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Report of the Second Workshop of National Age Readings Coordinators (WKNARC2)

13 – 17 May 2013

Horta, Azores

ICES International Council for the Exploration of the Sea

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Executive summary

The Workshop of National Age Readings Coordinators (WKNARC) met for the second time from 13 - 17th May 2013 in Horta, Azores (UAC DOP). The meeting was chaired by Lotte Worsøe Clausen (DTU AQUA), Julie Coad (DTU AQUA) and Ângela Canha (UAC). 19 nations were represented by 28 participants.

WKNARC was proposed by the Planning Group on Commercial Catches, Discards and Biological Sampling (PGCCDBS) 2010. Many activities of this group are closely linked to the activities of the Data Collection framework (DCF). WKNARC2 builds on the review compiled by the group's first meeting in 2011 while aiming to further develop tools and protocols for Intercalibration between laboratories.

Annual ageing and the inferred parameters (growth and mortality) can be used to infer population dynamics and stock status and are incorporated into stock assessment where the proportions of each age class are of primary importance. The age data is provided by National laboratories and is based on both validated and non-validated methods. International cooperation between laboratories aims to reduce the inherent uncertainty surrounding this data by standardisation of methods and procedures.

The meeting was preceded by an online questionnaire relative to the ToR's, the results of which were divided amongst sub groups and prepared for discussion prior to the meeting. The main points outlined that, in terms of standardisation of methods: improvements have been made but there is a lack of supporting documentation and comparative studies between old and new methods. The European Age Readers Forum (EARF) needs to be updated and promoted to be more user friendly and WebGR should be used for future exchanges and workshops. Quality control procedures should be summarized and shared on the EARF. Means of dealing with uncertainty in relation to age data in assessments were reviewed and as a result, the 3 point grading system should only be used for quality control and not as a quantitative measure of ageing error. Gaps in age validation and growth formation studies will be identified based on the needs of the Assessment Working Groups. Guidelines for Task Sharing were outlined and its importance, especially in light of new landing obligations was highlighted.

Plenary sessions were thus highly constructive and open to new proposals on how to progress with the objectives of the group. A full day was assigned to demonstration and hands-on training of the online WebGR tool. This package facilitates the annotation and exchange of images and a study proposal for its further development was compiled. State of the art validation protocols were collated and an outline for an ICES Cooperative Research Report (CRR) was suggested. A new Working Group on Biological Parameters (WGBIOP) was proposed; to continue the work of WKNARC and to facilitate a strengthening of the link between the end users and the national laboratories while supporting stock-based and ecosystem advice in terms of biological parameters.

The report summarises the work in relation to each of the ToR's, future recommendations for the proposed new Working Group on Biological Parameters, a WebGr study proposal and a review of the available validation material for a CRR.

1 Introduction

The Workshop of National Age Readings Coordinators (WKNARC) was proposed by PGCCDBS for the purpose of Intercalibration between ageing labs, within a Quality Control Framework, with the aim to standardise procedures. At the first meeting of the group in Boulogne-sur-Mer (IFREMER) France in 2011 this was done by reviewing: preparation methods, material and technique development, image processing methods, validation methods and tools for exchanges and WK's and by summarising quality management in institutes.

As a follow on the important work initiated at the first meeting of the group, WKNARC 2, chaired by Lotte Worsøe Clausen (DTU AQUA), Julie Coad (DTU AQUA) and Ângela Canha (UAC), met in Horta, Azores (UAC DOP), 13–17 May 2013 to:

a) Review and follow up of last WKNARC's recommendations and intersession work

b) Review progress in preparation methods and material and techniques development

c) Review progress in tools for the exchanges and workshops (WebGR, European Age Readers Forum (EARF) and other statistical tools)

d) Review progress in the validation methods and to analyse questionnaires from Assessment WG on the needs for validation studies

e) Review progress in the Internal and External Quality Control in institutes

f) Review the available protocols for a CRR (Cooperative Research Report) (with reference to the PGCCDBS 2012)

g) Report on the implementation of central labs for processing age reading; under this, review the success of existing bilateral agreements and the prospects for task-sharing (TS)

h) Review the means of dealing with uncertainty in relation to age data in assessments (e.g. in assessments performed in the Pacific, etc.) as a pre-task for the WKSABCAL

Overarching all of these ToR's is the progress on standardisation (within a Quality Control framework), to ensure the documentation of this progress, to further promote the use of images and the WebGR tool for exchanges and to promote the use of the Age Readers Forum (EARF), all with the needs of the end users in mind. A WebGR study proposal has been written and a draft outline for a Cooperative Research Report (CRR) of validation studies has been proposed.

The initial step was to build an online questionnaire addressing these ToR's and the recommendations from WKNARC and the PGCCDBS and to have it completed by all institutes within the member states. Possible actions were outlined as to how to deal with each of these ToR's and sub groups were made within the group to deal with these. Prior to the meeting, each of the subgroups received a document containing the relevant questionnaire results and suggested actions so that work could begin prior to the meeting. Sub group work was then presented on the first day of the meeting, discussed in plenary and continued throughout the week.

The results of the questionnaire showed that improved methods have led to increased precision but that documentation could be improved. The use of images is becoming

more common and thus the digitisation of images must be standardised. Both WebGR and the Age Readers Forum need to be improved and the improvements made to the Guus Eltink spreadsheet need to be made more widely available. There have been some developments in terms of validation but in general such work is being hampered by time and economic limitations. In general there has been an improvement in the Internal and External Quality Control in institutes. The number of institutes applying the 3 pt. grading system to their age readings is about 50% of those that answered the questionnaire, In most of the other institutes, the stock assessment scientists are aware of the grading system, but don't use it for modelling With new regulations there will be an increased need for ageing of new species and increased need to develop cooperation between institutes on a regular basis in the form of task sharing.

In this report each of the ToR's, the actions taken and the results of the subgroup work in relation to the recommendations will be described. The WebGR study proposal and feedback given by the group from the hands-on session is documented in Annex 5. The outline for the CRR document is in Annex 6.

1.1 Report Contents

Two main topics of other business were brought up and addressed by the members of WKNARC2; The first being a generic discussion on the inherent uncertainty in relation to assigning fish to a correct year-class, independently of variations in life history within a species (across stocks). The second discussion was in relation to the increasing difficulty in directing manpower and hours to the quality assurance work across all institutes; generally frustration is caused by having a dedicated group with limited resources and work tasks larger than can be managed by the relatively small community of coordinators for collection and quality assurance of biological parameters for stock assessment purposes.

The remaining report addresses the ToR's following the structure in the text table below. A list of annexes can be found in Section 11.

Table 1.1 ToR's and Section numbers

Term of Reference	Addressed in Section
Review and follow up of last WKNARC's recommendations and intersession work **(ToR a)**	Section 2
Review progress in preparation methods and material and techniques development **(ToR b)**	Section 3
Review progress in tools for the exchanges and workshops (WebGR, other statistical tools, age readers forum **(ToR c)**	Section 4
Review progress in the validation methods and to analyse questionnaires from Assessment WG on the needs for validation studies **(ToR d)**	Section 5
Review progress in the Internal and External Quality Control in institutes **(ToR e)**	Section 6
Review the available protocols for a CRR (with reference to the PGCCDBS 2012) **(ToR f)**	Section 7

Term of Reference	Addressed in Section
Report on the implementation of central labs for processing age reading; under this, review the success of existing bilateral agreements and the prospects for task-sharing **(ToR g)**	Section 8
Review the means of dealing with uncertainty in relation to age data in assessments (e.g. in assessments performed in the Pacific, etc.) as a pre-task for the WKSABCAL **(ToR h)**	Section 9

1.2 Interpretation of growth structures in calcified structures; assigning to the correct Year-Class independent of different life history within a species.

Achieving consistency between a group of age readers estimating the age of a certain species or a stock within a species has been a main objective for the age reader community since its beginning. The aim is to increase the adoption of procedures for age reading that include quality assurance and quality control mechanisms, for the improvement of stock assessment and environmental management techniques. The ultimate objective is to stimulate the achievement of a higher level of quality within, and integration between the partner institutes concerning fish age determination.

After the development of a European Fish Aging Network with two Concerted Actions, EFAN and TACADAR from 1997 to 2006, a lot of exchanges and workshops (14 from 2007 to 2012) were organised, most of them under the PGCCDBS umbrella.

A synthesis of 14 reports of the Workshop reports on Age Reading from 2006 to 2012 showed the sources of bias in the age estimation between readers may origin in two primary reasons: Differences in preparation techniques and different interpretation of the growth structures, including the position of the first ring, the annual structure of growth rings and the interpretation of when to include a structure on the edge of the otolith.

Most Workshops mediated the differences originating in the preparation methodology and also dealt with the divergence in interpretation of the first ring and definition of age structures. However only 3 out of 14 reports discuss action on how to interpret the last growth ring, which is a key issue when dealing with species displaying large variances in life-history, in particular for short-lived species.

When identifying the interpretation of the edge for specific stocks, additional information apart from the otolith structures should be considered:

- Date of capture
- Peak of spawning period for a given population i.e. date of birth which is not by default 1/1 for all stocks
- Main periods of seasonal increment formation for the species/stock
- Other features related to the growth characteristics of the calcified structure

These issues and the ecological characteristics of the individual stocks within a species must form the background for setting up schemes for interpretation of the edge structures over a year. As such, several schemes may be made for one species depending on the biology of the stocks within the species but also the agreed age-estimation methodology of the species.

WKNARC2 discussed the obvious lack of such schemes and their outmost importance for having consistency in the assignment of individual fish from a given species to the correct year-class independent of stock. A way to ensure that all age

readers will be able to do so, would be to have species-specific and stock-specific schemes for the interpretation of growth structures on the edge of the calcified structures. When having a varying date-of-birth within a species a decision should be made by either the Assessment WG or all the age-readers as how to assign to YCL based on the age-structures, as to ensure consistency in the ageing data. It does not rule out having several schemes for interpretation of the edge, however, it does require a calibration of the interpretations and an agreed methodology.

WKNARC2 decided to modify the Guidelines for Age Calibration Workshops to include a requirement for the formulation of such schemes. An Age Calibration Workshop should define the edge-structures during a year and decide on when to count – and not to count – the structure on the edge of the otolith.

Given the limitations in terms of time and funding for the number of workshops which can be realised within the near future, WKNARC2 asked all age reading institutes to populate a table, listing: species, area and definition of date-of-birth (and thus when the edge structure is included in the numeration of the age), see Annex 8. This table will then be an outline of where action should be recommended in terms of the formulation of the relevant schemes for edge interpretation. This table also includes information on: number of otoliths collected per year, reader contact details and a column for indicating whether there is an interest in bilateral agreement by reader. The final table will be presented at the PGCCDBS 2014 meeting by a WKNARC2 chair.

1.3 Resources in relation to exchanges and workshops

Recently assigning chairs/coordinators to the exchanges identified under the remits of PGCCDBS has become increasingly difficult and often the appointed coordinators are the same individuals for a lot of exchanges. In order not to wear these relatively few scientists out, it is necessary to widen the scope for appointing coordinators beyond the PGCCDBS; this could potentially be done by a WG dedicated to quality assurance of biological parameters or by having a list of volunteers prior to the PGCCDBS meeting.

The following are proposals for full-scale age exchanges in 2014. WKNARC 2 succeeded in appointing the following coordinators.

Table 1.2 Coordinators for upcoming exchanges

Species	Coordinator
Whiting (*Merlangius merlangus*)	Mark Etherton (CEFAS)
Megrim (*Lepidorhombus spp*)	Gordon Henderson (MARLAB)
Sole (*Solea solea*)	Loes Bolle (WUR) and Annemie Zenner (ILVO)
Horse mackerel and Mediterranean horse mackerel (*T. picturatus* and *T. mediterraneus*)	Pierluigi Carbonara (COISPA) and Kélig Mahé (IFREMER)

Getting a reply from all invited laboratories (be it positive or negative) appears to be of lesser importance for the invited parties which leaves the coordinators without any means to actually perform the exchange and calibration. This could be solved by setting up standard reply formulas (e.g. 'yes' or 'no' voting options). However, the more specific solutions to this were decided to be directed to the suggested WG dedicated to quality assurance of biological parameters (WGBIOP, see Annex 3).

WKNARC2 discussed at length the possible ways to facilitate a strengthening of the link between the need for quality assurance of biological parameters, such as age or maturity, by the end-users and the National laboratories. Clearly the current system of EARF and the annual PGCCDBS review does not cover the needs given the problems of getting the necessary engagement from experts within the National laboratories. The impression of WKNARC2 is not that this lack of participation is rooted in lack of interest, but merely a question of a) actual information flow of the on-going need, work and development within the quality assurance of biological parameters and b) prioritising of funds for the work by the individual National laboratories. Section 4 discusses the communication issues which ultimately lead to the resolutions for the WKNARC2 suggested new Working Group on Biological Parameters (WGBIOP, see Annex 3). The groups view is condensed in relation to the science supporting stock-based and ecosystem advice in terms of biological parameters (beyond technical aspects of QA & QC).

2 ToR a Review and follow-up on recommendations and intersession work from WKNARC 2011

Most of what was recommended in the report from the WKNARC meeting in 2011 was allocated to the various subgroups in WKNARC2 (table below).

Table 2.1 Table of recommendations and actions

Recommendation	Action	ToR
Age Reading Coordinators consult Annex 10 from WKNARC to evaluate preferred methods used in institutes within an eco-region.	Review, discuss and report on results of Questionnaire.	ToR. b
Methods and techniques are standardised as much as possible. If differences impose an impact on age reading of a stock then a comparative analysis should be performed.	Review, discuss and report on results of Questionnaire.	ToR. b
PGCCDBS ensures that all age reading coordinators use EARF and that all exchanges and WK's are run through this using the PGCCDBS guidelines	Review, discuss and report on results of Questionnaire Ensure all results of WK's and exchanges are collated and organise to have them put on EARF	ToR. c
Future exchanges and WK's use WebGR for annotation and exchange. PGCCDBS nominate a WebGR host. WebGR training WK. Work is put into WebGR statistics and reporting so it is in a format useful to age readers and stock assessors. The use of WebGR for the comparison of methodologies for calibration. Evaluation of precision levels for age estimates evaluated by species.	WebGR study proposal WebGR session Review, discuss and report on results of Questionnaire	ToR. c + new request
WebGR and EARF updates	WebGr session 7 points of WebGr improvements need to be addressed - Review, discuss and report on results of Questionnaire	ToR. c

Identification of major stocks/species needing validation	Review, discuss and report on results of Questionnaire Output from the AWG's. Suggest a suitable funding framework for such studies	ToR. d
Review and outline results of AWG's need for validation studies	Review, discuss and report on the output from the AWG's.	ToR. d
Using the same 3 pt. scale grading system for all species included in stock assessment and that age calibration WK's use this scale	Review, discuss and report on results of Questionnaire	ToR. e
Review the progress made on QC	Review, discuss and report on comments from the Age Readings Coordinators and PGCCDBS 2013	ToR. e
Proposed CRR on Protocols for the ageing of different species	Invitation to bring state of the art methodologies and validation studies to WKNARC. Review available protocols, Draft CRR by species group	ToR. f
The use of central labs for processing	Review, discuss and report on the success of existing bilateral agreements and the prospects for task-sharing Output from the RCM's	ToR. g
Inclusion of age reading variance in stock assessment	Review what experience there may be, world-wide, of incorporating age based uncertainties into age based assessments Check up on literature and twinning projects overseas	ToR. h
Review experience of incorporating age based uncertainties into assessment	Check up on literature and twinning projects overseas. WKAEH a good example for discussion	ToR. h

WKNARC 2 reviewed the recommendations of WKNARC and PGCCDBS and evaluated their implementation by sending questionnaire to age reading coordinators before the WKNARC2 meeting. The results of the questionnaire and subgroup work for each ToR are summarised below.

ToR. b) Age Reading Coordinators consult Annex 10 of WKNARC to evaluate preferred methods used in institutes within an eco-region. Methods and techniques are standardised as much as possible. If differences impose an impact on age reading of a stock then a comparative analysis should be performed.

In 2011, based on the questionnaires delivered to WKNARC from Member States (MS) institutes prior to the workshop, the group compiled information on materials, techniques and preparation methods for age determination (Annex 10, WKNARC, ICES 2011). It was stated that 27 species (24%) within an eco-region are treated in a variety of ways that have been developed at the institutes analysing these species. It is not clear whether utilisation of different methods resulted in differences in age determination since no calibration had been performed. In the period since the WKNARC 2011 meeting, the respective calibration work has been carried out for

Horse mackerel (WKARHOM 2012), red mullet (WKACM-2) and anglerfish (*Lophius piscatorius*, illicia and otoliths exchange 2011). WKNARC2 proposes that this issue is investigated by approaching stock coordinators of ICES assessment WG's together with the identification of validation needs for stocks/species (see next point ToR. d).

ToR. c) PGCCDBS ensures that all age reading coordinators use EARF and that all exchanges and WK's are run through this using the PGCCDBS guidelines.

WKNARC2 checked whether the results and reports of all exchanges and workshops could be found on EARF. In 2012, three PGCCCDBS age reading workshops were carried out: Age Determination of Salmon (WKADS-2), Workshop on Age Reading of Horse Mackerel, Mediterranean Horse Mackerel and Blue Jack Mackerel (WKAR-HOM) and Workshop on Age Reading of Red Mullet and Striped Red Mullet (WKACM-2). It was possible to find on EARF only the otolith images of horse mackerel. Evidently those were otoliths/slices which were selected for the reference collection during the workshop. The results, reports or images of other two workshops were not available on the EARF. It could be concluded that only few coordinators of exchanges and workshops use EARF and that EARF needs to be updated. WKNARC2 considers that PGCCDBS should pay more attention to this issue.

Future exchanges and WK's should use WebGR for annotation and exchanges. The use of WebGR for calibration and comparison of methodologies as well as evaluation of precision levels for age estimates should be established within ICES as a default tool. Efforts should be put into WebGR statistics and reporting so that the format is useful to age readers and stock assessors.

WKNARC2 reviewed the utility and success of the different tools used in age reading exchanges and workshops (e.g. WebGR, Age Readers Forum, Guus Eltink Spread-Sheet) as recommended by PGCCDBS 2013. The questionnaire results from the WebGR section indicated little knowledge about the tool, and therefore a training session was arranged at the meeting. The results and comments from the training session were included in a study proposal for improvement of the WebGR program as recommended by WKNARC 2011.

ToR. d) Identification of major stocks/species needing validation. Review and outline results of Assessment Working Groups (AWG) need for validation studies.

In 2011, WKNARC recommended that a questionnaire should be forwarded to each ICES and GFCM stock assessment working group to identify the gaps in age validation and growth formation studies (for stocks that are subject to age structured assessment or require such an approach). Such questionnaires were not prepared however this need was discussed at the ICES Assessment WG's meeting in 2012. WKNARC2 reiterates the need for such information and a table has been complied and proposed for presentation at the next ICES Assessment WG's meeting. The table contains an evaluation of the need for future validation work and age calibration workshop by ICES stock and can be found in Annex 7. It also provides information on whether the methods and techniques for age determination of the stock are standardized.

ToR. e) Using the same 3 pt. scale grading system for all species included in stock assessment and that age calibration WK's use this scale.

This is the standard grading system for mackerel age readers which can be applied to all age reading exchanges and WK's. The 3pt grading system is being used in eleven of the 27 institutes that answered the questionnaire. Only in two institutes, the scientists working with stock assessment are using the system. In most of the other insti-

tutes, the stock assessment scientists are aware of the grading system, but don't use it for modelling. Other grading systems (e.g. 4pt.) are also in use and +3point grading systems might make more sense for some stocks. From three PGCCCDBS age reading workshops in 2012, only the Workshop on Age Reading of Red Mullet and Striped Red Mullet (WKACM-2) used the 3pt system.

Review the progress made on Quality Control (QC)

In general, Age Estimation Quality Control procedures in the strict sense are already in place in most of the institutes but many institutes reported no real changes to their QC procedures since WKNARC 2011. WKNARC2 proposes that institutes summarise their Quality Control procedures (from sampling to estimated age) and share this on the EARF with other institutes and thus allowing the next meeting of this group to review, discuss and suggest improvements to protocols. Within institutes the use of images and WebGR is growing. Images for exchanges should be of the highest quality possible and guidelines for image capture given by the age reader. WGBIOP would be the recommended platform to evaluate exchanges and workshops and to provide better suggestions for exchanges/workshops to the PGCCDBS. The frequency of exchanges should be revised. A readability score is interesting for quality control; however, caution should be paid in relation to using a readability score as a quantitative measure of ageing error.

ToR. f) Proposed Cooperative Research Report (CRR) on Protocols for the ageing of different species.

PGCCDBS 2012 was approached by the ICES Publications Committee with a suggestion of combining the existing protocols on the ageing of fish species within the ICES area and publishing them as an ICES Cooperative Research Report. This idea was positively received by PGCCDBS. PGCCDBS 2013 specified the time schedule for the production of a CRR and specified tasks in preparation of a CRR for WKNARC2 to complete: nomination of Chapter editors, agreeing on headers for the introduction and compilation of a summary table of validation studies within the ICES community to date.

ToR. g) The use of central labs for processing

WKNARC2 recognizes the risks in concentrating the expertise on individual fish species amongst fewer people and Central laboratories. In agreement with the PGCCDBS 2012 advice, WKNARC2 recognises Task Sharing (TS) as an important tool to improve the standardisation and thus age data quality while ensuring the sharing of skills and knowledge required for age determination, validation etc. Already existing agreements between the national labs testify their importance for organizing this activity on regular basis.

TS could be organised within Regional Unit's (sub-regions Atlantic, Mediterranean and Black Sea). To facilitate such TS organisation a list has been provided showing the contact persons for receiving/sending calcified structures/readers by species within Institutes and can be found in Annex 8. The completed list will be presented in the next Regional Coordination Meetings (RCM's). Moreover this list and the update will be hosted on the EARF web site. The guidelines for TS are included in this report.

ToR. h) Inclusion of age reading variance in stock assessment. Review experience of incorporating age based uncertainties into assessment.

PGCCDBS recommended that WKNARC2 reviews the means of dealing with uncertainty in relation to age data in assessments, as a pre-task for the WKSABCAL. A lit-

erature search was carried out focussing on (quantifying) age-reading error (for use) in stock assessments. In section 9 we present an overview of the publications that were found. This overview includes a brief description of the general approach, the age data used and the statistical methods applied, to enable a first comparison of the different approaches.

3 ToR b Review progress in preparation methods and material and techniques development

WKNARC 2011 produced an extensive list of state-of-the-art methodologies in relation to preparation methods and material/technique development. To analyse the usefulness of such an inventory, WKNARC2 enquired how many institutes actually used this list. There were 47 answers to the questionnaire from 22 countries and from these responses, 75% of age readers rated the list's usefulness at a level of 3 or 4 (moderately useful to useful).

In reference to the inventory from WKNARC 2011, the general progress related to material used, techniques applied and preparation methods was analysed in WKNARC2:

- The majority of the institutes had not developed any new preparation methods (90%). Only 5 participants answered that they have developed new methods.
- Of these 5, 3 had described the methods and made these available outside of their own institutes, but only 2 had summarised the techniques used. All agreed that having these documents was useful.
- Of 47 answers, half said they were using images as standard for actual reading, storage and exchanges. Of the half that use images on a routine basis, 40% have made improvements by standardizing procedures such as light settings, equipment etc. In general this has led to an improvement in precision and to a lesser extent an improvement in validation. Only 4 participants have summarised these improvements in a document, and they considered this useful.

Table 3.1 Species for which new preparation methods have been developed.

	Species	Institute	Annual/ daily growth	Used in WK or exchanges?	Documentation available
1	*Lophius piscatorious*	IEO (Spain)	Annual	Yes (Exchange 2011)	Yes
2	*Argyrosomus regius*	IFREMER (France)	Annual	No	Internal
3	*Salmo salar*	IFREMER (France)	Annual	Yes (WKADS2 2012)	WK report
4	*Phycis blennoides*	IFREMER (France)	Annual	Yes (WKAMDEEP 2013)	YES manual available in EARF
5	*Limanda limanda*	IFREMER (France)	Annual	Yes (WKARDAB 2010)	YES manual available in EARF
6	*Scomber scombrus*	MRI (Iceland)	Annual	No	Internal
7	*Molva molva*	MRI (Iceland)	Annual	Yes (WKAMDEEP 2013)	Internal
8	*Platichthys flesus*	MIR (Poland)	Annual	Yes (WKARFLO 2008)	Internal manual for otoliths preparation and age reading of flounder (*Platichthys flesus L.*)
9	*Engraulis enacrasicolus*	IEO (Spain)	Daily	Yes (WKMIAS 2013)	Protocols will be presented at WKMIAS for possible adoption
10	*Sardina pilchardus*	IEO (Spain)	Daily	Yes (WKMIAS 2013)	Protocols will be presented at WKMIAS for possible adoption
11	*Scomber collias*	IEO (Spain)	Daily	Yes (Exchange 2013)	Draft protocol in place for exchange.
12	*Merluccius merluccius*	HCMR (Greece)	Daily	No	Internal

The improvements are more specifically described below by species:

1) *Lophius piscatorius*: Modifications in the preparation and observation of illicia.

Modifications in the i) preparation and ii) observation methodology of illicia, and iii) in the traditional biased age estimation criterion, were presented in the paper of Landa et al. (2013). Thicker illicia sections (0.50-0.55 mm) and lower magnifications (40–50×) helped to better identify the well-defined growth bands (annuli) than those not so well defined in thin increments (no annuli). Regarding the age estimation criterion, the recommendations of the study of Wright et al. (2002) based on micro-increments in hard parts of this species, of not counting the first supposed annual increment because it did not correspond to an annual period was also applied.

A protocol including those modifications was used in the "Anglerfish (*Lophius piscatorius*) illicia and otoliths exchange 2011" (Landa, 2011). Landa et al. (2013) showed that the illicia age estimations of *L.piscatorius* could be indirectly validated by tracking cohorts using the abundance indices per age class from surveys and length-frequency analyses in an area of its distribution (Porcupine Bank). Previous studies of cohort tracking using the traditional illicia age estimation criterion had shown a mismatch (Azevedo et al., 2008), suggesting a faster growth. With the new proposed age estimation criteria, abundant and scarce cohorts in that area were able to be tracked over the time throughout several age groups.

2) *Argyrosomus regius* – a new species for IFREMER, they are modifying existing methods, taking a thin slice from irregular shaped otoliths. It is very important that the cut is along the correct axis.

3) *Salmo salar* – a new species for IFREMER, but applying existing methodology in conjunction with Canada (workshop with Ministry of flora and fauna of Quebec).

4) *Phycis blennoides* – a new species for IFREMER, applying the same method that is used for roundnose grenadier (*Coryphaenoides rupestris*).

5) *Limanda limanda* – a new species for IFREMER, but applying existing methods.

6) *Scomber scombrus* - changed from storing loose to now stored in resin on black trays.

7) *Molva molva* - still read whole but using water instead of glycerol as the observation method.

8) *Platichthys flesus* - not a new method but new materials (resin) for embedding the otoliths.

9) 11. *Engraulis enacrasicolus* , *Sardina pilchardus, Scomber collias* - adaptations of the overall preparation methodology using otoliths for daily growth studies. *Scomber collias* is a new species to be monitored in the DCF.

12) *Merluccius merluccius* - otoliths were ground in sagittal plane following the methodology proposed by Morales & Albert, 1997, transformed, to expose daily increments in otoliths of specimen up to 2 years old (TL: 10-44cm). Agreement with otolith macrostructure interpretation.

In relation to the use of image for standard age reading including actual reading, storage and exchanges, the below table summarises the development since 2011 across all National laboratories participating in WKNARC2.

Table 3.2 Use of Images

Species	Institute	Description	Improvement in standardisation?	Used in WK/ exchanges?	Documentation available
Salmo salar	RKTL (Finland)	Routine saving of scale images	No information available from questionnaire	No information available from questionnaire	No information available from questionnaire
Sebastes spp.	IIM (Spain)	Agreed material (images?) used as a reference during age determination and for exchanges	No information available from questionnaire	Yes (WKADR)	Yes
All Species aged	ILVO (Belgium)	Daily readings of a number of samples from a control collection. These results are discussed the same day. Resulting in less variability between the age readers.	Improvement in precision	No	Yes, internal
Engraulis enacrasicolus, Sardina pilchardus, Scomber collias	IEO (Spain)	Images routinely used for estimation of daily growth and increasingly frequently for annual growth	Potential improvements to be discussed at WKMIAS	Yes (WKMIAS)	Protocols will be presented at WKMIAS for possible adoption
All species aged	COISPA (Italy)	Semi-direct validation (marginal analysis and marginal increment analysis)	Standardisation of ageing criteria.	Yes (WKHOM and WKACM 2)	Yes, internal
Capros aper	DTU AQUA (Denmark)	Images used for routine ageing and for validation study	Standardisation of ageing and for use in training manual	Yes, training exercise at MI Ireland	Yes, training manual with image library
M. merluccius, M. barbatus, M. surmuletus, S. smaris, P. erythrinus,	HCMR (Greece)	Calibrated images used for routine ageing	Improvement of internal agreement between readers	No information available from questionnaire	No information available from questionnaire

3.1 Conclusions

Some improvements has been implemented across the National laboratories participating in both WKNARC1 and 2; every institute that is instigating a change in procedures is doing so in order to improve the quality of their age reading programmes. There is, however, a lack of documentation of many of these improvements and thus these are not made available to all readers of the relevant species. This is certainly a point which should be improved and hopes are that the planned CRR (see section 7) may facilitate the sharing of the state-of-the art methodologies across laboratories and species. Another important issue is the apparent lack of comparative studies of results of old versus new methods – this is crucial if these new (improved) methods are to be applied across laboratories.

4 ToR c Review progress in tools for the exchanges and workshops (WebGR, other statistical tools, age readers forum)

Prior to WKNARC2 2013 a questionnaire was sent around among participants. The questionnaire had the aim to test the utility and success of the WebGR, EARF and the Guus Eltink SpreadSheet and discuss the outcomes during the meeting.

Concerning WebGR, this is a rather new tool and many of the questions concerned the common knowledge about the programme and the importance of essential improvements previously required by other expert groups. Furthermore, WebGR, currently hosted at www.azti.es, has not been updated since 2010. Hence the questionnaire investigated the option of transferring this software to an ICES server for a better maintenance.

In reference to EARF, the knowledge, use and benefits of this forum were also questioned and discussed. Furthermore participants were asked for an evaluation of the Guus Eltink SpreadSheet, pros and cons of this tool together with required improvements were examined.

4.1 Results from the questionnaire and introduction to the tools available for exchanges and workshops

4.1.1 WebGR

WebGR is Open Source software developed in 2008 by a consortium of research institutes and software developers from Federal Agency for Agriculture and Food (Germany), which can be used for age calibration workshops and otolith exchanges as well as maturity staging. WebGR has the advantage that it can be used similar to Paint Shop Pro and GIMP, but instead of creating a layer for each reader in a specified file format, WebGR saves each reader's annotation of each image as a set of xy-coordinates that can be mapped on to that image, but the original image and the associated metadata remain unaltered.

The coordinator of an age calibration workshop uploads the selected images to the server and it stores the images and metadata grouped by species, date, area etc. All participants of that workshop annotate and assign an age to each individual image without having access to the work of the other participants. When all the images have been annotated and aged, the coordinator arranges access for the participants to all the annotations and aged images. The participants can then compare and discuss each other's annotations and ages to identify sources of disagreement.

The use of WebGR will make workshops and exchanges more efficient and economic. Furthermore, it can contain reference collections with agreed ages, which can be used by inexperienced readers as a self training tool, where they can access images and comparing their annotation of images with those of experts.

WebGR is also used for the classification of reproductive organs but has the potential for further development into new areas of scientific research such as egg and larvae identification.

WebGR has not been updated since 2010. The programme has been used for several workshops and exchanges in the past four years, and numerous issues have emerged and been commented on by the users.

The WKNARC2 questionnaire which was sent out to participants prior to the meeting aimed to enlighten these issues. The questionnaire pointed out that only 50% of the 46 people asked are familiar with WebGR and they primarily use it for reference collections, exchanges and workshops. The 23 people not familiar with the programme claim that, in order to use it at their institutes some features are needed. An online training session and easy access to make a new calibration workshop are much needed. Furthermore, the user manual is very detailed and difficult for many; it would be beneficial to have a simple "quick guide". Some institutes have already made their own user friendly guide.

WebGR is a free programme, and it is possible to install a version at a server at any institute. This installation is, however, rather difficult and, most often, has to be done by IT administrators.

Many issues making WebGR difficult for the user have been mentioned. The most important needs are explained by the majority of age readers as:

- a more user-friendly interface
- easier set-up of the programme
- easier batch-upload of images and metadata
- allowing more than one image per fish
- improvement of the user manual
- a calibration tool for measurements
- a tool permitting an improved statistical output

Furthermore, several age readers expressed the need for a specific tool that will enable focusing in a certain part of a large mosaic image as required for daily increment studies.

WebGR is at the moment hosted by AZTI (Spain), who provide necessary help on the use of the programme voluntarily and in their own free time. However, AZTI personnel have not been able to make improvements on the programme since 2010. As ICES is recommending the use of WebGR, there is a strong need for both development and improvement. From the questionnaire it was clear that there was a wish that ICES would provide partial financial support for this. Furthermore, WebGR would most likely be much more operational if it was hosted, maintained and updated by ICES, and online help provided by ICES.

4.1.2 The 'Guus Eltink' spreadsheet

This Excel workbook ("AGE COMPARISONS.XLS") was developed during the EFAN project for an easy and fast analysis of age reading results. It allows for an immediate reporting of the results after an exchange/workshop and the results from the analysis

on age reading comparisons are easy to understand for the age readers, who have to calibrate their age reading method based on these results. Furthermore, this tool for age reading analysis is flexible allowing for different types of reference collections, to compare to known age instead of modal age, etc. The spreadsheet performs a series of calculations based on the individual age estimations by each reader, which are recorded in the spreadsheet and returns tables for relative bias, CV's, percentage agreement (by reader, month, modal age) as well as an overall estimate for CV and percentage agreement. The spreadsheet also produces illustrative figures of age bias; CV, percentage of agreement and standard deviation plotted against modal age; the distribution of the age reading errors in percentage by modal age; the relative bias by modal age and the estimated mean length at age by age reader.

The questionnaire illustrated that for most species the Guus Eltink spreadsheet is a very important and useful tool. There are however, issues regarding a limited use for long lived species, such as grenadier and boarfish, where large differences in age estimation among readers are often encountered. In these cases the Guus Eltink spreadsheet would evaluate this variation with a level of accuracy higher than appropriate.

Some institutes have made their own versions of the spreadsheet or are using other programmes in order to get the same kind of results.

UK-England (CEFAS) has modified the spreadsheet. Their version of the Eltink spreadsheet is called ORACLE (Otolith Reading Age Comparisons Like Eltinks'). The changes involve:

- The look of the spreadsheet has been much improved
- Tables have been formatted so they all follow one after the other
- Additional statistics (e.g. APE) to be used in exchanges and removal of some that were never used
- Better protection of the sheet so it doesn't get corrupted
- Validation of data entry, so it's difficult to put incorrect data into the sheet

UK-Scotland (Marine Scotland Science Institute) is using the free software R (R Development Core Team 2007) to produce the results and figures. In using R Script analysis, the readers' ages are first recorded on a spreadsheet which is set up in a way that R can read it, and the format must be kept accurate. Duplicate copies are produced for each reader with one column separation. R analysis is run on the spreadsheet and produces several outputs which are sent to linked drives/sites, and graphs of age comparisons are stored on a spreadsheet where each reader is listed with their allocated representative colour.

4.1.3 The European Age Readers Forum EARF

The European Age Readers Forum (EARF) was established by PGCCDBS in 2009, in response to feedback received from those engaged in age reading across Europe. This web-based forum can be used as a resource for training, sharing and discussion of all aspects related to age reading (Standard Operational Procedures, age reading manuals, preparation methods etc). Its contents includes; contact details and a mailing list of age readers of fish species in the various European laboratories, calendar of upcoming exchanges and workshops, PGCCDBS meeting details, a link to the PGCCDBS documents repository (where all past exchange and workshop reports are stored), PGCCDBS guidelines and checklist for otolith exchanges and workshop, as well as some key reports of European Fish Ageing Network (EU FAIR-CT 96/1304,

1997-2000). EARF also contains a forum for discussion of any questions that may arise. It is possible to receive an email alert when a new post is made in a thread.

From the questionnaire it turned out that EARF is not used to its full potential and many don't find it very beneficial or have difficulties navigating through it. Especially the readers find it difficult. The results showed that only 73% (25 of 34) of the participants have heard of the EARF, and 74% (34 of 46) have never used it. Those using the EARF are using it to keep in touch with age readers and find contact information on age reader coordinators, updates on manuals for ageing and reports, coordinating exchanges and workshops and to ask questions pertinent to species.

In order to promote EARF and make it more useful and operational for all potential users (more user friendly and more widely known) it has been recommended during the WKCNARC2 to:

- Modernise the website interface, incorporating a better categorisation and view arrangement of the contents/folders, providing a space for discussion and image uploading. Furthermore, users' personal profiles with photographs could be created in order to facilitate their recognition.
- Make easier the access to age readers e-mail addresses and other contact info.
- Increase its publicity, by having a link in the ICES website and upgrading its appearance rank at searching tools (e.g. at the 1st page of Google) when information on fish ageing is requested.
- Post all information sent to readers attending a workshop or exchange on it, so that readers not attending can still receive information. Most information is usually only posted at the workshop's SharePoint, at which one needs to be granted access to view.
- Upload relevant reports from WK's and exchanges to EARF.

4.2 WebGR training session

One of the tasks of WKNARC2 was to investigate the acceptance and use of WebGR in the ICES community and at the same time make age reader coordinators more familiar with the different features included in this tool. With these intentions an entire day of WKNARC2 was dedicated to WebGR. Participants were firstly introduced to WebGR backgrounds, its concept, paradigm and administration. Moreover they were shown how to use this tool, upload pictures, set up a workshop and perform calibration exercises. The rest of the day was dedicated to a full training session, during which participants were paired and given images and metadata in Excel as well as the WebGR manual. Participants were thus asked to upload images and create their own workshops and calibration exercises in order for them to get a hands-on feeling with the programme.

The session was much appreciated and results showed that although WebGR is deemed to be an extremely valuable tool, the usability is not as straightforward as it should be. The feedback given by the users was afterwards included in the WebGR 2 study proposal.

4.2.1 Outcome of the training session

During WKNARC2 a hands-on exercise as workshop manager of WebGR was carried out. Outcomes from this exercise are summarized in Annex 5 and include recommendations for the improvement and the development of WebGR to meet needs for fish ageing and maturity staging exchanges and calibration exercises.

4.2.2 WebGR study proposal

The increasing use of WebGR in the ICES community highlighted the potential high value of this tool but on the other hand, the need for great improvements to facilitate a wider use. Based on this ascertainment, a first draft of a study proposal was drawn up by the PGCCDBS. This document was reviewed and partly formalized during the WKNARC 2 as feedback from the WebGR hands-on session were also included in it. However the proposal currently included as Annex 6 of this report, is not yet in its final version as economic details and appointed coordinator for the different work packages are still lacking. The study proposal will be completed inter-sessionally by a dedicated subgroup.

5 ToR d Review progress in the validation methods and to analyse questionnaires from Assessment WG's on the needs for validation studies

Age information is of fundamental importance because it forms the basis for calculations of growth and mortality rate and is a key input parameter in fish stock assessment models.

Inaccurate age determinations are widespread and negatively impact the accuracy of population dynamics studies and stock assessment outcomes. There are numerous cases in which ageing errors contributed to the overexploitation of a population or species (Campana, 2001). Underestimation of age results in overly optimistic estimates of growth and mortality rates. Overestimation of age results in underestimation of growth.

Validation studies aim at determining the absolute age of the fish. However, most often it is not the age of the fish itself that is confirmed but the frequency of formation of a typical growth increment that is validated. Methods used for age validation of calcified structures can be classified as:

- validating absolute age,
- validating (only) the periodicity of growth increment formation,
- corroborating (but not validating) an existing set of age estimates.

It is important to distinguish between validating the periodicity of growth increment formation and absolute age. "Validation of an absolute age is equivalent to determining the accuracy of an age estimate" and determining the frequency of formation of a growth increment for a sample of fish is a necessary step towards the verification of that age estimate, but it is insufficient (Campana, 2001).

The following validation methods exist (in descending order of scientific value) (Campana, 2001):

- Release of known-age and marked fish
- Bomb radiocarbon
- Mark-recapture of chemically-tagged fish
- Radiochemical dating
- Discrete length model sampled for age structures
- Natural date-specific markers
- Marginal increment analysis
- Captive rearing

The features, advantages and disadvantages of the above (and additional) methods used to confirm or support the accuracy of age interpretations can be found in Table 1 of Campana (2001).

The workshop on age validation studies of gadoids (WKAVSG), held a week before WKNARC2, reviewed and summarized the validation studies carried out on gadoid species and stocks in European waters and the validation methods used. It was agreed that, though costly, mark-recapture programmes provide the best source for robust age validation studies. Past mark-recapture programmes involved mainly European hake and Baltic cod and otoliths were archived in national laboratories. It was concluded that the application of recently adopted technologies (e.g. microchemistry, trace element analysis) on existing material could significantly advance the methodological capacities and capabilities of national laboratories to validate fish age. New findings from recently adopted technologies will also improve our understanding on the link between environmental conditions and physiological responses recorded in the otolith macrostructure.

5.1 A review of the results from the questionnaire relating to validation

The questionnaire results for validation methods show that validation is perceived to be important, but that time and money are major factors in preventing more work being done in this area.

WKNARC 2011 presented a list of validation methods that could most easily be applied. Some of these are recognised to provide the definition of seasonal zones, some confirm that zones are annual, and some others seek to validate the age of the fish. Validation methods include: marginal increment analysis, margin analysis, chemical marking (e.g. Oxytetracycline), mark-recapture schemes, captive rearing, back-calculations of length and length-frequency analysis. Other methods such as bomb radiocarbon and radiochemical dating are more difficult and expensive.

The first question in the questionnaire related to awareness of these methods and how they were presented in the WKNARC 2011 report. Over 90% of respondents were aware of these methods from the report. It is hoped that everyone has now read the report and is aware of the list.

The second question relating to validation asked if the institute had collected any known-age or agreed-age material suitable for validation studies. Less than 40% of respondents thought they had this type of material. However, this is perhaps an under-estimate. While known-age material is hard to come by, agreed-age material requires much lower criteria to be a valid sample. If two, but preferably more, readers can agree on an age for a particular specimen, this could be regarded as being "agreed-age". Such specimens could form part of a reference or training collection. It is probable that many institutes could have this kind of material available. Of those institutes that said they had such material, there was a combination of OTC marked recaptures, external tag recaptures and agreed age samples. Of these, the latter was not surprisingly the most common answer. Those institutes that said no validation samples were available said that time, money or a combination of both were the reasons for this.

The next question related to new validation work at particular institutes. Some 30% of respondents said there was new validation work being carried out at their institute. Some of this work is published or being published, while other work is still in progress or is not strong enough for peer-review yet. Again, at those institutes that

answered no new validation work was going on, time and money were the driving factors.

When asked if the institutes applied the available methods routinely in their ageing programmes, less than 30% said yes. This means that although new validation work is going on, it is not always being routinely applied and some existing validation methods are only used occasionally. Time and money once again are problems.

When asked how regularly validation is applied, only 13 respondents answered the question. The largest group (6 institutes), said annually, 5 institutes said monthly and 2 said some other period. There is no standardisation here. It could be that annual validation does actually capture monthly data, but is only done once per year. This is not clear from the responses.

The importance of validation was discussed in the next question. By ranking the importance from 1 to 5, with 5 being the most highly important, over 80% of the 46 respondents said it was important or very important to apply validation methods. This raises the question that if it is so important to validate age determination, why is money not being spent on it?

The final question asked if a CRR (Cooperative Research Report) type document would make the application of validation methodology easier within institutes. Unfortunately, it was not specified what CRR means. This meant that a number of respondents answered no. Despite this, over 70% of respondents thought a CRR document would be useful. We can speculate that this figure would have been substantially higher if all respondents had been aware of the terminology. Most positively responding institutes felt that it would be a benefit because of its ease of use (easier than looking through workshop reports etc) and the standardisation of methodologies.

5.2 Feedback from Working Group chairs on validation studies

All Assessment Working Group Chairs:

- Were supportive of getting a better grip on the perceived variance around the estimated age proportions for their particular stocks;
- Encouraged further effort put into the quality grading system and the translation into values applicable for a statistically based assessment model;
- Wanted to obtain outputs from workshops and the WKNARC2 into a more operational state.

The group that participated at WGHMM EWG expressed that they would be potentially interested in age validation and in the inclusion of ageing uncertainty in the assessment (e.g. megrim and sole in some areas). It was mentioned that for the megrims, PGCCDBS has already planned a large-scale age exchange for 2014. Coordinators of these stocks suggested waiting for the output of this workshop before engaging into further work on that issue.

5.3 Possible funding streams

According to one of the workshop ToR's, WKAVSG had prepared a call for tender to be directed to the EU that may allow national laboratories to advance the methods used to validate age estimations and, thus pave the way for progress and future developments in age validation studies.

5.4 Other future developments

Getting funds for age validation studies is challenging. Some ideas were collected during WKAVSG and WKNARC2. National institutes are asked to submit research proposals involving age validation studies to national science institutes or to contribute to bi-lateral or multi-lateral research proposals.

The fishing industry uses our common resource on a commercial basis. They are major beneficiaries of improved scientific advice. Therefore, the regional advisory committees (RAC's) and the managers of national fisheries could be approached to explore possible funding of age validation studies. One option is full funding of a validation study on a selected stock. Alternatively, the fishing industry could be approached in an attempt to fund additional components, once basic funding from other sources has been achieved. For example, additional data storage units or the rewards in a mark-recapture programme. Close co-operation and involvement of the fishing industry may also result in increased recapture rates of both tags and otoliths.

If age validation studies are really given highest priority, the EU commission may consider regularly setting aside resources for this task. The group is not informed about details of the budget procedures of DCF but two possible sources within DCF may be considered to fund selected age validation studies:

- Several age calibration workshops are carried out each year, which actually only focus on determining and improving the precision, but are unable to improve the accuracy of age estimates. Improving WebGR may facilitate and reduce the expenses of otolith exchanges in the future.
- Considerable amounts of money are not used by MS each year. The money not spent could be dedicated to selected age validation studies.

5.5 Determination of the need of age calibration workshops:

Finally, the group agreed that it is helpful to have a list (see Annex 7), where for each stock the need to have an age validation study and / or age calibration workshop is assigned to one of three categories:

- urgently needed (red light)
- needed, but not urgently (yellow light)
- no need (green light)

The list could be prepared by ICES and distributed to the chairs of the assessment working groups and finalized by ICES. This list could be provided to PGCCDBS and WKNARC, where appropriate.

5.6 Conclusions

Validation of age determination is a key to providing quality results that can be confidently used by stock assessment scientists in determining the status of stocks. It is therefore imperative that as much validation as possible is conducted. Since the first WKNARC meeting in 2011, there has been very little if any new validation techniques developed by participating countries. Some stocks have been validated using existing techniques.

Routine age validation is only attempted by a few institutes. Most ageing laboratories rely on exchanges and workshops to corroborate their ages. One-off validation (via papers or other directed research) is possibly more common, but not necessarily cap-

tured in the questionnaire. It is clear from the questionnaire that ageing material suitable for validation is being collected, but not used in such studies to any great degree.

Most of the institutes questioned said that time and/or money are the main factors behind the lack of attempted validation work. It is suspected that the lack of funding is the driving factor here, with limited money precluding the allocation of time. If this is an issue at the national level, then we should be looking at funding such studies at the international level. Obtaining funding through a call to tender from the EU could solve much of the issues surrounding the lack of validation studies and should be actively pursued.

6 ToR e Review progress in the Internal and External Quality Control into institutes

Most of the institutes were familiar with the final report of WKNARC 2011, use it and find it helpful in their work. Only few institutes didn't recognize this report and therefore do not use the information provided there.

The method used for internal quality control on age-estimation differs between institutes/countries. Most institutes reported progress in the standardization of procedures. Some institutes do yearly internal calibration exercises; other institutes might perform these more frequently, e.g. every 6 months or quarterly. This internal calibration exercise can be on a set % of the sampled otoliths or can encompass the regular use of a set number of otoliths from a control collection. Control collections can be made up of samples of known age either through direct or indirect validation; these control collections are obviously preferred. Alternatively a quality control collection can be made up of samples with a modal age (based on estimations from multiple readers from different institutes). In general, Age Estimation Quality Control Procedures in the strict sense are already in place in most of the institutes but many institutes reported no real changes to their QC-procedures since WKNARC 2011.

Within institutes the use of images and WebGR is growing. There has been an increase in the use of images in internal calibration exercises and/or routine age determination in some institutes, and the use of images and WebGR has also increased in ICES exchanges. Images make it easier to detect issues in age-reading as they allow age readers to identify their interpretations of specific annuli. International exchanges not initiated by the PGCCDBS have also taken place or even occur frequently. Many institutes that have the one age reader for a species aim to have more readers per species (at least two age readers per species).

Many institutes interpreted the questions in the questionnaire differently which made it difficult to compare the status of the different institutes in terms of both internal and external quality control. WKNARC2 proposes the institutes compose a summary of their Quality Control procedures (from sampling to estimated age) and post this on the EARF. This will allow the EARF members to gain knowledge of other procedures possible for quality control. This will hopefully be helpful in the development of quality control protocols. The next meeting of national age reader coordinators could review the quality control protocols, discuss and suggest improvements.

Image quality; PGCCDBS had made a note to the WKNARC2 asking for comments on how to standardize/Quality assure the image digitalization process:

PGCCDBS notes that: "Quality assurance/improvement of image digitalisation:

- *Compilation of image material for ageing exchange studies is often hampered by image quality. Image digitalisation should follow standardised routines in all laboratories. Of particular importance are: Colour (colour/grey tone), Light setting, Magnification, and Image file name. While the parameters colour, light setting and image name are relatively easy to standardise and quality easy to check, magnification often poses severe problems. As it is also difficult to reconstruct the possible source for false magnification settings, a simple procedure is proposed:*
    - *A standardised object is prepared*
        - *This object is to be of a fixed size, i.e. a plastic square of 1x1 mm. This object is glued onto a microscope slide*
    - *A standardised object is distributed to all participating laboratories*
    - *Together with the specifications of requirements for otolith images, an image of the standardised object is distributed to the participants*
    - *Before digitising otolith images, each participant takes an image of the standardised object. This object image is also sent to the coordinator"*

Images for exchanges should be as good as possible and always need to be made in accordance with guidelines given by an age reader. Calibrations of pictures are obligatory. When acquiring the pictures it is possible to carry out a pre-treatment (increase the contrast, light, reduction of noise, detection of edges…). However, these settings really depend on the equipment used (microscope settings, image software, camera, ect.), the preparation procedure used e.g. thickness of the slides, use of staining, etc. which differ between species and institutes. When using WebGR the format is limited to "jpg, png, gif" and the image size should not be too large. Image size of around 2kb is recommended. The added value of using a standardized object for improvement of quality of routine ageing is not widely recognized, but using it could prevent errors caused by the reader being unaware of differences in image magnification.

It is recommended that institutes include microscope, image software settings and procedures for controlling these in the standard operating procedure. Thus preventing errors and enhancing image quality.

6.1 Advice as how to facilitate smooth and easy Quality Control (internal and external)

6.1.1 Internal QC (within an institute)

The age reading labs should be informed of possible systems for QC, i.e. experiences should be communicated. QC is of most importance in relation to the use of ages in stock assessments and their need for the integration of ageing errors in the assessments. The procedures for internal QC are dependent on the methods used and the number of age readers, and should not be standardized. However, the outcome should be standardized between institutes in such a way that they can be aggregated for use in assessments.

6.1.2 External QC (between institutes/countries)

Each country/institute should be given the freedom to use the preparation/age reading methods they prefer, as long as the results can be compared and can be aggregated into calculations/assessments.

Discussion on the frequency of ICES-exchanges

> *PGCCDBS (2010) recommends a three-stage process. (This process is illustrated in a schematic figure still under construction.) A* ***small scale exchange*** *should take place to ascertain if the precision of the age readers providing data for stock assessment is acceptable for a species or stock.* ***If the small-scale exchange*** *reveals reading problems that need to be addressed,* ***then a full scale exchange*** *must be carried out. In case the full scale exchange confirms the existence of age estimation problems a workshop needs to be set up. Workshops should be organized in accordance with the PGCCDBS Guidelines for Workshops on Age Calibration. The* ***frequency of exchanges*** *and workshops mainly* ***depends on the quality of the age determination*** *and will be revised by national age reading coordinators and by expert groups. Even if no age reading issues were revealed in workshops or exchanges, quality assurance requires the organization of* ***an exchange at least once every 3-5 years****. The possibility for a workshop should be offered every 5 years.*

In reality however, exchanges are not organized every 3-5 years for all stocks. Although for some stocks (more difficult to age/interpret) it might be better to organize small scale exchanges more frequently. These could even consist of a small set of images (e.g. 50). Regular small scale exchanges can detect quality issues/age reading problems in case these exist. These issues can then be clarified in a larger scale exchange. The use of a small set of images in WebGR is not too time-consuming. Institutes that regularly take images or institutes that have reference collections could provide images more easily in order to limit the use of time even more.

The newly proposed WGBIOP would be a better place than the PGCCDBS to evaluate exchanges and workshops and to provide better suggestions for exchanges/workshops to the PGCCDBS.

6.1.3 Application of the 3point grading system

WKNARC 2011 recommended a 3 point grading system to be implemented across all National laboratories performing age reading:

> *AQ1: Easy to age with high precision.*
>
> *If a scale of 1-100 is applied, where 100 is when the reader has the highest possible confidence in the age reading and 1 is when the reader has no confidence in the age reading, age quality 1 (AQ1), will apply to approximately the top 25 % of the possible quality ratings. AQ1 is an indication that the age data is considered reliable for stock assessment.*
>
> *AQ2: Difficult to age with acceptable precision.*
>
> *Age quality 2 (AQ2), will apply approximately to age readings within 25 and 75 percentiles of the possible quality ratings. AQ2 is an indication that the age data is sufficiently reliable to be used for stock assessment purposes but improvement is required.*
>
> *AQ3: Unreadable or very difficult to age with acceptable precision.*
>
> *Age quality 3 (AQ3), will apply to approximately the lowest 25 % of the possible quality ratings. 3 AQ3 is an indication that there are serious concerns about the reliability of the age data and/or its value to stock assessment WGs.*

This 3pt grading system is being used in eleven of the 27 institutes that answered the questionnaire. Only in two institutes, the scientists working with stock assessment are using the system. In most of the other institutes, the stock assessment scientists

are aware of the grading system, but don't use it for modelling. Other grading systems (e.g. 4pt.) are also in use and +3point grading systems might make more sense for some stocks.

A readability score is interesting for quality control, for example, when in an exchange (internal or external) most age readers grade an otolith as easy to read, but one age reader grades this otolith as very difficult. The latter might have read a wrong otolith or an issue might exist. Another example is where different age readers grade an otolith as easy to read, but have different ages for this otolith. When age estimations are graded frequently as "very difficult" it is likely an issue exists. This could be in terms of preparation method (incorrect pH of staining solution, incorrect staining period, microscope issue, ect.) or due to a specific age reader who might need training. A readability score is thus very useful for internal quality control; however, caution should be paid in relation to using a readability score as a quantitative measure of ageing error (see also ToR h).

7 ToR f Review the available protocols for a CRR (with reference to the PGCCDBS 2012)

PGCCDBS 2012 was approached by the ICES Publications Committee with a suggestion of combining the existing protocols on the ageing of fish species within the ICES area, and publishing them as an ICES Cooperative Research Report (CRR). This idea was positively received by PGCCDBS and during the PGCCDBS meeting in 2013 it was decided to forward the drafting of the CRR to WKNARC2.

The proposed CRR will represent a collation of the state-of-the-art scientific work on the methods and validated age estimation of commercially exploited fish species across Europe. Improving precision in age reading is extremely important for many species and the information included in existing protocols should be more widely available. The CRR will provide a comprehensive manual on the methodology of age reading and validation. Given the wide span of validated methods already existing within the ICES community, the collation of these protocols would provide a useful resource to the ICES community. Having a collation of all hitherto validated and effectuated methodologies is intended to facilitate a fast and quality assured development of a method suitable for a new species given the power of example.

Prior to WKNARC2 all age reader coordinators were asked whether a CRR document would pave the way for an application of validation methodology in their respective institutes. More than 70% felt that they would greatly benefit from having such a document, primarily as it would facilitate a more streamlined quality assurance of any age readings done given the availability of a peer-reviewed methodology. Additionally, the CRR would be useful when training new readers and/or handling new species in terms of age estimations.

WKNARC2 endorsed the suggested structure of the CRR on methodologies of age reading and validation suggested by the PGCCDBS in 2013. The group discussed the suggested contents of the individual chapters and specified the outline following an extensive review of available material for the CRR. The work plan and chapter outline for the CRR can be found in section 7.1 and 7.2 respectively.

The review table of all available material on a) peer-reviewed validated methods, b) workshop agreed methods and c) National protocols, sorted by species group can be found below. For each species, identified by its family and its Latin name, the year of the last workshop (or exchange, if there was no workshop) and used ageing method

in this workshop were identified. The validation studies were classified according to Campana (2001) and the report of WKAVSG 2013 (Workshop on Age Validation Studies of Gadoids). The methods are explained in the WKAVSG Report 2013 according to whether they are indirect and direct validation methods. Each publication was identified by number reprenting ICES and FAO GSA areas of the study. This table presents an updated synthesis of validation studies from the WKNARC 2011. This extensive review will form the basis for the individual CRR chapters for each species group and the appointed chapter editors will be informed of this material. The accompanying full list of references, sorted by method, can be found in the Reference list in section 10.

After the development of a European Fish Aging Network with two Concerted Actions, i.e. EFAN (European Fish Ageing Network) and TACADAR (Towards Accreditation and Certification of Age Determination of Aquatic Resources) from 1997 to 2006, a lot of exchanges and workshops were organised in order to standardize the ageing process from the sampling to the ageing data used during the assessment groups. During these meetings, the calcified pieces (otoliths, scales, illicia...) and the preparation methods of ageing were discussed and compared. However, there exist a lot of bias in the age determination. Validation studies should give rise to better accuracy and precision. A review of 372 papers was published in 2001 (Campana, S.E. 2001). Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods, Journal of Fish Biology, 59: 197-242). The WKNARC (2011 and 2013) try to update the new studies, in particular for the species in the ICES and FAO GSA areas. The following table compiles by species the methods used during the ageing workshops and the validation studies using the same classification defined by Campana (2001).

Table 7. 1 Review of all available material on a) peer-reviewed validated methods, b) workshop agreed methods and c) National protocols

Family	Species	Ageing Workshop	Used Ageing method	Released marked fish	Mark recapture chemical tagged fish	Captive rearing from batch	Microstructure	Mean length Analysis	Marginal increment analysis	Radiochemical dating	Bomb radiocarbon
Anguillidae	European eel (*Anguilla anguilla*)	2011	Polished & stained otolith				37.1.3, 37.2.2 (Capoccioni et al., 2010)				
Anguillidae	European eel (*Anguilla rostrata*)	2011	Polished & stained otolith								
Caproidae	Boarfish (*Capros aper*)						27.6; 27.7j, 27.h (Hussy et al., 2011)		27.6; 27.7j, 27.h (Hussy et al., 2011)		
Clupeidae	European Atlantic Sardine (*Sardina pilchardus*)	2011	Whole otolith				27.8c (Alemany & Álvarez, 1994 ; Álvarez, 2002) ; 27.2.1, 27.2.2 (Dulcic, 1997), 27.9a (Ré, 1984) ; 37.2.1 (Panfili et al., 2010)	37.1.1 (Pertierra & Morales-Nin, 1989)			
Clupeidae	Atlantic herring (*Clupea harengus*)	2005	Whole otolith								NAFO area (Melvin & Campana, 2010)
Engraulidae	European Anchovy (*Engraulis encrasicolus*)	2009	Whole otolith				27.2.1, 27.2.2 (Dulcic, 1997) ; 27.8, 27.9, 37.1.1 ; 37.1.2, 37.1.3 (Hernandez et al., 2009) ; 37.2.1 (La Mesa et al., 2009), 37.2.1 (Panfili et al., 2010)	27.9 (Bellido et al., 2000)			

Gadidae	Cod (*Gadus morhua*)	2008	Thin section of otolith	27.3 (Hussy et al., 2009)	27.3 (Rehberg et al.,2012) ; 27.3 (Hussy, 2010 ; Hussy et al., 2010) ; 27.4 (Pilling et al., 2007)	27.4 (Pilling et al., 2007)
Gadidae	Whiting (*Merlangius merlangus*)	2005	Thin section of otolith		27.3 (Ross & Hussy, 2013)	27.3 (Ross & Hussy, 2013)
Gadidae	Saithe (*Pollachius virens*)	2008 (exchange)	Sectioning and breaking otolith			
Gadidae	Blue Whiting	2005				
Lophiidae	Monkfish (*Lophius piscatorius*)	2004	Sectioning illicia and otolith	27.7b-k, 27.8, 27.9a (Landa et al., 2008)		
Lophiidae	Black anglerfish (*Lophius budegassa*)	2004	Sectioning illicia and otolith		37.2.1 (La Mesa et al., 2008)	
Macrouridae	Roundnose grenadier (*Coryphaenoides rupestris*)	2007	Thin section of otolith			27.6 (Gordon & Swan, 1996 ; Swan & Gordon, 2001)

7.1 The following work plan for the CRR was outlined at the meeting:

- May 2013: WKAVSG: Age Validation Studies for Gadoids
  - Responsible for the Chapter on Gadoids. The chairs of WKAVSG (Karin Hüssy and Beatriz Morales-Nin) will be the editors of this chapter
- May 2013: WKNARC2: National Age Reading Coordinators meeting
  - Nomination of Chapter editors
  - Location and distribution of all available material starting with what was collated during WKNARC1 (ToR f)
  - Agreeing on headers for the introduction ('topic sentences')
  - Chapter 11 and 12 started
  - Chapter 8 a) literature overview (ToR h)
- October 2013: DEADLINE for draft versions of Chapter 1 – 7 and 10 – 12
- May 2014: WKSABCAL: Statistical Analysis of Biological Calibration Studies
  - Making the uncertainty of age estimations operational for all
  - Recommendations from WBSABCAL
- June 2014: DEADLINE for Chapter 1 – 7 and 10 – 12
- September 2014: DEADLINE for Chapter 8 on statistics
- October 20th – 24th 2014: 5th International Otolith Symposium
  - Poster/Presentation of the CRR
- December 2014: Submission of the CRR

7.2 WKNARC2 produced an outline of Chapter 1 (Introduction) and appointed the following chapter editors:

- Chapter 1 (Introduction): Lotte Worsøe Clausen, Francesca Vitale and Grainne Ni Chonchuir
- Chapter 2 (Gadoids): Beatriz Morales-Nin and Karin Hüssy (chairs of WKAVSG 2013)
- Chapter 3 (Flatfish): Mark Etherton, Sally Songer
- Chapter 4 (Widely Migrating Species): Suggested to approach George Tserpes (Greece) as well as RCM Med and RCM North Atlantic
- Chapter 5 (Small Pelagic Fish): Begoña Villamor, Coispa and Stelios Somarakis
- Chapter 6 (Deep Sea Fish; including demersal fish not described in Chapters 2 & 3): Suggested to approach Ole Thomas Albert
- Chapter 7 (Statistical handling of uncertainty in age estimations): Ernesto Jardim and Lotte Worsøe Clausen (chairs of WKSABCAL 2014)

All appointed editors will be officially approached by WKNARC2 and PGCCDBS for acceptance of the task.

Chapter 1 (Introduction) was decided to hold the following main points:

- Why age fish? And how (calcified structures, refer to Panfilli, 2002)
- History of QA and QC
- Quality check and assurance, … EFAN, TACADAR, WGNARC
- Acreditation possibilities (pros/cons)
- Benefits of agreed (validated?) manuals
- Standardisation of procedures
- Reference to tools available for QA/QC
- Concept of accuracy/precision

- Reasoning behind this CRR
- Set-up (structure of chapters, etc.)
- Contributors

Chapter 8 was included in the tasks of the subgroup dealing with ToR h. Review the means of dealing with uncertainty in relation to age data in assessments (e.g. in assessments performed in the Pacific, etc.) as a pre-task for the WKSABCAL and can be found in Section 9.

8 ToR g Report on the implementation of central labs for processing age reading; under this, review the success of existing bilateral agreements and the prospects for task-sharing

During WKNARC 2011, the general agreement was that some labs could send otoliths or other calcified structures on a voluntary basis to some regional centres that are experienced, capable, and willing to perform the age reading. The reasons for sending could be calibration, exchange, training or an extremely low number of specimens caught per year (low importance for the lab). The reasons for receiving calcified structures could be exchange, inter-calibration, training, stock assessment, intensive study of species, publications and/or economic issues.

In this context, particular attention should be paid on the species recently included in the DCF list, such as elasmobranchs.

The PGCCDBS 2012 report stated the importance to"recognize the increasing need for regional cooperation and task sharing to provide quality assured data on age compositions and life-history parameters (growth, maturity, fecundity) for a growing number of species and stocks to be included in single and multispecies management advice." Moreover the revised DCF will need to support the additional work in identifying and agreeing upon task sharing (TS) through; review of scientific and technical expertise, equipment and financial capacity of institutes to ensure the functionality of TS.

The WKNARC2 recognizes the risks in concentrating the expertise on individual fish species amongst fewer people and laboratories (Central Laboratories). In agreement with the PGCCDBS 2012 advice, WKNARC2 recognises TS as an important tool to improve the age data quality and the knowledge about age study (age determination, validation etc.). Considering the future discard ban and regionalisation, both the number of fish and the number of new species requiring ageing will increase (i.e. white anglerfish, hake, cod). There will therefore be a need for more collaborative studies to standardize age reading and the development of cooperation between national institutes on a regular basis would be an essential tool for improvement of age data quality.

Regarding some species (i.e. elasmobranches and Boarfish) few labs (i.e. CNR - Italy, IFREMER – France, DTU AQUA - Denmark) have enough knowledge to age them and so in this context these institutes could be reference labs for training/ageing.

In order to develop the respective cooperation and coordination between national institutes a letter was sent to RCM chairs requesting information on existing bilateral agreements. Unfortunately the WKNARC2 did not receive any such information.

The WKNARC2 considered the following points as a good basis to organize TS:

- The TS should be organised by the National Ageing Coordinator.

- The sharing should be organised at Regional level: sub-regions Atlantic, Mediterranean and Black Sea.
- The exchange should include not only the hard structure but also readers (the mutual exchange of readers among NI's may promote standardization of methodologies, knowledge sharing and the improvement of the age data quality);
- The revision of DCF (2014-2020) could identify the financial support for the exchanges of hard structures/readers;
- Identification of some key species with high priority for collaborative study and sharing activity.

The TS participants could come from each Regional Unit (sub-regions Atlantic, Mediterranean and Black Sea). A list has been provided (Annex 8) to facilitate the composition of the TS groups, showing the contact person receiving/sending calcified structures/readers by species. The results of the list will be presented in the next RCM meetings: Baltic RCM, 26 - 30 August, in Talinn, Estonia, Chaired by Jørgen Dalskov; Mediterranean and Black Sea RCM, 2 - 6 September, in Constanca, Romania, Chaired by Constantin Stoie; Long Distance RCM, 2 - 6 September, in Constanca, Romania, Chaired by Ireneusz Wójcik; North Sea and Eastern Arctic RCM, 9 - 13 September, in Vigo, Spain, Chaired by Frans van Beek; North Atlantic RCM, 16 - 20 September, in Sukarieta, Spain, Chaired by Kelle Moreau.

Moreover this list will be hosted and updated on the EARF web site.

Already existing agreements between the national labs are summarized below:

- Agreement between ILVO (Belgium) and CEFAS (UK) involved 4 readers. The ILVO received hake otoliths (500-750), turbot otoliths (165) and brill otoliths (173). CEFAS receive cod otoliths (750). Both ILVO and CEFAS labs are accredited, so results comply with quality standards expected by accrediting bodies. The benefits for both labs are mostly in term of sharing of expertise/quality control. Turbot and brill are species ILVO would like to keep their expertise on in term of receive more samples.
- Agreement between ILVO (Belgium) and DTU Aqua (Denmark) involved 2 readers. The ILVO received turbot (629 otoliths) and brill (1016 otoliths). Turbot and brill are species ILVO would like to keep their expertise on in term of receive more samples.
- Agreement between IMARES (Netherland) and IFREMER (France) involved 2 readers. The IFREMER receive red mullet (100) and stripped mullet (200) otoliths. IMARES don't have experience with these species (small size samples), therefore they prefer not to invest in age-reading training .This agreement between IMARES and IFREMER is standing since 2011.
- Agreement between IMARES (Netherland) and CEFAS (UK) involved 1 reader. The CEFAS receive European sea bass, *Dicentrarchus labrax* otoliths. IMARES don't have experience with this species (small size samples) therefore they prefer not to invest in age-reading training. Age reading of Dutch sea bass samples by CEFAS is based on a bilateral agreement between UK and The Netherlands since 2011.
- Agreement between Finnish Game and Fisheries Research Institute (Finland) and DTU Aqua (Denmark) involved 1 reader. The Finnish Institute aged the salmon scales (about 600 specimens) from Danish samples.
- Agreement between DTU Aqua (Denmark), Finnish Game and Fisheries Research Institute (Finland) and SLU Aqua (Sweden). It has been agreed that

sprat otoliths from the survey in the Bothnian Sea (SD 30 in the Baltic Sea) will be aged in Denmark and there are 700-1150 specimens per year. Moreover herring otoliths from the Bothnian Sea survey have been aged by Finland and Sweden (roughly 1000 specimens).

- Bilateral agreement between the DTU Aqua, Denmark and SLU Aqua, Sweden for the age reading of a list of species collected during the ICES International Bottom Trawl Survey (IBTS). Sweden Institute sends the collected otoliths to Denmark of the following species: Norway Pout (*Trisopterus esmarki*) approximately 200-300 individuals per year, one reader is involved; Sole (*Solea solea*) approximately 50-100 individuals per year, one reader is involved; Whiting (*Merlangius merlangus*). Approximately 1000 individuals per year, one reader is involved. Moreover Denmark Institute sends the collected otoliths to Sweden of the following species: Witch flounder (*Glyptocephalus cynoglossus*), approximately 50-100 individuals per year, two readers are involved.
- Bilateral agreement exists between SLU Aqua (Sweden) and Marine Scotland Science Institute (MSS-Scotland). Scotland sends the collected otoliths to Sweden of the Witch flounder (*Glyptocephalus cynoglossus*). Approximately 50-100 individuals per year and two readers are involved.
- Agreement between IEO (CO Santander, Spain) and IPIMAR (Lisbon laboratory, Portugal), involved 4 readers: 2 from IEO and 2 from IPIMAR. The species involved in the exchange were both European anglerfish (*Lophius piscatorius* and *L. budegassa*) of the Iberian Atlantic stock (ICES Div. VIIIc-IXa). Around 500-800 illicia of each species were annually exchanged between both institutes. Over the last 10 years, all the illicia of the Iberian Atlantic stock of *L. piscatorius* were sent and aged by two readers from IEO, and all the samples of *L. budegassa* of that stock were sent and aged by two readers from IPIMAR. The readers of each institute aged all samples of each species, reducing the between-reader variability in the age estimates, and consequently improving their precision. This exchange was stopped because the traditional age estimation criteria for both species was tested that it was biased (Azevedo et al., 2008). When both species are to be routinely aged again, the exchange of illicia and readings between these institutes (or any others) could also be restored.

An existing unilateral agreement between DTU AQUA and MI Ireland could be used as an example of TS where Boarfish, *Capros aper* otoliths were sent to DTU AQUA to be aged by the only expert reader. These otoliths were used for both age and growth verification studies and provision of ALK's and catch at age data for preliminary assessment. An Age Training exercise has recently taken place at the MI Ireland and will continue via image exchange.

The above agreements testify the important role that TS will hold in developing the exchange of calcified structures\readers. The presence of such voluntary agreements between the labs is evidence of the importance in helping and organizing this activity on regular basis. The main role of TS will be to spread the information to different national labs and also manage the relationship between National Institutes (NI's), RCM's, PGCCDBS etc.

WKNARC2 proposed Pierluigi Carbonara, Lise Heggebakken and Barbara Grabowska as responsible for receiving and sending the information regarding the TS from the NI's to the RCM members.

8.1 Summary

The WKNARC2 recognizes the risks in concentrating the expertise on individual fish species amongst fewer people and laboratories (Central Laboratories). In agreement with the PGCCDBS 2012 advice, it recognises TS as an important tool to improve the age data quality and the knowledge about the age study (age determination, validation etc.).

Already existing agreements between the national labs testify the importance to helping and organizing this activity on regular basis. The TS participants could come from each Regional Unit (sub-regions Atlantic, Mediterranean and Black Sea). A list is provided by species to facilitate the establishment of TS and the results of the list will be presented in the next RCM meetings. Moreover this list and the update will be hosted on EARF web site.

9 ToR h Review the means of dealing with uncertainty in relation to age data in assessments (e.g. in assessments performed in the Pacific, etc.) as a pre-task for the WKSABCAL

Age determination requires a subjective assessment of whether growth checks in calcified structures should be interpreted as annual rings. Consequently, age reading errors (in accuracy and precision) are inevitable. To quantify between-reader variation of independent reads of the same otolith, a number of statistics have been applied, including average percent error (APE, Beamish & Fournier, 1981) and coefficient of variation (CV, Chang, 1982). Age reading precision and accuracy have also been examined by comparing independent reads with modal age across readers (precision), or true age (accuracy) if known age material is available (e.g. the "Guus Eltink spreadsheet"). These are useful tools for a general understanding of the uncertainty in age determinations for a stock or for an age reader. However, these estimates are not suitable for incorporation of age reading uncertainty in stock assessments.

Within the ICES community, age reading error is generally not included in stock assessments, but world-wide, fisheries scientist have addressed this issue. Publications are available on how to quantify age reading error for use in stock assessments, and the effect of age reading error on the results of stock assessments. As a pre-task for WKSABCAL (planned for May 2014), we carried out a literature search focussing on means of including age reading error in assessments. We present a literature overview including a brief description of the general approach, the age data used and the statistical methods applied, to enable a first comparison of the different approaches.

9.1 Stock assessment models

A deterministic assessment model can be used to examine different scenarios reflecting the variation in age determinations. A stochastic assessment model is required to enable inclusion of age reading error estimates. Several stock assessment models enable input of an ageing error matrix (e.g. statistical catch-at-age analysis, stock synthesis, CASAL, Coleraine), but none of these packages include the facility to estimate ageing error matrices.

A recent report (ICES, 2012) presents a classification of the various stock assessment methods. Although this classification is not primarily based on the error functionali-

ties of the different assessment models, it does provides a useful overview within the current context.

9.2 Age reading errors and stock assessment

Different approaches have been taken to account for age reading error in stock assessments. Several studies compare stock assessment results based on different age scenarios. These scenarios can reflect inter-reader variability or differences between observed and true ages. They can be calculated based on alternative ALK's, CAA's or growth models.

Most of the recent studies addressing this issue quantify an ageing error matrix (AEM) to use in the stock assessment model. The elements of the AEM are the probabilities that a sampled fish of true age class a is assigned to one of the observed age classes. Although the basic concept is the same, the approaches taken to estimate the probabilities differ. Firstly, the statistical models differ, both in functional forms and distributional assumptions. Secondly, what is taken to be "true age" is usually not really the true age. Examples include simulated true age, known age (based on mark-recapture studies), nearest integer to mean age across readers, modal age, otolith age (with observed age based on other CS), or one preparation method (with observed age based on other preparation methods).

One study (Candy et al. 2012) includes a readability score as a factor in their statistical model to estimate the probabilities of the AEM. This is of particular interest with regard to the 3pt grading system recommended by PGCCDBS and WKNARC 2011.

An overview of the literature examined during this WK is presented in Annex 9. This overview presents, for each reference, a brief description of the applied methodology to examine age reading uncertainty in relation to stock assessment. The full references can be found in the Reference list in Section 10.

9.3 Considerations

This literature review was limited to age reading error as this is relevant within the context of WKNARC2. However, during WKSABCAL it might be necessary to address age sampling (sample size and stratification), in conjunction with ageing-error. Wilhelm et al. (2008) argue that most reading effort should be directed at age groups more abundant in the fishery (mainly to improve the cost-effectiveness of age sampling). Whereas, Richards et al. (1992) caution that, as ageing error increases, sample sizes must also be increased to obtain a specified level of precision. However, the results by Coggins & Quinn (1998) suggest that attempting to mitigate imprecision resulting from poor reader performance by increasing sample size is not an effective tactic.

From an age readers point of view it is pointed out that ageing errors may differ between seasons, related to the spawning period and the onset of a new annulus. This should be taken into consideration when quantifying an AEM.

Readability score, such as the 3pt grading system recommended by PGCCDBS and WKNARC or the 5 class system used in Australia, is a (subjective) variable. It is not a probability or error estimate and therefore not directly applicable in a stochastic assessment model. We caution not to use readability score as a selection criterion for age data included in the stock assessment, because this may cause bias as readability score can be correlated with age (Candy et al. 2012) and it is expected to be correlated with growth rate. Candy et al. (2012) included readability score in their statistical

model to estimate the probabilities for an AEM. This approach requires the selection of a readability score to produce the predicted probabilities for the AEM to be used in the assessment model. We have two concerns about this approach and we suggest that WKSABCAL take these concerns into consideration. Firstly, age and readability score are both included in the statistical model, but the results suggest collinearity between these 2 variables. Secondly, the selection of a readability score to produce an AEM for the assessment model implies that the AEM is not representative of the observed (variability in) readability scores.

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ToR b)

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ToR f)

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12 Annex's:

Annex 1: List of participants

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Annex 2: Agenda

Monday 13th		
14:00 – 14:30	**Introduction and welcome**	*Chairpersons*
14:30 – 15:15	**Presentation of ToR's and subgroups aims revisited**	*Chairpersons*
15:15 – 15:45	**Any other business which participants feel should be discussed at WKNARC2**	*Plenary session*
15:45 – 16:00	**Agreeing on agenda**	*Plenary session*
16:00 – 16:15	**Break**	
16:15 – 16:45	**EARF presentation**	*Chairpersons*
16:45 – 18:00	**Subgroup presentations of results with respect to ToR's**	*Subgroup chairs*
Tuesday 14th		
09:00 – 11:00	**Work in subgroups on respective tasks**	*Subgroups*
11:00 – 11:15	**Break**	
11:15 – 13:00	**Work in subgroups on respective tasks**	*Subgroups*
13:00 – 14:00	**Lunch**	
14:00 – 16:00	**Work in subgroups on respective tasks**	*Subgroups*
16:00 – 16:15	**Break**	
16:15 – 18:00	**Status update from each subgroup**	*Plenary session*
Wednesday 15th		
09:00 – 10:00	**WebGR presentation and set up**	*Francesca Vitale/Jane Godiksen*
10:00 – 11:00	**Hands on time with WebGR**	*Plenary session*
11:00 – 11:15	**Break**	
11:15 – 13:00	**Hands on time with WebGR**	*Plenary session*
13:00 – 14:00	**Lunch**	
14:00 – 15:00	**Hands on time with WebGR and Feedback**	*Plenary session*
15:00 – 16:00	**WebGR study proposal**	
16:00 – 16:15	**Break**	
16:15 – 18:00	**WebGR study proposal**	
Thursday 16th		
09:00 – 11:00	**Work in subgroups on respective tasks**	*Subgroups*
11:00 – 11:15	**Break**	
11:15 – 13:00	**Work in subgroups to finalize drafts**	*Subgroups*
13:00 – 14:00	**Lunch**	
14:00 – 16:00	**CRR session**	*Plenary session*
16:00 – 16:15	**Break**	
16:15 – 18:00	**CRR session**	*Plenary session*
Friday 17th		
09:00 – 11:00	**Cleaning up, continue finalizing report and CRR chapters**	*Plenary session*
11:00 – 11:15	**Break**	
11:15 – 12:00	**Cleaning up, continue finalizing report and CRR chapters**	*Plenary session*
12:00 – 13:00	**Recommendations**	*Plenary session*

Annex 3: WGBIOP resolutions and terms of reference for the next (first) meeting

Proposal for a new Expert Group (WGBIOP)

WKNARC strongly **recommends** that ICES creates an expert group (Working Group on Biological Parameters - WGBIOP) which will, foremost, continue the work started by WKNARC 1 and 2. The group will also take over the responsibilities of PGCCDBS (Planning Group on Commercial Catches, Discards and Biological Sampling) on co-ordination of a practical implementation of quality assured and statistically sound development of methods, standards and guidelines for the provision of accurate biological parameters for stock assessment purposes.

The reasons behind the need for such an expert group are as follows:

- The series of WKNARC's are coming to an end in 2013. They have defined and drafted guidelines on "best practice", achieved international consensus and built the foundations for a more standard approach to quality assured collation of biological parameters in terms of age determinations. WKNARC provided the forum for national age reader coordinators to compare and learn from each other contributing to a more common approach to collation, estimation and quality assuring of biological parameters for stock assessment. The group was able to concentrate in detail on all practical aspects for designing and carrying out quality assurance and control of age determinations across all species. Hitherto PGCCDBS has been the forum for planning and reviewing the outcomes of workshops, study groups, exchange schemes and other intersessional work related to interpretation and quality assurance of data on stock-related biological variables (age and growth; maturity and fecundity; sex ratio). However, the biological parameters have been but a small part of the PGCCDBS and an ICES Expert Group that continues with the work carried out by both the specialised WKNARC and the more broad PGCCDBS will improve the allocation of efforts targeting highly warranted improvements of available biological parameters for stock assessment. Thus, the creation of a dedicate Expert group will give the possibility to broaden and deepen this crucial area of expertise. The focus of such a group will be not only on technical aspects of data collection and quality assurance but also on accuracy in life history parameter estimations to support stock assessment. Hence WGBIOP will review stock specific life history parameters and monitor potential changes in biological processes, such as growth rate, onset of maturity, maturity and fecundity at size/age, and related causal factors.
- The issues around collating precise and accurate biological parameters and provision of these to end users are complex and changing. The effect of new management measures, for example the discard bans, may affect the need for, and quality of the necessary biological parameters. Furthermore, there is greater flexibility in the new EU multi-annual data collection programme (DC-MAP) to accommodate end-user-driven changes to biological data collection requirements. National programmes will have to adapt to changing data needs, whilst upholding the high demands of quality, precision and accuracy of the collated biological data outlined by WKNARC and PGCCDBS. Such a dedicated Expert group will therefore be prone to provide a more rapid and efficient handling of the consequent increasing demands for new bio-

logical parameters and new number of species included in EC-ICES Memorandum of Understanding (MoU).

- Age and maturity data are fundamental parts of the stock assessment process and a great deal of effort is put into ensuring high quality data. With the changes towards ecosystem assessments, the demands for state-of-the-art analysis and provision of biological parameters are increasing, and the extent of communication between data collectors and end users will require ongoing attention. These drivers all imply the need for a frequent process for providing expert advice on biological parameter provision for stock assessment and advisory process. This is more efficiently carried out through the continuity of a dedicated expert group than by workshops or study groups of limited life span, or during the restricted time available each year in a subgroup of PGCCDBS.
- Calibration workshops dealing with age and maturity estimation are funded and held under the auspices of the PGCCDBS, however given the recent increase in ToR's and agenda points for the PGCCDBS, time and effort allocated to review the outcomes of these workshops and evaluate the needs for further action has diminished within the remits of PGCCDBS. The main objectives of these important workshops are to decrease bias and improve the precision of age/maturity determinations among scientists from different laboratories. Moving beyond precision is increasingly common in calibration workshops and creating outputs better tailored to input for stock assessment models would greatly improve the application of the results. WKBIOP will be able to fully appreciate the outcomes of these WK's and also more efficiently evaluate necessary follow-up actions.
- Creating a single working group dealing with issues related to biological parameters will provide a strong interaction between members of both PGCCDBS and PGMed, the Mediterranean Planning Group for Methodological Development. Those two groups meet synchronously every year working in parallel although often on the same issues but related to different areas. Common issues and outcomes are successively reviewed in plenary. Merging PGMed and PGCCDBS subgroups dealing with biological parameters will be highly beneficial and hence increased homogeneity in planning and enhanced standardization of methods are expected to occur.
- The number of experts in this field is limited, and issues are further complicated by pressure on resources. Consolidating the responsibilities of WKNARC and the PGCCDBS age and maturity subgroup into a single expert group will reduce costs where the same staff attend more than one of these meetings, avoid any duplication of work, and develop synergy.
- An expert group devoted to all stages of the provision of biological parameters (methodological improvements, implementation, quality assurance, statistical analysis) at a national, regional and stock level will provide a bridge between the data collectors and end users that has often been lacking. This group will be able to provide regular expert advice to the Commission, STECF, Liaison Meeting, PGCCDBS/PGMED, ICES assessment groups, multispecies working groups, and ecosystem working groups or other related Expert Groups, and Regional Coordination Groups (RCG's).
- WGBIOP will initially begin with a meeting frequency of every other year with a yearly WebEx meeting to keep track of immediate needs in relation to biological parameters from end-users.

WKNARC2 proposes that generic ToR's (recurrent WG tasks over a period of years), additional specific ToR's and duration of the first WGCATCH meeting are developed in consultation with end users and agreed at the ICES-Commission DCF meeting at the 2013 ASC.

To assist this process, WKNARC2 has drafted a proposal for the supporting information for establishment of WGBIOP:

The **Working Group on Biological Parameters** (WGBIOP), chaired by Lotte Worsøe Clausen (Denmark), Francesca Vitale (Sweden), and Pedro Torres (Spain), will be established and will meet in Malaga, 2nd-6th of June 2014 to:

(a) Address generic ToR's:

1) Continue the development of methods and guidelines for best practice in the analysis of biological samples providing parameters meeting end-user needs.
2) Develop and update quality assurance procedures and quality indicators for biological parameters derived from catch sampling programmes and RV surveys, to support the ICES Assessment WG's, in particular during the benchmark assessment process.
3) Review the progress of increasing precision and accuracy in estimating biological parameters and creating outputs better tailored to input for stock assessment models.
4) Respond to requests for technical and statistical advice related to biological parameters from Regional Coordination Groups and the main data end-users (assessment EG's).
5) Identify and promote technological developments for assuring an efficient collection and an accurate estimation of biological parameters, including the maintenance and update of tools for the exchanges and workshops (e.g. WebGR, other statistical tools, age readers forum).
6) Review the outcomes of workshops, study groups, exchange schemes and other intersession work related to interpretation and quality assurance of data on stock-related biological variables, i.e. age and growth; maturity and fecundity; sex ratio (as previously dealt with under the remits of PGCCDBS).
7) Data table formulation and update in order to meet the needs from EG's on biological parameters; synchronise with the Benchmark process.
8) Updating and maintaining the Interactive spreadsheet of workshops and exchanges (from PGCCDBS).

(b) Address specific ToR's

1) Review and discuss all National protocols on Quality Assurance and Control and thus to drive up standards
2) Review and promote the Task Sharing between National laboratories
3) Create a poster representing WGBIOP at the 5th International Otolith Symposium (October 2014; abstract to be drafted inter-sessionally)

4) Reviewing status of the CRR on age-estimations

5) Updating/reviewing EARF content and operationality

6) Follow up on the WebGR upgrade developments

7) Establishment of WGBIOP's aims and objectives with respect to the needs of the end users

WGBIOP will report by September 2013 for the attention of ACOM at the ICES ASC, Reykjavík.

Supporting information

Priority	WKNARC recommends that a new expert group WGBIOP should be established in 2014, based on the extension of WKNARC, and the equivalent work conducted within PGCCDBS. A main objective of WGBIOP will be to support the development and quality assurance of regional and national provision of biological parameters as reliable input data to stock assessment and advice, while making the most efficient use of expert resources. As biological parameters are among the main input data for most stock assessment and mixed fishery modelling, these activities are considered to have a very high priority.
Scientific justificatior	The biological parameters collected from the commercial fisheries and RV surveys have a primary function of supporting stock assessments and informing fleet-based management decisions. The WGBIOP will work to help European countries achieve sufficient accuracy (increase precision and minimize bias) of biological parameters that are used as input to the ICES stock assessment, mixed-fishery, and ecosystem-based analysis and associated advisory process. The WG will operate within the ICES Quality Assurance Framework and respond to the requirements of the EU Data Collection Framework (DCF) and future DC-MAP, and recommendations from end-users. Currently all EU Member States provide biological parameters from their catch and survey (e.g., estimates of maturity ogives, size/age composition of catches) according to practices under the DCF. The EU commission spends large budget on DCF-related data collections from fisheries. Biological parameters are essential features in fish stock assessment to estimate the rates of mortalities and growth. However, the approach has several limitations and shortcomings such as stock structure, natural mortality and growth. Biological parameters based on sampled data from catch and surveys are provided by different countries and are estimated using international criteria which may have not been validated. For the purpose of inter-calibration between all laboratories across Europe and non-MS WKBIOP will review methods by species and areas, material and techniques development, methods in processing, and the validation methods. WGBIOP will provide RCM's/RCG's with the tools to review efficiencies and adapt and improve on their programmes, and will provide end users such as ICES assessment EGs and STECF with procedures for auditing the quality of data used in analyses underpinning stock-based, fleet-based and ecosystem-based fishery management advice.

Resource requirements	The WG builds extensively on experiences gained within PGCCDBS, WKACCU, WKPRECISE, WKNARC 1 and 2 and all past calibration workshops. MS and non-MS are encouraged to provide the WG with documentation of their biological analysis programmes, updated manuals and protocols for review and feedback by the WG, and to ensure that their national members of WGBIOP have sufficient resources to conduct the necessary inter-sessional work to address the ToR's.
Participants	It is expected that WGBIOP will normally be attended by some 20-25 members from all MS and non-MS.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	WGBIOP supports ACOM by promoting improvements in quality of biological parameters from fishery and survey data underpinning stock-based and mixed fishery assessments, and ecosystem indicators related to fishery impacts, and in developing data quality indicators and quality reports for use by assessment EGs and benchmark assessments.
Linkages to other committees or groups	WGBIOP links with PGCCDBS and PGMED in relation to collection of stock-based biological variables from sampling of fishery and survey catches. It links to stock assessment EGs and benchmark assessment groups by providing input on the data quality of commercial catches. WGBIOP also links closely with Regional Coordination Groups, the Regional Database Steering Group, STECF EWGs dealing with DC-MAP and the Liaison Meeting.
Linkages to other organizations	The outputs of WGBIOP will be of interest to FAO and RFMOs, and productive linkages may be established over time.

The first meeting of WGBIOP would be expected to spend some time on developing and agreeing on its own method of working in future, for example, further developing the initial proposals for generic ToR's for the next period of years, identifying how the balance of skills in the WG should be developed, considering the need for external experts with specific skills, and developing how the WG will operate both during the meetings and inter-sessionally to address generic ToR's and specific ToR's.

In line with other current ICES expert groups, there will be a need for WG members to carry out work and to draft report text on ToR's prior to the annual meeting, so that WGBIOP can spend more time in plenary discussing and agreeing its outputs. The generic ToR's for the WG should include development of inter-sessional work plans. During each meeting, WGBIOP should develop a draft inter-sessional work plan for WG members for the forthcoming year to address generic ToR's and any specific additional ToR's known at that time, identifying the tasks, responsibilities, milestones and approximate staff time needed. This is needed so that WG members can secure the resources for the work in their home laboratory and to maximise the efficiency of the WG.

WKNARC2 notes that WGBIOP will address topics that have been covered by the PGCCDBS subgroup on age-and maturity related issues, particularly in the last few years. Due to increased focus on several of the subgroup tasks within PGCCDBS (statistically-sound fishery sampling designs, RDB development, regionalisation and other related issues), PGCCDBS is finding it more difficult to address all its ToR's and agree outputs in plenary. The transfer of work on biological parameters to WGBIOP will provide time to focus on biological parameters such as age and maturity, from the individual fish level (collection and interpretation of material; accuracy; precision)

to the population level (e.g. estimation of growth parameters, maturity ogives etc.) and to have these more fully explored in plenary. PGCCDBS and WGBIOP will retain a strong linkage since the majority of stock-based biological parameters such as growth or maturity are estimated from sampling of commercial catches.

Annex 4: Recommendations

Recommendation	Adressed to
1. Major improvements of EARF to transform it into an operational and userfriendly website. Internal promotion of EARF in National laboratories. Continous documentation of procedures in relation to new species to be published on EARF	ICES IT department; National age reader coordinators
2.Establishment of WGBIOP as uniting follow-ups of WKNARC and PGCCDBS age/maturity subgroup	ACOM
4. ICES to host WebGR	ICES IT department
5. WKSABCAL to take into consideration the findings of WKNARC in relation to the means of dealing with uncertaintity of age data in assessments	WKSABCAL

Annex 5: WebGR: Outcome of the training session

Interface improvement

The interface needs to be more user-friendly with login frame appearing on the first page and on the visible part of the screen. At present the login frame is hidden at the bottom, which can be a bit confusing. Furthermore, a clear downwards sequence of steps needed to create a workshop (e.g. as in Intercatch and Fishframe) is desirable. SQL could be used as model for improving WebGR interface.

User (with the role of Workshop manager) Support

- Need of sequential steps with a function preventing access to the next step if the previous step is not properly completed.
- Error messages have to include explanations on what is wrong and how to proceed.
- Need for a more user friendly set up for creation of metadata csv-file.
- Together with the template it should be possible to download an example showing how to compile a csv-file correctly.
- A list of requirements concerning e.g. image size and format is needed
- The programme is too sensitive to font format (e.g. upper or lower case letters).
- It should be possible to upload more than one document/protocol to a calibration exercise and remove the old one.

Improvement of available tools for a workshop manager

- It should be possible to choose "all images" by one click when selecting images for a calibration exercise. At the moment one has to click on every single image.
- The workshop manager should have the possibility to delete images uploaded by one-self.
- It would be advantageous to enable simultaneous invitation of several participants to a workshop by clicking all names at once from the WebGR users list.
- The workshop manager should have permission to add new institute names and species to the attribute list, a right currently given only to WebGR administrator.
- Only the workshop manager should have access to the statistical output during a calibration exercise. Currently all readers can check other readers chosen ages and change their own ages according to that.

Additional tools needed for WebGR

- The possibility of annotating in WebGR without internet access, with subsequent synchronization to the server.

- Availability and optional selection of different types and sizes of annotation symbols. E.g. micro-increments annotation (smaller symbol size) for species with very narrow zones.
- Possibility of double field aging, necessary for some species like salmon to mark separately years spent at sea and in fresh water.
- A field to note the readability (WKNARC 2011, 3 point scale) of the otolith.
- In the csv-output file two extra columns for readability and comments made by the readers should be implemented.
- Grouping of 2-3 images belonging to the same individual, as required for the examination of older fish and maturity stages. When annotating one image, all images of the same individual will automatically get the same result. This is also needed for micro-increments annotation in certain parts of otoliths.
- Output enabling the comparison of age resulting from two or more structures of the same individual (e.g. otolith and scale).
- Statistical output combining current WebGR output and an Eltink spreadsheet improved format, including figures on results similar to those obtained in the Eltink spreadsheet.
- Adjustment of the statistics (and Eltink SpreadSheet) sensitivity for short-lived and long-lived species ageing respectively.
- Uploading of larger size/mosaic images, as those used e.g. for micro-increments count.
- A tool that calculates the distance between annotations, correcting for when the annotations are not in a straight line. This is particularly necessary for annotation of micro-increments in different sections of mosaic images where rings are more clearly visible (function available in TNCP).
- A tool for calibrating images directly in the programme if a know relationship between pixel ratio and actual measure was known, or the possibility to mark an actual value in mm or micrometers on the image. The programme will use that for calibrating distances.

Annex 6: WebGR: Study Proposal

1. TITLE OF STUDY :
WebGR 2 - Web services for support of Growth and Reproduction Studies

2. TOPIC FIELD :	**3. PRIORITY AREA(S) :**

4. NAME OF ORGANIZATION :
…To be identified…

5. NAME AND TITLE OF COORDINATOR :	
…To be identified…	

6. PARTICIPATING COUNTRIES :	It is expected that around 6-8 national laboratories of at least 5 countries will be involved; 1-2 laboratories covering each major geographical area (Greater North Sea, Celtic Seas and Bay of Biscay and Iberian Coast, Azores and the Canary Islands, and the Mediterranean)
Portugal, UK, Spain (2 institutes), Germany (2 institutes), Greece, France, The Netherlands, Norway, Sweden, Italy, Denmark. It is anticipated that other countries will also join.	

7. TOTAL COST : XXX €	**8. EC CONTRIBUTION:**

9. DURATION : 24 MONTHS	**10. STARTING DATE :** XX-XX-2014

A. ADMINISTRATIVE DETAILS

A.1. ORGANISATION
A.2. FINANCIAL & BANK INFORMATION
A.3. TEAMS TO BE INVOLVED

B. DESCRIPTION OF WORK PROGRAMME

B.1. OBJECTIVES AND OUTLINE OF THE PROJECT

The objective of this study is to substantially improve the first version of WebGR developed within an EU tender project in 2008. WebGR is a set of web services to support fisheries scientists in the organization and data analysis of calibration workshops for biological structures classification and provide means to analyse the results of such exercises.

The project aims to improve the Open Source software previously developed to support studies of fish growth and reproduction. This will contribute to improve the quality of growth and reproduction studies, by guaranteeing a consistent application of age reading protocols and maturity scales, ultimately influencing fisheries management advice. However the use of this tool is not necessarily limited to age and maturity studies. In principle **WebGR can be applied to all situations, where individual scientists need to discuss the interpretation of a protocol, for the identification of the status of biological material.**

Presently, the WebGR consortium provides the Internet service in http://webgr.azti.es. The service is provided freely but without any warranties and the tool has not been developed since 2010.

Nevertheless, since 2010 several workshops and exchanges have used WebGR with variable success. Unanimously, the members of these expert groups saw a great potential in using this software and its tools. However they experienced different problems while using it and at the same time had several requests on how to improve this tool and obtaining more complex outputs. This feedback highlighted the strong need for further improvement of WebGR and is the basis for this study proposal.

The desirable improvement of WebGR is 2-folded. On the one hand it is necessary to upgrade the user interface, improve picture uploading and enhance exploring tools, in terms of new measuring tools. Moreover, at the moment the most basic features are implemented and the easy export procedure allows users to use the data on a standard statistical package or spreadsheet. The original idea is to develop an R package and implement a set of statistical methods. An extended statistical output will give a more complete evaluation of potential differences among readers/stagers, i.e. a step forward towards the standardization.

Concerning the hosting institute, it would be beneficial both for ICES and the users, if ICES could host the server. This would guarantee a wider dissemination of this useful tool and ensure a better site management.

Furthermore, an offline access to the workshop is to be aimed for. This features needs to be implemented so that all individual users' annotations will be synchronized with the server as soon as one goes online again.

The project will be conducted by the participating laboratories and will consist in 4 Units:

WP 1: Training and dissemination

WP 2: Development

WP 3 :Statistical methods

WP 4: Site management

B.2. SPECIFIC WORK PACKAGES AND SUB-TASKS

Work Package 1. Training and dissemination

The objective for WP1 is to disseminate WebGR, train users and channel feedback to others.

It will divided into the following two subtasks:

- WP 1.1. Training by the means of a widely used web conferencing tool (i.e.Webex). This will include at least three online meetings, one for coordinators and two open trainings.
- WP 1.2.Dissemination through the drafting of working documents or flyers to be distributed to different fora. Furthermore, review and maintenance of the WebGR website is also essential. The use of this tool will continuously produce feedback that needs to be organized and distributed internally

Work Package 2. Development

This WP has two objectives

- WP 2.1. Implement new features in terms of developing new measuring procedures.
- WP 2.2. Resolve issues with the detected bugs

Work Package 3. Statistical methods

This WP has the objective to extend and improve the present statistical analysis and it is divided into the following subtasks:

- WP 3.1 Review literature
- WP 3.2 Test methods with R and develop R package
- WP 3.3 Support implementation in WebGR
- WP 3.4 Promote reproducible research

Work Package 4. Site management

The final work package has the objective to update and maintain the site.

The increasing amount of pictures uploaded and stored on the server during each exercise intensifies the demands for the site maintenance. Moreover, WebGR has a wiki-page that requires as well be reviewing and keeping updated.

B.3. MATERIALS AND METHODS

B.4. PHASES OF STUDY

B.5. EXPECTED RESULTS

The expected outcome of the Study

B.6. DIFFICULTIES ANTICIPATED

B.7. SCIENTIFIC BACKGROUND

B.8. RELEVANCE OF SUBJECT OF STUDY

B.9. QUALIFICATIONS TO CARRY OUT STUDY
This field will need to be completed for the Final Study Proposal once the participating National laboratories have been identified as well as the coordination partner.

B.11. LINKS WITH SIMILAR STUDIES

B.12. DISSEMINATION OF RESULTS
The results from the Study will be disseminated through various channels providing information to stakeholders (the EC, the Science community, the Fishery Industry): The National Correspondents in the DCF system will be informed on the Study progress by a Newsletter every 6 months of the duration for the Study. Specific species information will be reported in ICES Working Documents and presented to the relevant Expert Groups within the ICES system and more broadly at the ICES Annual Science Conference.

C.1. DRAFT BUDGET
This section will be completed in the final Study Proposal Total budget for the Study: XXX €, divided between the following categories, which each holds sub-categories (personnel costs, overheads, travel expenses, consumables, external assistance, dissemination of results, and other costs): • External contract for designer and developers • External contract for statisticians and external experts • Travels • New servers

Annex 7: Needs for future validation work as assessed by the ICES Assessment Working Groups (the stock-coordinators)

To get an overview and call attention to the quality of age reading of the stocks in ICES waters and guide future efforts, the assessment working groups are kindly asked to provide information on the items given in the below table.

The information given in the cells of the table are examples. The Stock list and Type of assessment may be prepared by ICES and then distributed to stock coordinators and assessment working group chairs prior to the meetings.

Explanations of the columns A to E:

A: Validation study means: Need for determining the absolute age of the fish (accuracy); 3 categories: urgently needed (red light); needed, but not urgently (yellow light); no need (green light)

B: Indicate time of last Age Calibration Workshop

C: Age calibration workshop (ACW) means: Need for determining the precision between readers; 3 categories: urgently needed (red light); needed, but not urgently (yellow light); no need (green light)

D: No (N) or Yes (Y); please provide additional information

E: No (N) or Yes (Y); please provide additional information

Table 7.1 Needs for future validation work as assessed by the ICES Assessment Working Groups

							A	B	C	D	E
code	name	ecoregion	EG	Assessment Type	assessment model	Stock category in 2012	Need for age validation studies	When was the last age calibration workshop?	Need for age calibration workshop	Are different methods for age determination used for this stock?	Do all national institutes have expert readers, contributing to the assessment?
agn-nea	Angel shark (Squatina squatina) in the Northea	Widely distributed and migratory	wgef	Trends cpue/lpu	-	5.3.0	needed, but not urgently	2009	urgently needed	N, all countries use sliced otoliths	N, 2 countries with new readers, 4 countries experienced
alf-comb	Alfonsinos (Beryx spp.) in the Northeast Atlant	Widely distributed and migratory	wgdeep	Catch only	-	6.2.0	no need	No ACW done	needed, but not urgently	Y, 2 countries used sliced , 3 broken and 1 country still whole otoliths (WKFLABA); age not used in assessment	Y
anb-8c9a	Black-bellied anglerfish (Lophius budegassa) ir	Bay of Biscay and Iberian seas	wghmm	Analytic	ASPIC	1					
ane-bisc	Anchovy in Subarea VIII (Bay of Biscay)	Bay of Biscay and Iberian seas	wghansa	Analytic	Bayesia	1	urgently needed	2007	no need	Y, 2 countries used sliced , 5 countries broken otoliths	Y
ane-pore	Anchovy in Division IXa	Bay of Biscay and Iberian seas	wghansa	Trends survey	-	5.2.0	...		...	...	...
anb-78ab	Black-bellied anglerfish (Lophius budegassa) ir	Celtic Seas	wghmm	Trends survey	-	3.2.0	...		...	...	...
anp-78ab	White anglerfish (Lophius piscatorius) in Divisi	Celtic Seas	wghmm	Survey trends	-	3.2.0	...		...	...	...

Annex 8: An overview of the species aged, method used, birth date, reader experience, method and interest in bilateral agreements/TS

The list will be presented at the next RCM meetings and will be completed to provide the contact persons for receiving/sending calcified structures/readers by species within Institutes.

It also indicates the "Birth Date" assigned to each species and thus can be used as an outline of where action should be recommended in terms of the formulation of the relevant schemes for edge interpretation.

Table 8.1 Overview of species aged and assigned birth date

Country	Institute	Species	Area	Co-Ordinator	E-mail	Reader(s)	Structure	No. Collected each year	No. Read each year	Method	Birth Date	Interest - sending or receiving structures	Interest - sending or receiving readers	Read since (Inst.)	Read since (Reader(s))
UK (E&W)	Cefas	Plaice	VIId	Mark Etherton	mark.etherton@cefas.co.uk	Mark Etherton	Otoliths	1500	1500	Sections	Jan 1st	-	send	1946	2000

Annex 9: Table 9.1 Overview of the literature on age reading uncertainty in relation to stock assessment that was examined during this WK

Table 9.1 Overview of literature

Reference	General approach	Assessment model applied or suggested	Reference age ("true" age)	Variables examined	Statiscal model for AEM probability estimation	Remarks
Candy et al. 2012	ageing error matrix (AEM)	Suggested: CASAL	nearest integer to mean age across readers	combined inter-reader (# 4) and intra-reader differences; readability score	Combination of 3 steps: (1) model the predicted proportions (q_{ikj}) in each error class (j) of absolute integer error (AIE) as a function of age (i) and readability (k), using GLMs. (2) model the proportion of negative error (π_{ik}) as a function of age (i) and readability (k), using binomial GLMs. (3) calculate the age error matrix using q_{ikj} and π_{ik}, with readability (k) as the average readability of the relevant set of otoliths.	Readibility score included in statistical model for AEM probability estimation. Need to create an AEM for a specified readibility score when incorporating in assessment.
Catalano & Bence, 2012	AEM	statistical catch-at-age analysis (SCAA)	otolith age (scale age is "observed" age)	paired readings for 2 CS (scale and otolith)	General approach as Richards et al 1992, with varying functional forms and distributional assumptions (# 8). The observed age (scale) was modeled as a normal or gamma distribution, given the true age (otolith). The bias (mean) and the precision (variance) of such distribution were modeled either as a linear or a power function of true age. The best fitting model was then selected by AIC.	Sensitivity analysis using estimated errors and postulated errors.
Hirst et al. 2012	No quantification of AEM. Application of (double rowed an columned) AEM to multiple stock assessment	Bayesian hierarchical model	n.a.	n.a.	AEM is not based on any real analysis, but is thought to be representative of the kind of errors that exist in practice.	Model was developed to estimate catch-at-age from commercial fishery data. Most common forms of data can be utilized: age and length, length-stratified ages, and length only. There is no need to construct an age–length key. Both landings and discards can be estimated, as can the effects of age reading errors.
ICES 2009 (WKAEH report)	AEM	Stock assessment model coded in Bayesian software WinBUGS	improved age after consulting otoliths from mark-recapture study	inter-reader differences (# 6); fish length	General approach as Richards et al 1992, using improved age (called "tagged age" or "age with supervision" in report) as true age and first reading (called "untagged age" or "age reading without supervision" in report) as observed age.	Assessment model run in winBUGS takes 4.5 days (!)
Wilhelm et al. 2008	Scenarios (# 4); comparison of coefficient of variation (CV)	Age-structured production model (ASPM)	modal age obtained by experienced readers	combined inter-reader (# 8) and intra-reader (#3) differences	They propose a CV AEM	They recommend that most ageing effort is directed to age groups that are more abundant in the catches and suggest age sampling proportional to length distribution.
Punt et al. 2008	AEM	Suggested: Stock synthesis, Coleraine, CASAL	1 reader	combined inter-reader (≥ 2) and intra-reader (≥ 1) differences	General approach as Richards et al 1992; with varying functional forms (# 8) and Gaussian distribution.	Simulation study on performance of approach
Courtney et al 2007	Implimentation of AEM developed by Courtney et al. 1999	Customized Stock Synthesis age-structured model	see Courtney et al. 1999	see Courtney et al. 1999	see Courtney et al. 1999	Four rockfish species modeled.
Bertignac & de Pontual 2007	Comparison between "simulated" ALK and "current" ALK. Simulated ALK based on theoretical (mark-recapture study driven) growth parameters	Extended Survivors Analysis (XSA)	n.a.	n.a.	n.a.	Arguments for this approach as alternative to AEM probabilities: data limited and focus on effect.

Clark 2004	AEM	n.a.	mean assigned age of paired reading as proxy for modal age (called "cononical" age in paper)	bias related to method, i.e. whole vs. break-burn	This method aims to estimate the distribution of age reading error for a given canonical age A. This was done nonparametrically by predicting and fitting the observed distribution of differences of paired readings.	Arguments for this approach as alternative to parametric modelling of AEM probabilities: models fits can be misleading, especially if reread samples are small.
Reeves 2003	AEM (applied to ALK i.s.o. CAA) to create scenarios (# 4)	XSA	simulated true age	inter-group ("schools") differences	n.a.	Simulation study. Additionally, an operational model was developed to describe essential element of the fish population and the fishery exploiting it. The operating model was used to generate assessment data using age errors.
Courtney et al. 1999	AEM	Customized Stock Synthesis age-structured model (AD Model Builder)	mean age (?, not specifically stated)	inter-reader differences (# 2) and intra-reader differences (#2)	General approach as Richards et al 1992, model selection (AIC) based on 2 models	The purpose of this study was to summarize the data available for an age-structured model of northern rockfish, and to assess the fit of preliminary population estimates from the model to the data.
Heifetz et al. 1998	AEM	n.a.	true age, i.e. known age based on mark-recapture study	bias and inter-reader differences (# 2)	General approach as Richards et al 1992	Agreement between readers was considerably greater than between reader and known ages. Thus, use of between-reader agreement to assess ageing error may lead to a false sense of the true error.
Coggins & Quinn, 1998	AEM	Quin and Szarzi's age-structured model (1993), adapted in a new FORTRAN program (AGEERR)	expert reader	multiple age readings	General approach as Richards et al 1992	(1) Emphasize necessity of careful age validation techniques. (2) Surprising result: little effect of sample size. This suggests that attempting to mitigate imprecision resulting from poor reader performance by increasing sample size is not an effective tactic
Ralston & Ianelli, 1998	AEM	Stock Synthesis	break-burn age	Different otolith preparation methods (whole, break-burn).	not presented (?)	An evaluation of different sets of data point out that age composition data were in disagreement with all other sources, apparently due to bias and imprecision in ageing.
Beamish & McFarlane 1995	Review of ageing error sources. Description and types of ageing errors relevant to stock asssesment and management. No quantification of ageing error	n.a.	n.a	n.a.	n.a.	Stressing necessity of validation and inclusion of ageing errors in population dymanic assessment.
Richards et al. 1992	AEM	n.a.	mean assigned age	inter-reader differences (# 6)	(1) model the age error matrices, P(a'|a), i.e. probability that an animal of true age *a* is assigned to one of the observed age classes, using predefined bias/precision parameter functions, assuming normal/exponential distrbution of observed age for the true age (2) apply AIC/BIC to select the optimal model for P(a'|a)	They recommend increasing sample sizes with increasing ageing error to achieve a specified precision in estimates of true age proportions.
Bradford 1991	simulated AEM	Sequential Population Analysis (SPA)	simulated true age	bias and precision errors	n.a.	Simulation study examining effect ageing error on recruitment time series.
Lai & Gunderson, 1987	Comparison of yield per recruit for Von Bertalanffy growth parameters for reference ALK and 3 ageing error scenarios (no bias with normal distribution, no bias with skewed distribution and bias). The ageing error scenarios are modelled from observations.	Beverton & Holt's yield per recruit model, Gulland (1969) equation	1 reader, whole otolith (1981 ALK)	different CS (scales, dorsal and pectoral fin rays, otoliths); different methods for otoliths (whole, break-burn); inter-reader differences (# 2)	n.a.	Monte Carlo simulation study.