Workshop on Age Reading of Greenland Halibut

Vigo, Spain,
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Chairs: Ole Thomas Albert and Margaret Treble
A scientists meeting, not age reading comparisons

- Focus on **Validation**: That the ageing method on average provide **accurate** age estimates
- Not **Precision**: Similarity between readers or between reading sessions

**Workshop on Age Reading of Greenland Halibut**
17 participants from: Canada, Greenland, Norway, Poland, Portugal, Russia, Spain, USA (by correspondence)

Specially invited: Steven Campana and Yvan Lambert

Workshop on Age Reading of Greenland Halibut
Several Age reading methods currently used for Greenland halibut

A) Those that produce age-length relationships that broadly compare with the **traditional methods** described by the joint NAFO-ICES workshop in 1996 (ICES, 1997), typically indicating age around 10-12 years for 70 cm fish; and

B) Several **new methods** that provide much higher longevity and approximately half the growth rate from 40-50 cm onwards compared to the traditional method. These typically produce age estimates around 20 years or more for 70 cm fish.
The most accurate validation methods: (Steven Campana)
1) release of known-age and marked fish into the wild
2) bomb radiocarbon to identify fish born in the 1950-60’s
3) mark-recapture of chemically tagged wild fish after more than 1 yr at large

Some age corroboration methods:
1) modal length analysis
2) tag recapture analysis
3) progression of strong year-classes

Some common methods that don’t provide validation or corroboration:
1) age comparisons among age readers
2) growth back-calculation
3) comparisons among multiple structures within a fish
4) consistency with published papers that did not actually conduct age validation.
Validation studies on Greenland halibut:
1) OTC: DFO-Canada
2) OTC: IMR-Norway
3) SrCl: DFO-Canada and GINR-Greenland
4) $^{14}$C: DFO-Canada
5) $^{14}$C: AFSC-USA

Corroboration studies on Greenland halibut:
1) Tagging in NE-Atlantic (IMR)
2) Tagging in NW-Atlantic (DFO/GINR)
3) Length modes (IMR, PINRO, DFO, AFSC)
4) Morphometry (IMR)
5) Comparison between regions (WKARGH)

They all support type B: The new methods and reject type A: Traditional methods.
Growth of NE-Arctic Greenland halibut

Mean length at age (+/- Stand dev.)

Traditional ageing method

One of a few recent alternatives
Growth of NE-Arctic Greenland halibut

Traditional ageing method

C14 validations from NW-Atlantic

One of a few recent alternatives

Mean length at age (+/- Stand dev.)
Main conclusions

$^{14}$C data from the Northwest Atlantic and from the Bering Sea show that longevity of Greenland Halibut is much greater and growth rate less than half of that reported based on the traditional ageing method.

Data on SrCl from the Northwest Atlantic and from OTC and tag recaptures from both the Northwest Atlantic and Northeast Atlantic are consistent with the bomb radiocarbon results.

Based on all available evidence it appears that the traditional method underestimate ages for ages above 5 years.

A more accurate ageing method is currently under development and seems likely. Until such a method is accepted, stock assessments should note the likelihood that catch at age matrices based on the traditional ages are likely to be in error (too low ages).
Identification of annual zones in Greenland Halibut otoliths should preferably be done along the longest growth axis of the whole right otolith or towards the proximal edge of the sectioned left otoliths.

Identify archived samples from the Northeast Atlantic to be analyzed with the bomb radiocarbon method in order to provide information to validate the total age of the fish.

Construct validated growth models for each stock and use mixture models to estimate population numbers at age to be used in assessment working groups by decomposing length frequency distributions.

Establish a reference collection of digital images of otoliths, including those validated with 14C, OTC and SrCl to be made available for use by all labs to assist in improving and calibrating age reading methods.

A new WKARGH meeting should be arranged within 4 years with the aim to improve precision of the new methods and to further standardize the approach.

Recommendations
Minority statement:

Most of the group members agreed on the general conclusions, but scientists from VNIRO, Moscow, and PINRO, Murmansk, provide the following minority statements, not supported by the rest of the group:

1. The traditional method of the Greenland halibut age reading by unstained cross-section of otoliths and scale is adequate for the purposes of reading age of the Greenland halibut of the Barents Sea.

2. The new method shall not be recommended as appropriate until firm validation is in place.
Thank you
1. From the information that was reviewed concerning validation and corroboration techniques and results, none of the methods stands out as being ideal. There is still work to be done to determine the best methods, although considerable progress has been made.

2. Bomb radiocarbon results from the Northwest Atlantic and from the Bering Sea shows that longevity of Greenland Halibut is much greater and growth rate less than half of that reported based on the traditional ageing method. Data on SrCl, OTC and tag recaptures from the Northwest Atlantic and from OTC and tag recaptures from both the Northwest Atlantic and Northeast Atlantic are consistent with the bomb radiocarbon results.

3. The OTC results show that the left whole otolith, which is commonly used as the basis for the traditional age estimates, apparently shows no growth in surface area for slow growing individuals. Without improved techniques, this prohibits accurate age estimation of these individuals by use of the whole left otolith surface. The results show that the stoppage in otolith growth is evident from lengths around 40cm and larger, and for both mature and immature males and females.
Conclusions

4. A variety of ageing methods were examined. Several showed improved clarity and interpretation compared to the traditional whole left technique. Most of the new methods that were examined resulted in older age estimates above approx. age 5 (approx. 45-50 cm) compared to the traditional method.

5. The only ageing axis on the whole otolith surfaces that consistently showed additional growth in the OTC collections were along the longest axis of the right otoliths. The sectioned left otoliths also showed consistent growth towards the proximal edge. Additional growth axes in right otolith section planes or other left section planes were not examined.

6. Based on the validation results, the OTC uptake and the methods comparisons, it appears that age determination using transverse sections of the left otoliths are likely to give the most accurate ages. This conclusion requires further confirmation.

7. Based on all available evidence it appears that the traditional method underestimate ages for ages above 5 years. A more accurate ageing method is currently under development and seems likely. Until such a method is accepted, stock assessments should note the likelihood that catch at age matrices based on the traditional ages are likely to be in error (too low ages).
8. Although a new age reading method would be expected to be applicable to all stocks of Greenland halibut, there may be differences in population growth between areas that would warrant use of different interpretation methods. The total age of Greenland halibut otoliths has so far only been validated in the Bering Sea and the Northwest Atlantic. Even though the results from the OTC experiments, tag-recaptures, as well as previous growth comparisons based on the traditional ageing method (Bowering and Nedreaas, 2001) indicate otherwise, it is still possible that e.g. the Northeast Arctic stock has a very different and much higher growth rate than the Northwest Atlantic stock. If the growth rate of a given stock is more than double of that documented for the Northwest Atlantic and the Bering Sea for fish above approx. 40cm, the traditional ageing method may still be applicable for such areas. Validation of total age by bomb radiocarbon analyses is therefore warranted for all stock units for which required archived samples are available.
Bias in age reading of Greenland halibut calls for new assessment strategy.

Ole Thomas Albert ¹), Arnt-Børre Salberg ¹), Åge Høines ²) and Alf Harbitz ¹)

• ICES WS 1996: General agreement on methodology
• 80 cm fish > 11-15 years
• Reasonable precision between readers and between labs

• ICES AFWG notes from 2003 onwards about age reading uncertainty
• WD 2005: Traditional method severely underestimate age of older fish
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• ICES WS 1996: General agreement on methodology
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• WD 2005: Traditional method severely underestimate age of older fish
• NAFO WS 2006: Current production methods underage old fish
• Gregg et al. 2006: Left otoliths of larger specimens tend to grow in thickness rather than in surface area.
• Cooper et al. 2007: M is in accordance with slower growth than previously anticipated.
• Treble et al. 2008: Underestimation is between 1-15 years, with a mean of 6 relative to bomb ¹⁴C assays.
• Albert et al. 2009: Tagged adults >45cm grow less than 1cm a year on average.

Working Document for ICES Arctic Fisheries Working Group, Murmansk 19-28 April 2005

Improving the precision of otolith-based age estimates for Greenland halibut (Reinhardtius hippoglossoides) with preparation methods adapted for fragile sagittae

Jacob L. Gregg

Natural mortality rate, annual fecundity, and maturity at length for Greenland halibut (Reinhardtius hippoglossoides) from the northeastern Pacific Ocean

Daniel W. Cooper (contact author)
Katherine P. Maslenikov
Donald R. Gunderson

Growth analysis and age validation of a deepwater Arctic fish, the Greenland halibut (Reinhardtius hippoglossoides)

Margaret A. Treble, Steven E. Campana, Rick J. Wastle, Cynthia M. Jones, and Jesper Boje


Towards Accurate Age Determination of Greenland Halibut

Ole Thomas Albert, Merete Kvamsund, Tone Vollertsen
Institute of Marine Research, PO Box 6404, NO-9294, Trondheim, Norway
E-mail: oleta@imr.no
Arnt-Børre Solberg
Norwegian Computing Center, Post Office Box 114 Blindern, NO-0314 Oslo, Norway

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