark, Sweden, Norway, Scotland, the Netherlands and France participating. Sampling is done following the IBTS survey strategy of randomly sampling in the various statistical ICES rectangles in the North Sea, Skagerrak, Kattegat and Channel area. In principal, two Nations are responsible for each rectangle where 2 MIK hauls have to be done per each participant. Sampling is done with a 2 m ring trawl with 1600 µm mesh down to a maximum depth of 100 m or 5 m above the seabed. Herring larvae are sorted from the samples, counted and measured to the nearest 1 mm standard length (SL) below. Catches are standardized to abundance of herring larvae per m² and from those values an index for larval abundance is calculated for the entire survey area. In order to exclude the small, rather abundant but patchily distributed larvae of the Downs component from the index calculation, all stations south of 54 °N with a mean herring larvae length < 20 mm SL are excluded from the estimation.

With the increasing importance of the Downs component in total North Sea herring SSB it became apparent that the current algorithm for calculating the MIK herring larvae index became more likely to produce biased results. This was particularly true for the 2014 MIK survey when large numbers of small herring larvae originating from the Downs component resulted in an extraordinarily high MIK index. Part of this biased result originated from the too small mesh size (<< 1600 µm as stipulated in the MIK manual) utilized by participants particularly in the southern survey area where Downs larvae are most abundant. However, the major problem with these small larvae is rooted in the index calculation algorithm itself. An alternative calculation method to illustrate the possible bias is presented.

Steven Beggs (presented by Richard Nash)

An overview of the UK (Northern Ireland) Methot–Isaacs–Kidd Survey (NIMIK)

The survey uses a Methot–Isaacs–Kidd frame trawl to target pelagic juvenile gadoids in the Irish Sea since 1993. The survey is stratified and takes place in May and June during the period prior to settlement of gadoid juveniles. Indices are calculated as the arithmetic mean of the numbers-per-unit sea area. The survey also uses a Gulf-VII high-speed plankton sampler with on board CTD to collect abundance and distribution data on larval fish, zooplankton and water structure properties. While the main objective of the survey is to provide recruitment information on gadoids the survey provides the opportunity and tools to collect valuable information on the wider ecosystem.

Jeroen van der Kooij (presented by Steve Milligan)

PELTIC 2011 – 2014: Sardine ichthyoplankton surveys in the Western Channel and Celtic Sea

Jeroen van der Kooij, Steve Milligan, James Pettigrew, Paul Bouch, Scott Davis and Beatriz Roel

Sardine eggs and larvae were collected as part of two fieldwork programs in the Celtic Sea and Western Channel: a one-off multidisciplinary summer survey, which covered the whole of the Celtic Sea shelf at relatively low resolution and a new five-year multidisciplinary autumn survey series in ICES areas VIIe and f as part of project Poseidon. These surveys provide an opportunity to update knowledge of the spawning areas; whereas sardine spawning in the Bay of Biscay has been surveyed for several decades, previous records on spawning distribution in the western Channel have been shown to be of equivalent importance in terms of numbers of eggs spawned, yet information is limited about this region. Long time-series of sardine eggs are available from the Channel; however, these data are collected at fixed stations off Plymouth and therefore provide no spatial information. Monitoring the spawning behaviour is important because changes in seasonality, timing and intensity of sardine spawning have been observed. The results of the summer survey in 2011 and those of the first three autumn surveys (2012–2014) were presented. Good numbers of sardine eggs and larvae were found highlighting the importance of the area for this species. Preliminary results suggest that oceanography affect both timing and spatial distribution of spawning. A detailed analysis of the environmental drivers including the use of larval drift models will be used to shed more light in this.

Richard Nash

Using the 1st Quarter IBTS MIK sampling for determining the distribution of spawning in winter, from egg distributions: the MIKeyM nets

Richard D.M. Nash[1], Cindy J.G. van Damme[2] and Hannes Höffle[1*]

[1]Institute of Marine Research and Hjort Centre for Marine Ecosystem Dynamics, PO Box 1870, 5817 Bergen, Norway. [2]Wageningen IMARES— Institute for Marine Resources and Ecosystem Studies, PO Box 68, 1970, AB IJmuiden, The Netherlands.

Recent ichthyoplankton surveys were conducted in the North Sea in 2004 and 2009 with the intention of determining the extent of winter spawning in the area. In 2004, the area was surveyed on a number of different dates by a number of different countries and vessels, with most of the surveys dedicated to egg and larvae sampling. In 2009, the North Sea was only surveyed once with sampling either occurring in dedicated surveys or imbedded in to the standard 1st Quarter IBTS programme. These two surveys highlighted the interannual difference in egg distributions (hence spawning location and spawning intensity). These results highlighted the need for data that would indicate shifts in North Sea spawning, especially in relations to environmental and fishery induced changes in population abundance and demography. The ICES WGEGGS recognized the problem of mounting separate ichthyoplankton surveys so devised a sampling system for eggs and small larvae that could be undertaken simultaneously with the standard MIK survey for herring larvae. The solution was the addition of small (one or two, 20 cm rings with 335 μm mesh nets) attached to the standard 2m diameter (1.6mm mesh net) MIK trawls. This system does not involve

extra deployments of gear for the collection of eggs and larvae, thus there is the potential for 2 to 4 small mesh samples per ICES statistical rectangle over the whole North Sea. The system is referred to as MIKeyM nets with flowmeters for volume calculations in each ring. The system was trialed in 2011 and results on egg and larvae distributions from the Norwegian and Dutch sampling are shown. In addition, distributions of egg diameters from the northeastern North Sea are also shown. The feasibility of undertaking this type of sampling for the determination of winter spawning locations, on a regular basis, is discussed.

Cindy van Damme

Can the standard ICES coordinated IBTS-MIK survey provide reliable data on herring recruitment and spawning locations in the North Sea?

C.J.G. van Damme[1], M. Payne[2], C. Bakker[1], R.D.M. Nash[3]

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In February and March an ICES coordinated ichthyoplankton (IBTS-MIK) survey is conducted in the North Sea to estimate the number of herring larvae. The standard sampling utilizes an MIK (2m midwater ring trawl: 1.6 mm mesh size), designed to catch larger autumn spawned herring larvae. The MIK North Sea herring recruitment index ignores larvae below 11 mm. However, in recent years the numbers of small herring larvae has increased due to the increased winter spawning component and a prolonged spawning season. The international herring larvae surveys (IHLS), in September to December, use a Gulf VII high-speed plankton sampler (280 μm) for catching recently hatched larvae. This survey finishes too early for newly hatched larvae in February.

Recently an MIKey-M net (20cm ringnet: 335 μm) attached to the MIK ring, was developed to sample ichthyoplankton. In addition to catching small herring larvae, the MIKey-M gives the possibility of undertaking winter spawning sampling on the IBTS.

In this study the catchability of fish eggs and herring larvae are compared between gears. This examines the utility of the IBTS-MIK survey to provide a reliable index of recruitment for the North Sea herring stock and the possibility of providing data for determining spawning locations.

Patrick Polte

The Ruegen herring larvae survey: Is a single-bay monitoring suitable for a reliable recruitment forecast in the western Baltic Sea?

Patrick Polte, Rainer Oeberst, Christopher Zimmermann

Thünen Institute of Baltic Sea Fisheries
Alter Hafen Sued 2, D-18069 Rostock, Germany

The inshore waters of Greifswald Bay (ICES SD 24) are considered a main spawning area for Ruegen herring, which represents the most important component of the Western Baltic spring-spawning herring stock (WBSS). The Thünen Institute of Baltic Sea Fisheries in Germany monitors the density of herring larvae as a vector of recruitment success within the framework of the Ruegen Herring Larvae Survey. It delivers a unique high-resolution dataset on larval herring growth and survival dynamics in the

Western Baltic Sea. 35 stations are sampled weekly using a Bongo-net during the main reproduction period from March to June. The data collected provide an important basis for detailed investigation of spawning- and recruitment ecology. As a fishery-independent indicator of stock development, the recruitment index is incorporated into the ICES assessment of this stock conducted by the Herring Assessment Working Group (HAWG) since 2007. This is the only 0-group recruitment index for this assessment and thus the earliest opportunity to predict the future development of the stock. A significant correlation of year-class strength index over consecutive ages in different areas support the hypotheses that i) the Ruegen herring spawning component contributes significantly to the WBSS herring stock and ii) the majority of natural early life stage mortality occurs before larvae reach a total length of 20 mm, confirming the validity of the index.

Steven Beggs (presented by Richard Nash)

The Irish herring larvae survey

Herring larvae surveys of the northern Irish Sea (ICES area VIIaN) have been carried out in November each year since 1993. Sampling is carried out on a systematic grid of stations covering the spawning grounds and surrounding regions in the NE and NW Irish Sea. Larvae are sampled using a Gulf-VII high-speed plankton sampler with 280 μm net. Mean catch-rates (nos.m-2) are calculated over stations to give separate indices of abundance for the NE and NW Irish Sea. Larval production rates and birth-date distributions are computed based on the mean density of larvae by length class. A growth rate of 0.35 mm day-1 and instantaneous mortality of 0.14 day-1 are assumed based on estimates made in 1993–1997. The index is used as an indicator of spawning-stock biomass in the assessment of Irish Sea herring by the Herring Assessment Working Group (HAWG). The assessment of this stock was benchmarked in 2012 and issues concerning the survey raised. Current survey issues will be presented with an overview of recent efforts to resolve these.

Maria Manuel Angélico

The Atlantic Iberian sardine DEPM surveys: 1988 – 2014

Maria Manuel Angélico [1], Ana Lago de Lanzós[2], Paz Díaz[2], Cristina Nunes[1], Elisabete Henriques[1], Concha Franco[2], Jose R. Pérez[2]

[1.] *IPMA - Instituto Portugués do Mar e da Atmosfera,* [2] *IEO - Instituto Español de Oceanografía*

The DEPM methodology was first applied for spawning-stock biomass estimation for the Atlantic Iberian sardine (*Sardina pilchardus*) by Portugal (IPIMAR, currently IPMA) and Spain (IEO) in 1988. During the nineties, both countries organized surveys through informal contacts. From 2000 onwards, methodological and analytical developments and effective coordination have been carried out within ICES Study/Working Groups and the estimates produced (triennially) have been used in assessment modelling. To estimate spawning-stock biomass the DEPM involves surveying directed at egg abundances and spawning area definition, for daily egg production determination and adult sampling for daily fecundity calculation. Ichthyoplankton samples (both vertical tows and CUFES), simultaneous CTD(F) casts, and fishing hauls are undertaken over

the whole spawning region. In recent years the data collection during the DEPM surveys has been enhanced and diversified, not only for methodological improvements but also to take advantage of the comprehensive coverage of the pelagic environment and further the understanding of the ecosystem. This presentation describes the joint surveys and reports on methodological and analytical developments achieved along the years and addresses current issues under discussion.

Maria Manuel Angélico

Atlantic Southern Horse-mackerel DEPM Area IXa

Maria Manuel Angélico, Elisabete Henriques, Ana Costa and Cristina Nunes

IPMA – Instituto Português do Mar e da Atmosfera, Portugal

The Portuguese egg surveys directed at estimation of spawning-stock biomass for horse-mackerel (*Trachurus trachurus*) started in the 1990s in parallel with the efforts conducted for establishing the basis for the EPMs for sardine and anchovy in Atlantic Iberian waters. The first survey took place in 1995 and after, other were carried out following a triennial Annual Egg Production Method programme coordinated within the ICES-WGMEGS. Since the definition of the southern stock (Gibraltar-Cape Finisterre) and owing to the results from several studies on the southern horse-mackerel spawning strategy which highlighted its indeterminate fecundity type, Portugal (IPMA) adopted the DEPM methodology starting in 2007. This presentation points out the major developments in surveying and analyses achieved since the implementation of the DEPM methodology and addresses current issues under investigation concerning in particular adult parameter estimation.

Maria Manuel Angélico *et al.* IPMA and IEO

Plankton sampling during acoustic surveys PELAGO (IPMA) and PELACUS (IEO)

IPMA - Instituto Portugués do Mar e da Atmosfera

IEO - Instituto Español de Oceanografía

The Portuguese (IPMA-PELAGO) and Spanish (IEO-PELACUS) acoustic surveys for pelagic fish assessment in Atlantic Iberian waters started in the late eighties. Since then several improvements were attained and at present these surveys, which are coordinated through ICES-WGACEGG (PELAGO, PELACUS and PELGAS-Ifremer), encompass routine surveying for several disciplines that assist in the characterization and monitoring of the pelagic ecosystem. In addition to hydroacoustic surveying, extended plankton sampling (e.g. CUFES, WP2), hydrographic data acquisition and mammal and bird census are carried out during the spring acoustic surveys. A summary of the methods routinely used, during both surveys, for extra acoustics surveying is presented.

Paz Jiménez(presented by Paz Díaz)

BOCADEVA Series. Gulf of Cadiz Anchovy DEPM surveys

Paz Jiménez, J. Tornero, C. González, R. Sánchez and F. Ramos

Instituto Español de Oceanografía (IEO)

The Daily Egg Production Method (DEPM) to estimate the Anchovy Spawning-stock biomass in the Gulf of Cádiz (ICES, Subdivision IXa South) is conducted every three years by IEO (Spain). The first survey of this series (BOCADEVA0605) was carried out in 2005, and four surveys have been carried out to date. The surveyed area extended from Strait of Gibraltar to Cape San Vicente (Spanish and Portuguese waters in the Gulf of Cadiz). Plankton samples, along a grid of parallel transects perpendicular to the coast, are obtained for the spawning area delimitation and estimation of the daily egg production. Concurrently, fishing hauls are undertaken for estimation of adult parameters (sex ratio, female mean weight, batch fecundity and spawning fraction) within the mature component of the population. The BOCADEVA series objectives also include surveying to obtain biological parameters, including length distribution, for other important commercial fish species in the area. Characterization of the regional oceanographic and meteorological conditions are also undertaken during the surveys. This presentation provides a brief description on sampling and analyses methodological developments for eggs and adults parameter estimation conducted over the years of the BOCADEVA series.

Martin Huret

Ichthyoplankton sampling and processing during the PELGAS Ifremer survey in the Bay of Biscay

Martin Huret

The PELGAS survey aims at monitoring the Bay of Biscay pelagic ecosystem, in order to provide scientific data for the implementation of an ecosystemic management of living resources in the area. Data are collected within the EU Data Collection Regulation framework and are used to assess the anchovy, sardine and horse mackerel stocks within the ad-hoc International Council for the Exploration of the Sea (ICES) working groups. The cruise hence takes place in spring, during anchovy spawning season, to allow for the assessment of both eggs and adult stages. The presentation will briefly gives an overview of the ensemble of data sampled during the survey, before focusing on the ichthyoplankton. The main sampling for eggs is performed with the CUFES along the acoustic transects. Eggs are then sorted and counted for anchovy and sardine with binocular. Recently the Zoocam, an optical instrument, was developed, allowing for fast image capturing of all particles of a CUFES sample, and then their rapid and semi-automatic classification. In addition to eggs, this also allows mesozoopanktoncan to be classified in major groups, and size structure of the community to be derived. To derive total egg abundance, we use the surface abundance extrapolated over the water column using a 1D vertical model. The numerous parameters collected during the PELGAS cruises will provide indicators to assess the good ecological state of the Biscay pelagic ecosystem, within the framework of the new EU directive.

Maria Santos

BIOMAN: Anchovy DEPM surveys in the Bay of Biscay from 1987 to 2014

Maria Santos, Leire Ibaibarriaga, Andrés Uriarte.

The BIOMAN surveys series started in 1987 to monitor and assess the Bay of Biscay anchovy population. The main objective was to obtain a biomass index of anchovy in spring in the Bay of Biscay by the Daily egg production Method (DEPM). In addition, the survey aimed at improving the knowledge of the spawning and reproductive biology of anchovy. This survey collaborates with other triennial EPM surveys for the estimation of spawning stocks biomass of other pelagic species as sardine, mackerel and horse mackerel concerning the coverage of the Bay of Biscay. In this presentation, we report on the application of the DEPM to the Bay of Biscay anchovy from 1987 to 2014 describing the major methodological changes adopted. In this period the anchovy population showed high fluctuations, including a recent period of very low biomasses (2005–2009) in which the fishery was closed. The historical maximum was reached in 2011 with 135,732t (CV 0.16) and the minimum in 2005 with 4,832t (CV 0.20).The major variability of spawning biomass estimates arises from the assessment of the total Daily Egg production (mean 3.5 E+12 eggs per day, CV 0.72), whist daily fecundity is far less variable (mean 96 eggs/gram of biomass per day and CV 0.20).

Paula Alvarez

Ecology of hake recruitment in the Northwest Spanish Iberian coast (ICES Subdivision VIIIc west)

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The aim of this study is to analyse the ecological processes of hake recruitment, from egg production to the post-larva phase, when it changes from pelagic to demersal habits and recruits definitively to the population. In Galicia, hake presents a protracted spawning season, which covers the whole year, showing higher spawning activity during the first half of the year, with a main peak of spawning between January and March, and secondary peaks in June-July and October-November. During winter and summer, surveys (considering top priority winter-survey) hake eggs and larvae were collected following an adaptive cluster sampling. Both, selection of sampling locations and sampling effort depended on the number of hake larvae previously collected during the same survey. Ichthyoplankton samples for quantitative analyses were carried out with a multiple opening/closing net MultiNet_MiDi hauled at 5 depth strata. Additionally, in order to get more larvae and post-larvae, in areas with high concentrations of larvae sampling units in the neighborhood of that observation were carried out using a Bongo 90 and a Multi-net RMT. Juveniles were caught using a trawling gear of BACA type with a maximum mesh size of 20 mm. Otoliths of larvae and juveniles were used to determine the age and growth rate. The number of increments was counted and the distance between consecutive rings was measured using a microscope applied to an

image analyser (VISILOG/TNPC). Spatial and vertical distributions of hake eggs and larvae and growth variability during the early phase were analysed in relation to environmental conditions. Finally, acoustic data were obtained by using of an EK60 echosounder at 18, 38, 70, 120 and 200 kHz, to test if fish larvae aggregations may be detected and assessed by acoustics techniques in Galician waters, such as it was showed for hake larvae in Argentinean shelf).

A. Leonori (presented by Claudio Vasapollo)

Relations between eggs and larvae of *Engraulis encrasicolus* and biotic and abiotic variables in the southwestern Adriatic Sea

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Identification of possible spawning and nursery areas in relation to environmental conditions of European anchovy (*Engraulis encrasicolus*) is challenging from both ecological and management point of view because of the role in the food chain and the economic importance of this species. Early studies in the 1980s identified the Manfredonia Gulf in the southwest Adriatic Sea as both a spawning and nursery area, but since then no more investigations have been made neither to estimate the abundance of eggs and larvae of European anchovy nor to characterize the surrounding habitat. In this contest, the aim of the present work was to find relations between both eggs and larvae of *E. encrasicolus* and environmental and biological variables.

To address this objective, during the acoustic survey on small pelagic fish in July 2012 and in July 2013, 63 and 65 ichthyoplankton stations, respectively, were made (5 nm apart each other) along parallel transects (10 nm apart each other) perpendicular to the coastline to test for the presence/absence of eggs and larvae. Vertical plankton tows have been performed using a WP2 net (200 μm mesh size) until 5 m above the bottom (max depth sampled: 100 m). Every year, in 39 of these stations both biotic and abiotic variables (temperature, salinity, fluorescence and zooplankton) samplings have been made. While the analysis of 2013 samples are in progress, on the whole in 2012, 960 eggs and 887 larvae have been found. Two peaks of egg abundances have been observed in front of Gargano promontory and in front of Bari. Larvae showed two peaks of abundance in front of Bari and in front of Ostuni. The Spearman's Rank correlations showed a highly significant negative relation between larvae and salinity at 1 meter depth ($\varrho = -0.42$, $p < 0.001$) and a positive correlation between larvae and zooplankton ($\varrho = 0.48$, $p < 0.01$). On the contrary, no significant correlations have been found among eggs and any of the abiotic and biotic variables. These findings suggest that the spawning areas are neither selected based on the food availability, as the absence of correlation between eggs and biotic features showed, nor based on particular ranges of other biotic variables. It is likely that the eggs distribution is led by the dominant cyclonic circulation of the area. On the contrary, larvae feed on zooplankton and they tend to be concentrated in the same areas of the latter. More investigations are needed to verify if these spawning and nursery areas remain constant both in space and time.

Steve Milligan

Ichthyoplankton surveys at Sizewell, Suffolk, UK

Information was presented on the work being conducted by Cefas, around Sizewell nuclear power station on the Suffolk coast, UK. The aim is to provide baseline information in preparation of a potential new power station (Sizewell C) which is currently going through the strict planning process. The impact of entrainment of plankton distribution and abundance and the impact of a warm-water plume emanating from the proposed new station is being assessed. Distributions of ichthyoplankton eggs and larvae from a series of five surveys conducted monthly from February to June 2011 were presented, showing the importance of the area for Dover sole and Bass spawning. Surprisingly, high densities of anchovy eggs were found in the area in June.

Hannes Höffle

The Norwegian spring survey on the distribution of fish eggs and larvae in the northern North Sea – sampling strategy and bottlenecks

Hannes Höffle and Richard D.M. Nash

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The Norwegian Ichthyoplankton survey in the northern North Sea has been undertaken since 2010 as part of the annual ecosystem survey, which covers several transects across the northern North Sea in April/May. The survey covers the area between the Shetland Isles in the North and as far south as Aberdeen. The sampling strategy is aimed at resolving the horizontal and vertical distribution of fish eggs and larvae. The horizontal distribution is investigated with a Gulf VII high-speed sampler at selected stations along the standard transects, while the vertical distribution is examined using a Multinet at two process stations. These stations are situated off the Shetland Isles and in the central North Sea or the Skagerrak and occupied over 24 to 48 hours. Fish eggs and larvae are sorted from the samples at sea and preserved for further processing in the laboratory. A limiting factor in the number of samples is the time needed to pick the ichthyoplankton between stations, governed by the available manpower and the stability of the survey vessel. Manpower is a bottleneck in the laboratory as well. While the zooplankton community is sampled, generally it is only analysed in terms of size fractionated biomass, while the capacity for taxonomic work is limited. Similarly, analysing the ichthyoplankton requires the use of automated techniques, such as image analysis, to handle the numbers involved. The scientific output related to the survey as of now consists in two published papers, while a Masters project based on the survey is currently underway.

Finlay Burns

Developments in Total Annual Egg Production estimates for the Northeast Atlantic Mackerel Egg Survey 1992 – 2013

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The mackerel egg survey (MEGS) in the western component has been undertaken on a triennial basis since 1977 and from 1992 has surveyed both the southern and western components of the NEA mackerel stock. It aims to provide an estimate of total annual egg production (TAEP) utilizing the annual egg production method (AEPM). From 1977 to 2010, MEGS utilized the Lockwood (1977) egg development equation for converting the sampled egg production (eggs/m2) to daily egg production (eggs/m2/day) for mackerel. After discussions at WGMEGS in 2012, it was decided that for the 2013 survey the MEGS group would replace the Lockwood equation with a new updated development equation based on the recent findings of Mendiola *et al*. (2006). The new equation reduced the development time of mackerel eggs at lower temperatures and would therefore provide a significantly different TAEP estimate compared to one where the Lockwood equation had been utilized. Subsequently, it was also necessary for WGMEGS to recreate the TAEP time-series for the historical MEGS surveys using the new Mendiola equation. The challenge of creating a new historical MEGS database –where hitherto the data only existed as a series of excel spreadsheets in various formats- was a formidable one requiring extensive quality checks prior to the recalculations being performed and the results presented in time for WGWIDE in 2014.

Jens Ulleweit

On the way towards using hydroacoustic multifrequency techniques to assess Northeast Atlantic mackerel (*Scomber scombrus*)

Tim Kirchner[1,2], Matthias Schaber[1], Matthias Kloppmann[1], Jens Ulleweit[1], Sascha Fässler[3], Jeroen van der Kooij[4], Axel Temming[2]

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Hydroacoustic and plankton data were determined in the area western of Ireland (Porcupine Bank) and the Celtic Sea, during the German contribution to the triennial ICES Mackerel and horse mackerel egg survey (MEGS) in spring 2013. Spawning-stock biomasses (SSB) for Northeast Atlantic mackerel (*Scomber scombrus*) were estimated from multifrequency echosounder data and plankton hauls of sampled mackerel eggs. Estimated biomasses of both methods show clear similar spatial distribution patterns and size ranges. Additionally tests for differences between the spatial distributions of the estimated biomasses from both methods were performed.

Timo Arula

Clupeid larval fish surveys in the NE Baltic Sea

Timo Arula

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In my talk I am going to focus on three distinct larval fish surveys conducted for clupeids in the NE of the Baltic Sea: spring- and autumn spawning herring surveys in the Gulf of Riga and sprat surveys in the open proper of the Baltic Sea.

Regular weekly sampling of spring herring larvae with a Hensen net on the main spawning grounds in the Gulf of Riga are carried out since 1947 and dataseries last until 2014. The initial intention of these surveys was to provide additional measure for more accurate estimation of spawning success of the species and the larval fish index was used for recruitment predictions. Autumn spawning herring have never been managed as a separate stock in the Baltic Sea. Investigations in autumn herring larvae were frequent historically (in the 1950s–1970s), and re-initiated after a long break in the 2009. The Baltic sprat larval surveys are regularly conducted in Latvian EEZ since the 1970s. Due to sprat high SSB and wide distribution of larvae, exploratory surveys expanded to further north into Estonian EEZ. Targetted larval sprat surveys are being conducted in 2014 and 2015 and will hopefully provide an answer about the relative importance of the central/northern Baltic Sea as a sprat recruitment formation areas.

Marta Moyano

Implementing routine larval surveys in the North Sea: progresses and perspectives

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The International Herring Larval Survey (IHLS) constitutes one of the oldest, annually conducted ichthyoplankton surveys in Europe. Including additional sampling on lower trophic levels is highly desirable but potentially challenging in these types of surveys due to time constraints aboard vessels and a shortage of manpower and/or funding. New imaging techniques and advances in automatic identification software will lead to vast reductions in the processing time of plankton samples. We introduce a successful, two-year collaboration established among several European partners participating in the IHLS in order to i) evaluate the potential effects of prey type and availability (micro-, mesozooplankton) on larval herring growth and condition, and ii) better characterize in situ prey fields required for biophysical individual-based models of larval herring foraging and growth . In order to prolong and expand this type of initiative, potentially as part of integrated monitoring programs, a joint (funded) action would be needed. We hope to stimulate a lively discussion within the group to address potential challenges and limitations as well as define further opportunities of broadening the types of data routinely collected on larval surveys.

Richard Nash

Fine scale distribution and temporal variability in plaice (*Pleuronectes platessa*) and cod (*Gadus morhua*) eggs during the 2000 Irish Sea ichthyoplankton surveys

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Between January and May 2000, a series of eight ichthyoplankton surveys were undertaken covering the whole of the Irish Sea. Approximately 100 stations were sampled on a semi-regular grid using a Gulf VII high-speed plankton sampler. Sampling of five stations, within a 4 square nautical mile area, on each date was undertaken off the Welsh coast (11–22 March 2000) and off the Irish coast (28 March – 10 April 2000). The sampling locations were between a set of four standard Irish Sea wide grid stations and between the 29 February – 7 March and 20–29 March surveys and then between the latter survey and 7–10 April survey. The earlier survey in the east was dominated by plaice eggs with dramatic declines in stage 1A and IB abundances over the two week period with similar patterns seen in later stage eggs. There were two peaks in the stage III plaice eggs which, utilizing the temperature mediated stage development times indicated they were spawned either side of the preceding new moon. There was considerable variability of the estimates of abundance of eggs per square metre over the five samples taken on each occasion. The CVs varied from 14 to 140% over all stages. The highest CVs were generally seen in stages IA and IB. On average, the CVs varied between 48 and 91% but if stages IA and IB were amalgamated then the CVs varied between 48 and 66%. As with plaice, there was considerable variability of the estimates of abundance of cod eggs per square metre over the replicate samples. The CVs varied from 0 where no eggs were caught to 220% in stage IB. On average, the CVs ranged from 58 to 97% with the higher CVs occurring in the older stages. This study highlights the inherent spatial and temporal variability of the distribution of eggs, which is partly brought about by the spawning behaviour of the species and the physical environment driving drift patterns and development rates.

Carlos Pinto (presented by Cindy van Damme)

ICES egg and larval database

Carlos Pinto and Anna Osypchuk

ICES has been developing Eggs and Larvae Data portal for the last four years (since 2010), this is an international portal to access data from ichthyoplankton surveys carried out in the ICES areas. Fish egg and fish larvae data have been collected in the ICES area for a long time for use in stock assessments and fisheries management. The Eggs and Larvae Data portal aimed to store, and make available, data collected by ichthyoplankton surveys for use by ICES and the wider marine community. It provides an overview of available fish egg and larvae survey data, and allows direct download of data in standard and extended format, as well as a number of web services. The amount of surveys in Eggs and Larvae portal is increasing, as well as the amount of data users.

Annex 7: Report of session 1 Egg and larval surveys

Bastian Huwer presented ichthyoplankton surveys in the Baltic. Ichthyoplankton surveys have been conducted in the Baltic since the early 1900s. This region has strong vertical stratification with low salinity at the surface and low oxygen towards the bottom. These conditions have previously been mediated by strong inflows from the west. However, these inflows have decreased since the 1980s, which has meant that the strong stratifications have been maintained. There are therefore severe oxygen limitations for cod spawning, particularly in the eastern Baltic, leaving the Bornholm basin as the major site for cod spawning in the Baltic, in water depths >60m. More standard, regular surveys have been conducted since 1986, focusing on the eggs and larvae of cod and sprat. Both species have protracted spawning periods (sprat; February-June and cod; March to November) meaning that several surveys have to be conducted each year, involving a number of countries/institutes. These surveys have become increasingly multidisciplinary, involving oceanography, and trawling as well as sampling the whole plankton community. Plankton is sampled with bongos and baby bongos with mesh sizes of 500 μm, 300 μm and 150 μm. There are recent indications of increased cod spawning further west in the Arkona basin but due to hydrographic conditions the eggs are close to the bottom, and are difficult to sample. Some suggestions for potential suitable gear (tall, epi-benthic sledges) were offered by other participants. The eggs of Baltic cod are neutrally buoyant at 60–80 m but they are impacted by low salinity in this region. Transition between late eggs and early larvae has been identified as the most critical life stage for Baltic cod. The larvae then need to migrate upwards to feed on the highest density of copepod nauplii at 30–40 m. The growth of Baltic cod larvae is very slow with limited food availability leading to larval starvation and low recruitment. There is high variability of spawning intensity and timing with a shift from spring to summer spawning. Three assessment methods have been used to estimate stock size biomass (SSB): AEPM, DEPM and DFRM. All three methods produce very similar results, which compare well with estimates of SSB from trawl surveys. However, the 2014 assessment was rejected by ICES and was identified as a 'data poor stock'. This is because ageing of Baltic cod is impossible. Future plans are to produce an SSB estimate based on egg production methods or larval abundance indices.

Andrei Makarchouk presented ichthyoplankton surveys in the eastern Baltic. These Latvian surveys use an IKS-80 ringnet of 0.5 m aperture and 500μm mesh net. These nets are either vertically hauled or towed at the surface in a slow circle, keeping the net out of the wake of the ship. The surveys are targeted at sprat eggs and the nets catch both eggs and larvae in good condition, but low volumes are filtered. Comparisons between Bongo nets and IKS-80 nets have revealed that the results can be combined with no problems. Sprat egg production peaks in May-June and spawning can continue into July. Spawning probably takes place at 25–30 m but egg densities peak at 60–80m. In the past, there have been ad-hoc surveys with different countries/institutes using different survey grids, so little consistency from year-to-year. In the last three years, there have been more consistent surveys from individual institutes, between March and April using a standard grid design. However, there has been little coordination of surveys, or results to date between institutes. There is no Latvian RV at the moment and commercial vessels are becoming increasingly difficult to charter for a number of reasons. Hopefully these problems can be overcome by better collaboration between institutes.

Christophe Loots presented multidisciplinary sampling during the French IBTS in the English Channel and North Sea. The French International Bottom Trawl Survey (IBTS)

takes place from mid-January to mid-February each year. Since 2006, Ifremer have taken a more ecological approach on these surveys by incorporating additional sampling using a variety of gears. One of the drivers was the increasing need to improve stock assessment models by integrating early life stage mortality. Since 2008, the nightly MIK net sampling for herring larvae has therefore been used to assess all the macrozooplankton. This has included the identification and enumeration of 15 species of ichthyoplankton and all macrozooplankton using zooscan. To date 63 macrozooplankton taxa have been identified, with euphausids, chaetognaths and ctenophora being the most abundant. Since 2009, counting and identification of jellyfish, including the invasive Mnemopsis leidyi, has also been undertaken, because of their potential impact as predators or competitors of fish larvae. Since 2006, CUFES has been used to take underway samples of pelagic fish eggs every 30mins of the cruise track to delineate fish spawning habitats. From 2008 mesozooplankton, sampling has been undertaken with a WP2 vertically hauled net to describe the distribution and assemblages of these taxa, again using zooscan. Information on phytoplankton, pigments, nutrients, temperature and salinity have all been measured at the same time. The latest addition to the wide range of sampling already conducted was to attached two small nets to the MIK net in 2012, to contribute to the working group for cod and plaice eggs surveys in the North Sea (WGEGGS2). This has now become a multifaceted ecological survey with many contributions to various projects and monitoring programmes.

Matthias Kloppmann presented results from the MIK net survey. The aim of this survey is to provide an abundance index for large herring larvae (> 20 mm SL). Mean herring larvae abundance is then used in the assessment as a recruitment index for North Sea herring. This survey therefore forms an important component of the North Sea herring assessment. In order to exclude the Downs larvae, which spawn later (too young), are patchily distributed and might reach extreme abundances, the abundances of larvae south of 54°N for which the mean size at a station is below 20 mm, are excluded before calculating the standard IBTS0 index. i.e. all larvae captured at these stations are currently excluded. The 2014 survey resulted in an unusual distribution of smaller larvae, which dramatically affected the index.

a) There was poor weather, which restricted the survey.

b) There was a high proportion of small larvae, which resulted in 37 stations from the southern North Sea being excluded from the calculations.

c) There were strong southerly winds, which advected small Downs larvae into the central North Sea, north of 54°N. This meant that two stations in this area with high abundances of small larvae had to be included in the calculations. In addition, there was another station in this area, which produced a mean length just above 20mm SL, but contained very high numbers of smaller larvae.

These factors severely affected the index, which rose from 68 in 2012 and 50.4 in 2013 to 164.8 in 2014. This posed the questions; 'how reliable was this most recent index?' and 'was the exclusion of the full range of larvae lengths from stations with mean lengths <20mm, justified? While trying to answer these questions, the whole survey was critical appraised. During this appraisal, differences were found in MIK net design between participating countries. Some were using 10m bridles (as in the manual) but others were using 5m bridles, with unknown influences on larvae catchability. The nets were also found to be different between some countries with meshes being of different pore sizes and filtering areas varying between 18.2% and 61.9%. This will therefore

affect the numbers of small larvae caught by each net design. The current Index calculation was also found to have some flaws. First, it makes very little use of the length information, as this is only used for calculating a mean length per station. Second it has rather rigid criteria for station/data inclusion or exclusion, as either the total number of herring larvae per station is used or if the thresholds are breached, none at all. An alternative approach was investigated where all larvae >15mm SL, from all stations were used in the calculation. This reduced the 2014 Index from 164.8 to 128.8. Some suggestions for future work were then made. First, there is a clear need to standardize the sampling gear to overcome size selection differences between countries. Progress is already being made, particularly in standardization of net mesh size. Second, there is a need to redesign the algorithm of index calculation, to make better utilization of extensive length information in the data and to resolve the contribution of single-stock components (such as the Downs stock) to the index. The next job will be to re-run the new index calculations for a number of consecutive years in order to use the new index for the assessment. Once all the above work has been completed, the final job will be to improve the quality of the MIK database by checking all the data from 2000 onwards. Eventually to upload these data to the ICES egg and larvae database and then conduct quality checks on the data prior to 2000. Discussion concerned the identification of a suitable larval length to use in the new algorithm to exclude the Downs component.

Richard Nash presented on behalf of Steven Beggs an overview of the UK (Northern Ireland) Methot–Isaacs–Kidd Survey (NIMIK). NIMIK is a summer survey targeting pelagic stages of juvenile gadoids (cod, haddock and whiting) in the Irish Sea. Provides an abundance index used in the assessments at WGCSE. Time-series of this survey dates from 1993 in the Eastern Irish Sea and from 2005 for the western area. Gears used are MIK (square frame) in the hours between dusk and dawn and a high speed gulf sampler during daylight hours. Both gears deploy using a double oblique tow to within 5m of the seabed. Samples are sorted fresh for fish, crustaceans, and gelatinous zooplankton. Where possible fish are identified to species with the juvenile fish also being measured. The remainder of the sample is stored in ethanol. The western area is covered twice as this is where the large concentrations of juvenile gadoids are found. Outputs from the survey are the MIK index for cod haddock and whiting that are used in the assessment for these species. Also provides valuable spatial data on distribution of these species. In addition to this, the MIK is also very efficient at sampling Jellyfish and these data are also feeding into current research on Jellyfish species. During the discussion, the general question was raised about the switching from the original square frame (used here) to the round MIK frame currently used by IBTS participants. Response was that this was largely down to ease of deployment with the round frame being much easier to deploy in the poor sea conditions often encountered in the Q1 North Sea IBTS survey. It was also suggested that the round frame provided a more uniform flow through the net than the square frame.

Steve Milligan presented results from the sardine ichthyoplankton in the western English Channel and Celtic Sea. Motivation for this survey was the change in commercial landing patterns of sardine in the English Channel/ SW Channel throughout the 20th /21st Century. More sardines were currently being caught in the western channel as opposed to the eastern areas which was the case through most of the 20th century. Are these different stock components or just the same stock distributed elsewhere? Coupled with this is an apparent change in spawning period with the emphasis away from summer spawning which previously was the case to autumn spawning in recent years. Cited historical research findings (Coombs) to emphasize this point. Two survey projects commissioned to address these issues:

2010–11 – EEF funded project.

Summer multidisciplinary project using acoustics, trawl, seabird/mammals observations and oceanography. 4 ringnets for egg and larval collection using 80, 200, 270 and 1000 micron mesh. Sampled whole of the Celtic sea shelf. 67 stations were completed but no sardine eggs or larvae were found. One anchovy egg was recorded.

2012–14 – Poseidon Project (UK Gov. funded)

Autumn multidisciplinary survey using 2 ringnets (80 and 270 micron mesh). Survey was located this time in and around the 'mackerel box' in Cornwall (ICES area VIIE and VIIF). 72 stations were completed and this time sardine eggs and larvae were recorded although nothing like the large numbers recorded back in the 1960s when the Coombs paper was published. Surveys between 2012–2014 completed during the same temporal period (within 2 weeks). Numbers of sardine eggs increased from 2012 to 2014. Larvae were abundant during all three surveys. Eggs and smaller larvae more abundant south of the Cornish peninsula and then appear to drift west and then north over time. Satellite data of sea surface temperatures appears to show close correlation between the Celtic sea front boundary and the areas where concentrations of sardine eggs and small larvae were recorded. This would potentially provide a barrier to the sardines moving further east as the best feeding conditions for the adults are likely to be located around the boundary of the Celtic Sea front. Future work will focus on investigating and delineating the nursery areas and also identifying the spawning triggers for sardine in this area.

Subsequent discussion after the presentation centred on the seasonal timing of the survey and the reasons why the first EEF project yielded no sardine eggs or larvae. No clear reason was provided by the group.

Richard Nash presented the possibility of using the 1st Quarter IBTS MIK sampling for determining the distribution of spawning in winter, from egg distributions: the MIKeyM nets. Background to this issue was the need to monitor winter spawning areas for gadoid species in the North Sea. 2003/4 Series of dedicated surveys (December – April) covering the whole of the North Sea sampling ichthyofauna for gadoid eggs. This was a large-scale expensive and resource heavy project and was not repeatable. Next in 2009 project piggybacking IBTS Q1 IBTS North Sea survey where additional sampling was undertaken to collect gadoid and other fish eggs. When the results (nos. eggs/m2) from this project were compared with those from 2003/4 they did not correlate well with those observed in 2003/4. Possibility of utilizing IBTS fish data were discounted on the grounds that fish move and therefore this is not considered to be a suitable proxy for delineating spawning grounds. Eggs provide a much better answer. At WGEGGS meeting in Sète in 2011, the idea of attaching additional nets to the MIK nets during the IBTS Q1 North Sea survey was proposed and the MIKeyM net was born. Net is secured on a 20 cm ring on the side of the MIK net and utilizes a 335 micron mesh net. Each net has a flowmeter located in the centre of the ring. These are manufactured by SPARTEL in Devon. It should be noted that the MIKeyM net rings are detachable and can be located anywhere on the MIK net frame. Four nations deployed the MIKeyM nets in 2012 (FRA/NOR/GER/NED). Egg density data for 2012 was presented for cod-like eggs and other species. Samples from the MIKeyM nets are preserved immediately after retrieval of the net in 4% formalin. Samples are then processed back in the lab and in addition to egg identification egg diameter is measured digitally. In addition to delivering information on egg abundance and therefore spawning areas it also provides information on fish larval densities. This method does

not hinder MIK sampling and the samples are manageable on account of the low volume filtered. No genetics work has been possible as this time on account of the formalin preservation which is necessary to allow species identification and diameter measurements to be completed on the eggs. The results from the MIKeyM net provide a valuable snapshot of winter spawning locations for NS fish species. Post presentation discussion focused on the preservation method used. Formalin preserves the size and colour allowing staging and ID to be completed. It does however prevent any subsequent genetics work from being undertaken on those samples. At the moment gadoid eggs cannot be identified to species level and are just coded as cod-like eggs. At present, there is no resolution as to how this can be achieved within the current sampling protocols.

Cindy van Damme presented whether the standard ICES coordinated IBTS-MIK survey can provide reliable data on herring recruitment and spawning locations in the North Sea. 2 sources providing data/information on herring larvae in the North Sea: International herring larval survey (IHLS) – December to January – uses a Gulf 7 high speed sampler to sample recently hatched larvae and North Sea IBTS Q1 – MIK survey – February – uses a MIK sampler to sample larger larvae. Can the MIK survey be used to augment the data collected on the IHLS and also provide distribution maps for winter spawning fish? Undertake comparative hauls with Gulf 7 sampler net and also adding a MIKeyM net to the MIK. Results showed that as expected MIK sampled a higher volume of water on account of it large aperture (2m), however volume filtered between the Gulf 7 and the MIKeyM net (both with aperture of 20cm) was comparable. In terms of the numbers of herring larvae recorded the MIK collected very few, the MIKeyM net caught more larvae and proportionately smaller larvae and the Gulf 7 recorded larger numbers. GAM showing catchability of both the MIK and the G7 was constant for larvae up to 13mm and therefore a correction factor can be applied to those data. The data for all 3 samplers was also spatially comparable showing that catchability within sampler was consistent. As far as eggs were concerned, the MIK did not record any eggs whereas the MIKeyM and G7 samplers showed comparable rates of eggs and were also spatially comparable. Conclusions are that the Gulf 7 and MIKeyM catch larger numbers of herring larvae while the MIK is designed for sampling larger herring larvae which provide the MIK time-series index. For herring, larvae less than 13mm the MIK data can be used by applying a correction factor for use in the IHLS index. MIKeyM sampling can be undertaken during the IBTS-MIK survey with the only associated additional costs being the analysis of the samples. The additional benefit of the MIKeyM is the data can also be used for mapping spawning distributions. Discussion after the presentation focused on further explanation of the main driver for this work. IHLS is concerned that they are missing a component of the herring stock hence the need to augment the existing IHLS dataset and index. Point made that possibility exists that herring in the North Sea are one giant spawning stock comprised of various components that spawn at different areas at various times throughout the year. Genetic evidence is inconclusive regarding any ability to discriminate between different stock components.

Patrick Polte presented the Ruegen herring larvae survey, is a single-bay monitoring suitable for a reliable recruitment forecast in the western Baltic Sea? The Western Baltic spring-spawning herring comprises a genetically distinct herring population in the Baltic Sea. Extensive spawning migrations can be observed. The inshore waters of Greifswald Bay (ICES SD 24) are considered a main spawning area for Ruegen herring, which represents the most important component of the Western Baltic spring-spawning herring stock (WBSS). This stock is investigated since the 1930s, since 2007, an index

series is created which is used in the assessment for the Baltic herring since 2007. Within the Ruegen Herring Larvae Survey 35 stations are sampled weekly using a Bongo-net during the main reproduction period from March to June. Problematic is the sample size with up to 10.000 herring larvae and the difficulties to subsample because of clogging. Other challenges are the intended incorporation of historical data and the future inclusion of the Ruegen Herring data into the ICES survey database. Recently, larger larvae found at the start of survey are indicating that the samples are containing autumn spawners.

Richard Nash presented, on behalf of Steven Beggs, the Irish herring larvae survey. Herring larvae surveys of the northern Irish Sea (ICES area VIIaN) have been carried out in November each year within 5 survey days since 1993. These are autumn spawning fish. Sampling is carried out on a systematic grid of stations covering the spawning grounds and surrounding regions in the NE and NW Irish Sea around the Isle of Man. Due to the hydrographic situation highest concentrations of larvae are found on the eastside of the Island. The index was assessed during the benchmark process in 2012 since then its use was down-weighted. This was due to the deviant trend to the trend found in acoustic surveys which is evident since 2007. Reason is unclear; missing temporal coverage was discussed as one possible reason. In future, it is possible that the survey will be skipped if it is not used in the assessment

Paula Alvarez presented the project CRAMER: Ecology of hake recruitment in the Northwest Spanish Iberian coast (ICES Subdivision VIIIc west). Investigations were part of a greater national project which was carried out from 2011 to 2013. The aim of this study within the project was to analyse the ecological processes of hake recruitment, from egg production to the post-larva phase, when it changes from pelagic to demersal habits and recruits definitively to the population. Samples were taken in 2012 on dedicated surveys which timing was set according to the expected spawning events. The conclusions are that hake larvae were successfully collected applying an adaptive sampling method. Through combining different gear types, it was possible to obtain a wide range of larval sizes. During the survey in 2012 the main spawning peak in winter could be confirmed but not the second one in summer. It was furthermore concluded that hydrography characteristics directly determine the spatial and vertical structure of plankton community including hake eggs and larvae.

Maria Santos presented the BIOMAN project: Anchovy DEPM surveys in the Bay of Biscay from 1987 to 2014. The BIOMAN surveys series started in 1987 to monitor and assess the Bay of Biscay anchovy population to obtain a biomass index of anchovy by the daily egg production method. The sampling design is adaptive on transects either 15nm or 7.5nm apart depending on egg abundance. Egg sampling is undertaken with PairoVET and CUFES, adults are sampled in parallel with egg sampling. 2005 was a new aging method applied and since 2013 a new method for the spawning fraction estimation. The survey is also used for sardine, mackerel and horse mackerel. Increasing daily egg production of anchovy can be observed during the last years to highest values in 2014 (mean 81/m²). It was concluded that the total egg production is the parameter of major relevance determining biomass. Biomass is provided by age as well, consistent with the results estimated by the parallel undertaken acoustic survey. Furthermore, the survey contributes to the study of reproductive biology and spawning dynamics of anchovy. The use of GLM for the mortality model was discussed and it was concluded that the quantile regression method could be tested for a better estimation of mortality.

Maria Manuel Angélico presented the Atlantic Iberian sardine DEPM surveys: 1988 – 2014. This is a triennial survey, which since 25 years supplies a time-series of spawning-stock biomass estimation for the Atlantic Iberian sardine. From 2000 onwards, formal coordination between institutes was set up to run the surveys and produce SSB estimates to be used for assessment modelling. To estimate spawning-stock biomass the DEPM involves surveying directed at egg abundances and spawning area definition, for daily egg production determination and adult sampling for daily fecundity calculation. Ichthyoplankton samples (both vertical tows and CUFES), simultaneous CTD(F) casts, and fishing hauls are undertaken over the whole spawning region. Recruits of the stock are found in northwestern Portugal and Gulf of Cadiz areas but in recent years the numbers increased in the Bay of Biscay.

Maria Manuel Angélico presented the southern horse mackerel DEPM. Survey deals with a long lived species (up to 35 years). Distribution of southern horse mackerel along the coasts of Spain and Portugal is mixed with two similar other Trachurus species (*T. picturatus* and *T. mediterraneus*) which involves extra effort for egg identification. The stock is important to the Portuguese bottom trawl fishery but landings dropped in 2004. The DEPM survey is conducted every 3 years and the results presented to WGMEGS and WGHANSA, The current time-series includes data from 1995–2013. The sampling period is January-February. Transects are 10nm apart and the distance between stations is 3–6 nm. Samples are taken by a CALVET net (40 cm diameter, mesh 150μm). Fishing hauls are taken with the RV and from commercial vessels.

Paz Díaz presented on behalf of Maria Paz Jimenez GoC anchovy DEPM. Main objective of the survey is the estimation of the Gulf of Cadiz Anchovy spawning-stock biomass by daily egg production. Ichthyoplankton sampling is carried out along a grid of parallel transects perpendicular to the coast, in order to obtain the spatial distribution of Anchovy eggs, the delimitation and calculation of the extension of the Anchovy spawning area, and the estimation of the daily egg production and total egg production. Fishing hauls are carried out to obtain the adults spatial distribution as well as to obtain samples for the estimation of DEPM-based adult parameters. The question about horse mackerel predation on anchovies and a potential predator/prey mismatch was negated since horse mackerel is rather preying on euphausids and small fish of other species.

Maria Manuel Angélico presented plankton sampling during spring acoustic surveys PELAGO (IPMA) and PELACUS (IEO). The surveys started in the 1980s with the objective to assess the pelagic fish community in particular sardine and anchovy but also mackerel, chub-mackerel, horse-mackerel and other pelagic fish species. Plankton, hydrographic and top predators surveying are included in spring acoustic surveys. Sampling is conducted in March/April. The Continuous Underway Fish Egg Sampler (CUFES, 335 μm mesh) is used along the acoustic transects at 3–5 m depth, and samples taken every 3 nm. Additional sampling includes CTD and CHL a, measurements, plankton nets, multinet, CalVET, Bongo, etc. Zooplankton samples are being processed using image analyses methodologies.

Martin Huret presented ichthyoplankton sampling during the PELGAS survey in the Bay of Biscay. The sampling and resulting index of egg production represents a complementation of acoustics for the assessment small pelagics (sardine, anchovy, horse mackerel). For estimating spatial mortality and production it is necessary to increase efforts on egg stage distinction. Samples are taken by CLUFES and processed by ZooCam. Future research includes characterization of spawning habitats and investigations of permeability and density of eggs. In addition, some indicators of ecosystem

status will be developed. These will be useful amendments as covariables to the fish stock assessment. Descriptors of ecosystem traits will feed into MSFD. Temperature effects on egg density are negligible since eggs are in equilibrium with temperature regimes and density effects will be compensated. It is suggested to investigate the effect in experiments using controlled temperature regimes. ZooCam is suitable for processing of Mesozooplankton and Microzooplankton samples. If this results in an underestimation of e.g. nauplii larvae of the fraction 55–100 µm, smaller fractions these could be potentially processed by a Flowcam. Other discussion subjects included the question if experiments must be conducted for each survey or if models can help to simplify efforts. Another discussion point included the question whether egg densities can be compared to larval production. However, there are not enough larvae sampled to include such analyses.

Claudio Vasapollo presented relations between eggs and larvae of *Engraulis encrasicolus* and biotic and abiotic variables in the southwestern Adriatic Sea. During the acoustic survey on small pelagic fish in July 2012 and in July 2013, 63 and 65 ichthyoplankton stations (distance 5nm) are sampled on transects perpendicular to shore (10nm) for presence/absence of eggs and larvae using vertical WP2 net (200 µm mesh size) until 5 m above the bottom (max depth sampled: 100 m). Every year on 39 stations biotic and abiotic variables (temperature, salinity, fluorescence and zooplankton) samplings have been made. Two peaks of egg abundances have been observed in front of Gargano promontory and in front of Bari. Findings suggest that the spawning areas are neither selected based on the food availability, nor based on particular ranges of other biotic variables. Further investigations are needed to verify if these spawning and nursery areas remain constant both in space and time. The discussion included the question if larval length is measured. This was negated. The peak spawning is in July. Future cooperation will include sampling campaigns conducted on other Adriatic coasts. The egg and larvae data correlate with hydroacoustic data although production of eggs is rather low. Potentially patchiness affects results.

Steve Milligan presented ichthyoplankton around a potential nuclear new build at Sizewell in Suffolk, UK. Information was presented on the work being conducted by Cefas, around Sizewell nuclear power station on the Suffolk coast, UK. The aim is to provide baseline information in preparation of a potential new power station (Sizewell C) which is currently going through the strict planning process. The impact of entrainment of plankton distribution and abundance and the impact of a warm-water plume emanating from the proposed new station is being assessed. Distributions of ichthyoplankton eggs and larvae from a series of five surveys conducted monthly from February to June 2011 were presented, showing the importance of the area for Dover sole and bass spawning. Surprisingly, high densities of anchovy eggs were found in the area in June. Discussion: Water temperatures at the occurrence of anchovy larvae were about 15 C°. It was hypothesized that bass will probably profit from warm-water flow emerging from the power plant site. An uncertainty is the origin of 15 mm long herring larvae in February. There are no inshore juvenile fish surveys conducted anymore. The original temperature in the area was approximately 1.5 C° lower, however exact pre-impact data are not available. The question whether impact assessment could potentially stop constructions was negated.

Hannes Höffle presented the Norwegian spring survey on the distribution of fish eggs and larvae in the northern North Sea – sampling strategy and bottlenecks. Early life stages have been sampled at the Norwegian spring surveys to gain information about year-class strength, spawning grounds and drift patterns. These cruises take place in

late April-early May and have been running since 2010 almost every year (2011 missing). The survey consist of 5 standard transects (Gulf VII; PUP-net; MIK + MIKeyM, 90cm Bongo) and two 48h-process stations (+ CTD, MOCNESS, MULTINET). All larval samples are processed on board: larvae are sorted and measured (while sample is on ice), zooplankton biomass partly identified and the rest goes into formalin. Limits to processing are: weather, ship stability and time to next station. Egg densities were more widely distributed over the sampling area in 2012, 2013. Higher abundances were found along the edge of the Norwegian trench. Larval abundances were highest in the NW North Sea. Specific research questions answered during the survey and already published:

- where does Norway pout spawn in the N? (Nash *et al.*, 2012 ; ICES, JMS). Small larvae near Shetland and Orkney Islands. Larger, less abundant, larvae to the South and East. This is one of the most abundant Gadoids in the area together with whiting.

- How are fish larvae distributed in the northern North Sea, both horizontally and vertically? (Höffle *et al.*, 2013, Mar Biol Res). Two types of larval assemblages were found depending on their vertical distribution. Over the past 4 years a lot of larvae have been collected (>16.000), therefore a lot of man power is needed to process this samples. Right now there is one technician and a msc student working on this.

Conclusions:

- good results leading to published papers
- at sea a more stable platform would be desired
- more funding is needed to continue the work

Discussion after the presentation:

- Identification between poor cod and Norway pout is complicated, but is feasible at some stages (in reply to Maik T). They have the intention to bring the genetics, to validate the ID

- Working with the MOCNESS was a problem sometimes, the Multinet was more reliable, but the MOCNESS has been used since the 60s, are people are reluctant to change the gear.

- Some discussion was generated regarding the larval measurements done with larvae not fixed but kept on icevs.not kept on icevs.fixed in formalin. Hannes pointed out that the larval sorting and measuring can take up to 2h per station, to which Matthias K mentioned that it would be worthy checking any shrinkage that may occur during this time. No samples stored in formalin can be worked up in the Norwegian vessel, therefore this way is the only that works for their purposes. A general agreement was met that larvae can be measured fresh, but need to be kept on ice and room temperature would need to be as closer as water temperature as possible.

Finlay Burns presented developments in Total Annual Egg Production estimates for the Northeast Atlantic Mackerel Egg Survey 1992 – 2013. MEGS is a truly international survey (10 institutes participating). Three main components: North Sea, Western and Southern, which started in 1968, 1977 and 1992, respectively. Runs from February

through the end of July, and several samplers are used (Gulf VII, Bongo and CalVET net). The objective of the triennial surveys is to cover the entire spawning area in space and time and produce both an index and a direct estimate of the biomass of the Northeast Atlantic mackerel stock and an index for the southern and western horse mackerel stocks. Current problem with NW area, since eggs are found in the boundary of the sampling grid. MEGS provides: 1) total annual egg abundance (from ichthyoplankton samples), TAEP; 2) estimate of realized relative fecundity (from adults). The TAEP calculation can be calculated using Mendiola or Lockwood's equations for egg development rates. The former suggest a faster development at low temperatures than the latter. Given the discrepancies, the mackerel benchmark decided to create a new MEGS database with Mendiola's equation, to be done by august 2014 (WGWIDE). Preparing the database needed quite some effort to check and clean the historical data. Also crossreferencing against WGMEGS reports, but the database has been now created. The new calculations were correlated well with reported results. Overall, there was a difference of 12% between both equations in TAEP. Only a few issues in 1992 and 1995. This new calculations were accepted by WGWIDE and new Mendiola index incorporated in the mackerel benchmark.

Discussion after the presentation:

- What is the correction coefficient 1.08 used in the calculation for SSB.
- There has been a potential change in the egg developmental rates, so this would need to be revisited (in reply to Richard N)
- Also, maybe one would need a different equation for the southern and western surveys (in reply to Richard N and Steve M) On this same line, if the population is dominated by the western stock, maybe one can take out the southern stock and the index will not change (e.g. like for Downs herring larvae).

Jens Ulleweit presented on the way towards using hydroacoustic multifrequency techniques to assess Northeast Atlantic mackerel (Scomber scombrus). NE Atlantic mackerel stock has been increasing for nearly a decade. The stocks show changes in distribution both spatial (north and westward expansion) and temporally (spawning earlier in the year). This expansion may be a result of increased SSB but also due to environmental variables. The stock was benchmarked in 2014, and new survey indices were implemented. This presentation was only based on the German MEGS. The survey samples the eggs with a Gulf sampler (eggs are staged for biomass estimation, and TAEP calculated), trawl sampling (female weight, sex ratio) and acoustics. SSB was calculated by two methods: from the eggs and from acoustics. Both methodologies did not shown significant differences However, only 2 fish trawls were available for validation, due to bad weather. No significant differences were found in Statistics were applied to test whether distributions are similar (Syrjala test).

Conclusions:

- Multifrequency classification/detection of mackerel possible
- Despite differences in total biomass calculations, there are comparable results of hydroacoustics and backward calculation of AEPM
- Mackerel distribution shows comparable patterns for egg and acoustic data. Survey design would allow for a combination of both methods to further improve result and facilitate the ecosystem approach.

- Acoustic view: Advantages of hydroacoustic measurements: 1) Higher spatial coverage of survey area, less dependent on aggregation patterns; 2) Direct measurement of abundance.
- Further applications of hydroacoustic methods in Atlantic mackerel stock estimates should be considered, maybe during regular egg survey or in alternative surveys

Discussion after the presentation:

- No information on the population structure (in reply to Maria M)
- Potential differences between day and night will be checked in the upcoming cruises. This approach looks promising for the future (in reply to Cindy vD, Andrés U, Matthias K): potential differences on day/night. Will be checked in next cruises. Promising for the future.

Timo Arula presented clupeid larval fish surveys in the NE Baltic Sea. Atlantic herring is the most important commercial species in Gulf of Riga, and it is managed as a separate unit in the Baltic Sea. Herring spawns in April-May in the Gulf (2–18°C). NE part of Gulf is the most important spawning ground. Depth: 2–5m. Sal: 3–5 psu. Larval surveys (9 stations) are conducted weekly from May to August using several gears:

- Hensen net (500 µm, codend 180µm, larvae)
- Juday net (100 µm, zooplankton)
- CTD: temperature, salinity, oxygen, turbidity, Chl a measures
- Windspeed and transparency (secchi disk)

Samples are preserved in formalin. ZooScan is used for accounting for zooplankton biomass and measuring larval lengths. Thanks to the weekly sampling, cohorts can be followed and growth rates calculated. Growth rates calculated using mixdist package in R. Instantaneous mortality rates also estimated. Indices proposed to predict recruits:

- Abundance larvae <17mm
- Recruitment potential (G:Z ratio)
- Environmental sensitive recruitment models.

Good correlation (r2=0.73) between large larvae and annual recruitment. This seems to be correlated to SST during growth period (r2=0.69). Autumn-spawning herring has been in a big depression since early 80s, also low in the early 70s. Decrease due to high fishing pressure, pollution, eutrophication. Some facts suggest that this spawning component may be recovering in the last years. Therefore additional ichthyoplankton sampling is being conducted to check whether historical spawning sites are still in use 2009–2012. Results suggest that fish use the same spawning grounds as historically. Regardless of drastic decrease in autumn spawners population, larval abundance and distribution seems to be the same. The females from these autumn spawners present ovarian abnormalities. These abnormalities have been observed for all ages and all years. Histological samples from these ovaries are under investigation at DTU (DK). Timo asks for feedback on this topic. Finally, Timo introduces a recent sprat survey that has been conducted in the eastern Baltic (coasts of Estonia and Latvia) as part of the INSPIRE project, in which they investigate the contribution of other areas in the Baltic Sea to the sprat stock. Discussion after the presentation was linked to the population dynamics of the spring and autumn spawners in the Baltic Sea.

Marta Moyano presented implementing routine larval surveys in the North Sea: progresses and perspectives. A new collaboration to implement the Dutch herring larval surveys (IHLS) is introduced. The objectives of this collaboration are:

- Evaluate the potential effects of prey type and availability (micro-, mesozooplankton) on larval herring growth and survival.
- Better characterize in situ prey fields required for biophysical Individual-based Models of larval herring foraging and growth.

- The sampling protocol includes sampling with herring larvae but also the lower trophic levels with several gears:

  - Microzooplankton diversity and abundance
  - CTD-rosette: diversity, abundance (15–150μm)
  - PUP-net: diversity, abundance (55–300μm)
  - Mesozooplankton abundance
  - Gulf net: ZooScan (size and abundance)
  - Larval abundance (IHLS), condition, trophic position
  - RNA:DNA ratio (condition, growth)
  - Fatty acids (condition)
  - Stable isotopes (microzoo, larvae)

Sampling was conducted with the Buchan/Banks (September) and Downs (December and January) cruises in 2012, 2013 and 2014. Carrying out this implementation only required some extra time for the CTD casts (1–2 per day). In order to obtain in situ prey fields for modelling efforts, samples for microzooplankton have been collected from the entire North Sea basin in the IBTS 2014 thanks to the collaboration with several countries (FR, GE, NL, NO). Also, continuing this type of sampling with mesozooplankton will be very interesting Time-series (18 years) for mesozooplankton using samples from German IHLS from the English Channel. There are several challenges and limitations to prolonging this collaboration, e.g. students finishing their PhDs, etc. However, a feasible plan is proposed to continue monitoring these lower trophic levels, which uses automatic image analysis on selected stations to reduce the workload. Then several questions are introduced to the audience and the need to integrate this type of integrated approach to the routine surveys is discussed. Most of the countries doing this type of analysis are funded at the national level; therefore a joint action to obtain funding at the European level does not seem very realistic on the short term. Some suggestions for funding are proposed: e.g. MSFD.

Richard Nash presented fine scale distribution and temporal variability of plaice (*Pleuronectes platessa*) and cod (*Gadus morhua*) eggs during the 2000 Irish Sea ichthyoplankton surveys. Introduction to the surveys in the Irish Sea in January – May 2000. The surveys were design to estimate SSB of cod, plaice and sole, and the sampling was done with Gulf VII. Two specific objectives:

- Small-scale spatial variability in egg abundance
- Fine scale temporal variability in egg abundance

Temporal variability in egg abundance (per stage) at both the welsh and Irish sampling site show some discrepancies ☐ importance of a variability in survey analysis.

Conclusions:

- Important to understand the temporal dynamics between surveys
- Important to understand the spatial dynamics between stations (i.e. the optimal station spacing).
- Need to take account of the variability inherent in the survey design.
- How much of this is really masked by the sampling efficiency and all other unknowns in spatial and temporal variability

Discussion after the presentation: CUFES is not optimal to address the spatial variability issue, because it works at a fixed depth, so it does not account for depth (in reply to Martin H). Importance of accounting or drift dynamics, inputs of FW, etc. The potential discrepancies due to the sampling gear also need to be taken into account: e.g. between cone nose size, clogging.

Annex 8: Abstracts of session 2 Recent advances in egg and larval mortality studies

Aitor Albaina

A real-time PCR assay to estimate invertebrate and fish predation on anchovy eggs in the Bay of Biscay

Aitor Albaina, Xabier Irigoien, Unai Aldalur, Unai Cotano, María Santos, Guillermo Boyra and Andone Estonba

In order to investigate the role of predation on eggs and larvae in the reported delay of stock recovery, potential predators, including sardine (*Sardinapilchardus*), sprat (*Sprattussprattus*) and 52 macrozooplankton taxa, were assayed for anchovy remains during the 2010 spawning season using a molecular method. This real-time PCR based assay was capable of detecting 0.005 ng of anchovy DNA (roughly 1/100 of the DNA extracted from a single egg) and allowed detecting predation events up to 6h after ingestion by small zooplankton taxa. A total of 1069 macrozooplankton individuals, 237 sardines and 213 sprats were sorted for assay application. Both fish species and 32 macrozooplankton taxa showed remains of anchovy DNA within their stomach contents. The two main findings are (1) that the previously neglected macrozooplankton impact in anchovy eggs/larvae mortality is in the same order of magnitude of that due to planktivorous fish and that, (2) a contrasting predation pressure corresponded to the two main spawning centers of Bay of Biscay anchovy. While relatively low mortality rates were recorded at the shelf break spawning center, a higher predation pressure from both fish and macrozooplankton was exerted at the shelf one. While predation by sardine accounted for a 7% of the daily anchovy egg mortality , macrozooplankton consumed around 1–4% of the anchovy eggs at shelf break and between 14–89% in the shelf stations where mysids and decapods larvae prevailed.

Marta Moyano

Using laboratory ecophysiological studies to improve individual-based models of North Sea larval herring foraging and growth

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Long-term field survey data on the abundance and distribution of North Sea herring (*Clupea harengus*) larvae suggest that mortality acting on early larval stages controls year-class success. Developing realistic biophysical individual-based models (IBMs) can greatly improve our understanding of how bottom–up processes (changes in temperature, prey concentration, or advective transport) may influence larval survival. Laboratory experiments play a critical role in the development and parameterization of larval IBMs. We summarize the results of a suite of laboratory experiments and how these measurements and data are integrated into an IBM for herring larvae (Hufnagl and Peck, 2011; Hufnagl *et al.*, In Press). Laboratory Experiments included measuring physiological (respiration, cardiac output) and behavioral (swimming) responses as well as growth and survival of larvae within different prey x temperature treatments

The ultimate goal is to utilize a coupled Lower Trophic Level-IBM to simulate interannual differences in larval herring drift, feeding, growth and survival prior to, during and after winter which help explain observed changes in pre- and post-winter field data on larval abundance, distribution and body size.

Paz Díaz

Egg mortality and egg production estimates for Atlanto-Iberian sardine (1988–2014) using an external mortality model

Paz Díaz[1], Maria Manuel Angélico[2], Ana Lago de Lanzós[1], Concha Franco[1], Cristina Nunes[2] and Elisabete Henriques[2]

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An important discussion that arises during the process of egg parameter estimation for the Atlanto – Iberian sardine DEPM dataseries is the reliability of the mortality estimates per spatial strata (south, west and North) obtained for each survey separately. In some cases (surveys or spatial strata) spurious positive (or almost positive) egg mortality estimates were obtained from the observations taken during the egg production surveys.

To attain statistically significant and biologically plausible mortality estimates the approach described by Bernal *et al.* (2011) is adopted for the whole dataseries. Using all data available (1988–2014) the external mortality model developed by Bernal *et al.* (2011) is updated and used to estimate mortality per strata for all surveys; the average mortality values are then used to obtain P0 estimates per strata. The model is allowed to be a function of spatial and temporal strata and water temperature.

Mortality and egg production estimates obtained from the traditional method for the 2011 dataseries revision (ICES 2011) are compared to the results achieved using the external mortality model. The implications for SSB estimation and sardine assessment modelling are discussed.

Paz Jiménez (presented by Paz Díaz)

Implementing an external mortality model to estimate egg mortality and egg production for anchovy in the Gulf of Cadiz (2005–2014).

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The egg mortality rate is one of the parameters required to estimate egg production by the DEPM. An external mortality model for anchovy eggs in the Gulf of Cadiz is under development in order to overcome the high variability introduced by yearly estimates for mortality and therefore improve the egg production estimation. To establish the model, extra data on abundances by stage were obtained by revising all the data from several research surveys that included plankton sampling, carried out in waters of the Gulf of Cadiz, between 2005 and to 2014. A total of 31119 anchovy eggs were classified

into the development stages described by Moser and Ahlstrom, 1985. For each sample the information on water temperature was also recovered. The process to estimate mortality and egg production include 3 steps: 1) estimation of daily cohort abundance by age; 2) mortality estimation considering other variables e.g. temperature and geographical and temporal strata; 3) gets p0 estimates using the mortality values obtain in previous step.

Leire Ibaibarriaga

A Bayesian hierarchical model for estimating daily egg production and mortality rates

L. Ibaibarriaga, C. Fernandez, A. Uriarte and M. Santos

Some of the common problems encountered when fitting the egg mortality curve for estimating daily egg production and mortality rates in the Daily Egg Production Method (DEPM) are obtaining negative mortality rates and the sensitivity of the results to tail-cutting criteria. Here we present a new approach which tries to overcome these difficulties. It consists of a hierarchical model that represents the distributions of the total number of eggs and their classification stages at each sampling station according to the temperature-dependent egg development model and the spawning time distribution of the species. The model is developed within the Bayesian framework and inference conducted using Markov chain Monte Carlo methods. The estimated parameters are the daily egg production rate per unit area at each sampling station, and the hourly mortality rate, which is assumed constant in space. The parameters of the temperature-dependent egg development model and the spawning time distribution can also be estimated. The hierarchical model was applied to the Bay of Biscay anchovy DEPM egg survey conducted in 2012. The approach looks promising since it provides higher precision on the final estimates. However, the computational cost is much higher and the differences with the estimates obtained in the traditional approach need to be further studied.

Bastian Huwer

Characteristics of juvenile survivors reveal spatio-temporal differences in early life stage survival of Baltic cod

B. Huwer, H.-H. Hinrichsen, U. Böttcher, R. Voss and F. Köster

The spatio-temporal origin of surviving juvenile Baltic cod was investigated by coupling age information from otolith microstructure analysis and hydrodynamic modelling, which allowed backtracking of drift routes in time and space. The suitability of hydrodynamic modelling for drift simulations of early life stages of Baltic cod up to the pelagic juvenile stage was validated by comparing model simulations with the catch distribution from a survey targeting pelagic juveniles, and mortality rates and hatch date distributions of pelagic and demersal juveniles were estimated. Hatch dates and hatch locations of juvenile survivors show distinct patterns which do not agree well with the abundance and spatial distribution of eggs, suggesting marked spatio-temporal differences in larval survival. The good agreement of the spatio-temporal origin of survivors from this field investigation with previous modelling studies on the

survival chances of early stage larvae and with general spatio-temporal patterns of larval prey availability suggests that differences in survival were related to food availability during the early larval stage. Results are discussed in relation to the recruitment process of Baltic cod, in particular with respect to the critical period and match–mismatch hypotheses, and to possible implications for the placement of a Marine Protected Area which was established to ensure undisturbed spawning of Baltic cod.

Andrei Makarchouk

Calculations of mortality rates of sprat eggs

Andrei Makarchouk

Instantaneous mortality coefficients (per day), mortality rates and total mortality coefficients of eggs of sprat have been calculated for the number of years from 1973 to 2013 using the databases of BIOR on ichthyoplankton and hydrology. Some of the results were described in different ICES papers.

The duration of development of sprat eggs on each stage was computed using Thompson *et al.* (1981) results of incubation experiments of the North Sea sprat under the range of temperatures. The mean ambient temperature was calculated as the mean weighted one using the hydrographical data and the calculated vertical distribution of eggs. The vertical distribution of sprat eggs was determined using the procedure we had developed in 2001.

The number of eggs on the 1st stage per 1 day (also called "production of eggs per day") was calculated for every station by dividing the observed number of eggs by the duration of the stage in days. After that the map of horizontal distribution was made in the "Surfer" program, and the total abundance of eggs on the 1st stage (per 1 day) was calculated, using the "Volume" function in the same program. Then the same procedure was repeated for the sprat eggs on the 2nd and 3rd stages of development. Afterwards these values were used for the calculation of the instant mortality coefficient between stages I-II and II-III.

Patrick Polte

Drivers and stressors of herring early life stage mortality in inshore spawning areas of the western Baltic Sea)

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It is a major challenge to quantify the role of small- and meso scale drivers and stressors for overall herring recruitment strength. Ruegen herring is considered a significant component of the spring-spawning herring stock in the Western Baltic Sea. Since the majority of the recruitment takes place on a basin scale, local hazards to early life stages can potentially introduce survival bottlenecks transported to higher spatial scales and affect entire population dynamics. To increase mechanistic understanding on the effects of local stressors, top down as well as bottom up drivers were investigated so

were patterns of highly fluctuating physico-chemical environment in the shallow transitional waters and effects of single storm events on herring egg mortality. Results indicate that two major survival bottlenecks occur at different life stages in different periods along the reproductive phase. Larvae hatching in March are subjected to limitations in suitable plankton food whereas later in the season survival bottlenecks are more pronounced on the egg development period. Strong egg predation by sticklebacks as well as storm induced turbulence can cause drastic losses of herring eggs on macrophyte spawning beds.

Marta Moyano

Linking short-term physiological responses to longer-term climate impacts: a case study using Atlantic herring early life stages

Marta Moyano*, Patricia Hüdepohl, Marc Hufnagl, Myron A. Peck

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Increasing knowledge of how key factors affect physiological and vital rates (metabolism, growth, survival) of organisms will help us gain a cause-and-effect understanding of historical, climate-driven changes in species and to make more robust projections of future impacts. We use Atlantic herring (*Clupea harengus*) larvae as an example of how to explore physiological-based relationships underpinning temperature-dependent growth and thermal windows supporting growth and survival. Since meeting metabolic requirements is a primary challenge of organisms (especially at environmental extremes) emphasis was placed on understanding responses of the mass-specific respiration rate (R) and the circulatory system (e.g. heart rate, stroke volume, cardiac output (CA)) to changes in temperatures. We explore how short-term measurements of R and CA may reveal temperature optima and pejus limits and how R and CA are related to longer-term responses of temperature-dependent growth under ad libitum feeding conditions. We investigate how intrinsic (developmental) and extrinsic (temperature, prey) factors interact to affect growth potential of larvae using a physiological-based IBMs.

Franziska Bils

Can microzooplankton support the growth and survival of Atlantic herring larvae in wintertime?

Franziska Bils, Marta Moyano and Myron A. Peck

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Traditionally copepod nauplii have been considered the natural prey of fish larvae in the wild, meanwhile the role of microzooplankton (size range 20 – 200 μm) has been disregarded. However these small protists are crucial to first-feeding, and can support larval growth for short periods of time. Little is known about the prey environment

experienced by larvae of autumn and winter spawning Atlantic herring (*Clupea harengus*) in the North Sea during winter, a period when low mesozooplankton abundance is not expected to support growth rates observed in situ. Can a diet mostly consisting of Dinoflagellates and Ciliates then help the larvae withstand these low mesozooplankton environments? Samples were taken in September 2013, January and February 2014 during the ICES-coordinated International Herring Larval Surveys (IHLS) and the International Bottom-Trawl Surveys (IBTS). This sampling technique obtaines the first large-scale (North Sea wide) snapshot of microzooplankton abundance and distribution prior to and during the winter. Relationships between patterns in the distribution and abundance of microplankton and larval herring were investigated. Furthermore the nutritional condition of herring larvae related to microplankton abundance/biomass will be discussed. Further plans involving physiological larval measurements and trophic level analysis are also presented.

Hubert Keckeis

Effect of temperature and development on mortality rates of a riverine fish species (Chondrostomanasus): comparison of laboratory and field results. Larval mortality in the Danube river

Hubert Keckeis

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This contribution for the ICES-WGALES represents a summary of results derived from a series of laboratory and field experiments conducted to study growth and bioenergetics during early ontogeny of a riverine cyprinid species, which is abundant in many European rivers and hardly exposed to fisheries (Kamler *et al.,* 1998; Keckeis *et al.,* 2000; Keckeis *et al.,* 2001; Bartl and Keckeis, 2004; Schludermann *et al.,* 2009). In the laboratory, mortality of embryos and larvae from fertilization until the end of the larval period (age 66 days) was monitored during experimental conditions. The rates were clearly temperature dependent and ranged from 7 to 20% from fertilization to hatching and from 8 to 24% from fertilization to beginning of exogenous feeding. During the period from exogenous feeding to the juvenile stage, mortality rates ranged from 0 to 6% under controlled laboratory conditions. Mark-Release field experiments in a small river revealed markedly higher total mortality rates in the range of approx. 99% during the first two months of life. Here, a very distinct reduction of mortality rates was observed during the period from larval to juvenile stages.

Christophe Loots

First steps towards an integrative modelling approach of fish larvae habitat. An application to Downs herring larvae

Christophe Loots

In habitat models, observed spatio-temporal distributions of marine organisms obtained from sea sampling surveys are related to physical measurements in order to disentangle the respective effects of underlying processes that led to these observed

distributions. In fisheries research, the way habitat models were applied mainly to juvenile and adult phases has been revealed largely unadapted for the larval phase. So far, the challenge of properly evaluate and model what controls the spatio-temporal distribution of fish larvae in their natural environment remained unresolved. Since spatio-temporal distribution of food availability in terms of prey quality and quantity acts as a main driving factor of the nutrition process, it should be taken into account in habitat modelling approach dedicated to fish larvae. We will focus on the critical period of the Downs subpopulation of North Sea herring, a relevant fish regarding its ecological interest and economical value. The main objective will be to characterize for several years their feeding strategy using gut content analysis based on Scanning Electronic Microscopy. Gut contents analyses revealed that Downs herring larvae from 6 to 20 mm were omnivorous, specialized on invertebrate eggs and more rarely consumed a variety of phytoplankton and zooplankton prey types. They seemed to positively select some phytoplankton prey types that were poorly abundant in the water whereas they negatively select several zooplankton prey types. Next steps will be to study larval condition and growth in relation to nutrition and finally integrate larval nutrition, growth and condition into a modelling approach.

Maik Tiedemann

Upwelling at the Senegalese coast: A suitable spawning area of small pelagic fishes

Maik Tiedemann

The Canary Current Ecosystem (CUE) is known to be one of the most productive marine regions of the world oceans heavily exploited by regional and international fisheries. Productivity is not least attributed to strong upwelling of cold and nutrient rich water enhancing phytoplankton blooms serving as food source for small pelagic fish. Although food seems not to be the limiting factor for growth, strong upwelling is often suggested to be disadvantageous in terms of recruitment processes such as the drift of larvae into unfavorable oceanic habitats. As one might suggest that recruitment is intermittent while strong upwelling occurs, spawning of small pelagic species such as sardinella or horse mackerels coincides with upwelling events. A survey was conducted along the Senegalese coast at the peak upwelling season in March 2013 to investigate the relationship of the upwelling and larval fish distribution patterns. It is the purpose to show the different spawning strategies of fish and the vertical migratory behavior of fish larvae along the Senegalese coast. While in inshore regions high densities of fish larvae occur, less and other larval fish assemblages are found further offshore. Vertical distribution patterns of fish larvae indicate an accumulation at depths where the near-ground upwelling flow might be able to transport larvae towards the shelf. It is suggested that the larval migratory behavior is related to the larval transport functioning as retention in an upwelling system to cope with the advection to offshore regions. It is suggested that the vertical migration could be one of mayor processes explaining the success of small pelagic species in the mayor boundary upwelling systems of the world oceans.

Richard Nash

Egg mortality rates, an exploration of specific and spatial variability: are we making any progress and is it really necessary to have a precise estimate?

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Since the 1991 review by Pepin on mortality rates in the early life-history stages of fish there has been a considerable amount of research that has highlighted egg mortality rates. The research has involved laboratory, field and modelling studies and is now encompassing new techniques for identifying and quantifying species occurrences both at large and in the stomachs of predators. While we are beginning to understand many of the factors that determine the survival rate of eggs a quantification of mortality rates still remains difficult to obtain and there are still many uncertainties as to the causes. There are species-specific differences in mortality rates and some of these are related to egg sizes and their relationships to the available predator fields. There are also physiological factors, especially in extreme or marginal habitats which will include latitudinal optimal habitat ranges. With unguarded eggs e.g. broadcast or even benthic spawners the mortality rates will also be a function of the predator dynamics thus imposing both a temporal and spatial variability in mortality rates. Due to this variability there are inherent methodological problems with estimating mortality rates. Knowledge of egg mortality rates is important for a number of reasons and these include estimations of eggs vented in ecological studies and Egg Production methodologies, estimates of predation and determining the correct scalars for individual based modelling, for example. I raise the questions of whether we really need precise estimates of egg mortalities, how much detail do we need on the processes and given the stochastic nature of survival over broad spatial scales whether we can ever make realistic estimates. In addition, is it possible or even desirable to make clear distinctions between individual and population responses in regard to mortality rates.

Annex 9: Report of session 2 Recent advances in egg and larval mortality studies

Aitor Albaina presented a real-time PCR assay to estimate invertebrate and fish predation on anchovy eggs in the Bay of Biscay. Predation is one of the major causes of mortality during early life stages. Fish eggs and larvae can be counted in the guts of other fish only a few hours after ingestion, but it is not possible with crustaceans that macerate their prey. An alternative is to use molecular approaches, and in particular, DNA techniques. In this work DNA was extracted of the stomach contents of potential E. encrasicolus eggs/larvae predators and a real-time PCR based assay, targeting an anchovy specific DNA region, was applied. Real-time PCR was selected because it is faster, more sensitive and with higher detectability than alternative molecular methods. The authors sampled at night at the highest anchovy egg abundance centers in 2010 and 2011. Macrozooplankton and fish (sardine and sprat) were sampled with MIK and pelagic trawl respectively. While both fish species showed remains of anchovy DNA within their stomach contents, 29 out of 52 macrozooplankton taxa in 2010 and 27 out of 38 macrozooplankton taxa in 2011 did. In order to estimate mortality the following assumptions were done:

- Macrozooplankton: assume 1 egg predated in the last 24 hours per positive assay
- Fish: Estimate the number of eggs consumed by predator based in the assay´s standard curve assuming that the signal corresponded to just ingested, raw, anchovy eggs (conservative assumption). Predator fish biomass from PELGAS and anchovy eggs mortality rates from BIOMAN surveys

Results:

- Local mortality value at station for zooplankton.
- Low mortalities due to predation of macrozooplankton at the shelf break (<4%), higher predation in the Gironde shelf area (14–89%).
- Minimum proportion of anchovy egg mortality (Z) that can be assigned to sardine and sprat predation (that comprise 78% of fish abundance by PELGAS).
- 7% of anchovy egg mortality due to sardine predation.
- Less than 7% of anchovy egg mortality due to sprat predation. Overestimated because all the sprat biomass within the area considered (even if not overlapping with the anchovy spawning area).
- Two papers accepted [Progress in Oceanography 131 (82–99) and IJMS (doi:10.1093/icesjms/fsu205)]
- Future work: new technique (metabarcoding) to be applied to fish gut contents.

Marta Moyano presented the use of laboratory ecophysiological studies to improve individual-based models of North Sea larval herring foraging and growth. IBMs of larval growth and survival are useful tools to understand bottom–up effects on population dynamics. Eggs and larvae as passive particles are part of the puzzle. A good parameterization is needed, and for that, laboratory experiments play a central role. In this work, several laboratory experiments useful for IBM for herring larvae are presented. Energy loss:

- Body-mass and temperature dependent respiration rates. Measures in individual larvae Moyano *et al.* (in prep).
- Metabolic and behavioural changes under starvation.
- Activity multiplier depends on starvation.
- After 2 days larvae significantly decrease their activity. They also down regulate their metabolizm.
- Work in progress: optimization of respiration rate protocols.
- Work in progress: Try to use cardiac output as a proxy for metabolic rates

Energy gain:

- Ontogeny of routine swimming: swimming speedvs.length depending also on temperature and day/night.
- Ontogeny of maximum sustained swimming: maximum speed they can sustain as a function of length depending on temperature.
- IBMs are data hungry: nice to integrate physiological measurements.
- Multifaceted approach is needed: Field + lab + models in IBM.
- How to integrate these results into an IBM in Thursday talk

Leire Ibaibarriaga presented a Bayesian hierarchical model for estimating daily egg production and mortality rates. Some of the common problems in the DEPM when estimating Ptot and Z are: having and incorrect sign or non-significant value of z and the sensitivity to where the tails are cut. Some solutions proposed have been: estimate z from various datasets and then back-estimate P0 or add larval stage to fit the mortality curve. In this work a new model trying to overcome some of these problems is presented. The model is a hierarchical model incorporating the egg development model from incubation experiment and the spawning time distribution among others. The estimation is done in a Bayesian framework. Two approaches: assuming P0 is constant in space and allowing P0 to vary in space. In all cases, the egg mortality is constant. Applied to 2012: Larger estimates and with higher precision in Ptot and total egg mortality. Bad residuals for the last egg stage (XI). This might be due to imprecise data from the incubation experiment. Promising approach, because it solves some of the problems with the traditional approach, but the differences need to be further studied.

Paz Díaz presented egg mortality and egg production estimates for Atlanto-Iberian sardine (1988–2014) using an external mortality model. The survey of Atlanto-Iberian sardine egg production, using DEPM, reaches from Gibraltar to the inner Bay of Biscay. The standard gear is a CalVET. Egg mortality (z) is traditionally estimated for three spatial strata (south, west, north) but in some cases there is the need to combined strata since spurious positive or nearly positive mortality rates area attained for the estimations per stratum. In 2012 the estimates where revised, juxtaposing the traditional approach with the application of Bayesian ageing (Bernal *et al.*, 2008) and an external mortality model (Bernal *et al.,* 2011). Three models using the traditional estimation were compared. Model 1 used a common model for egg production (P0) as well as mortality for the entire survey area. Model 2 used separate models for both, production and mortality, for the different spatial strata. Model 3 used separate models for the strata for production but a common mortality model. Model 3 exhibited the best fit and was the only one significant for the entire time-series. Using the approaches by Bernal *et al.* (2008, 2011), 3 spatial and two temporal strata (1985 – 1994 and 1995 – 2011) were

used. The two spatial strata were necessary because of differences in how sardine occupied the shelf in those two periods. Mortality was taken as a function of these strata and of SST. Using the external models P0 and SSB estimates were usually higher than with the traditional model with significant differences in 2002 and 2011 (only P0). The external models offer several advantages, as the estimates are coherent and consistent over the series and P0 as well as z can be estimated for strata to better represent the population structure.

Paz Díaz presented, on behalf of Maria Paz Jiménez, implementing an external morality model to estimate egg mortality and egg production for anchovy in the Gulf of Cadiz (2005–2014). The egg mortality rate is one of the parameters required to estimate egg production by the DEPM. An external mortality model for anchovy eggs in the Gulf of Cadiz is under development in order to overcome the high variability introduced by yearly estimates for mortality and therefore improve the egg production estimation. To establish the model, extra data on abundances by stage were obtained by revising all the data from several research surveys that included plankton sampling, carried out in waters of the Gulf of Cadiz, between 2005 and to 2014. A total of 31 119 anchovy eggs were classified into the development stages described by Moser and Ahlstrom, 1985. For each sample, the information on water temperature was also recovered. The process to estimate mortality and egg production include 3 steps: 1) estimation of daily cohort abundance by age; 2) mortality estimation considering other variables e.g. temperature and geographical and temporal strata; 3) gets P0 estimates using the mortality values obtain in previous step. Yearly egg mortality estimates from the triennial BOCADEVA survey for anchovy eggs, covering the Gulf of Cadiz, are highly variable. The development of an external model, following the approach by Bernal *et al.* (2011) should solve that problem. To have more data available, the data of the egg survey was supplemented with data from the monthly GOLFO plankton survey and the quarterly STOCA series. Together these surveys cover the months February to November. A total of 31119 anchovy eggs was combined and was staged in the 11 stage scheme of Moser and Ahlstrom (1985) and used to estimate the time of peak spawning. The approach by Bernal *et al.* (2011) has three steps:

1) Estimation of age/cohort abundance
2) Estimation of Mortality
3) Calculation P0 with the external mortality

Steps 1 and 2 are based on available data of egg age and mortality, egg production calculation uses data from DEPM. Step 1: Egg stage and age are related to temperature with a multinomial model. Peak spawning time is used to define the cohorts, their abundance and mean age. Then the mortality curve is fitted to the abundance-by-cohort estimates. Step 2: Establishes a model for the expected number of eggs for a cohort with a given age, resulting from egg production rate and mortality. The model is then expanded to include temperature, spatial strata and interactions with these covariates. Backward selection, by deleting the least significant covariate, is done for model optimization. AIC is also used to compare models and to avoid bias cut-offs are set at the tails of the mortality curve. The thus achieved mortality rates are all positive and within the range of previous studies. Step 3: The optimized model is expanded to include weights for increased sampling in areas where high egg densities are expected. Then P0 is estimated with that model. In conclusion mortality rates using this approach are all plausible and within the range of previous studies.

Bastian Huwer presented a recruitment study on Baltic cod based on a characteristics of survivors approach. It is difficult to relate recruitment to food availability, growth

and mortality. Hence, the characteristics of survivors approach samples larvae as well as the later juveniles to compare traits of survivors with the larval population, assuming that the survivors are not a random selection but the outcome of selective mortality. In Baltic cod, egg survival depends on O2 supply and egg predation. Yet, good conditions, in years with inflow from oxygen rich water from the North Sea, do not necessarily mean good recruitment and vice versa. A lack of inflow may also have effects in the larval stage, as it influences the timing and proportion of *Pseudocalanus* spp. and other species of Copepods, less suitable as food for the cod larvae. As salinity decreases *Pseudocalanus* spp. decreases together with salinity and more of it may be available as on the edges of the Bornholm basin than in the centre. Hinrichsen *et al.* (2005) showed according differences in cod larvae survival in a model study, indicating that surviving cod is either hatching early in the season or late and at the edge of the Bornholm basin. In November 2000, a survey for pelagic juveniles was conducted. They were aged by using their otoliths and their origin back calculated, assuming them to drift as passive objects. That active swimming was negligible was tested by calculating an overlap coefficient, which was 0.83. Settled juveniles where accounted for by using data from trawl surveys and age–length relationships from the literature. To account for cumulative mortality a catch curve analysis was done. Both pelagic and demersal juveniles had a mort rate of 7.5% d-1. Comparison to egg abundances at the calculated time of hatching shows a window of low survival in the middle of the spawning season. Spatially survivors come from north of Bornholm and 60–80 m depth areas, less than 20% from the deep central part of the basin. Stage I egg distribution is more or less the same across the spawning area, while late stages are more common in the centre and southern part of the basin. Hence, the result does not come from differences in spawning intensity. The result also fits with the *Pseudocalanus* spp. availability. This is confirmed by RNA/DNA data for condition.

Andrei Makarchouk presented calculations of mortality rates of sprat eggs. Considering 5 areas in the Baltic Sea, the Bornholm Basin, Gdańsk Deep, Southern Gotland -, Central Gotland -, and Northern Gotland Deep. Eggs from ichthyoplankton surveys are staged in four stages (stage I split into (a) and (b)). Ambient H2O temperature is estimated from temperature profiles and an empirical vertical distribution model of sprat eggs. Duration of the stages is calculated based on Thompson *et al.* (1981) Then a Ricker equation (Ricker, 1975) is applied to calculate mortality (z) and number of surviving eggs (n) from the total number of sprat eggs per day across the survey area. Horizontal distribution of sprat eggs is much larger in stage I than in stage II due to z=0.64 or 47% daily mort between stages I and II. For 1973–2004 interannual changes in mortality in the southern and central Gotland basin were estimated. In the central basin highest mortalities are found in May and June, for all stages but most pronounced between stages I and II. In the southern basin the period is extended from April to June, for stage I and II and more variable for later stages. Only in June was mortality rate significantly related to ambient H2O temperature. Probably because in other months water temperature only rose in the deeper layers where oxygen content was low. Hence, the rise in water temperature was irrelevant. As temperature dropped the stage duration of sprat eggs increased in the central as well as the southern Gotland basin. The total mort coefficient in the central Gotland basin was negative related to the change in ambient temperature, while there was no significant relationship in the southern part. In turn, year-class strength and survival index were negatively related to the total mortality coefficient. Compared to year-class strength showed that longer egg incubation lowered year-class strength and survival rate. The increased stage du-

ration may increase mortality by factors of up to 20. Total mortality over the egg development was ca. 95% and up to 1 year old, mortality may be about 99%. Maternal effects were statistically not significant. To investigate the effects of ambient temperature and oxygen concentration, an opening/closing BIOMOC net was used on 18 surveys in the Gotland basin and Gdańsk deep from 1996–2005. Low temperature (3–4°C) had a low impact on daily mortalities, but total mortality increased considerably. Oxygen concentration exhibited a strong effect on mortality with sinking oxygen saturation, particularly when the concentration fell under 1.5ml L-1. Spawning of sprat apparently occurred in about 30 m of depth, as in those depth almost only stage I eggs were found. However, the largest numbers of eggs, in all stages, occurred in deeper layers (ca. 70 m in the Gdańsk deep, ca. 80 m in the Gotland basin). Overall early stages suffered more from unfavourable conditions. The presenter suggested to also estimate the amount of eggs in water with less than 1 ml L-1 oxygen, since those eggs, while being fated to die, would improve the calculation of SSB.

Cindy van Damme presented on behalf of Carlos Pinto and Anna Osypchuk the Eggs and larval database portal created in the frame of ICES. At the beginning of the project the objectives of this database were recovered datasets scattered in the different institutes, make them publically available and helps researchers to make an assessment of them. After 4 years a minimum data format has been stablished and five egg and larvae surveys have been accommodated (vg. data from mackerel and horse mackerel eggs surveys, from Cod surveys and herring larvae surveys). Cindy said that we need discuss on the current database format and what we want to modify to fix our data on that. We need to agree with Carlos and Anna (from ICES data Centre) on the format because they are in charge of doing that work. New data are in process of being loaded to the database, namely: Rügen herring larvae survey, MIK larvae survey and WGIPS survey. Cindy remarked the relatively high number of visitors that the webpage received. The page was consulted by people from 42 different countries from the five continents, although the European visitors were the most frequent. Cindy proposed some discussion issues, such as reporting standard data format, calculation index to include in the database, revision of standard and extended output formats, facilitation of regular submission, so on. A 3 days meeting in Copenhagen to homogenize a common format will be schemed. Finlay Burns pointed out that a big effort has been made to build a common MEGS surveys format and wanted to know whether ICES will incorporate them to the database. Cindy replied that it should be agreed with Carlos and Anna.

Patrick Polte presented drivers and stressors of herring early life stage mortality in inshore spawning areas of the western Baltic Sea. Patrick presented a study focused on herring larval survival dynamics in GW Bay, which it is the main spawning area for the Western Baltic spring-spawning herring. He indicated that this Bay is a eutrophicated system, which is subjected to steep seasonal temperature gradients. On average represents a highly fluctuated environment compared to outer coastal shelf spawning grounds. Herring immigrating in spring attach their sticky demersal eggs to benthic vegetation. Fish return to this Bay as spawners two or three years later. Patrick pointed out that traditionally most research on early herring ontogenesis happens in rather exposed coastal shelf areas - for example in the North Sea-. The hypothesis he proposed was that those shallow, brackish estuaries and lagoons present a differing suite of challenges to herring reproduction success. The monitoring of the RHLs that he presented on Tuesday delivered them a quite high resolution dataset on weekly larval abundances and length distribution. Patrick showed weekly larval length abundances (numbers m³) from 2007 to 2011 with the smaller 9 mm group representing hatchlings.

Following the larval abundance along the season two distinct cohorts are distinguished in every year. The first cohort in mid-march can include huge amounts of hatchlings but following this cohort over consecutive weeks does not result in any growth represented by larger larvae- Those peaks usually completely disappeared. The second peak in April can be much smaller but those larvae actually growth over the coming weeks and they will eventually made the year classes. The bottleneck for this second peak seemed to be rather somewhere before hatching. Whereas the bottleneck for the first peak seems to be located after hatching most probably during the critical period of first-feeding, the question they launched was if in this eutrophicated waters, full of nutrients, exist any mismatches among larvae and food. Paulsen *et al.* (2014) confirmed a regular mismatch between first-feeding of larvae from the first cohort and spring plankton blooms. Early in the season the zooplankton was limited both in abundance and quality and that affected larval growth. The elimination of herring larva by mean of current exportation was rejected so R. Bauer's Lagrangian model in GWB central area of the bay indicated a high potential of retention. However it remains to be investigated how long in their life cycle herring larvae will remain in the system. The second cohort was rather structured by the initial amount of hatched larvae. This indicates a bottleneck before hatching, on the egg stage. The second part of this study was focused on testing whether inshore spawning habitats provide any particular threats to reproduction success, under the hypothesis: "Spawning in the upper littoral zone exposes eggs to storm induced mortality". To investigate the effect of those forces and track the egg survival over the spawning season, two major spawning areas on opposite shores were selected and started a weekly sampling campaign on three transects parallel with shore. Data analysis suggested that egg biomass was significantly higher in the very shallow zone above 2m. The effect of strong storm on the herring egg survival was investigated in 2012 sampling the eggs biomass prior and immediately after to a multiple day storm event at spawning site, quantifying the number of herring eggs transported to the beach. Results confirmed the hypothesis when around 118 million of herring eggs were found on 904 macrophyte dry mass. Finally, top–down effect of herring eggs was investigated studying the predation of brackish population on them (Kotterba *et al.*, 2014). The predator exclusion experiment showed a significant mortality of herring eggs caused by estuarine predatory fish species. They found a significant positive correlation between egg concentration per area and predation intensity. Nearly all eggs were consumed at concentrations > 25 eggs cm2, but predation was less intense at egg concentrations below that threshold. The work aroused the interest of many participants in relation to many issues: For example, if alternative bottom spawning habitats have been observed for herring. He replied that gravel seems an alternative. What is happened at deeper water is something unknown so far. Other aspect to be investigated is larvae depredation. Although some attempts were made there were no clear results. Perhaps genetic studies help clarify this issue. Cannibalism should be considered, however that is more difficult to estimate.

Marta Moyano presented linking short-term physiological responses to longer-term climate impacts: a case study using Atlantic herring early life stages. Marta presented experimental laboratory studies on the estimation of metabolic rates in relation to temperature using herring larvae like case of study. The final goal of this study was to link short-term physiological responses to longer-term climate impacts. He explained different metabolic concepts integrated into the thermal windows and the term Metabolic Scope (MS), which is the difference between the active and standard metabolic rates; MS is the animal's capacity to perform useful activities like swimming, feeding, and growth. MS is a function of temperature and DO and is higher in areas where MS is

maximized. Taking into account all these concepts, an optima temperature is defined (Topt). Laboratory experiment focused on the estimation of standard metabolic rate (Rs) and active metabolic rate (RM) were performed. As the determination of metabolic scope via respiration estimates was not possible, "cardiac output" measurements were used like a proxy. The main deliverable of this work was the proposal of a thermal performance curve for Atlantic herring larvae, which was obtained using a combination of physiological measurements and growth estimations. This mechanistic understanding of thermal limitations to performance will be incorporated into a physiologically based IBM, that embedded into a more complex model (hydrodynamics, prey fields) will allow them to explore the effects of climate-driven impacts on herring larvae growth and survival, in different areas and Compare stocks (Baltic, N Sea); explore spawning strategies on the life beyond Tpejus and gaining a better understanding of recruitment dynamics. The discussion aimed on the temperature used during the experimentation and its application on the field data. She stressed the need to improve Rm measurements, carry out CT estimations via enzyme assays and estimate thermal limits throughout the life cycle.

Franziska Bils presented whether microzooplankton can support the growth and survival of Atlantic herring larvae in winter. Franziska presented her PhD work focusing on the importance of microzooplankton on growth and survival of herring larvae in winter. Microzooplankton represents that fraction of plankton comprised between 20 -200 um. She remarked the little information we have on those heterothoph or mixotroph organism. She showed larval experiments which revealed that combination of algae and ciliates improved the quality of larvae. At sea, studies were carried out on board three herring surveys from autumn and winter of 2012 to 2015. Sampling areas were located in the Irish Sea, in the Channel and Buchan/Banks. Data for Irish Sea revealed no relation between larvae abundance and microzooplankton biomass. Larval growth estimates using RNA/DN analysis did not show any relationship with the microzooplankton abundance either. Data for Buchan/Banks indicated a preferential abundance of herring larvae in mixed waters. When the composition of microzooplankton was considered, herring larvae were not present when the biomass of ciliates was low. This works is still in progress and new analysis such us: i) RNA/DNA and fatty acids for larvae and microzooplankton; ii) stable isotopes; iii) Gulf VII zooscan analysis and i) pup net samples (52 um) for species abundances using a flowcam. The discussion of this work was addressed on the absence of temporal series of microzooplankton. Data from Channel area from French survey were offered during the discussion.

Hubert Keckeis presented the effect of temperature and development on mortality rates of a riverine fish species (Chondrostomanasus): comparison of laboratory and field results. Larval mortality in the Danube River. The aim was to investigate the causes of mortality among fish larvae in freshwater with the Danube River as an example. Mortality seems to be temperature-dependent for both endogenous and exogenous feeding larvae. Capture-recapture methods showed greater mortality rate for larvae than for juveniles. It seems also that mortality in the field might be higher than in laboratory. The explanation could be the "Bigger is Better" Hypothesis however it works only for a short time period as lot of small larvae are again observed at the end of the spawning period. Therefore, there might be several causes that remain unclear. In the future, role of= temperature, density-dependence, size, food and dispersal on larval mortality should be investigated.

Christophe Loots presented first steps towards an integrative modelling approach of fish larvae habitat. An application to Downs herring larvae. Classical habitat models

based on observed presence-absence or abundances are not totally suited to fish larvae as they experience a high mortality rate during the critical period. These models should be based on other responses like feeding, growth and condition status. A first step has been addressed to Downs herring larvae during winter by studying their feeding behaviour at length between 7 and 14 mm. Next steps will be to relate this feeding behaviour to growth and condition indices to be integrated in a habitat model dedicated to map suitable areas for Downs larvae to feed, grow and survive.

Maik Tiedeman presented upwelling at the Senegalese coast: A suitable spawning area of small pelagic fish. The aim was to investigate on fish larvae distribution in the upwelling at the Senegalese coast in term of spawning strategies and retention mechanisms of fish larvae. Three main areas could be observed: inshore, offshore and upwelling areas. Each are characterized by different environmental conditions and larval assemblages, e.g. anchovy and horse-mackerel are typical of the upwelling area. Diel vertical migrations were also observed and were different according to the area. In the future, the larval spatial distribution and retention according to larval size should be studied.

Richard Nash presented egg mortality rates, an exploration of specific and spatial variability: are we making any progress and is it really necessary to have a precise estimate? Estimation of fish eggs and larvae mortality rate is important as they can be used to calculate spawning-stock biomass or recruitment indices through DEPM methods for example. Mortality rate estimation is complicated and problematic as several factors can affect fish eggs and larvae mortality, including environment (temperature, salinity, oxygen, pollution, mechanical stress, and solar radiation), predation (fish, gelatinous plankton, cannibalism, invertebrates) and maternal effects (first time vs. repeat spawners). Future research on eggs and larvae mortality should combine field, experimental and modelling studies. These studies should account for processes acting at different scales (individual/population, spatio-temporal variability…) and their associated uncertainties. They should also end with several indices rather one.