WORKSHOP ON SCALLOP AGING (WKSA)

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International Council for the Exploration of the Sea
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H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Editors

David Palmer • Karen Vanstaen

Authors

Lynda Blackadder • Isobel Bloor • Matthew Coleman • Adam Delargy • Peter Duncan • Eric Foucher • Peter Gibson • Ellen Sofie Grefsrud • Shona Kinnear • Claire Lambden • Roger Mann • James McArdle • Carrie McMinn • David Palmer • Charlotte Reeve • David Rudders • Claire Szostek • Adrain Tait • John Turriff • Karen Vanstaen • Julia Wouters

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i Executive summary

The ICES Workshop on Scallop Aging (WKSA) seeks to review and compare current scallop age reading methodologies, standard operating procedures and quality assurance processes across member institutes and collaborate to develop best practice. Assessments utilising age-based models need reliable age reading. Previous WGScallop age determination exchange results indicated inconsistencies within and among exchange participants and institutes. The workshop therefore aimed to understand these differences, identify consensus, and improve accuracy and agreement across institutes when aging shells. During the workshop, the institutes shared expertise and methodologies to develop understanding, agree standard principles and consensus aging for reference sets, appraise the potential use of SmartDots and discuss future exchange programmes.

The group provided insights in the field of age-determination across geographic scallop fisheries and stocks, with agreement that the aging method utilised reflected shell morphological traits and the visibility of annuli. A set of standard principles was established which lists agreed common attributes that would provide baseline information and standard terminology across institutes. Microscope aging was identified as an essential technique for aging shells presenting challenges to age or quality check by eye with a number of institutes concluding that they would look to include microscopes in future as part of their quality assurance. The group agreed that microscope age training would be a beneficial part of a further workshop, proposed for 2021.

Consensus aging that included both visual and microscope techniques reduced variation in age determination and the group agreed that consensus aging was required to produce a reference set for each institute. ToR d), starting a consensus reference collection has been carried over to next meeting of WKSA. At present, WKSA do not recommend attempting another shell aging exchange until reference sets have been consensually agreed upon.

Smartdots has been initially investigated for its potential use in scallop shell aging as part of ToR c), however there is further work to do on this to fully test the usability of the software for future aging exchanges and ager training. WKSA will provide feedback to the Working Group on Biological Parameters (WGBIOP).

This workshop initiated a regular platform to progress information flow and development of a cohesive understanding of shell aging across diverse fisheries, stocks and populations, vital for use in fisheries stock assessments and informing any future ecosystem-based fisheries management. To allow further exchange of best practice, microscope age training and consensus-aging of reference sets, the group agreed that a further workshop is recommended in 2021.

ii Expert group information

Expert group name	Workshop on Scallop Aging (WKSA)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chair(s)	Karen Vanstaen, UK
	Dave Palmer, UK
Meeting venue(s) and dates	10–12 February, Aberdeen, UK (22 participants)

1 Summary

This workshop compared current aging methodologies and quality assurance processes used by member institutes. Collaboratively identifying and understanding the criteria and variables that can introduce differences in age assessments between experienced readers. Preliminary results from analysis of the previous scallop exchange (for age determination) showed inconsistencies within and among exchange participants and institutes. Clear understanding and standardization of age reading procedures would aim to improve the accuracy and precision in the age reading of this species.

The first day of the meeting focussed on presentations of current aging methodologies and quality control procedures used at each institute. Alternative methodologies also presented included isotopic analysis and historic hinge aging. The second and third days focused on aging a selection of scallops provided from each institute to more closely identify variables and obtain agreement in annuli signatures. Aging was first undertaken independently by attendees aging shells from samples supplied from each organisation. Shells from each institute were then aged by groups, who then arrived at a consensus age. Each group included one member trained in the microscopic examination of striae patterns. This exercise resulted in a much higher level of agreement when the results were analysed. Discussions examined the reasons behind varying age interpretations and advances were made in understanding differences in interpretation. Assessing the same annuli characteristics and gaining agreement on the same final age was pivotal.

The workshop additionally introduced the utility of SmartDots (an age reading platform developed within ICES) for king scallops and discussed the usability for future aging exchanges and as a training tool. The workshop will also provide feedback to the Working Group on Biological Parameters (WGBIOP). WGScallop will review the report from WKSA and determine the value and benefit of future workshops.

Microscope aging was deemed to be important for QC purposes or in locating less visible edge annuli therefore the group agreed on basic microscope age training would be beneficial to allow institutes to QC scallop ages. The group agreed that this would be an integral part of a further workshop, which should be proposed for 2021.

To allow further exchange best practice, microscope age training and consensus-aging of reference sets, the group agree that a further workshop would be valuable, proposed for 2021.

2 Report on Terms of Reference

2.1 ToR a) Review and compare current scallop age reading methodologies (including quality assurance) and agree on best practice

Each institute presented their age reading methodologies and quality assurance processes. A summary is provided below with aging protocols specific to the fisheries or stocks sampled. Three elements were identified: in-house protocols, reference sets and aging exchanges.

In-house protocols: Detailed discussion on methodologies highlighted similarities and differences between methods. Key differences included aging by eye or microscope, dictated by the ease at which the annuli were visible on the flat shell. Shells from different geographical areas or habitat types exhibited specific morphological or growth characteristics.

The group acknowledged that the method used to age usually reflected the shell morphology and therefore it was less important to follow the same protocol 'methodology' but it was important to assess the same annuli characteristics leading to consensus on the final age. Other differences were the recording of plus groups indicating where no further ages could be determined with confidence. Some methodologies include measurement of each annuli to allow plotting of growth rates. Therefore, in-house protocols may differ between institutes.

Reference sets: Discussion highlighted the requirements of holding reference sets for each institute reflecting the local morphologic and growth characteristics of the fisheries. Consensus aging that included both visual and microscope techniques reduced variation in age determination and the group agreed that consensus aging through the forum of experienced readers such as the WKSA forum was required to produce a reference set for each institute. A list of best practices was agreed based on common traits currently used in methodologies. This contributed to the standard procedures for future aging exchanges (see ToR b).

Institute aging methods are described below.

Marine Scotland Science, Scotland, UK

MSS have been undertaking scallop assessments since the mid-1990s. Data are collected from scallop surveys and by visiting shellfish processors, where ages are determined by counting annuli markings visually. Annuli markings are generally relatively clear although growth rates can vary between areas. Older scallops can be more difficult to age due to annuli at the outer edge being closer together, so scallops with an age of over 10 are aged as a 10+ group.

Scallops for assessment purposes are measured across the shell (not from umbone to outer edge) to the nearest half centimetre below. All paperwork is checked at the laboratory to ensure that it is complete and that all details are correct. To ensure consistency between samplers, training is provided both in the laboratory and in the field. Trained staff are evaluated on an annual basis by aging 25 scallop shells that have been independently aged by two experienced members of staff and must attain a 90% agreement rate. Where 90% is not achieved, further training is provided. The data collected are used in the regional stock assessments carried out by MSS.

AFBI, Northern Ireland, UK

The Agri-Food and Biosciences Institute (AFBI) carry out an annual *Pecten maximus* survey in Northern Ireland waters, currently onboard the RV Corystes. Catches from the survey are standardised to estimate abundances per 100m^2. Biological information collected includes scallop shell length, shell breadth, total weight, muscle weight, gonad weight and maturity stage. In addition, all scallops caught are aged during the survey

Prior to the survey, staff carry out a check of a random selection of scallop shells to ensure there is agreement in technique. Whilst on the survey, all shells are scrubbed clean to display the growth rings on the flat shell. The rings are then visually counted. Scallops are aged to 10 years, with older scallops pooled in to a 10+ group. All shells are labelled with the unique tow information and archived once back at the laboratory. AFBI currently hold an archive of scallop shells going back annually to 1992, with shells from sporadic surveys held prior to then.

CEFAS, England, UK

Scallop fisheries were at a low level in England prior to the mid-1970s and were only sporadically sampled. Aging, where carried out, was by naked eye examination and counting visible rings. As the fishery expanded in the English Channel from about 1974 somewhat more intense sampling commenced and doubts were expressed about the accuracy of aging by eye, particularly in the Western English Channel where a high proportion of shells are not clearly marked.

In 1986 a project was undertaken to validate shell ages using the stable isotopes of oxygen that are laid down at different proportions as water temperature changes (*Dare and Deith, 1989*). By sampling at intervals across the shell it was possible to identify the point at which water temperature was at its lowest. Microscopic examination showed that growth striae bunched close together during the cold period, as growth slowed, before opening out as growth accelerated with warmer temperatures. This pattern is discernible under the microscope even when no mark on the shell is clearly visible to the naked eye.

Microscopic examination of the stria pattern is now the standard method used by Cefas for aging scallops from commercial and survey programmes.

Quality control (QC) of scallop aging is undertaken whereby all new agers (trainees) have 100% of aged samples checked by an experienced ager. Once an ager is signed off, several shells (approximately 4 or 5) from a sample are checked by an experienced ager to ensure agreement. If the shells checked are deemed to be of a different age, then 100% of the sample undergoes QC.

Reference

Deith and Dare 1989. Dare, P. and Deith, M. (1989). Age determination of scallops, Pecten maximus (L.), using stable oxygen isotope analysis, with some implications for fisheries management in British waters. 7th International Pectinid workshop, Portland, Maine, USA, April 1989.

Isle of Man & Bangor University, Isle of Man & Wales, UK

Sampling of king scallops is undertaken by Bangor University within the Isle of Man territorial sea. Despite the relatively small area that encompasses the Isle of Man territorial sea there are large differences in the growth rates of king scallops around the island.

The king scallop survey and assessments in the Isle of Man have been undertaken since 1992. The survey has been run during that time by different institutions and different lead scientists. Bangor University has run the survey and assessments since 2007 and the current lead scientist has been in charge of the aging protocols since 2013. The growth rings of king scallops in the Isle of Man are typically quite visible and clear and therefore can be aged by eye. Disturbance rings do occur and should not be counted as annual growth rings.

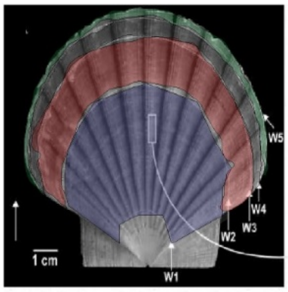
Depending on the spawning time the first growth ring is typically around 20–40 mm from the umbo (the oldest part of the shell). Only visible growth rings are counted, however, if no visible first growth ring the 'rule of thumb' is applied to ascertain ring 2 (i.e. the location of a first ring is ignored and the top segment of thumb is instead placed at the bottom of the shell and the next large ring above the thumb is counted as ring 2). Depending on the timing of the survey there may be visible growth outside of the last ring. In this instance a '+' is added to the age (i.e. 5+ indicates a scallop with 5 visible growth rings and visible growth after the 5th growth ring). All scallops are aged as far as possible and no plus groups (i.e. Age 8 and above) are used in the initial aging process (data may be grouped later as necessary).

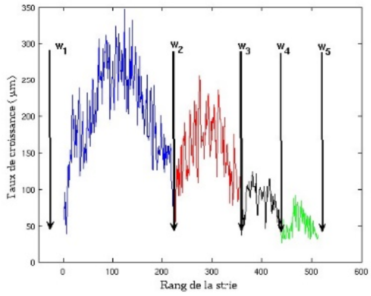
The majority of aging is done at sea by volunteer scientists. An initial training quiz with a reference set of shells is undertaken prior to aging and initial aging estimates are overseen. Scientists work in pairs and cross-checking is done by multiple volunteers where possible (but this can often difficult at sea with low staffing levels). With large growth rates around the island experience of the growth rates in each fishing ground is useful when aging. A sample of up to 20 shells from each survey station are retained and checked by an experienced ager (lead scientist) in the laboratory on return from the survey and the data are then cross checked with ages collected at sea.

In the Isle of Man, the data is used for stock assessment. At present Bayesian stock assessment methods are under development. The data are used as a basis to support the setting of TACs and other management measures for king scallops within the Isle of Man territorial sea.

IFremer, France

The King scallop is present practically everywhere in the English Channel. Two main beds are exploited by French fisheries, one in the Western Channel within the Normand-Breton Golf, including the Bay of Saint-Brieuc (between 5 and 10 000 tons per year) and the other in the Eastern Channel, with two main areas, the bay of Seine and the seabed located north-east of Dieppe (between 15 and 25 000 tons per year). A third smaller seabed is also exploited in the centre of the eastern English Channel, around the Greenwich buoy. The main spawning takes place in spring (in the bay of Seine) or between early July and mid-August (bay of Saint-Brieuc); with the anniversary date for each age group is fixed on the 1st of July. The growth of the King scallop is very quick in the bay of Seine, and especially high during the first two years of the animal's life. Growth is weak in winter and daily growth stria are therefore very close together making it easy to estimate a winter mark of growth limitation. Growth is rapid in spring and summer, in the Seine bay a height (direction of symmetry of the shell) of 95 mm (corresponding to the minimum regulatory size of 110 mm applied in the East Channel) is reached around 2 years±3 months. In the bay of Saint-Brieuc, the height of 86 mm (102 mm in length equivalent to the minimum size authorized in France in the Western Channel and in the Atlantic Ocean) is reached around 2.8 to 3 years.





Figures 1 & 2. Growth of King scallop in the bay of Seine (*Le Goff et al.*, 2017[1]).

French King scallop assessment surveys in the bay of Seine started in 1976. A similar survey is done in the bay of Saint-Brieuc in Western Channel (started in 1974). These two surveys are the oldest scientific surveys in France with age estimations since the beginning of the data series. Aging is by visually counting annuli rings and not colouration as rings are easy to see and read (Figure 3). Around 80% of exploited King scallop in the bay of Seine are between 2 and 4 years old, oldest scallops are not frequent.

Generally, the first ring (6 months old, settlement done the 1st of July, by convention) is not easy to see, but the second ring is always easy to see. Due to the rapidity of growth, the second ring appears between 7 and 10 cm height. New readers start at sea during the 2 scientific surveys (bays of Seine and Saint-Brieuc) with training and knowledge transmission done there. All data are used to annual assessment of the 2 main sea beds in France, bay of Seine in Eastern Channel and bay of Saint-Brieuc in Western Channel.

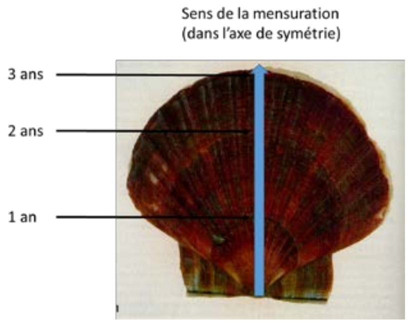


Figure 3. French King scallop aging.

[1]Le Goff C., Lavaud R., Cugier P., Jean F., Flye-Sainte-Marie J., Foucher E., Desroy N., Fifas S. and Foveau A., 2017. A coupled biophysical model for the distribution of the great scallop *Pecten maximus* in the English Channel. Journal of Marine Systems, 167, 55-67.

Institute of Marine Research, Norway

Field reading:

1. General assessment of ring positions related to expected trend:
    a. Pattern of unclear first ring and a clear second ring at typically ~ 35–50 mm;
    b. Decline in distance between rings with age after third ring;
    c. Same visible sequence of shell surface colour and/or distance of ridges/stria between growth zones (area between two rings).
2. Close examination of possible first winter ring or interpreted as ring caused by transition from byssal attachment to benthic life. Typically, first ring may not be identified, while more effort is on identification of the second ring.
3. Rings with adjacent scars identified as chipping from crab claws or other damage, and/or position of ring differing from the expected trend, will be examined as false age rings.
4. Age rings older than 8+ typically difficult to identify.

Laboratory reading:

1. Use of binocular to confirm reading methodology above.
2. Examination of concentric ridges/stria and the sequence of distance between.
3. First ring may have a transition from invisible stria to visible stria.
4. Other rings typically have decreasing distance between stria before the age ring, which often is formed by elevated area with congestion of stria. Distance between stria after (when growth resume) is typically larger than before the age ring.
5. By analysing oxygen isotopes sampled from the shell cross sectioned over visually identified age rings, relationship to the expected seasonal temperature profile can be used to confirm the identification of age rings.

In addition to the annual growth rings, the shells of *Pecten maximus* also bear fine concentric ridges or striae. Growth variation on a larger regional scale and growth differences related to life history strategies seen on a species distribution scale may also be significant when considering site selection for scallop aquaculture. Chauvaud *et al.* (2012) compared growth in *P. maximus* from populations along the Northeast Atlantic coast from Spain to Norway, by investigating differences in annual or daily growth rates, and difference in the length of the growing season. They found that low annual growth rates in northern populations are not due to low daily growth values, but to the lower number of days available each year to achieve growth compared to the south. There is a general trend which shows a decline in growth rate with age, regardless of latitude, which is mainly related to a decrease in the annual number of growth days; however, the shorter growing season and lower growth rate in the north persisted over a greater number of years than in the south where sharp declines in length of growing season and growth rate was shown at a younger age.

Reference

Chauvaud, L., Patry, Y., Jovivet, A., Cam, E., Le Goff, C., Strand, Ø., *et al.*, 2012. Variation in size and growth of the great scallop Pecten maximus along a latitudinal gradient. PLoS One 7 (5), e37717, oi:10.1371/journal.pone.0037717.

Orkney Sustainable Fisheries (OSF), UK

OSF commenced its research project focused on king scallops *Pecten maximus* in the Orkney inshore fishery in 2019. This project involves collecting baseline data from both the Orkney dive and small resident dredge fishery through a combination of onboard observer trips and an industry led annual stock assessment survey. Part of this ongoing work is to collect regionally appropriate growth parameters collected through scallop aging. Currently visual aging is the primary method, which is done at sea during both the annual stock assessment survey and during onboard observer trips on commercial dive boats. A stratified subsample of shells is retained from each survey station from the annual stock assessment for quality control of aging, whilst a monthly stratified subsample is collected from the dive fishery. Orkney Sustainable fisheries follows the current aging standard operating procedure of Marine Scotland Science and maintains an Orkney specific reference shell aging set which is reviewed annually by all staff members. Orkney is unique regarding the composition of its fishing fleet, with the fishery being diver dominated, with preliminary aging results demonstrated distinct differences in growth rates between the dive and dredge fisheries. OSF is currently exploring the implementation of two separate stock assessments to best represent the population and exploitation dynamics of both fisheries.

Additional age methodology presentations

The group also heard presentations on other methods trialled to obtain the age of scallop shells: Karen Vanstaen, England, UK presented preliminary results from the stable isotope research, Carrie McMinn, Northern Ireland, UK presented work previously undertaken on hinge aging and Adam Delargy Wales, UK presented work undertaken with Virginia University.

Isotope analysis and laser ablation for verification of early annuli location, Karen Vanstaen, Cefas, UK

Collaborative work with Alina Marca, UEA and Phil Hollyman BAS.

There are known challenges in resolution of first and second annual growth increments in English scallops aged by microscope. Moving into new stock areas requires quick, reliable and cost-effective validation of early annuli location. Current methods to corroborate microscope-derived age results include the 'gold-standard' for age determination: isotope analysis alongside other methods such as resilium/resilifer analysis and rapid line-scan analysis of Mg/Ca ratios with LA-ICP-MS (Laser Ablation Inductively Coupled Plasma Mass Spectrometry). Initial research aimed to validate the location of the first two annuli derived by microscope assessment and laser ablation (Durham *et al.*, 2017) by comparison to isotopically derived annuli loci (Dare & Deith 1989). Annuli were assessed along the standard growth axis of the top valve and the wing or auricle. Significant issues with laser ablation equipment meant that results were not present for review here and are awaiting processing. Stable isotope $\delta^{18}O$ results obtained for several shells correlated to expected annual peak loci as determined microscopically (Figure 4). Initial ear analysis did not demonstrate sufficiently repeatable correlation and more results are required to reduce variation observed.

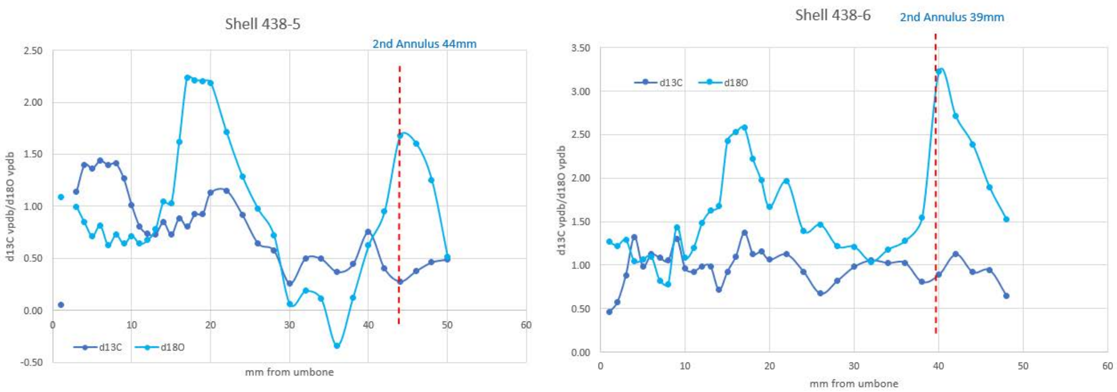


Figure 4. Isotope peaks compared to microscopic loci of second annulus.

References

Deith and Dare 1989. Dare, P. and Deith, M. (1989). Age determination of scallops, Pecten maximus (L.), using stable oxygen isotope analysis, with some implications for fisheries management in British waters. 7th International Pectinid workshop, Portland, Maine, USA, April 1989.

Rapid determination of oyster lifespans and growth rates using LA-ICP-MS line scans of shell Mg/Ca ratios (2017). Palaeogeography, Palaeoclimatology, Palaeoecology, 2017, Vol 485. 201-209.

Hinge Aging, AFBI, NI, UK

Whilst the current technique used by AFBI is visual inspection of the flat shell, historically shell aging was also carried out by reading the hinge, in addition to the flat shell. This was carried out either during the survey, or when the shells were returned to the lab. The hinge plate was brushed with water to make the growth rings more legible, before being placed under a low power optical microscope, at a magnification of x6 or x12, and the rings counted. With the hinge rings protected from external factors which may damage the outer shell, this can be a more accurate method to age scallops. The oldest scallop aged by this method was estimated at 28 years of age. Currently, when preparing the scallops for archiving, the hinge ligament is still removed to allow us to return to this technique if/when required.

2.2 ToR b) Develop, agree and write a standard procedure for use in future scallop ex-changes

A set of standard principles were agreed by comparing the methodologies presented and drawing on commonalities to improve consistency in aging. These can be used when establishing reference sets through consensus agreement across institutes, agreed as a more important step than further exchange programmes at this time. The group are keen to hold a future WK focused on producing a full reference set that is aged by consensus for each institute (or fishery/stock area).

The group discussed reasons behind individual aspects of the pre-existing methodologies and how they varied between institute. Different methodologies reflect confidence in visibility of annuli, which is phenotypically influenced by growth, geography and habitat. It is clear that there are morphological differences in the shells from different regions and that annuli may not be visible to the naked eye. A standard protocol alone would therefore not therefore 'fit all'. It was therefore more useful to gain agreement on common traits and principles that will ensure consistent terminology and baseline information for aging. These can then be used for consensus aging and to provide a standard guide for new agers and are described below in Table 1.

Table 1. Standardised procedures to improve consistency to aging.

Reference sets	Census aged during workshop rather than exchange.
Year Cohort	Standard reference point: Date of Birth recorded as 1st Jan regardless of spawning time. *Scallops caught after this date would be counted in the next year's cohort aligning with accredited otolith aging practices.*
Microscope use	Microscope use recommended for verification and QA.
Protocols	Utility of own survey protocols i.e. visual, microscopic, wet/dry etc relative to morphological/phenotypical characteristics of fishery or stock. Incorporation of standardised procedures
"Rule of thumb"	Typically the first annulus is laid down within the first ~30 mm of growth and not strongly visible in the striae, therefore growth rings observed outside this area (corresponding to the size of a thumb tip) are counted as the second annulus. *Not applicable to fast growth i.e. Baie de Seine scallops.*
Age Plus groups	Plus, groups denote the last age where age-determination of annuli is confident but there is growth suspected after. i.e. 8+ indicates annuli visible with confidence up to 8 years but not confident of number of annuli after.
Characterised fishery/stock parameters	Background data for fisheries to be provided when undertaking future scallop consensus aging: Typical growth rate for fishery Spawning time and frequency Estimated Size at Maturity (SoM) Minimum Landing Size
Characterised fishery/stock areas	Environmental / Habitat Genetics Phenotype Fishery
Reference sets	To agree reference set held per institute through consensus aging by a specialist panel/workshop rather than exchange. Reference set per geographic area/habitat/phenotype location: 12 shells. Number of age cohorts in reference set (min 3 scallops per cohort, one easy to read, one medium and one difficult): 2y* or 3y 5y 7y 9 and above *If typical growth is rapid i.e. as Baie de Seine.

2.3 ToR c) Assess the potential use of SmartDots for king scallops

A member of WGBIOP introduced SmartDots and explained the function of the application. Lynda Blackadder (Scotland, UK) presented a short presentation on the set up of the camera used to capture images of a high enough quality for the trial event. The final set up is described in Annex 3. These high-resolution photos of scallop shells had previously been uploaded onto SmartDots to create an event for this workshop. The group aged these images of scallop shells and provided feedback on the system and its potential for future use. Annex 4 presents the report for the SmartDots *Pecten maximus* trial event, for the purpose of the report agers were ranked based on their experience, this is a requirement of the SmartDots program.

It is important to note that in this trial, 22 samples were used. A full trial/full exchange would aim to use 200 samples from mixed regions. The reduced number of samples used should be taken into consideration when reviewing the statistical output results featured in Annex 4.

Whilst technical issues were encountered that prevented all experts from accessing the trial event, the general view from the institutes was that it could provide significant advances logistically when compared with previous aging exchanges if they are confident that the visual assessment of the high resolution photographs is sufficient to make a confident age assessment. The group agreed that there was the need to investigate better imaging before being used for a full international aging exchange; the current image resolution did not allow for the images to be zoomed in to a level where striae were clearly visible. The group agreed that SmartDots could provide a useful platform for the training of new agers, allowing them to complete training remotely with access to shells from a range of sea areas. WKSA will report back to WGBIOP (See Annex 4) on the usability for future shell aging and any adjustments that may be required.

Technical issues around access to the SmartDots event during the meeting resulted in not all participants completing the workshop, this is reflected within the results presented in Annex 4. When coupled with the small original sample size, the results are not thought to be representative of a full event, they serve the purpose of identifying the use of SmartDots in the future and challenges faced by shell aging when using this method. The report has been produced to show the capability of the SmartDots application when analysing inputs at the end of the event.

Next steps for SmartDots are to start collating high definition images from each institute to attempt a full trial event and discuss results at next meeting of WKSA/WGSCALLOP. As part of the workshop, participants were also requested to age the same scallop shells which had been photographed for the SmartDots trial. The shells were randomised and aged independently by each participant. MSS will collate and analyse these data to compare age readings to those recorded in SmartDots. The results will be presented at the next workshop.

2.4 ToR d) Start a reference collection of scallop shells with a consensual age

The group independently aged a range of scallops from each institute. A shell was selected at random from set of approximately 20 shells brought to the workshop by six research institutes. Each member of the group aged the same six shells. All participants were asked to age the scallops using the methodology followed by their institute. Additionally, participants were asked to measure the distance from the hinge out to the annual rings to allow for comparison between the interpreted location of the rings. The results from the initial aging are shown below. This exercise was conducted to establish initial unbiased variation amongst agers present.

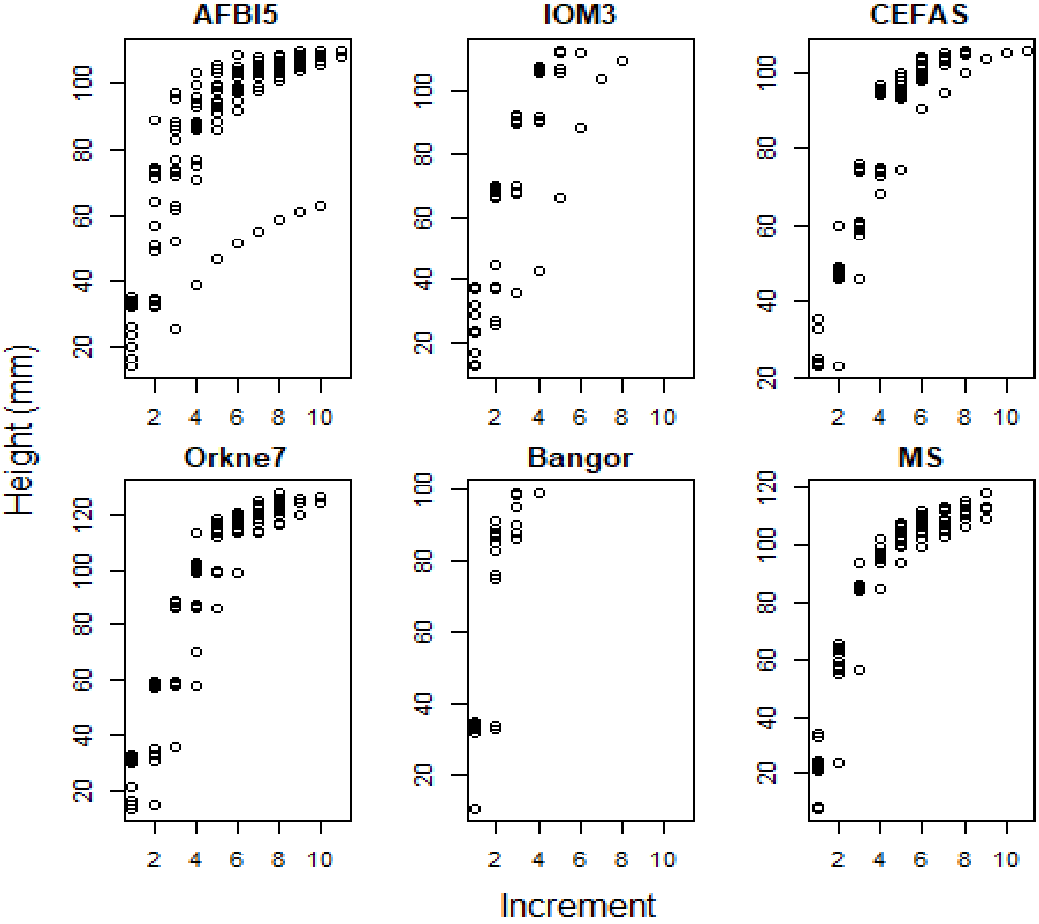


Figure 5. Graphs showing a comparison of measured age increments from shell umbo for each shell by all readers.

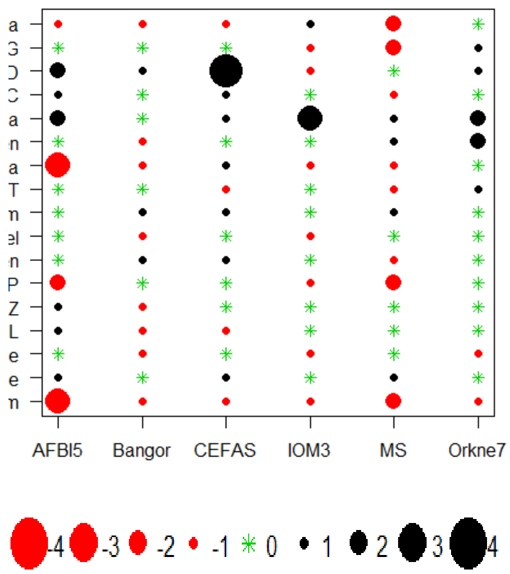


Figure 6. Plot of individual performance against expert truth age (expert truth denotes age assigned to the shell by owning institute). Green shape indicates estimated age matches expert age. Red indicates underestimation of expert age by reader and black indicates overestimation of expert age by reader. Red and black points are scaled by magnitude of deviation (in years) from expert age as indicated in figure legend.

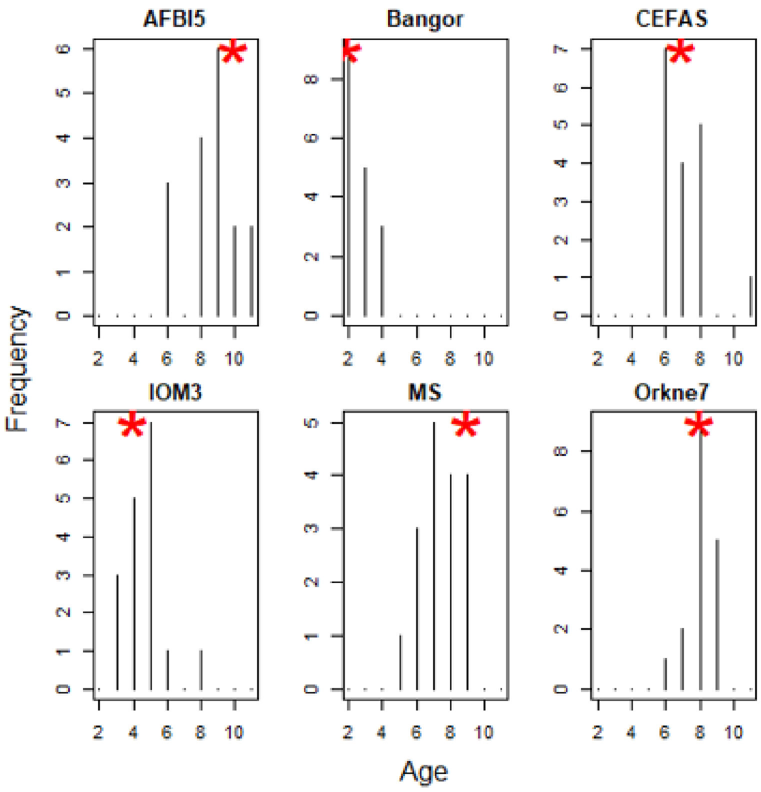


Figure 7. Representation of frequency of age assessment across experts vs the original institutes age assessment. Frequency of estimated ages for each shell by members of the workshop denoted by bars. Red shape indicates expert age provided by shell owner institute.

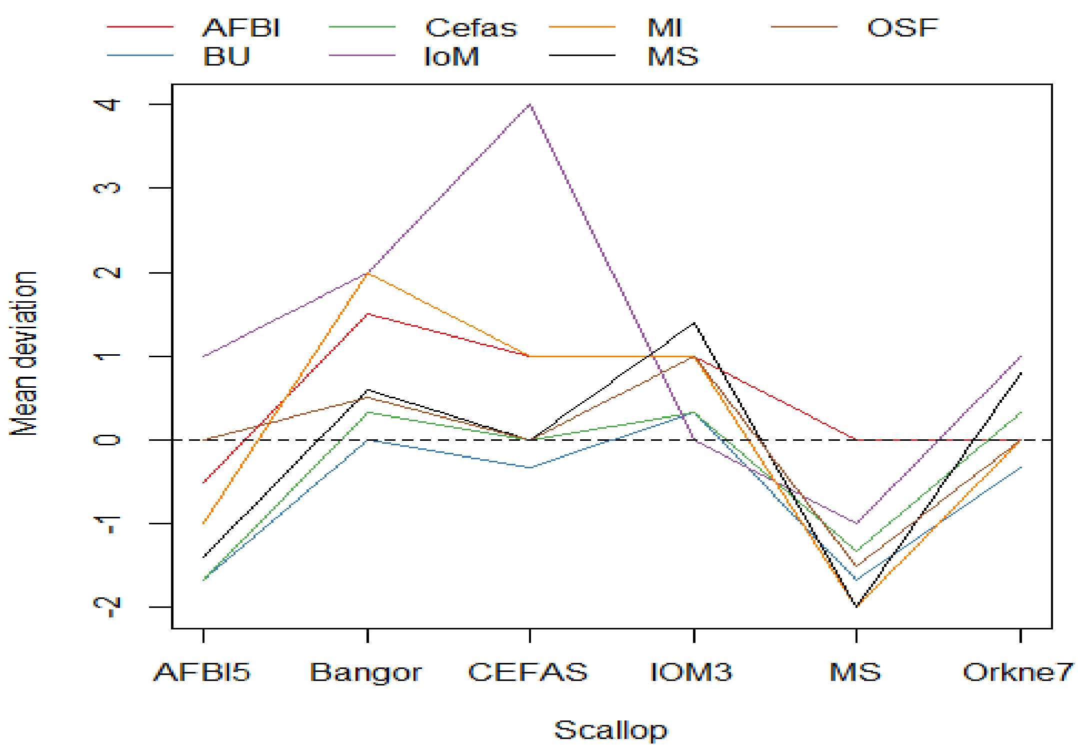


Figure 8. Agers grouped by institute. Figure denotes mean deviation, by institute, from the expert truth for each shell (expert truth denotes age assigned to the shell by owning institute(Y axis)).

The WK discussed the results and identified the shells causing the greatest inconsistences between agers. On day three, agers were split up into groups of 4 (mixed institutes with one trained microscope ager), participants were asked to age a larger sample of shells using the agreed standard procedures. The groups then compared individual ages and agreed on a consensus age. Consensus ages were recorded and compared between groups. The results form consensus aging are presented below. Group consensus ages were similar between groups, which highlighted that the standard procedures could be used to age king scallops. It was agreed that microscope aging provided clarity on shells that were difficult to read and allowed for edge rings to be observed which cannot be observed when eye aging.

The group agreed that consensus aging was required to produce a reference set for each institute. ToR d) is expected to be carried over to next meeting of WKSA.

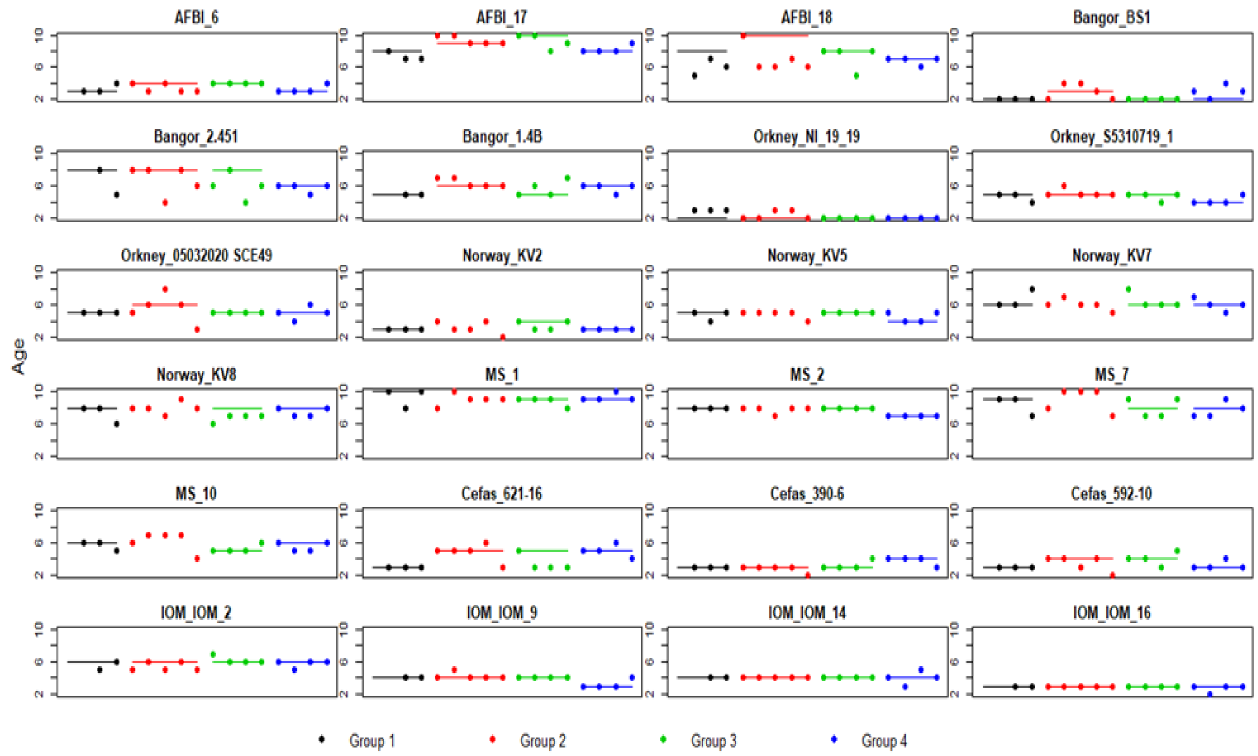


Figure 9. Consensus age reading results. Point denote individual aging; lines denote group agreed age. Both points and lines are coloured by group. Note: Consensus aging not completed for group 2 (red) due to time restraints.

2.5 ToR e) Discuss the benefits of future exchanges or workshops

Aging methodologies have been reviewed from the institutes participating in the WK as part of ToR a). A standard procedure has been agreed on as part of ToR b) and the standard procedure has been used on a sample of shells as part of ToR d), however ToR d) has not been completed as the WK has not produced a full reference set of shells. The group are keen to hold a future WK focused on producing a full reference set that is aged by consensus for each institute (or fishery/stock area). At present, WKSA do not recommend attempting another shell aging exchange until reference sets have been agreed upon.

Smartdots has been initially investigated for its potential use in scallop shell aging as part of ToR c), however there is further work to do on this to fully test the usability of the software for future aging exchanges and ager training.

Microscope aging was identified as an essential technique for aging shells presenting challenges to fully age by eye. It also was invaluable for identifying edge rings when closely bunched near the shell edge on older scallops. Members of the group expressed interest in further utility and familiarity with microscope aging to use the method for QC at their own institutes.

Annex 1: List of participants

Name	Institute	Country (of institute)	Email
Dave Palmer	CEFAS	England, UK	dave.palmer@cefas.co.uk
Karen Vanstaen	CEFAS	England, UK	Karen.vamstaen@cefas.co.uk
Charlotte Reeve	CEFAS	England, UK	Charlotte.reeve@cefas.co.uk
Lynda Blackadder	Marine Scotland Science	Scotland, UK	Lynda.Blackadder@gov.scot
Shona Kinnear	Marine Scotland Science	Scotland, UK	Shona. Kinnear@gov.scot
John Turriff	Marine Scotland Science	Scotland, UK	John.Turriff@gov.scot
Peter Gibson	Marine Scotland Science	Scotland, UK	Peter.Gibson@gov.scot
Adrain Tait	Marine Scotland Science	Scotland, UK	Adrian,tait@gov.scot
Adam Delargy	Bangor University	Wales, UK	adam.delargy@bangor.ac.uk
Claire Szostek	Bangor University	Wales, UK	c.szostek@bangor.ac.uk
Carrie McMinn	AFBI	Northern Ireland, UK	Carrie.McMinn@afbini.gov.uk
Jim McArdle	AFBI	Northern Ireland, UK	James.McArdle@afbini.gov.uk
Eric Foucher	IFREMER	France	Eric.Foucher@ifremer.fr
Ellen Sofie Grefsrud	IMR	Norway	ellen.sofie.grefsrud@imr.no
Claire Lambden	Orkney Sustainable Fisheries	Scotland, UK.	c.lambden@orkneysustainablefisheries.co.uk
Matt Coleman	Orkney Sustainable Fsheries	Scotland, UK	matt@orkneysustainablefisheries.co.uk
David Rudders	Virginia Institute of Marine Science	USA	rudders@vims.edu
Roger Mann	Virginia Institute of Marine Science	USA	rmann@vims.edu
Isobel Bloor	Isle of Man	Isle of Man	i.bloor@bangor.ac.uk
Peter Duncan	Isle of Man	Isle of Man	peter.ducan@gov.im
Julia Wouters	Aberdeen University	Scotland, UK	j.wouters@abdn.ac.uk

Annex 2: WKSA Resolution

Workshop on Scallop Aging (WKSA), focusing on age reading of the king scallop (*Pecten maximus),* chaired by David Palmer, UK, and Karen Vanstaen, UK, will meet in Aberdeen, Scotland, UK, 9–13 March 2020 to:

a) Review and compare current scallop age reading methodologies (including quality assurance) and agree on best practice; (Science Plan codes: 3.1);

b) Develop, agree and write a standard procedure for use in future scallop exchanges; (Science Plan codes: 3.1);

c) Assess the potential use of SmartDots for king scallops; (Science Plan codes: 4.1, 4.4);

d) Start a reference collection of scallop shells with a consensual age; (Science Plan codes: 3.1);

e) Discuss the benefits of future exchanges or workshops; (Science Plan codes: 3.1).

WKSA will report by 1 May 2020 (via EPDSG) for the attention of WGScallop, WGBIOP and SCICOM.

Supporting information

Priority	WGScallop review and undertake scallop stock assessments and a number of institutes utilise age based models. It is fundamental to get reliable age readings in order to contribute to accurate assessments and the issues surrounding aging methodologies are considered to have a very high priority. A scallop exchange program was undertaken in 2018 but one of the main problems identified was the lack of common procedures and that the various laboratories involved were utilising different methodologies. The results of the exchange will be discussed at WGScallop 2019 it is expected that the percentage agreement between readers will be very low.
Scientific justification	The aim of the workshop is to identify the current aging problems between readers and standardize the age reading procedures in order to improve the accuracy and precision in the age reading of this species.
Resource requirements	No specific resource requirement beyond the need for members to prepare for and participate in the meeting.
Participants	In view of its relevance to the DCF, and ICES WG, the Workshop will try to join international experts on growth, age estimation and scientists involved in assessment in order to progress towards a solution. The workshop is expected to be attended by some 20–25 researchers from United Kingdom, France, Norway, Iceland and interest has been received from Canada and the United States. Participants should announce their intention to participate in the WK no later than two months before the meeting.
Secretariat facilities	Standard support
Financial	No financial implications.
Linkages to advisory committees	There are no obvious direct linkages with the advisory committees.
Linkages to other committees or groups	WGBIOP

Linkages to other organizations	There is a direct link with the EU DCF.

Annex 3: Image-based age reading method for SmartDots photographs

The ICES Scallop Assessment Working Group (WGScallop) undertook a scallop exchange programme in 2018. This took place over a number of months and the planning and logistics of the exchange were not easy to manage. The possible use of image-based age reading for king scallops was first discussed at WGScallop in 2019 and members agreed this was something they wanted to investigate further.

Marine Scotland Science (MSS) trialled a number of different camera set ups where photographs were taken using dry, wet or submerged scallops (including use of oils). Different colours of backgrounds, light sources (including back lit) and various types of flash were also investigated. The final set up is shown below (Figures 1 & 2) and was selected because the images were deemed to be the clearest and the set up was fairly simple and easily replicated.

Figure 1 & 2. Photographs of the camera set up used to take images of king scallops.

The scallop was wet with water and excess dried off to minimise glare. A single scallop was placed onto a black background with a ruler used as a scale bar. The camera was set to auto focus, with a macro lens, and held using a stand. Two lights were directed on to the shell and all room lights were switched off (inside a dark room). Images were saved to a USB and copied to shared drive. An example photograph is shown in Figure 3.

Figure 3. Example of king scallop photographs taken using the set up described in the text.

Annex 4: SmartDots Event feedback and Results

i) WKSA All readers

All samples included

Results from the initial trail on the use of SmartDots for age reading.

The weighted average percentage agreement based on modal ages for all readers is 47 %, with the weighted average CV of 38 % and APE of 26 %.

Table 1: Coefficient of Variation (CV) table presents the CV per modal age and reader, the CV of all readers combined per modal age and a weighted mean of the CV per reader. A rank is also assigned to each reader.

Modal age	R01 GB	R02 GB	R03 GB	R04 GB-SCT	R05 GB-SCT	R06 GB-NIR	R07 GB-SCT	R09 GB-SCT	R10 GB	R11 GB	R13 GB-SCT	R14 GB-SCT	R17 GB-SCT	all
4	-	-	47 %	9 %	-	13 %	11 %	-	-	-	-	-	0 %	**39 %**
5	-	0 %	12 %	17 %	-	0 %	11 %	0 %	-	-	-	0 %	27 %	**33 %**
6	-	-	-	11 %	-	0 %	20 %	-	-	-	-	-	33 %	**50 %**
7	-	0 %	20 %	7 %	-	17 %	10 %	0 %	-	-	-	-	11 %	**46 %**
8	0 %	0 %	16 %	13 %	-	5 %	13 %	12 %	-	8 %	0 %	10 %	16 %	**31 %**
9	-	-	-	-	-	-	-	-	-	-	-	-	-	**56 %**
Weighted Mean	**0 %**	**0 %**	**20 %**	**11 %**	**-**	**9 %**	**12 %**	**7 %**	**-**	**8 %**	**0 %**	**7 %**	**16 %**	**38 %**

The percentage agreement per reader per modal age tells how large part of the readings that are equal to the modal age. The weighted mean including at the bottom of the table is weighted according to number of age readings. A rank is also assigned to each reader.

Table 2: Percentage agreement (PA) table represents the PA per modal age and reader, the PA of all readers combined per modal age and a weighted mean of the PA per reader. A rank is also assigned to each reader.

Modal age	R01 GB	R02 GB	R03 GB	R04 GB-SCT	R05 GB-SCT	R06 GB-NIR	R07 GB-SCT	R09 GB-SCT	R10 GB	R11 GB	R13 GB-SCT	R14 GB-SCT	R17 GB-SCT	all
4	-	0 %	50 %	0 %	0 %	0 %	0 %	100 %	-	-	-	-	100 %	**29 %**
5	0 %	100 %	67 %	33 %	0 %	0 %	67 %	100 %	0 %	100 %	0 %	100 %	67 %	**52 %**
6	-	-	100 %	50 %	0 %	100 %	50 %	100 %	-	-	-	-	0 %	**50 %**
7	-	100 %	43 %	71 %	0 %	29 %	57 %	100 %	-	-	-	-	50 %	**47 %**
8	100 %	0 %	43 %	57 %	17 %	86 %	43 %	60 %	-	50 %	0 %	50 %	50 %	**48 %**
9	-	-	100 %	-	0 %	100 %	100 %	-	-	-	-	-	0 %	**60 %**
Weighted Mean	**67 %**	**50 %**	**52 %**	**52 %**	**5 %**	**52 %**	**50 %**	**82 %**	**0 %**	**67 %**	**0 %**	**67 %**	**50 %**	**47 %**

The relative bias is the difference between the mean age (per modal age per reader) and modal age. As for the previous tables, a combined bias for all readers and weighted means are calculated and finally a rank is assigned to each reader.

TABLE 3: RELATIVE BIAS TABLE REPRESENTS THE RELATIVE BIAS PER MODAL AGE PER READER, THE RELATIVE BIAS OF ALL READERS COMBINED PER MODAL AGE AND A WEIGHTED MEAN OF THE RELATIVE BIAS PER READER. A RANK IS ALSO ASSIGNED TO EACH READER.

Modal age	R01 GB	R02 GB	R03 GB	R04 GB-SCT	R05 GB-SCT	R06 GB-NIR	R07 GB-SCT	R09 GB-SCT	R10 GB	R11 GB	R13 GB-SCT	R14 GB-SCT	R17 GB-SCT	all
4	-	3.00	2.00	3.50	-1.00	1.50	2.50	0.00	-	-	-	-	0.00	-
5	1.00	0.00	-0.33	1.00	-2.67	1.00	0.33	0.00	1.00	0.00	1.00	0.00	-0.67	**0.13**
6	-	-	0.00	0.50	-6.00	0.00	1.00	0.00	-	-	-	-	0.50	-
7	-	0.00	0.00	0.29	-7.00	0.43	0.14	0.00	-	-	-	-	-0.17	-
8	0.00	-1.00	-1.00	0.43	-5.00	0.14	0.14	-0.60	-	0.50	1.00	0.00	0.17	-
9	-	-	0.00	-	-9.00	0.00	0.00	-	-	-	-	-	-1.00	-
Weighted Mean	**0.33**	**0.00**	**-0.19**	**0.76**	**-5.24**	**0.43**	**0.45**	**-0.27**	**1.00**	**0.33**	**1.00**	**0.00**	**-0.10**	**0.13**

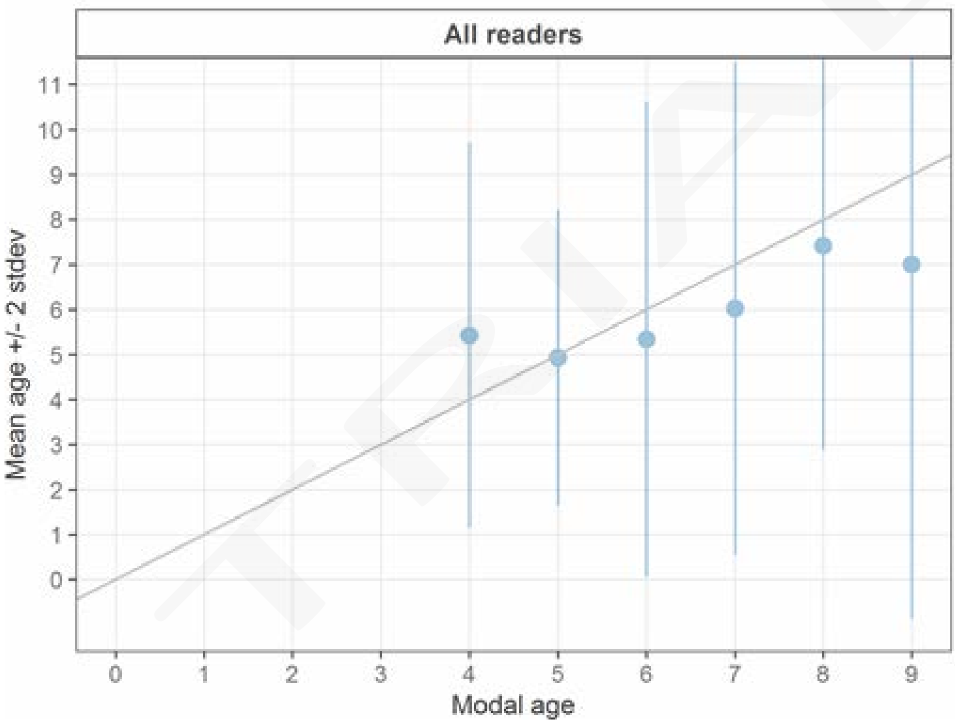


FIGURE 1: AGE BIAS PLOT FOR ALL READERS. MEAN AGE RECORDED +/- 2 STDEV OF EACH READER AND ALL READERS COMBINED ARE PLOTTED AGAINST MODAL AGE. THE ESTIMATED MAN AGE CORRESPONDS TO MODAL AGE, IF THE ESTIMATED MEAN AGE IS ON THE 1:1 EQUILIBRIUM LINE (SOLID LINE). RELATIVE BIAS IS THE AGE DIFFERENCE BETWEEN ESTIMATED MEAN AGE AND MODAL AGE.

For each pair that is being compared, the differences between the readings per image are found and the frequency of each occurring difference is obtained. A rank value is calculated for the positive and the negative differences (R+ and R- in the Guus Eltink sheet). The value with the smallest rank is then used to calculate a z-value that determines the level of bias (not clear from Guus Eltink sheet how the equations are defined.).

TABLE 4: INTER READER BIAS TEST. THE INTER-READER BIAS TEST GIVES PROBABILITY OF BIAS BETWEEN READERS AND WITH MODAL AGE. - = NO SIGN OF BIAS (P>0.05), * = POSSIBILITY OF BIAS (0.01<P<0.05), * * = CERTAINTY OF BIAS (P<0.01)

Comparison	R01 GB	R02 GB	R03 GB	R04 GB-SCT	R05 GB-SCT	R06 GB-NIR	R07 GB-SCT	R09 GB-SCT	R10 GB	R11 GB	R13 GB-SCT	R14 GB-SCT	R17 GB-SCT
R01 GB	-	-	-	-	-	-	-	-	-	-	-	-	-
R02 GB	-	-	-	*	-	-	-	-	-	-	-	-	-
R03 GB	-	-	-	**	**	*	-	-	-	-	-	-	-
R04 GB-SCT	-	*	**	-	**	-	-	*	-	-	-	*	-
R05 GB-SCT	-	-	**	**	-	**	**	-	-	-	-	-	**
R06 GB-NIR	-	-	*	-	**	-	-	*	-	-	-	-	-
R07 GB-SCT	-	-	-	-	**	-	-	-	-	-	-	-	-
R09 GB-SCT	-	-	-	*	-	*	-	-	-	-	-	-	-
R10 GB	-	-	-	-	-	-	-	-	-	-	-	-	-
R11 GB	-	-	-	-	-	-	-	-	-	-	-	-	-
R13 GB-SCT	-	-	-	-	-	-	-	-	-	-	-	-	-
R14 GB-SCT	-	-	-	*	-	-	-	-	-	-	-	-	-
R17 GB-SCT	-	-	-	-	**	-	-	-	-	-	-	-	-
Modal age	-	-	-	*	**	-	-	-	-	-	-	-	-

Results by strata

TABLE 5: NUMBER OF AGE READINGS PER STRATA FOR ALL READERS.

Modal age	27.4.a	total
4	14	**14**
5	27	**27**
6	12	**12**
7	45	**45**
8	58	**58**
9	5	**5**
Total	**161**	**161**

TABLE 6: CV PER STRATA.

Modal age	27.4.a	all
4	39 %	**39 %**
5	33 %	**33 %**
6	50 %	**50 %**
7	46 %	**46 %**
8	31 %	**31 %**
9	56 %	**56 %**
Weighted Mean	**38 %**	**38 %**

TABLE 7: PERCENTAGE AGREEMENT PER STRATA.

Modal age	27.4.a	all
4	29 %	**29 %**
5	52 %	**52 %**
6	50 %	**50 %**
7	47 %	**47 %**
8	48 %	**48 %**
9	60 %	**60 %**

Weighted Mean	**47 %**	**47 %**

TABLE 8: RELATIVE BIAS PER STRATA.

Modal age	27.4.a	all
4	1.43	**1.43**
5	-0.07	**-0.07**
6	-0.67	**-0.67**
7	-0.98	**-0.98**
8	-0.59	**-0.59**
9	-2.00	**-2.00**
Weighted Mean	**-0.48**	**-0.48**

ii) Advanced readers

All samples included

TABLE 9: COEFFICIENT OF VARIATION (CV) TABLE PRESENTS THE CV PER MODAL AGE AND ADVANCED READER, THE CV OF ALL ADVANCED READERS COMBINED PER MODAL AGE AND A WEIGHTED MEAN OF THE CV PER READER. A RANK IS ALSO ASSIGNED TO EACH READER.

Modal age	R01 GB	R02 GB	R03 GB	R04 GB-SCT	R05 GB-SCT	R06 GB-NIR	R07 GB-SCT	R09 GB-SCT	R10 GB	R11 GB	all
0	-	-	-	-	-	-	-	-	-	-	**-**
1	-	-	-	-	-	-	-	-	-	-	**-**
2	-	-	-	-	-	-	-	-	-	-	**-**
3	-	-	-	-	-	-	-	-	-	-	**-**
4	-	-	-	-	-	-	-	-	-	-	**-**
5	-	0 %	12 %	17 %	-	0 %	11 %	0 %	-	-	**36 %**
6	-	-	20 %	14 %	-	10 %	17 %	28 %	-	-	**42 %**
7	-	0 %	24 %	13 %	-	17 %	9 %	9 %	-	-	**47 %**
8	0 %	0 %	12 %	11 %	-	5 %	11 %	6 %	-	8 %	**33 %**
9	-	-	-	-	-	-	-	-	-	-	**67 %**
Weighted Mean	**0 %**	**0 %**	**18 %**	**13 %**	**-**	**11 %**	**11 %**	**10 %**	**-**	**8 %**	**41 %**

TABLE 10: PERCENTAGE AGREEMENT (PA) TABLE REPRESENTS THE PA PER MODAL AGE AND READER, ADVANCED THE PA OF ALL ADVANCED READERS COMBINED PER MODAL AGE AND A WEIGHTED MEAN OF THE PA PER READER. A RANK IS ALSO ASSIGNED TO EACH READER.

Modal age	R01 GB	R02 GB	R03 GB	R04 GB-SCT	R05 GB-SCT	R06 GB-NIR	R07 GB-SCT	R09 GB-SCT	R10 GB	R11 GB	all
0	-	-	0 %	0 %	100 %	0 %	0 %	-	-	-	**20 %**
1	-	-	-	-	-	-	-	-	-	-	**-**
2	-	-	-	-	-	-	-	-	-	-	**-**
3	-	-	-	-	-	-	-	-	-	-	**-**
4	-	-	-	-	-	-	-	-	-	-	**-**
5	0 %	100 %	67 %	33 %	0 %	0 %	67 %	100 %	0 %	100 %	**48 %**
6	-	0 %	50 %	33 %	33 %	67 %	67 %	50 %	-	-	**47 %**
7	-	100 %	44 %	67 %	0 %	22 %	56 %	67 %	-	-	**44 %**
8	100 %	0 %	60 %	80 %	20 %	80 %	40 %	75 %	-	50 %	**57 %**

9	-	-	100 %	-	0 %	100 %	100 %	-	-	-	**75 %**
Weighted Mean	**67 %**	**62 %**	**52 %**	**57 %**	**14 %**	**43 %**	**55 %**	**73 %**	**0 %**	**67 %**	**48 %**

Table 11: Relative bias table represents the relative bias per modal age and advanced reader, the relative bias of all advanced readers combined per modal age and a weighted mean of the relative bias per reader. A rank is also assigned to each reader.

Modal age	R01 GB	R02 GB	R03 GB	R04 GB-SCT	R05 GB-SCT	R06 GB-NIR	R07 GB-SCT	R09 GB-SCT	R10 GB	R11 GB	all
0	-	-	5.00	7.00	0.00	8.00	10.00	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-
5	1.00	0.00	-0.33	1.00	-2.67	1.00	0.33	0.00	1.00	0.00	**0.13**
6	-	1.00	1.00	1.00	-4.00	-0.33	0.67	-1.00	-	-	-
7	-	0.00	-0.33	0.56	-7.00	0.33	0.22	-0.33	-	-	-
8	0.00	-1.00	-0.60	0.40	-4.40	0.20	-0.20	-0.25	-	0.50	-
9	-	-	0.00	-	-9.00	0.00	0.00	-	-	-	-
Weighted Mean	**0.33**	**-0.12**	**0.00**	**0.95**	**-5.10**	**0.62**	**0.64**	**-0.36**	**1.00**	**0.33**	**0.13**

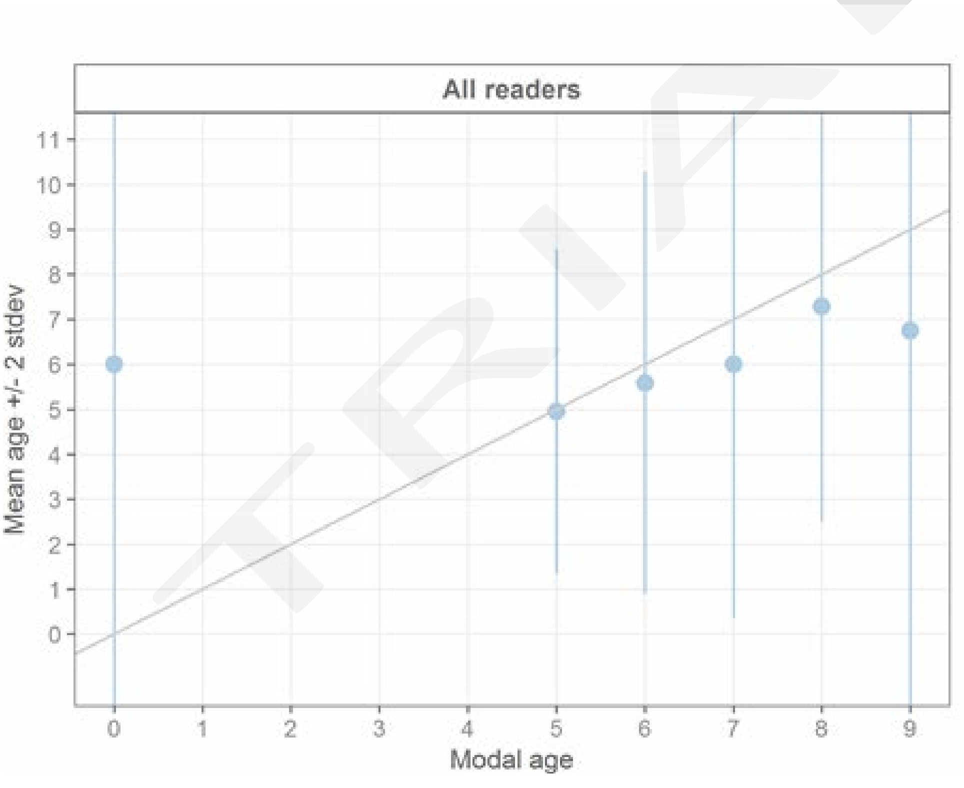


Figure 2: Age bias plot for advanced readers.

Table 12: Age error matrix (AEM) for 27.4.a. The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases. Only advanced readers are used for calculating the AEM.

strata	Modal age	0	5	6	7	8	9
27.4.a	Age 0	0.2	0.09524	0.11765	0.16	0.08571	0.25
27.4.a	Age 4	-	0.04762	0.05882	0.04	-	-
27.4.a	Age 5	0.2	0.47619	0.05882	0.02	-	-
27.4.a	Age 6	-	0.28571	0.47059	0.06	0.02857	-

27.4.a	Age 7	0.2	0.09524	0.11765	0.44	0.17143	-
27.4.a	Age 8	0.2	-	0.17647	0.24	0.57143	-
27.4.a	Age 9	-	-	-	0.02	0.08571	0.75
27.4.a	Age 10	0.2	-	-	0.02	0.05714	-

Results by strata

TABLE 13: NUMBER OF AGE READINGS PER STRATA FOR ALL READERS.

Modal age	27.4.a	total
0	5	**5**
1	0	**0**
2	0	**0**
3	0	**0**
4	0	**0**
5	21	**21**
6	17	**17**
7	50	**50**
8	35	**35**
9	4	**4**
Total	**132**	**132**

TABLE 14: CV PER STRATA.

Modal age	27.4.a	all
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	36 %	**36 %**
6	42 %	**42 %**
7	47 %	**47 %**
8	33 %	**33 %**
9	67 %	**67 %**
Weighted Mean	**41 %**	**41 %**

TABLE 15: PERCENTAGE AGREEMENT AND RELATIVE BIAS PER STRATA.

	% Agreement per strata		Relative Bias per strata	
Modal age	**27.4.a**	**all**	**27.4.a**	**all**
0	20 %	**20 %**	6.00	**6.00**
1	-	-	-	-
2	-	-	-	-
3	-	-	-	-
4	-	-	-	-
5	48 %	**48 %**	-0.05	**-0.05**
6	47 %	**47 %**	-0.41	**-0.41**
7	44 %	**44 %**	-1.00	**-1.00**
8	57 %	**57 %**	-0.71	**-0.71**
9	75 %	**75 %**	-2.25	**-2.25**
Weighted Mean	**48 %**	**48 %**	**-0.47**	**-0.47**

Results all readers

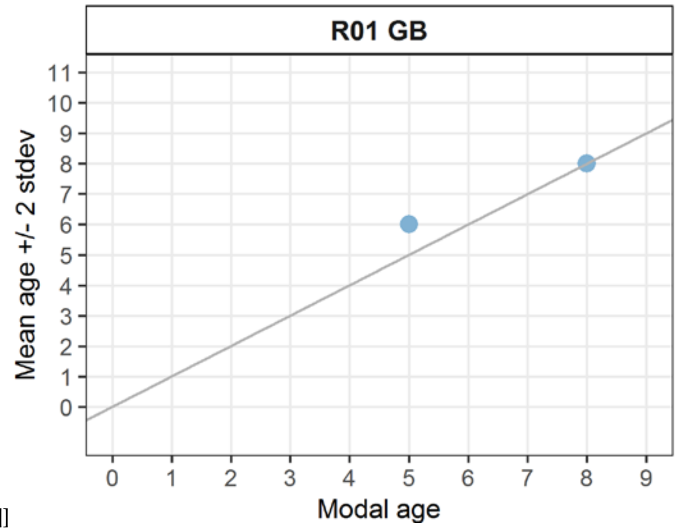
Data Overview

Table X: Summary of statistics; PA (%), CV (%) and APE (%).

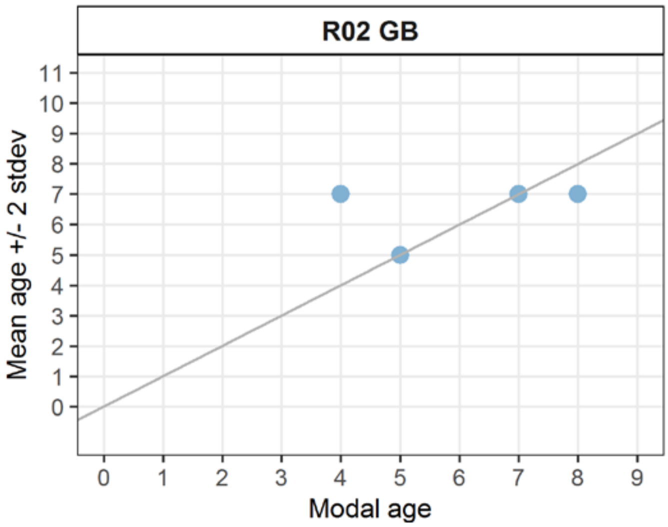
CV	PA	APE
38 %	47 %	26 %

Table X: Data overview including modal age and statistics per sample.

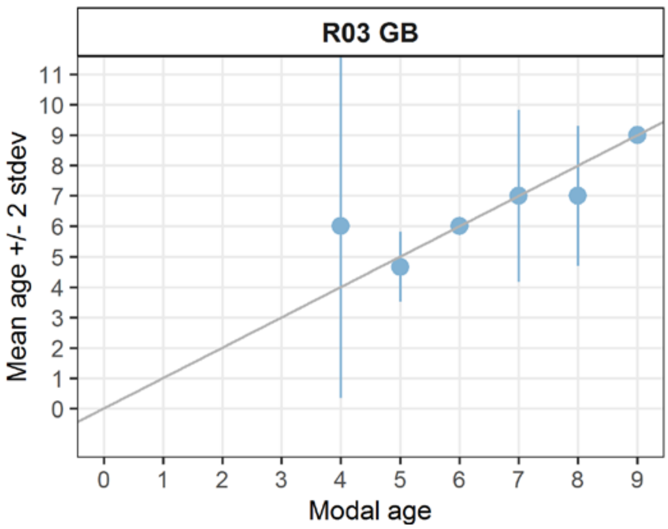
Fish ID	Event ID	Image ID	length	sex	Catch date	ICES area	R01GB	R02GB	R03GB	R04GB-SCT	R05GB-SCT	R06GB-NIR	R07GB-SCT	R09GB-SCT	R10GB	R11GB	R13GB-SCT	R14GB-SCT	R17GB-SCT	Modal age	PA %	CV %	APE %
1	272	-	999	-	01/01/2001 00:00:00	27.4.a	8	7	8	8	10	8	8	8	-	8	9	8	-	8	73	9	6
2	272	-	999	-	01/01/2001 00:00:00	27.4.a	8	7	6	8	8	8	7	7	-	9	9	7	8	8	42	12	9
3	272	-	999	-	01/01/2001 00:00:00	27.4.a	6	5	5	7	7	-	6	5	6	5	6	5	3	5	42	20	15
4	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	5	4	6	0	6	5	5	-	-	-	5	5	5	56	40	25
5	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	8	10	0	8	7	8	-	-	-	9	6	8	38	44	29
6	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	7	8	0	7	8	-	-	-	-	-	7	7	50	50	33
7	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	5	7	0	8	10	-	-	-	-	-	8	8	33	55	40
8	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	4	7	0	5	7	-	-	-	-	-	8	7	33	57	42
9	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	7	8	0	7	7	-	-	-	-	-	7	7	67	49	33
10	272	-	999	-	01/01/2001	27.4.a	-	-	4	7	0	6	7	-	-	-	-	-	4	4	33	57	43


R01 GB
Mean age +/- 2 stdev
Modal age

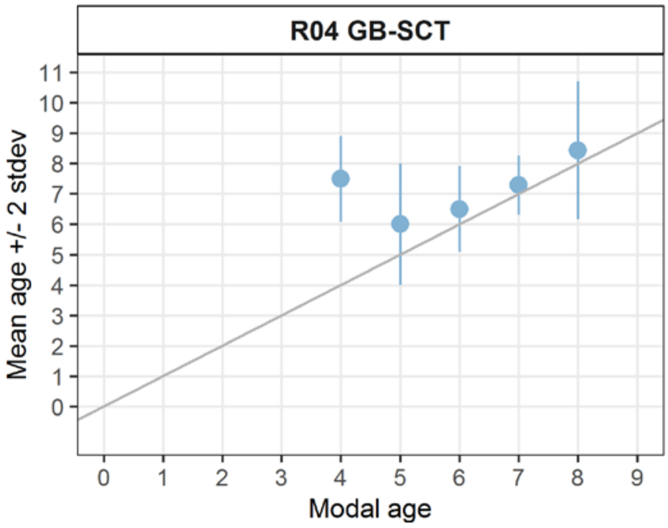
[[1]] [[2]]


R02 GB
Mean age +/- 2 stdev
Modal age

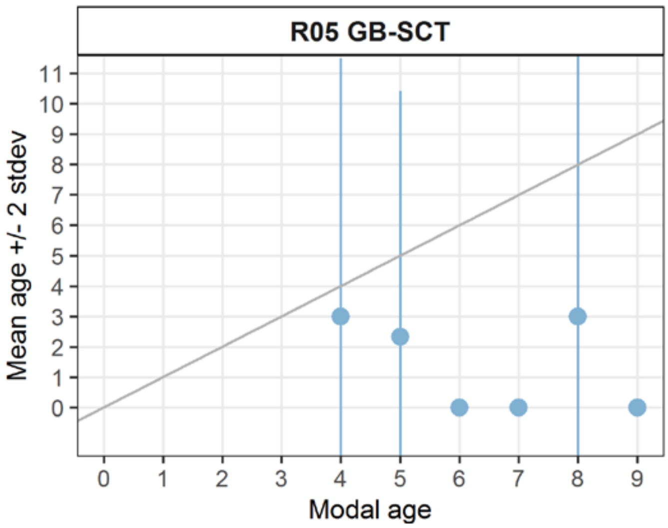
[[3]]


R03 GB
Mean age +/- 2 stdev
Modal age

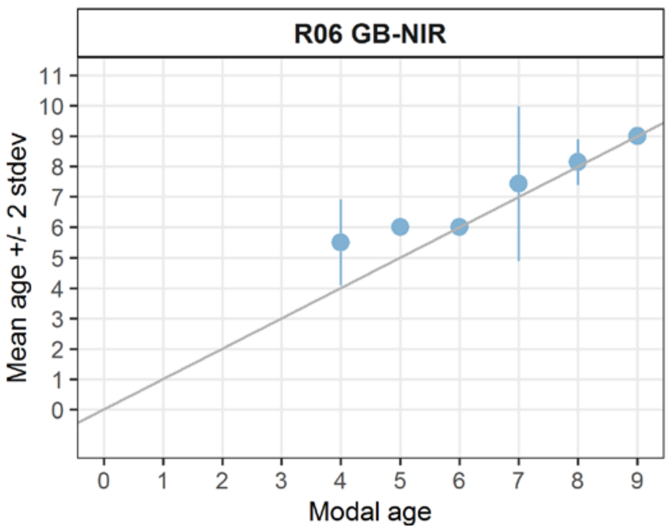
[[4]]


R04 GB-SCT
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

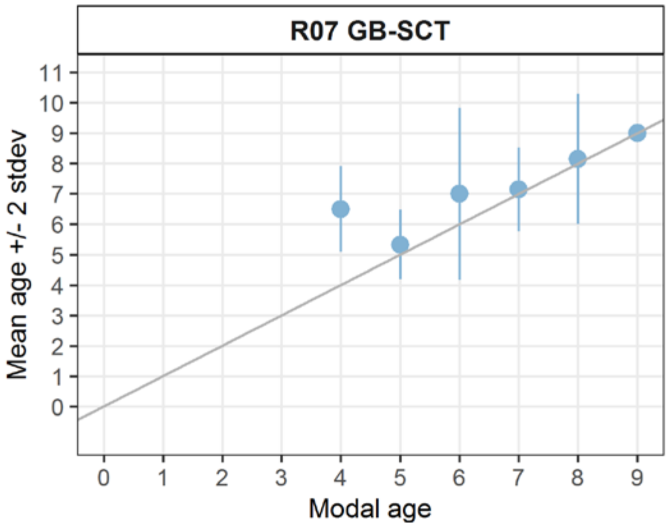
[[5]]


R05 GB-SCT
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

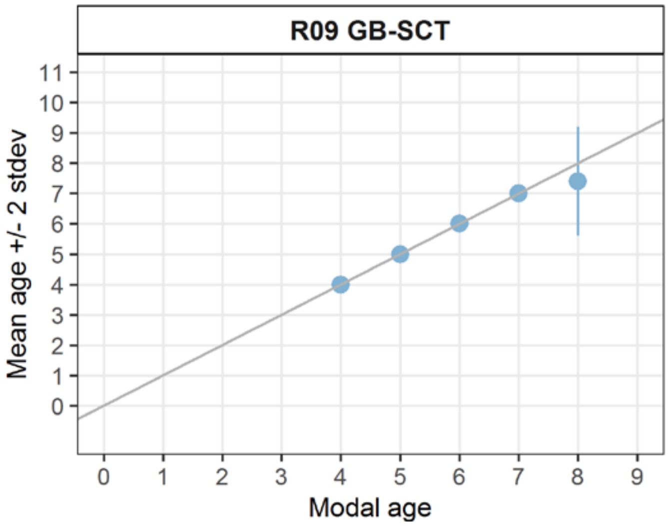
[[6]]


R06 GB-NIR
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

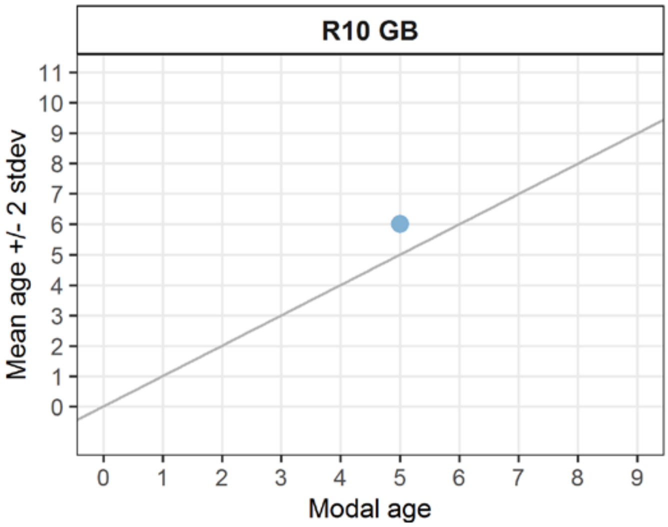
[[7]]


R07 GB-SCT
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

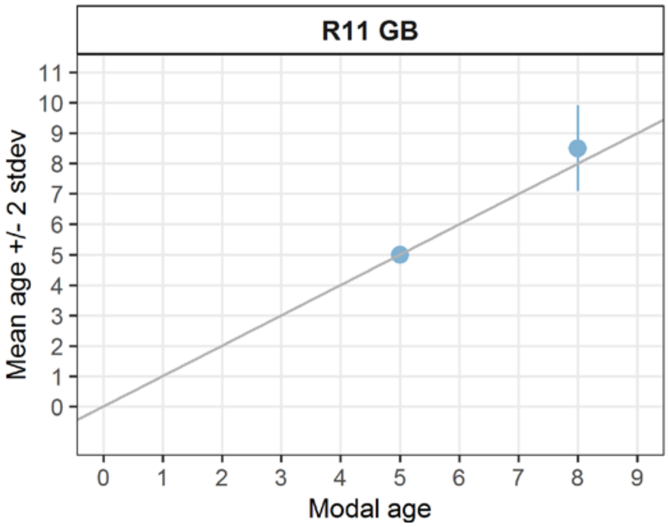
[[8]]


R09 GB-SCT
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

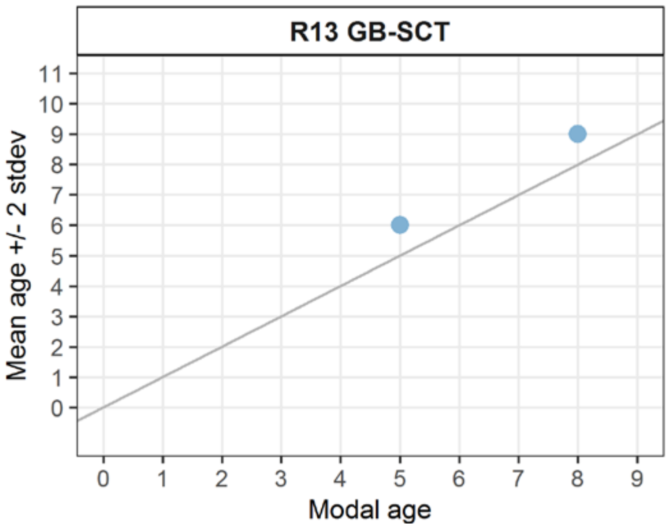
[[9]]


R10 GB
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

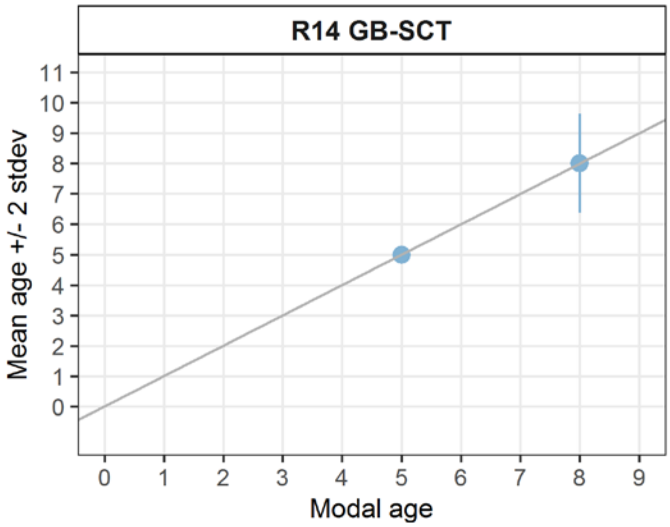
[[10]]


R11 GB
Mean age +/- 2 stdev
0
1
2
3
4
5
6
7
8
9
10
11
Modal age
0
1
2
3
4
5
6
7
8
9

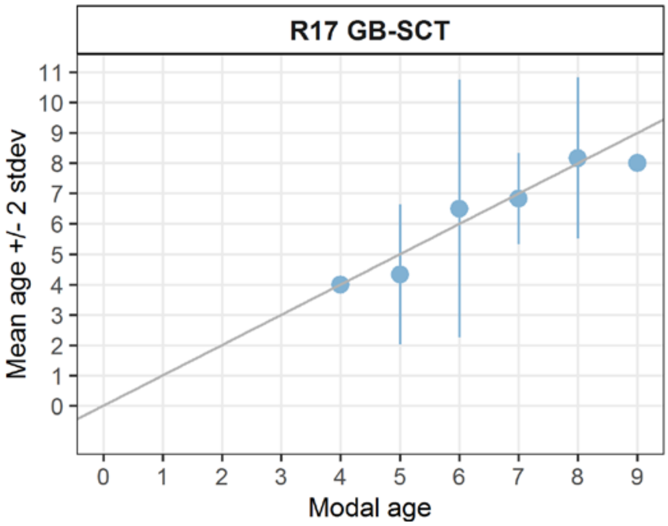
[[11]]


R13 GB-SCT
Mean age +/- 2 stdev
0
1
2
3
4
5
6
7
8
9
10
11
Modal age
0
1
2
3
4
5
6
7
8
9

[[12]]


R14 GB-SCT
Mean age +/- 2 stdev
Modal age
0 1 2 3 4 5 6 7 8 9
0 1 2 3 4 5 6 7 8 9 10 11

[[13]]


R17 GB-SCT
Mean age +/- 2 stdev
Modal age
0 1 2 3 4 5 6 7 8 9
0 1 2 3 4 5 6 7 8 9 10 11

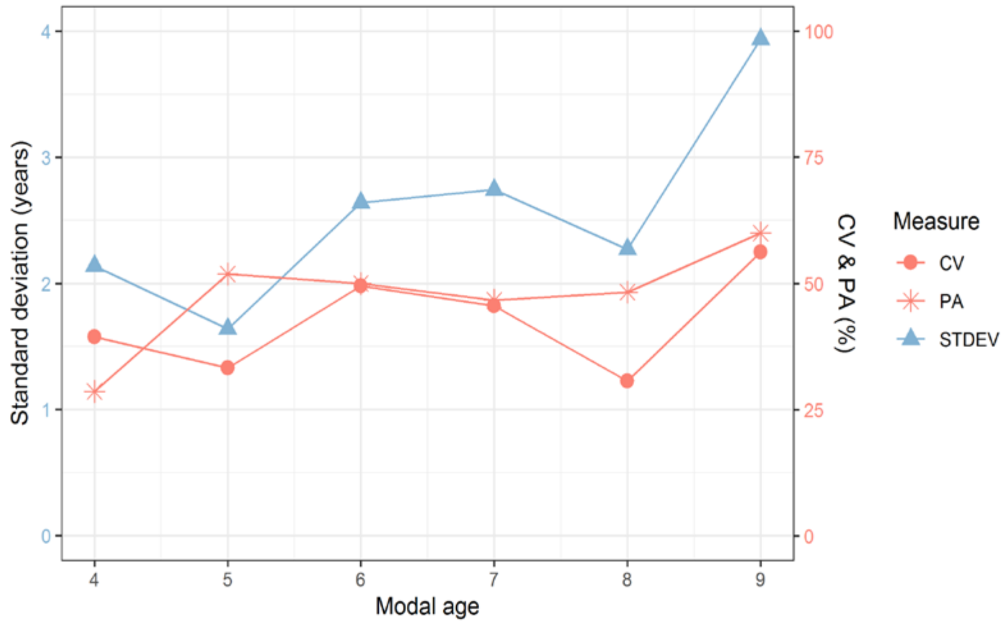


Figure 3: CV, PA and (STDEV (standard deviation) are plotted against modal age.

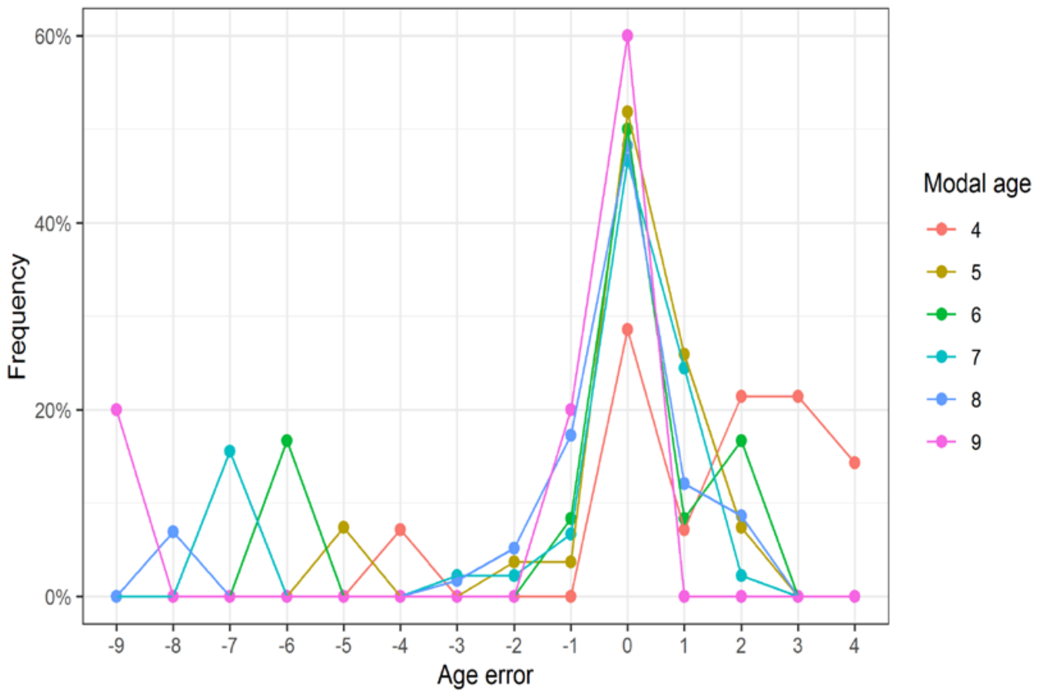


Figure 4: The distribution of the age reading errors in percentage by modal age as observed from the whole group of age readers in an age reading comparison to modal age. The achieved precision in age reading by MODAL age group is shown by the spread of the age readings errors. There appears to be no relative bias if the age reading errors are normally distributed. The distributions are skewed if relative bias occurs.

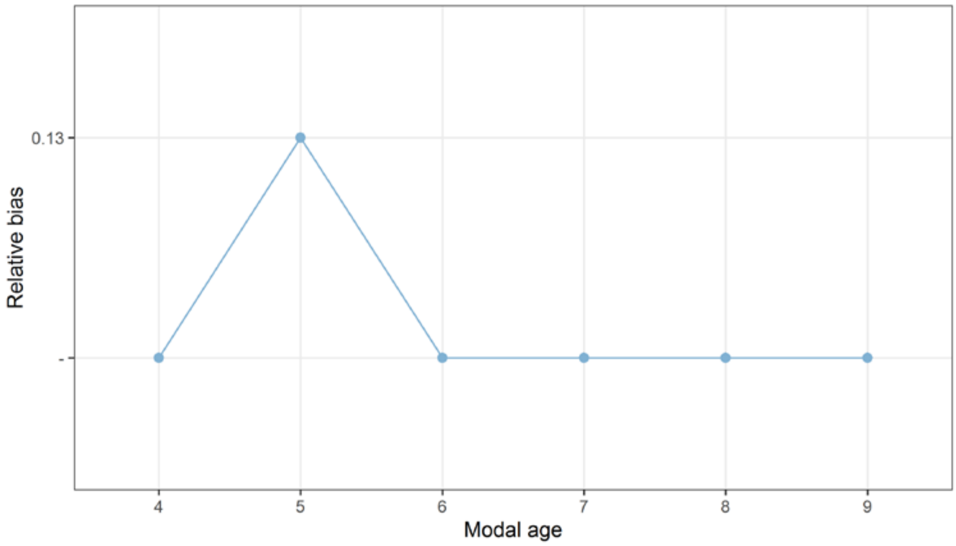


Figure 5: The relative bias by modal age as estimated by all age readers combined.

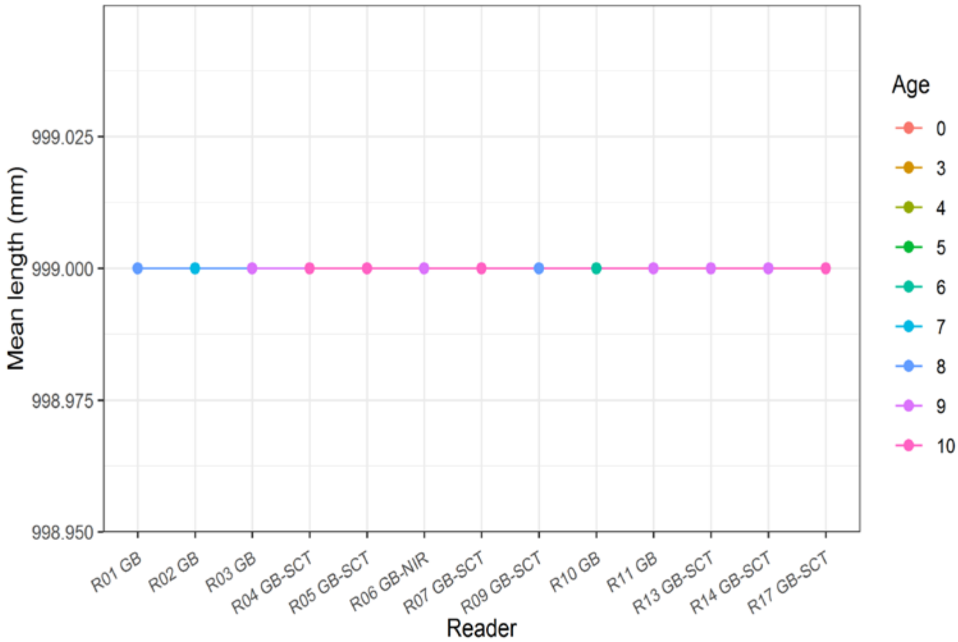


Figure 6: The mean length at age as estimated by each age reader.

Results Advanced readers

All samples included

Data Overview

Table 16: Data overview including modal age and statistics per sample.

Fish ID	Event ID	Image ID	length	sex	Catch date	ICES area	R01GB	R02GB	R03GB	R04GB-SCT	R05GB-SCT	R06GB-NIR	R07GB-SCT	R09GB-SCT	R10GB	R11GB	Modal age	PA %	CV %	APE %
1	272	-	999	-	01/01/2001 00:00:00	27.4.a	8	7	8	8	10	8	8	8	-	8	8	78	10	5
2	272	-	999	-	01/01/2001 00:00:00	27.4.a	8	7	6	8	8	8	7	7	-	9	8	44	12	9
3	272	-	999	-	01/01/2001 00:00:00	27.4.a	6	5	5	7	7	-	6	5	6	5	5	44	14	12
4	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	5	4	6	0	6	5	5	-	-	5	43	47	31
5	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	8	10	0	8	7	8	-	-	8	50	51	33
6	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	7	8	0	7	8	-	-	-	7	40	57	40
7	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	5	7	0	8	10	-	-	-	0	20	-	-
8	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	4	7	0	5	7	-	-	-	7	40	63	45
9	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	7	8	0	7	7	-	-	-	7	60	56	40
10	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	4	7	0	6	7	-	-	-	7	40	61	47
11	272	-	999	-	01/01/2001	27.4.a	-	-	8	7	0	8	7	-	-	-	7	40	57	40

					00:00:00															
12	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	8	8	0	8	9	-	-	-	8	60	56	40
13	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	6	6	0	6	8	-	-	-	6	60	58	40
14	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	9	-	0	9	9	-	-	-	9	75	67	50
15	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	7	8	0	9	8	8	-	-	8	50	50	33
16	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	5	5	0	6	5	-	-	-	5	60	57	40
17	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	8	7	0	9	7	7	-	-	7	50	51	33
18	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	7	7	7	0	8	8	7	-	-	7	57	45	29
19	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	-	-	7	0	6	6	6	-	-	6	60	57	40
20	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	7	8	7	0	8	6	-	-	-	7	33	51	33
21	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	7	8	8	6	5	6	4	-	-	6	29	24	19
22	272	-	999	-	01/01/2001 00:00:00	27.4.a	-	7	7	10	-	8	8	6	-	-	7	33	18	13

Table 17: Number of age readings table gives an overview of number of readings per reader and modal age. The total numbers of readings per reader and per modal age are summarized at the end of the table.

Modal age	R01 GB	R02 GB	R03 GB	R04 GB-SCT	R05 GB-SCT	R06 GB-NIR	R07 GB-SCT	R09 GB-SCT	R10 GB	R11 GB	total
0	0	0	1	1	1	1	1	0	0	0	**5**
1	0	0	0	0	0	0	0	0	0	0	**0**
2	0	0	0	0	0	0	0	0	0	0	**0**
3	0	0	0	0	0	0	0	0	0	0	**0**
4	0	0	0	0	0	0	0	0	0	0	**0**
5	1	2	3	3	3	2	3	2	1	1	**21**
6	0	1	2	3	3	3	3	2	0	0	**17**
7	0	3	9	9	8	9	9	3	0	0	**50**
8	2	2	5	5	5	5	5	4	0	2	**35**

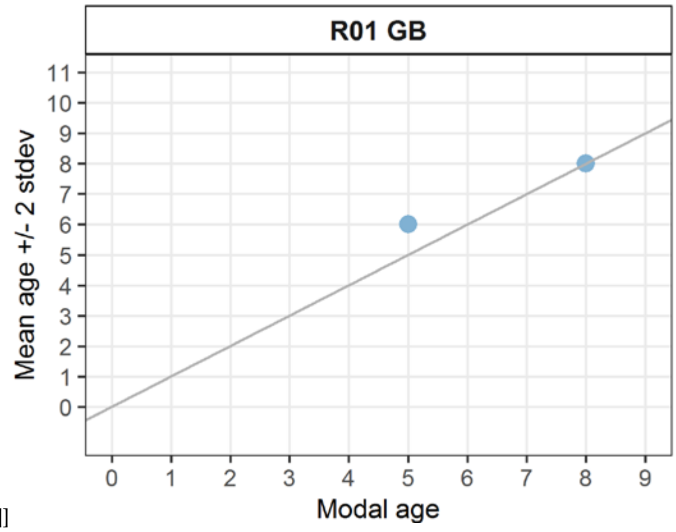
9	0	0	1	0	1	1	1	0	0	0	**4**
Total	**3**	**8**	**21**	**21**	**21**	**21**	**22**	**11**	**1**	**3**	**132**

Table 18: Age composition by reader gives a summary of number of readings per reader.

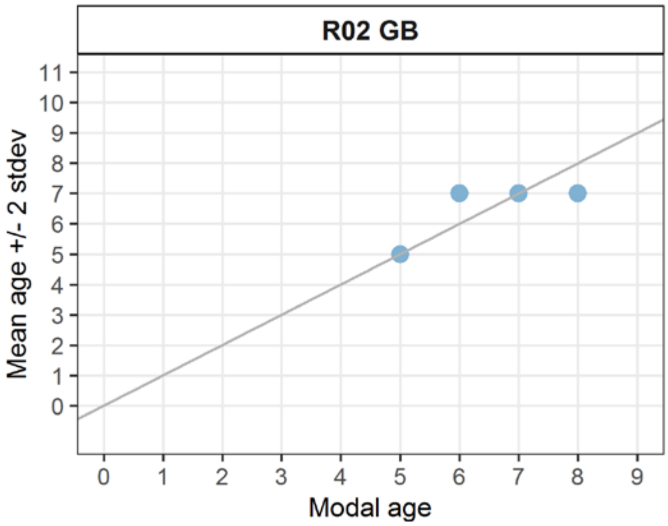
Modal age	R01 GB	R02 GB	R03 GB	R04 GB-SCT	R05 GB-SCT	R06 GB-NIR	R07 GB-SCT	R09 GB-SCT	R10 GB	R11 GB
0	0	0	0	0	17	0	0	0	0	**0**
4	0	0	3	0	0	0	0	1	0	**0**
5	0	2	3	1	0	2	2	2	0	**1**
6	1	0	2	2	1	5	4	2	1	**0**
7	0	6	5	9	1	2	7	3	0	**0**
8	2	0	7	7	1	9	6	3	0	**1**
9	0	0	1	0	0	3	2	0	0	**1**
10	0	0	0	2	1	0	1	0	0	**0**
Total	**3**	**8**	**21**	**21**	**21**	**21**	**22**	**11**	**1**	**3**

Table 19: Mean length at age per reader is calculated per reader and age (not modal age) and for all readers combined per age. A weighted mean is also given.

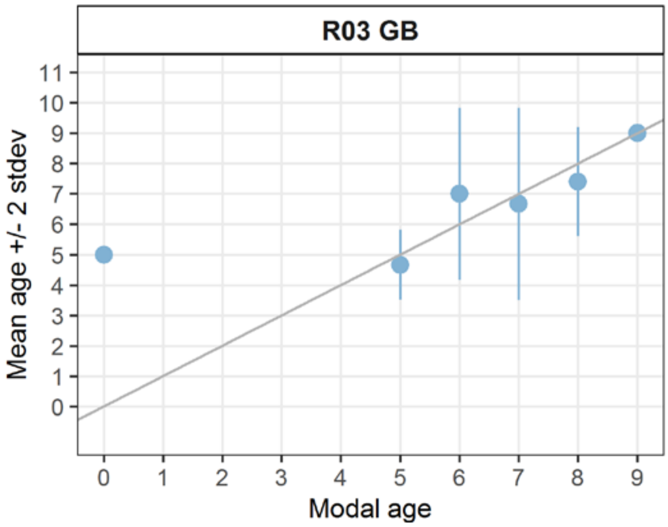
Age	R01 GB	R02 GB	R03 GB	R04 GB-SCT	R05 GB-SCT	R06 GB-NIR	R07 GB-SCT	R09 GB-SCT	R10 GB	R11 GB
0	-	-	-	-	999 mm	-	-	-	-	-
4	-	-	999 mm	-	-	-	-	999 mm	-	-
5	-	999 mm	999 mm	999 mm	-	999 mm	999 mm	999 mm	-	**999 mm**
6	999 mm	-	999 mm	999 mm	999 mm	999 mm	999 mm	999 mm	999 mm	-
7	-	999 mm	999 mm	999 mm	999 mm	999 mm	999 mm	999 mm	-	-
8	999 mm	-	999 mm	999 mm	999 mm	999 mm	999 mm	999 mm	-	**999 mm**
9	-	-	999 mm	-	-	999 mm	999 mm	-	-	**999 mm**
10	-	-	-	999 mm	999 mm	-	999 mm	-	-	-
Weighted Mean	**999 mm**	**999 mm**	**999 mm**	**999 mm**	**999 mm**	**999 mm**	**999 mm**	**999 mm**	**999 mm**	**999 mm**


R01 GB
Mean age +/- 2 stdev
Modal age
0 1 2 3 4 5 6 7 8 9 10 11

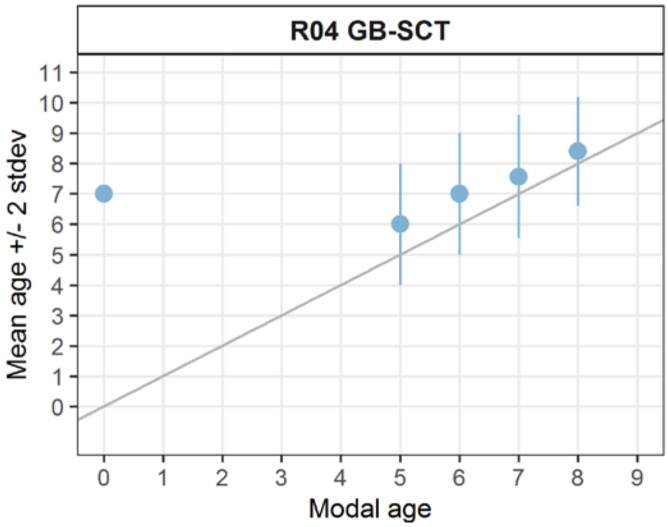
[[1]] [[2]]


R02 GB
Mean age +/- 2 stdev
Modal age
0 1 2 3 4 5 6 7 8 9 10 11

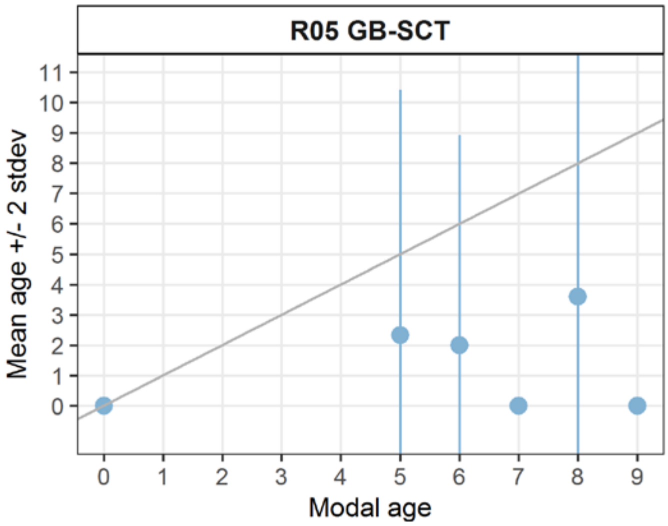
[[3]]


R03 GB
Mean age +/- 2 stdev
Modal age
0 1 2 3 4 5 6 7 8 9 10 11

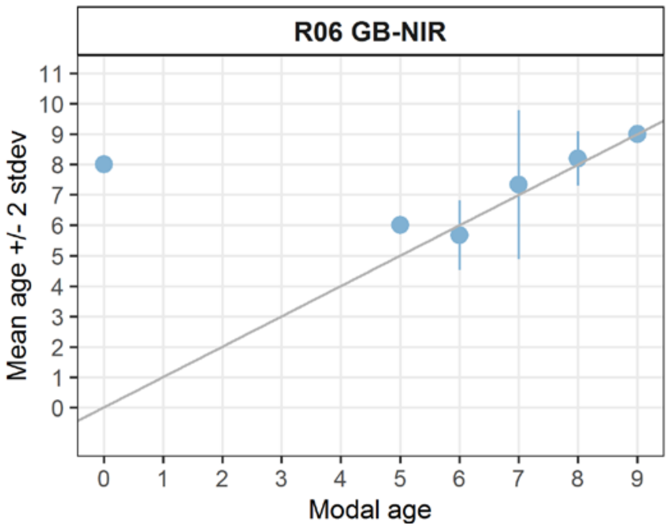
[[4]]


R04 GB-SCT
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

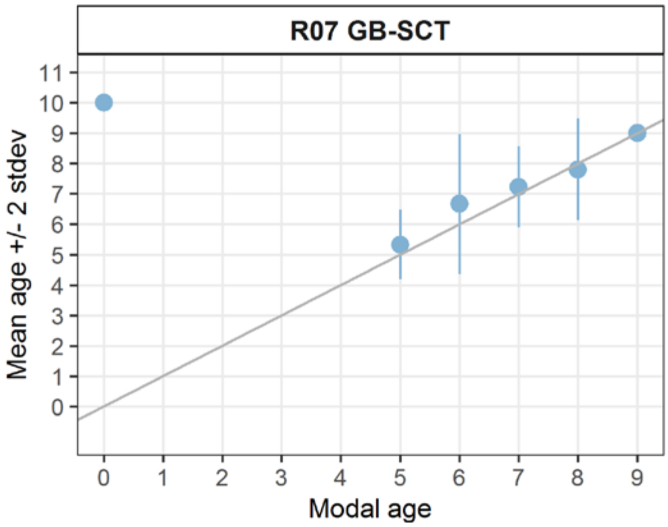
[[5]]


R05 GB-SCT
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

[[6]]

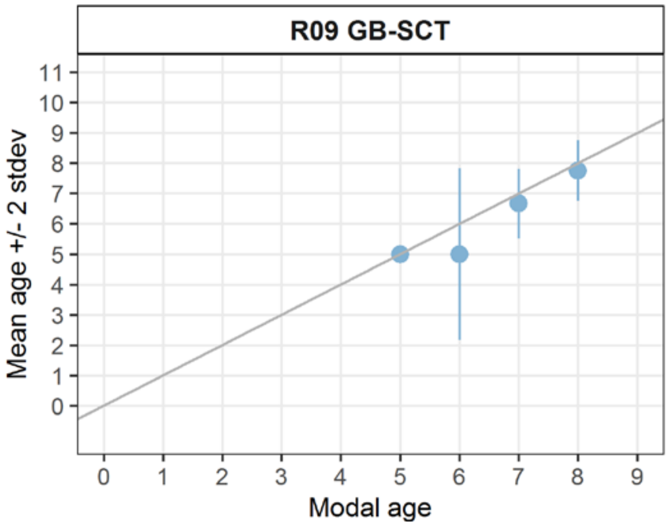

R06 GB-NIR
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

[[7]]



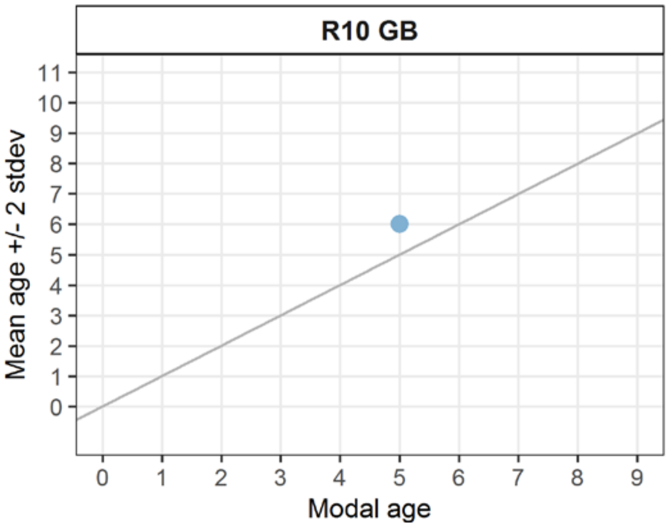
R07 GB-SCT
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

[[8]]

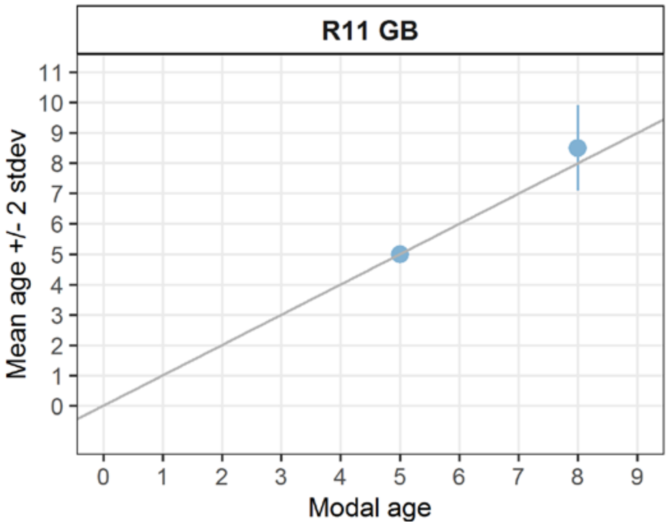


R09 GB-SCT
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

[[9]]


R10 GB
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

[[10]]


R11 GB
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8
9
10
11

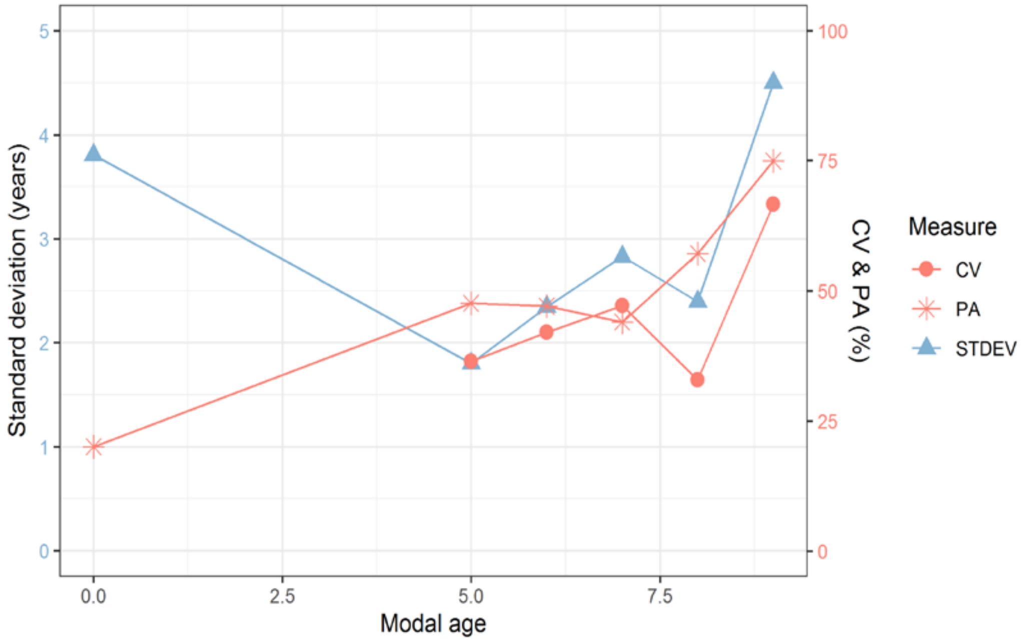


Figure 7: CV, PA and (STDEV (standard deviation) are plotted against modal age

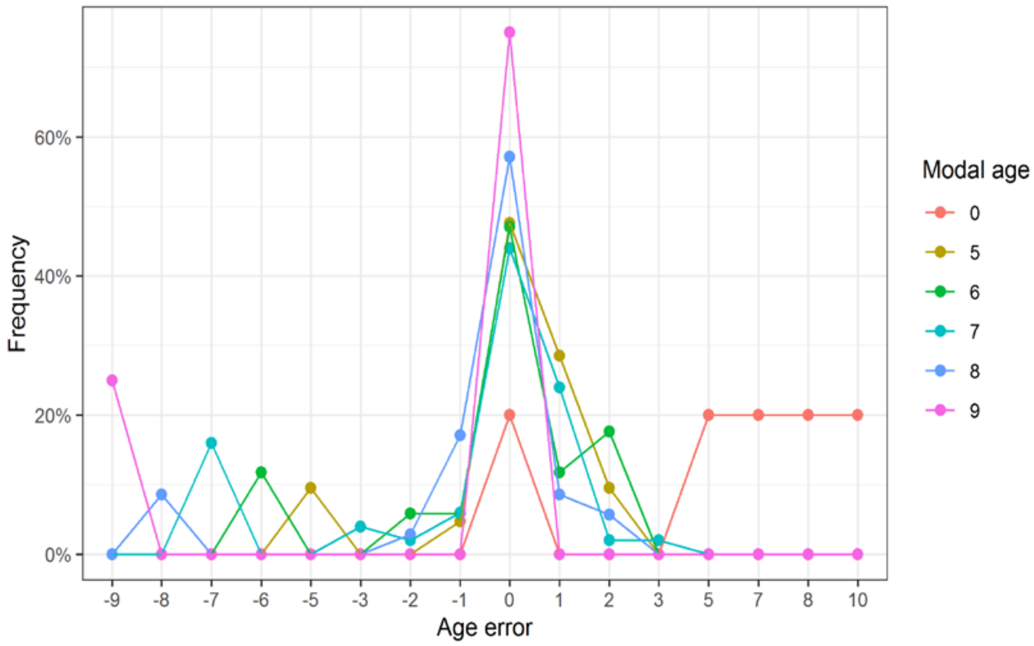


Figure 8: The distribution of the age reading errors in percentage by modal age as observed from the whole group of age readers in an age reading comparison to modal age. The achieved precision in age reading by MODAL age group is shown by the spread of the age readings errors. There appears to be no relative bias if the age reading errors are normally distributed. The distributions are skewed if relative bias occurs.

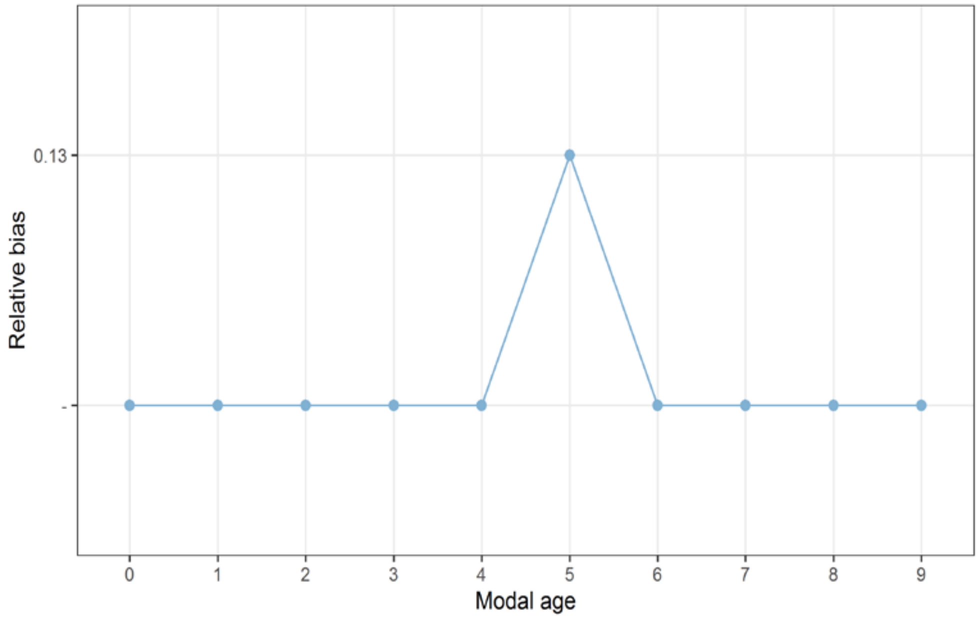


Figure 9: The relative bias by modal age as estimated by all age readers combined.

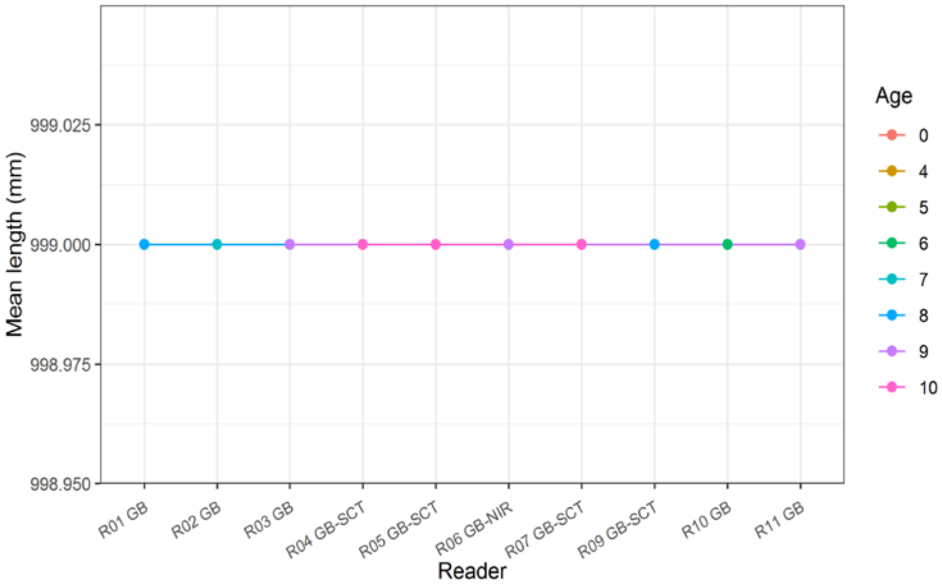


Figure 10: The mean length at age as estimated by each age reader.

SmartDots FEEDBACK

Feedback for WGBIOP on Smartdots trial for scallop shells:

- Software stopped working and recording when used by multiple users at the same session.
- Login and start-up procedures are convoluted and not streamlined.
- Issues with some firewalls for installation.
- The set of photographs in SmartDots would still need to be accompanied by the physical shells. This is because a) the photographs are not high enough definition and b) we are aging shells rather than photos in practice and so it makes sense to continue with this methodology for standardising but with the additional benefit that smart dots provides in being able to electronically record and report the results.
- The utility and resource has potential, however access is not one click and multiple technical issues prevented it working at the workshop when accessed by multiple users.
- SmartDots was a potentially useful tool for recording the results of standardised aging of reference shell datasets.

I did miss holding the shell in my hand and feeling it, I often think you can feel differences. With Smartdots I was getting more distracted by changes in colour which may not necessarily be due to a change in growth. I also found it very difficult to see the edge of the shell where there may be several rings almost on top of each other on older shells. I think confidence would increase with a bigger sample size and I can see the benefits. I think it should still remain an option.