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Proceedings of the Technical Expertise in Stock Assessment (TESA) national workshop on 'Best practices in age estimation', 31 January to 02 February 2023 in Moncton, New Brunswick

Daniel Ricard, Peter Comeau, Aaron Adamack, Jacob Burbank, Abby Daigle, Allan Debertin, Kim Emond, Tracey Loewen, Andrea Perreault, Gregory Puncher, Karen Robertson, Nicolas Rolland, Meredith Schofield, Andrew Smith, François-Étienne Sylvain and Stephen Wischniowski

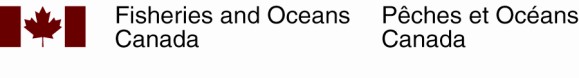
Science Branch Gulf Region

Fisheries and Oceans Canada

Moncton, New Brunswick, E1C 5K4, Canada

2023

Canadian Technical Report of Fisheries and Aquatic Sciences ####



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**Canadian Technical Report of Fisheries and Aquatic Sciences**

Technical reports contain scientific and technical information that contributes to existing knowledge but which is not normally appropriate for primary literature. Technical reports are directed primarily toward a worldwide audience and have an international distribution. No restriction is placed on subject matter and the series reflects the broad interests and policies of Fisheries and Oceans Canada, namely, fisheries and aquatic sciences.

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Numbers 1-456 in this series were issued as Technical Reports of the Fisheries Research Board of Canada. Numbers 457-714 were issued as Department of the Environment, Fisheries and Marine Service, Research and Development Directorate Technical Reports. Numbers 715-924 were issued as Department of Fisheries and Environment, Fisheries and Marine Service Technical Reports. The current series name was changed with report number 925.

**Rapport technique canadien des sciences halieutiques et aquatiques**

Les rapports techniques contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui ne sont pas normalement appropriés pour la publication dans un journal scientifique. Les rapports techniques sont destinés essentiellement à un public international et ils sont distribués à cet échelon. II n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques de Pêches et Océans Canada, c'est-à-dire les sciences halieutiques et aquatiques.

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Les numéros 1 à 456 de cette série ont été publiés à titre de Rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de Rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de Rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

3 Canadian Technical Report of

4 Fisheries and Aquatic Sciences nnn

5 2023

6 PROCEEDINGS OF THE TECHNICAL EXPERTISE IN STOCK ASSESSMENT (TESA)

7 NATIONAL WORKSHOP ON BEST PRATICES IN AGE ESTIMATION, 31 JANUARY TO 02

8 FEBRUARY 2023 IN MONCTON, NEW BRUNSWICK

9 by

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57 **ABSTRACT**

58 Ricard, D., Comeau, P., Adamack, A., Burbank, J., Daigle, A., Debertin, A., Emond, K., Loewen,

59 T., Perreault, A., Puncher, G., Robertson, K., Rolland, N., Schofield, M., Smith, A., Sylvain,

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62 in Moncton, New Brunswick. Can. Tech. Rep. Fish. Aquat. Sci. nnn: [v](#_bookmark1) + [22](#_bookmark28) p.

63 A three-day workshop was held in Moncton, New Brunswick, from January 31 to February

64 02 2023. The aim of the workshop was to examine and discuss best practices in the use of

65 structures for age estimation.

66 **RÉSUMÉ**

67 Ricard, D., Comeau, P., Adamack, A., Burbank, J., Daigle, A., Debertin, A., Emond, K., Loewen,

68 T., Perreault, A., Puncher, G., Robertson, K., Rolland, N., Schofield, M., Smith, A., Sylvain,

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71 in Moncton, New Brunswick. Can. Tech. Rep. Fish. Aquat. Sci. nnn: [v](#_bookmark1) + [22](#_bookmark28) p.

72 Un atelier de trois jours a eu lieu à Moncton, au Nouveau-Brunswick, du 31 janvier au 02 février

73 2023. Le but de l’atelier était d’examiner et de discuter des meilleures pratiques dans l’utilisation

74 des structures pour l’estimation de l’âge.

# 75 1 Introduction

76 The purpose of the Technical Expertise in Stock Assessment (TESA) program is to promote

77 stock assessment excellence through organizing national activities that contribute to the

78 development of expertise in stock assessment across Fisheries and Oceans Canada (DFO).

79 TESA was created in 2009, in response to a loss of stock assessment expertise in DFO owing

80 to retirements. Each year, TESA organises three or four training courses and one or two

81 topical workshops on stock assessment issues. TESA is a national program with one or two

82 representatives in each region – for more details see the [GCpedia website](http://www.gcpedia.gc.ca/wiki/DFO_Science_TESA_ETES) (only accessible from

83 the DFO network).

84 This report provides a written record of the TESA workshop on “Best practices in age estimation”

85 that was held in Moncton, NB, from January 31 to February 02 2023. The list of participants

86 can be found in Table [2](#_bookmark16) and all resources related to the workshop were stored in a [git repository](https://github.com/TESA-workshops/ageing-best-practices-2023)

87 [maintained by TESA](https://github.com/TESA-workshops/ageing-best-practices-2023).

# 88 1.1 Motivations

89 The use of an age-based population model is often lauded as the “gold standard” in stock

90 assessment. Age-based models are favored over simpler population models because of their

91 ability to convey biological realism and to provide a more nuanced understanding of population

92 dynamics, including the effects of fishing on harvested populations. As the name implies, an age-

93 based model requires information about the age of individuals in the population, which provides

94 scientists with a foundation for analyzing the demographics of a population as it evolves over

95 time. Ageing information, in conjunction with other observations, can inform us on the growth of

96 individuals, the age-at-maturation of individuals, the age structure of a population and on other

97 vital factors necessary to understand variations in numbers and biomass.

98 All DFO regions collect structures from marine organisms that are used in estimating their age.

99 The procedures associated with collecting, cataloguing, storing, and obtaining age estimates of

100 samples vary from lab to lab. It is important to follow best practices when estimating age from

101 hard structures and not all personnel are aware of these.

102 In any given year, DFO collects otoliths for a number of stocks and processes these structures to

103 obtain age estimates. It is estimated that tens of thousands of otoliths and scales are collected

104 yearly in scientific activities at DFO.

105 While the use of age-based models is common and the software available to implement such

106 assessments are available and evolving, the manipulation of the input data that feeds into

107 those models is often done in an ad-hoc fashion particular to the lab or agency in charge of the

108 assessment. While these ad-hoc methods are most likely defensible and appropriate, the details

109 that go into the computation of catch-at-age matrices are often poorly documented, making

110 results hard to reproduce by someone outside a given lab or agency. This workshop provided an

111 opportunity for DFO scientists using age-based assessments, and those involved in the analyses

112 of age and length information, to share ideas and develop better methods to use ageing data in

113 assessments.

114 **1.2 Objectives**

115 The objectives of this workshop were to create a forum for discussion and for exchanging ideas

116 among DFO scientists that use age-based models and that are involved in ageing activities. In

117 particular, the workshop provided:

118 • guidance on ageing structures collection and on the sampling design for collecting ageing

119 structures

120 • guidance on age determination using ageing structures, best practices for annuli validation,

121 reference collections, age estimation technician calibration, archival of ageing structures

122 and data warehousing

123 • guidance on digital imaging of ageing structures

124 • guidance on going from length frequency samples and age-length keys to catch-at-age

125 matrices that feed into age-based population models

126 **1.3 Format**

127 A hybrid meeting was held from January 31 2023 to February 02 2023. The list of participants

128 and the attendance can be found in Table [2](#_bookmark16). A total of 76 participants attended the event (30

129 in person and 46 virtually), including two external experts who joined the meeting virtually. The

130 workshop was attended by a wide variety of DFO personnel ranging from research scientists, to

131 biologists, to fisheries technicians and also included two students and a professor from a local

132 university.

# 133 2 Workshop activities and presentations

134 A number of presentations were given during the workshop (Table [1](#_bookmark15)).

135 As part of the workshop planning, participants were asked to provide a summary of physical

136 collections of age structures and to identify the programs that were involved in the collection

137 and analysis of ages using these structures. Given the large number of taxa for which ageing

138 materials are collected by different regions of Fisheries and Oceans Canada (Figure [2](#_bookmark18)), the

139 recommendations from this workshop involve programs spanning the whole country, and

140 concern stocks in the Atlantic, Arctic and Pacific oceans, as well as a number of diadromous

141 and freshwater species.

# 142 2.1 Day 1 - Basics of age estimation

143 The first day covered the basics of ageing. The literature on research associated with otoliths is

144 vast and varied. Peter Comeau gave a presentation on the history and realities of age estimation

145 of marine organisms. His presentation highlighted the importance of age estimation in stock

146 assessments. He also pointed out that there once was a stigma associated with jobs that

147 involved age estimation, they were perceived as an entry-level position with a low retention

148 rate, whereas the reality is that they require a unique skill set, considerable experience and are

149 essential to scientific inquiries related to fish population dynamics.

150 Julie Coad Davies gave an overview of the age estimation activities that she is involved in, in her

151 role as lab manager for DTU Aqua and also through her chairing the ICES Working Group on

152 SmartDots Governance ([WGSMART](https://www.ices.dk/community/groups/Pages/WGSMART.aspx)) and the ICES Working Group on Biological Parameters

153 ([WGBIOP](https://www.ices.dk/community/groups/Pages/WGBIOP.aspx)). Julie highlighted the importance of clear communication between laboratories

154 and the paramount role of exchanges of both physical otoliths and digital images to identify

155 potential age estimation biases that may exist between laboratories. Similarly, the ICES working

156 groups have in their mandate the formulation of shared methodologies and protocols and

157 provide guidelines for how to best captures information on biological parameters and how to

158 conduct otolith exchanges between laboratories ([“WGBIOP guidelines for otolith exchanges and](#_bookmark25)

159 [workshops”](#_bookmark25)).

160 Stephen Wischniowski shared his experience of running an age estimation laboratory (the

161 [Sclerochronology Lab](https://www.pac.dfo-mpo.gc.ca/science/species-especes/agelab-scalimetrie/index-eng.html) at the Pacific Biological Station) and being involved in the Committee of

162 Age Reading Experts ([CARE](https://care.psmfc.org/)). The demands for age estimation services from the lab far exceed

163 its ability to process samples and a “quota” is imposed on the number of otoliths that the lab can

164 process. The lab technicians are taught the intricacies associated with age estimation from all

165 types of species and structures. Stephen estimates that it takes five years to train a technician to

166 the point where they can reliably estimate ages and can teach others.

167 Sylvie Robichaud and Karen Robertson presented the procedures associated with age

168 estimation of Atlantic Herring in the Gulf Region. There are two spawning components that must

169 first be distinguished from each other before age estinates can be made. The morphology of

170 otoliths is used to distinguish between spawning components and the number of annuli and the

171 date of capture are then integrated into an age estimate. The otoliths come from a variety of

172 sources, ranging from reasearch surveys to experimental fishing and from commercial fisheries.

173 The laboratory protocols used to process samples require the extraction of otoliths, which are

174 subsequently mounted in epoxy resin, photographed, and are then used for age estimation.

175 Kim Emond and Hélène Dionne presented the procedures associated with age estimation of

176 Atlantic Herring in the Québec Region. The stock assessment for this stock relies on a variety of

177 data sources and on a comprehensive sampling of otoliths.

178 Tania Davignon-Burton gave a talk of reconciling expectations and realities in a production

179 ageing environment. There are often high expectations for estimating ages using otoliths, but

180 the laboratory activities required to obtain age estimates mean that some prioritization must take

181 place.

182 Tracey Loewen and Rick Wastle presented their work on estimating ages of Greenland Halibut

183 in the Arctic. This species is difficult to age because of its slow growth but the methods that they

184 developed improve the understanding of growth.

185 Daniel Ricard presented the Standard Operating Procedures document used in the Gulf

186 Region. This document is meant as a central point for any person seeking information about

187 age estimation in the Gulf Region. The summary of otolith collections held by the Gulf Region

188 and available as OpenData records was also presented and suggested as a starting point for

189 documenting physical collections, including reference collections.

# 190 2.2 Day 2 - Digital imaging of ageing structures

191 The second day of the workshop focused on topics related to the capture of digital images of

192 ageing structures and how to annotate them.

193 The day started with a tour of the laboratory facilities used in age estimations at the Gulf

194 Fisheries Centre. The laboratories used for age estimation of Atlantic Cod, American Plaice,

195 Winter Flounder, Yellowtail Flounder and Atlantic Herring. The facilities used for imaging whole

196 otoliths mounted in epoxy and imaging of whole otoliths were visited and participants had the

197 opportunity to ask questions and try the tools and software used by their Gulf Region colleagues.

198 A presentation about *SmartDots* from external expert Julie Coad Davies showed how this

199 tool is being used for otolith exchanges between laboratories in Europe. The development of

200 the *SmartDots* application is managed by ICES Working Group on SmartDots Governance

201 ([WGSMART](https://www.ices.dk/community/groups/Pages/WGSMART.aspx)) in close collaboration with the ICES Secretariat as well as national fisheries

202 laboratories.

203 Karen Robertson gave a presentation on taking good images of otoliths. She showed how it is

204 important to have a reliable workspace with appropriate lighting and a microscope equipped with

205 a digital camera. The image capture can be done in a number of software, including the one

206 provided by the microscope manufacturer, the Leica LAS X software suite. Karen also pointed

207 out the importance of having a well-defined naming convention for images and a strict protocol

208 for file storage. Image processing is an important step to improve the readability of otolith images

209 and a number of filtering options are available.

210 David Fishman presented options for developing a storage solution for otolith images. A

211 discussion about DFO Dots followed. Participants felt that having access to a tool that helps

212 in managing otolith collections and curating reference collections would be beneficial to their

213 work.

214 A group discussion on the reporting features of *SmartDots* and how the tool can be used for

215 obtaining growth increments followed.

216 Capturing digital images of ageing structures adds time to the laboratory process used to

217 obtain age estimates. It is unclear whether the benefits of obtaining digital images of ageing

218 structures outweighs the costs associated with the additional time required. As a starting point,

219 a reference collection should be imaged. Having a reference collection of imaged otoliths allows

220 you to document examples of what otoliths of a particular age-class look like and to explain why

221 classification of being a different age would be incorrect. Reference collections are also useful

222 for training new readers and for providing continuity in ageing methodologies when there are

223 discontinuities in an aging program (e.g. times when there is no overlap between new and former

224 readers).

225 Once digital images of ageing structures are available, an additional step is to annotate them. It

226 is probably impractical to annotate images in production ageing situations, but as a starting point

227 the reference collection should be annotated in SmartDots. This provides an authoritative record

228 that can be used to better document the reference collection.

# 229 2.3 Day 3 - Analysis of age estimates

230 The third day of the workshop focused on what is done with age estimates, namely the use of

231 such data in fitting growth models and in computing catch-at-age matrices.

232 Daniel Ricard and Andrea Perreault gave presentations on growth models. The importance of

233 accounting for length-stratified sampling was emphasized since it can lead to biased estimates of

234 growth model parameters ([Perreault et al. 2020](#_bookmark23)).

235 Lisa Ailloud from NOAA NMFS gave a presentation about age-length keys. She discussed the

236 distinction between forward and reverse age-length keys, and provided an alternative hybrid

237 methodology that was previously applied to bluefin tuna ([Ailloud et al. 2019](#_bookmark21); [Ailloud and Hoenig](#_bookmark20)

238 [2019](#_bookmark20)).

239 Catch-at-age calculations presentation by Andrew Smith from the Quebec Region described

240 his experience with trying to replicate catch-at-age calculations that were previously done in a

241 bespoke software called *catch.exe*. An R package that was developed to compute catch-at-age

242 matrices was also presented ([Ouellette-Plante et al. 2022](#_bookmark22)).

243 Kim Emond from the Quebec Region presented the methodologies used in the herring stock

244 assessment to compute catch-at-age matrices from commercial landings and from hydroacoustic

245 surveys.

246 Christopher Corriveau and Ellie Weise from Dalhousie University presented their work on

247 using DNA methylation to estimate ages. The presentation provided an overview of this new

248 methodology.

249 A group discussion finally took place to draft the recommendations that appears in section [5](#_bookmark12). The

250 recommendations cover a variety of subjects, ranging from practical recommendations for age

251 estimation to institutional recommendations that could foster the development of a community of

252 age readers within DFO.

# 253 3 Remarks from external experts

254 Remarks from Julie Coad Davies from DTU Aqua:

255 The workshop has been an excellent forum for those working with age reading

256 and the age data resulting from their work. With such a variety of expertise across

257 labs and regions under the DFO it is important that a community is formed to

258 facilitate knowledge sharing on best practices. There are opportunities for age

259 reading calibration across labs who are age reading the same stocks, cooperation

260 on updating reference collections and knowledge sharing on image acquisition and

261 method testing.

262 Future plans to have a DFO version of SmartDots will facilitate this and will

263 support an overall improvement in the quality of the age data coming from the

264 age reading labs and how the data is subsequently used in the stock assessment

265 process. Forming a working group who meet annually will foster the communication

266 required to sustain the community.

267 Remarks from Lisa Ailloud from NOAA NMFS:

268 The 2023 TESA best practices in ageing workshop was a very successful

269 meeting. It provided a forum for experts from different labs and regions to share

270 experiences, pain points and new developments in fish age determination and

271 modeling. Age and growth play an important role in stock assessment and any

272 biases in these input quantities can ultimately affect the correct evaluation of stock

273 status and management advice. It is therefore essential to identify the potential

274 sources of bias and take the necessary steps to mitigate them. Discussions carried

275 out during the workshop helped advance this goal. Having a wide range of expertise

276 present helped broaden the discussions and bridge the gap between the various

277 stages of data and model development.

278 As participants shared their individual experiences, advances and setbacks, it

279 became clear that many of the issues raised were common across labs and relevant

280 to the group as a whole. This type of forum where solutions can be worked out and

281 shared among experts is an important step towards homogenizing protocols and

282 increasing overall efficiency. Participants clearly showed an interest in understanding

283 past practices and improving upon them. Discussions around making use of

284 automation and open science principles to increase transparency in the process

285 were very encouraging. New technological developments were also shared with the

286 group. Preliminary results for their application appear very promising.

287 **4 Discussion**

288 Over and over during the workshop, it was emphasized that while otoliths are the most common

289 structure used for estimating ages, other ageing structures are also used, and the best practices

290 used for otoliths are applicable to other structures.

291 It was discussed how age estimation using ageing structures is more than just “counting the

292 rings” and requires a wealth of experience in order to interpret the patterns observed on ageing

293 structures.

294 The workshop attendees identified the need to develop and foster a community of DFO

295 scientists whose tasks involve age estimation. As such, the workshop provided a starting point in

296 establishing this community.

# 297 5 Recommendations

298 The working group formulated the following recommendations for how to deal with physical

299 collections of structures used for age estimation.

300 1. Institutional

301 (a) Foster a community of DFO scientists whose mandated tasks include sampling

302 of ageing structures, age estimation using ageing structures or analysis of age

303 estimates data.

304 (b) Emulate the Pacific Ocean’s Committee of Age Reading Experts

305 ([CARE]https://care.psmfc.org/) for the Atlantic and Arctic Oceans.

306 (c) Creation of a DFO working group that meets regularly to ensure that age estimations

307 practices in different labs follow shared best practices.

308 (d) Provide support for inter-regional ageing structure exchanges and secondary reader

309 testing.

310 (e) Achieve Canadian representation on appropriate ICES working groups related to

311 quality assurance of age estimation as input for stock assessment (WGBIOP) or

312 those developing the SmartDots platform (WGSMART).

313 (f) Recognise the fact that the skills required to obtain unbiased age estimates from

314 ageing structures are unique and take time and dedication to acquire.

315 2. Ageing structure cataloguing, storage and inventory

316 (a) Ensure that physical collections of ageing structures follow the DFO "Policy on

317 Collection, Storage, Management and Use of Physical Samples for Science

318 Research".

319 (b) Ageing structures should be stored in an environment that minimizes degradation and

320 that maintains readability.

321 (c) Ageing structures removed from an individual should be uniquely identified.

322 (d) Clearly label ageing structures so they can be traced back to their collection,

323 implement good bookkeeping of your ageing structures.

324 (e) An electronic inventory of the physical ageing structures available should be

325 documented and updated regularly.

326 (f) A subset of ageing structures should be preserved in their unaltered state for future

327 unforeseen usage (i.e. not in resin or glycerin).

328 3. Reference collection

329 (a) Actively curate reference collections so that old ageing structures that have lost their

330 readability are replaced by new ageing structures, this includes renewing ageing

331 structures.

332 (b) Ensure that the age structures in the reference collection are representative of what

333 will be available to age estimation technicians (the structures should cover wide

334 spatial and temporal ranges, both annual and inter annual, all ages used in the stock

335 assessment and both easy and difficult to read ageing structures,...).

336 (c) Ensure reference collections are updated with samples from recent years.

337 (d) In addition to a physical reference collection, develop its digital equivalent by taking

338 images of the ageing structures.

339 (e) Ideally, also annotate your digital reference collection using SmartDots.

340 (f) Strive to have a validation study to ascertain the periodicity of ageing patterns.

341 4. Laboratory operations

342 (a) Strive to obtain unbiased age estimates by regularly performing age reader

343 calibrations and by carrying out regular quality-checks for each species/stock (both

344 within and across laboratories).

345 (b) Develop and publish Standard Operating Procedures for each lab.

346 (c) Develop standardized protocols to validate age estimates (add to your regional SOP).

347 (d) Favour age estimation in a “blind” setting, where no prior knowledge (except date

348 of capture) is used when interpreting patterns in ageing structures, don’t let outside

349 information influence your age estimates.

350 (e) Establish a quality-control process to identify mistakes made during data entry (e.g.

351 typos).

352 (f) Document the uncertainty associated with age estimates by means of a standardized

353 quality assurance scale.

354 (g) Generate an age-error matrix as part of your standard procedures.

355 (h) Have at least two age readers for any given stock, for redundancy.

356 5. Training

357 (a) Develop a document that details the training steps for new agers, and/or add it to your

358 regional SOP.

359 (b) Establish procedures that integrate current practices (e.g. labels that have been used

360 for many year) into improved practices.

361 6. Digital imaging of ageing structures

362 (a) Ensure that a correctly calibrated scale bar is present in the image so that the image

363 scale in pixels per mm can be determined.

364 (b) The file naming convention to use when taking images of ageing structures should

365 uniquely identify each ageing structure, a recommended nomenclature would be as

366 follows:

367 (c) When practical, promote the capture of digital images of ageing structures.

368 (d) Digital images (JPEG format) of ageing structures should be stored in enterprise-level

369 infrastructure where proper backups are in place.

(e) A DFO-led app to store and retrieve digital images of ageing structures should be implemented to facilitate the management of these images and to provide integration with the SmartDots software.

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Analysis of age estimates

1. When computing catch-at-age matrices, the sampling design used in the collection of data should be accounted for.
2. Analyses that compute catch-at-age matrices from length samples and age estimates should strive to be fully documented and reproducible.
3. Contemporary procedures that reduce bias in age structure estimates should be used.
4. Assessment methods would ideally incorporate ageing errors into the assessment framework.

Preparing for changes associated with a warming climate

1. Rates of growths are likely to change, so are the patterns associated with age estimation. So regularly revisit the pattern in the growth structures recognition used for estimating ages to identify periods of weaker or stronger growth and/or changes in the timing of annuli formation.
2. Continue inter-regional communication and organise events that promote collaborations.
3. Northward migration of species will shift stock boundaries and change the species that will require science advice.
4. Establish a process so that “cheat sheets” and guides used for training agers, and the associated laboratory processes for age estimation are updated regularly.

Research and development

1. Pursue further studies in sclerochronology that will support the identification of changes in patterns used in estimating ages.
2. Investigate the trade-offs involved between taking images and annotating them versus just estimating a single age-length pair.

398 These recommendations were formulated at the workshop and further revised by all authors.

399 They represent procedures that should be followed by all DFO personnel involved in age

400 estimations and also contain suggestions for fostering a community of age readers within DFO.

# 401 6 Acknowledgements

402 The authors would like to acknowledge all the workshop participants for their attendance and

403 their active participation in discussions. Joeleen Savoie helped with workshop organisation and

404 logistics. Lisa Leblanc from the ASEC was extremely generous with her time and hospitality

405 during the workshop. We thank the Gulf Region publication coordinator Jeffery Clements for his

406 help in handling this report submission.

407 **7 Tables**

Table 1. List of presentations given at the TESA workshop on best practices in age estimation.

|  |  |  |
| --- | --- | --- |
| Presenter(s) | Presentation title | Link to slides |
| **Day 1** |  |  |
| Peter Comeau | Fish age determination - Some of the | [Power Point](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/Ageing%20Workshop%20Comeau.pptx) |
|  | basics | [file](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/Ageing%20Workshop%20Comeau.pptx) |
| Julie Davies |  | [PDF file](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/QA-for-stock-assessment.pdf) |
| Tracey Loewen and Rick | Otolith microchemistry, difficult- | [PDF file](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/TESA-Age-Workshop_Loewen2023.pdf) |
| Wastle | to-age marine species, element |  |
|  | marking in otoliths |  |
| Stephen Wischniowski |  | [PDF file](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/SCL_TESA-2023-Stephen-Day1.pdf) |
| Daniel Ricard |  |  |
| Kim Emond and Hélène | Age determination of Atlantic Herring | Power Point |
| Dionne | in the Québec region | file |
| Sylvie Robichaud and Karen | Age determination of Atlantic Herring | [Power Point](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/Age%20determination%20of%20Atlantic%20Herring%20in%20the%20Gulf.pptx) |
| Robertson | in the Gulf region | [file](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/Age%20determination%20of%20Atlantic%20Herring%20in%20the%20Gulf.pptx) |
| Tania Davignon-Burton | Reconciling dreams, expectations | [Power Point](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/Reconciling%20dreams%2C%20expectations%20and%20reality%20in%20a.pptx) |
|  | and reality in a production ageing | [file](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/Reconciling%20dreams%2C%20expectations%20and%20reality%20in%20a.pptx) |
|  | environment |  |
| **Day 2** |  |  |
| Julie Davies | SmartDots – a tool created by the | [PDF file](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/SmartDots%E2%80%93a-tool-created-by-the-users-for-the-users.pdf) |
|  | users for the users |  |
| Karen Robertson, Isabelle | Taking good pictures of otoliths, and | [Power Point](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/Taking%20Good%20Pictures%2C%20annotating%20in%20Smartdots.pptx) |
| Forest and Sylvie Robichaud | annotating them in SmartDots | [file](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/Taking%20Good%20Pictures%2C%20annotating%20in%20Smartdots.pptx) |
| **Day 3** |  |  |
| Andrea Perreault | Impacts of ignoring length-stratified | [Power Point](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/Perreault_length_stratified_sampling.pptx) |
|  | sampling design | [file](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/Perreault_length_stratified_sampling.pptx) |
| Lisa Ailloud | Analyses of ageing data / A general | [Power Point](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/AilloudALK_sent20230130.pptx) |
|  | theory of age-length keys | [file](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/AilloudALK_sent20230130.pptx) |
| Kim Emond and Hélène | Catch-at-age of commercial herring | [PDF file](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/TESA_workshop_CAA_Feb2-Kim-Emond.pdf) |
| Dionne | landings and numbers-at-age from |  |
|  | acoustics surveys |  |
| Chris Corriveau and Ellie | Developing aging clocks for fish | [Power Point](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/TESA%20presentation_2023-DNA-methylation-Ellie-and-Chris.pptx) |
| Weise | using DNA methylation | [file](https://github.com/TESA-workshops/ageing-best-practices-2023/blob/main/sessions/TESA%20presentation_2023-DNA-methylation-Ellie-and-Chris.pptx) |

Table 2. Alphabetical list of participants (by last name) to the TESA worskhop on best practices in age estimation. Particpants from Fisheries and Oceans Canada (DFO) are identified by their region (NL is the Newfoundland and Labrador Region, MAR is the Maritimes Region, GUL is the Gulf Region, QUE is the Quebec Region, OP is Ontario and Prairie Region, ARC is the Arctic Region and PAC is the Pacific Region).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name | Affiliation | Attendance | Day 1 | Day 2 | Day 3 |
| Aaron Adamack | DFO - NL | Virtual | ✓ | ✓ | ✓ |
| Lisa Ailloud (external | NOAA NMFS | Virtual |  |  | ✓ |
| expert) |  |  |  |  |  |
| Laura Alsip | DFO - ARC | Virtual | ✓ | ✓ | ✓ |
| Kelly Antaya | DFO - NL | Virtual | ✓ | ✓ | ✓ |
| Mark Billard | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Jacob Burbank | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Lauren Burke | DFO - OP | Virtual | ✓ | ✓ | ✓ |
| Barbara Campbell | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
| Karalea Cantera | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
| Lynn Collier | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Peter Comeau (co-chair) | DFO - MAR | In person | ✓ | ✓ | ✓ |
| Chelsea Cooke | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
| Christopher Corriveau | Dalhousie University | In person | ✓ | ✓ | ✓ |
| Abby Daigle | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Andrew Darcy | DFO - GLF | In person | ✓ | ✓ |  |
| Guillaume Dauphin | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Julie Davies (external | DTU Aqua | Virtual | ✓ | ✓ | ✓ |
| expert) |  |  |  |  |  |
| Tania Davignon-Burton | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Allan Debertin | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Nell den Heyer | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Mathieu Desgagnés | DFO - QUE | Virtual | ✓ | ✓ | ✓ |
| Hélène Dionne | DFO - QUE | In person | ✓ | ✓ | ✓ |
| Dwight Drover | DFO - NL | Virtual | ✓ | ✓ | ✓ |
| Kim Emond | DFO - QUE | In person | ✓ | ✓ | ✓ |
| Gillian Forbes | DFO - NL | In person | ✓ | ✓ | ✓ |
| Isabelle Forest | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Danni Harper | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Sarah Hawkshaw | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
| Victoria Healey | DFO - NL | Virtual | ✓ | ✓ | ✓ |
| Erin Herder | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
| Kendra Holt | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
| Matthew Horsman | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Mary-Jane Hudson | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
| Samantha Hudson | DFO - GLF | Virtual | ✓ | ✓ | ✓ |
| Yeongha Jung | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
| Kelly Kraska | DFO - MAR | In person | ✓ | ✓ | ✓ |
| Madeline Lavery | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
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| --- | --- | --- | --- | --- | --- |
| Name | Affiliation | Attendance | Day 1 | Day 2 | Day 3 |
| Michael Legge | DFO - OP | In person | ✓ | ✓ | ✓ |
| Marc Legresley | DFO - NL | Virtual | ✓ | ✓ | ✓ |
| Lingbo Li | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Tracey Loewen | DFO - OP | In person | ✓ | ✓ | ✓ |
| Ellen MacEachern | DFO - MAR | In person | ✓ | ✓ | ✓ |
| Colin MacFarlane | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Brendan K Malley | DFO - ARC | Virtual | ✓ | ✓ | ✓ |
| Kiana Matwichuk | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
| Mackenzie Mazur | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
| Judy McArthur | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
| Kelsey McGee | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Jessie Mcintyre | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Liz Miller | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Maya Miller | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
| Kirby Morrill | DFO - GLF | In person | ✓ | ✓ | ✓ |
| George Nau | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Andrea Perreault | DFO - NL | Virtual | ✓ | ✓ | ✓ |
| Hannah Polaczek | DFO - NL | Virtual | ✓ | ✓ | ✓ |
| Gregory Puncher | DFO - MAR | In person | ✓ | ✓ | ✓ |
| Catriona | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Regnier-McKellar  Daniel Ricard (co-chair) | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Kierstyn Rideout | DFO - NL | In person | ✓ | ✓ | ✓ |
| Karen Robertson | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Sylvie Robichaud | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Nicolas Rolland | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Chelsea Rothkop Daniel Ruzzante  Meredith Schofield | DFO - PAC  Dalhousie University DFO - NL | Virtual Virtual  In person | ✓  ✓ | ✓  ✓ | ✓  ✓  ✓ |
| Andrew Smith | DFO - QUE | Virtual | ✓ | ✓ | ✓ |
| Jolene Sutton | DFO - GLF | In person | ✓ | ✓ | ✓ |
| François-Étienne Sylvain | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Jaime Thomson François Turcotte  Audrey Ty | DFO - NL DFO - GLF  DFO - PAC | In person Virtual  Virtual | ✓  ✓ | ✓  ✓ | ✓  ✓  ✓ |
| Kari Underhill | DFO - GLF | In person | ✓ | ✓ | ✓ |
| Lenore J Vandenbyllaardt | DFO - ARC | Virtual | ✓ | ✓ | ✓ |
| Rick J Wastle | DFO - ARC | Virtual | ✓ | ✓ | ✓ |
| Emily Way-Nee | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Ellie Weise | Dalhousie University | In person | ✓ | ✓ | ✓ |
| Gabrielle Wilson | DFO - MAR | Virtual | ✓ | ✓ | ✓ |
| Stephen Wischniowski | DFO - PAC | Virtual | ✓ | ✓ | ✓ |
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| --- | --- | --- | --- | --- | --- |
| Name | Affiliation | Attendance | Day 1 | Day 2 | Day 3 |
| Emily Yungwirth | DFO - PAC | Virtual | ✓ | ✓ | ✓ |

408 **8 Figures**



Figure 1. Day 1 of the TESA workshop “best practices in age estimation” held at the Atlantic Science Enterprise Center in Moncton, NB on 31 January, 01-02 February 2023.

20

Scale

Otolith

Other

15

Diadromous

10

5

0

20

15

Marine fish

10

5

0

20

15

Freshwater fish

Number of stocks

10

5

0

20

15

10

Mollusc

5

0

20

15

Marine mammal

10

5

0

GUL MAR NEW ONT PAC QUE

GUL MAR NEW ONT PAC QUE

DFO Region

GUL MAR NEW ONT PAC QUE

Figure 2. Number of stocks for which ageing materials are collected and analysed by the different regions of Fisheries and Oceans Canada. The list of collections used to generate this figure appear in Table [A.1](#_bookmark27).

409 **9 References**

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422

# 423 APPENDIX A List of DFO age structure collections

424 As part of the planning for the workshop, participants were asked to provide an overview of

425 age structures that are collected as part of scientific activities in different regions of DFO. The

426 list appearing in Table [A.1](#_bookmark27) shows the different collections that exist at DFO.

Table A.1. Fisheries and Oceans Canada (DFO) regions (NL is the Newfoundland and Labrador Region, MAR is the Maritimes GUL is the Gulf Region, QUE is the Quebec Region, OP is Ontario and Prairie Region, ARC is the Arctic Region and PAC is t Pacific Region). SFA is Salmon Fishing Area, NAFO is the Northwest Atlantic Fisheries Organization and PMFC is the Pacific Fisheries Commission

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Region | Common name | Scientific name | Stock | Type of structure | Years co |
| GUL | Atlantic Cod | Gadus morhua | NAFO 4T | otolith | 1971 to |
| GUL | White Hake | Urophycis tenuis | NAFO 4T | otolith | 1971 to |
| GUL | American Plaice | Hippoglossoides platessoides | NAFO 4T | otolith | 1971 to |
| GUL | Winter Flounder | Pseudopleuronectes americanus | NAFO 4T | otolith | 1971 to |
| GUL | Yellowtail Flounder | Limande ferruginea | NAFO 4T | otolith | 1971 to |
| GUL | Witch Flounder | Glyptocephalus cynoglossus | NAFO 4RST | otolith | 1971 to |
| GUL | Winter Skate | Leucoraja ocellata | NAFO 4T | vertebrae | 2004 to |
| GUL | Smooth Skate | Malacoraja senta | NAFO 4T | vertebrae | 2004 to |
| GUL | Thorny Skate | Amblyraja radiata | NAFO 4T | vertebrae | 2004 to |
| GUL | Atlantic Herring | Clupea harengus | NAFO 4T | otolith | 1965 to |
| GUL | Alewife | Alosa pseudoharengus | SFA 16, 18 | scale | 1983 to |
| GUL | Atlantic Salmon | Salmo salar | SFA 15, 16, 18 | scale | 1973 to |
| GUL | Blueback Herring | Alosa aestivalis | SFA 18 | otolith | 2021-20 |
| GUL | Striped Bass | Morone saxatilis | SFA 16, 18 | scale | 1995 to |
| MAR | Atlantic Cod | Gadus morhua | NAFO 5Z | otolith | 1970 - 2 |
| MAR | Atlantic Cod | Gadus morhua | NAFO 4X | otolith | 1970 - 2 |
| MAR | Atlantic Herring | Clupea harengus | NAFO 4VWX | otolith | 1954-20 |
| MAR | Haddock | Melanogrammus aeglefinus | NAFO 5Z | otolith | 1970 - 2 |
| MAR | Haddock | Melanogrammus aeglefinus | NAFO 4X | otolith | 1970 - 2 |
| MAR | Pollock | Pollachius pollachius | NAFO 4X | otolith | 1970 - 2 |
| MAR | Silver Hake | Brosme brosme | NAFO 4VWX | otolith | 1975 - 2 |
| MAR | Atlantic Halibut | Hippoglossus hippoglosus | NAFO 3NOPs4VWX5Zc | otolith | 1995-20 |
| MAR | Arctic Surf Clam | Mactromeris polynyma |  | shell | ?? |
| MAR | Sea Scallop | Placopecten magellanicus |  | shell | ?? |
| MAR | Atlantic Salmon | Salmo salar |  | scale | 1950? - |
| MAR | Alewife | Alosa pseudoharengus |  | scale | 1970? - |
| MAR | Blueback Herring | Alosa aestivalis |  | scale | 1970? - |

*Continued on next page ...*

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Region Common name Scientific name Stock Type of structure Years co

MAR Striped Bass Morone saxatilis otolith / Scales 1980? -

MAR American Eel Anguilla rostrata otolith 1980 - 2

QUE Atlantic Herring Clupea harengus NAFO 4RS otolith 4R: 196 QUE Capelin Mallotus sp. NAFO 4RST otolith 1984 to QUE Atlantic Mackerel Scomber scombrus NAFO 3-5 otolith 1973 to QUE Atlantic Halibut Hippoglossus hippoglossus NAFO 4RST otolith 1990 to QUE Atlantic Cod Gadus morhua NAFO 3Pn4RS otolith 1974 to PAC Turbot/Arrowtooth flounder Atheresthes stomias PMFC 3CD, 5ABCDE otolith 1980 to PAC Petrale Sole Eopsetta jordani PMFC 3CD, 5ABCDE otolith 1964 to PAC Dover Sole Microstomus pacificus PMFC 3CD, 5ABCDE otolith 1979 to PAC Rougheye Rockfish Sebastes aleutianus PMFC 3CD, 5ABCDE otolith 1978 to PAC Pacific Ocean Perch Sebastes alutus PMFC 3CD, 5ABCDE otolith 1973 to PAC Redbanded Rockfish Sebastes babcocki PMFC 3CD, 5ABCDE otolith 1986 to PAC Shortraker Rockfish Sebastes borealis PMFC 3CD, 5ABCDE otolith 1980 to PAC Silvergray Rockfish Sebastes brevispinis PMFC 3CD, 4B, 5ABCDE otolith 1973 to PAC Copper Rockfish Sebastes caurinus PMFC 3CD, 4B, 5ABCDE otolith 1984 to PAC Widow Rockfish Sebastes entomelas PMFC 3CD, 4B, 5ABCDE otolith 1979 to PAC Yellowtail Rockfish Sebastes flavidus PMFC 3CD, 4B, 5ABCDE otolith 1977 to PAC Bocaccio Sebastes paucispinis PMFC 3CD, 5ABCDE otolith 1978 to PAC Canary Rockfish Sebastes pinniger PMFC 3CD, 4B, 5ABCDE otolith 1973 to PAC Redstripe Rockfish Sebastes proriger PMFC 3CD, 5ABCDE otolith 1977 to PAC Yellowmouth Rockfish Sebastes reedi PMFC 3CD, 5ABCDE otolith 1977 to PAC Yelloweye Rockfish Sebastes ruberrimus PMFC 3CD, 4B, 5ABCDE otolith 1979 to PAC Quillback Eockfish Sebastes maliger PMFC 3CD, 4B, 5ABCDE otolith 1979 to PAC Black Spotted Rockfish Sebastes melanostictus PMFC 3CD, 5ABCDE otolith 1966 to PAC Sablefish Anoplopoma fimbria PMFC 3ACD,5ABCE otolith 1965 to PAC Lingcod Ophiodon elongatus PMFC 3CD,5ABCDE finray/otolith 1965 to PAC Hake Merluccius productus PMFC 3CD,4B,5ABCE otolith 1985 to PAC Eulachon Thaleichthys pacificus selective collections otolith 2015 to *Continued on next page ...*

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Region Common name Scientific name Stock Type of structure Years co

PAC Herring Clupea harengus pallasi 2E,2W,3-8,10, 14,17,19,23-27 SA6 scale 1992 to PAC Chum Oncorhynchus keta 2-29, 110-130, WCVI, Yukon scale 1900 to PAC Coho Oncorhynchus kisutch 2-20, 110-130 scale 1901 to PAC Steelhead Oncorhynchus mykiss incidental scale 1902 to PAC Sockeye/Kokanee Oncorhynchus nerka 1-29,120,130, WCVI scale 1903 to PAC Chinook Oncorhynchus tshawytscha 2-29,110-130, WCVI, Yukon scale 1904 to PAC Abalone Holiotus kamtschatkana Research shell 2000 to PAC Geoduck Panopea abrupta NC, CC, HG, SOG, WCVI shell 2003 to PAC Manila clam Tapes philippinarum Research shell 1995 to PAC Rocky Mountain Riged Mussel Gonidea angulata Okanogan lake CAN shell 2019 to NEW Capelin Mallotus villosus NAFO 2J3KL otolith 1978 to NEW Atlantic Herring Clupea harengus NAFO 3KLPs otolith 1965 to NEW Atlantic Cod Gadus morhua NAFO 2J3KL, 3NO, 3Ps otolith 1950s to NEW American Plaice Hippoglossoides platessoides NAFO 2J3KL, 3NO, 3Ps otolith 1978 to NEW Greenland Halibut Reinhardtius hippoglossoides NAFO 2+3KLMNO otolith 1978 to NEW White Hake Urophycis tenuis NAFO 3PLNO otolith 1984 to NEW Atlantic Salmon Salmo salar NAFO 2HJ, 3KLMNO, 3Ps, 4R scale 1975 to NEW Harp seal Pagophilus groenlandicus Northwest Atlantic canine tooth 1979 to NEW Wolffish (3 Species) Anarhichadidae spp. NAFO 2J3KLNOP otolith 2001 to NEW Sand Lance Ammodytes spp. otolith

NEW Redfish Sebastes spp. NAFO 2HJ3K, 3LN, 3O otolith 1978 to NEW Yellowtail Flounder Limande ferruginea NAFO 3LNO otolith 1978 to NEW Witch Flounder Glyptocephalus cynoglossus NAFO 2J3KL, 3NO, 3Ps otolith 1978 to NEW Atlantic Halibut Hippoglossus hippoglossus NAFO 3NOPs4VWX5Zc otolith 1978 to NEW Haddock Melanogrammus aeglefinus NAFO 2HJ3K, 3LNO, 3Ps otolith 1978 to NEW Skates (Various) Rajidae spp. NAFO 2J3KLNOP vertebrae 2004 to ONT Broad Whitefish Coregonus nasus Western Canadian Arctic otoliths and fin clips 1970s to ONT Lake Cisco Coregonus artedi Canadian Arctic otoliths and fin clips 1970s to ONT Arctic Cisco Coregonus autumnalis Western Canadian Arctic otoliths and fin clips 1970s to *Continued on next page ...*

*... Continued from previous page*

Region Common name Scientific name Stock Type of structure Years co

ONT Least Cisco Coregonus sardinella Western Canadian Arctic otoliths and fin clips 1970s to ONT Inconnu Stenodus leucichthys Western Canadian Arctic otoliths and fin clips 1970s to ONT Arctic Grayling Thymallus arcticus Various Locations Arctic Canada otoliths and fin clips 1970s to ONT Round Whitefish Prosopium cylindrecium Western Canadian Arctic otoliths and fin clips 1970s to ONT Arctic Char Salvelinus alpinus Canada and international locations otoliths and fin clips 1970s to ONT Lake Trout Salvelinus namaycush Canada otoliths and fin clips 1970s to ONT Bull Trout Salvelinus confluentus Western Canadian Arctic otoliths and fin clips 1970s to ONT Dolly Varden Char Salvelinus malma Western Canadian Arctic otoliths and fin clips 1970s to ONT Burbot Lota lota Canada otoliths 1970s to ONT Walleye Sander vitreum Southern Canada otoliths, dorsal spines 1970s to ONT Greenland Halibut Reinhardtius hippoglossoides NAFO Div. 0 otoliths 1996 to ONT Northern Pike Esox lucius Canada otoliths and cliethra 1970s to ONT Arctic Flounder Liopsetta glacialis Canadian Arctic otoliths 2012 to ONT Starry Flounder Platichthys stellatus Canadian Arctic otoliths 2012 to ONT Slimy Sculpin Cottus cognatus Canadian Arctic otoliths 2012 to ONT Fourhorn Sculpin Myoxocephalus quadricornis Canadian Arctic otoliths 2012 to ONT Arctic Staghorn Sculpin Gymnocanthus tricuspis Canadian Arctic otoliths 2012 to ONT Grubby Sculpin Myoxocephalus aenaeus Canadian Arctic otoliths 2012 to ONT Longnose Sucker Catostomus catostomus Canadian Arctic otoliths 2012 to ONT Pacific Herring Clupea pallasii Canadian Arctic otoliths 2012 to ONT Bering Wolffish Anarhichas orientalis Western Canadian Arctic otoliths 2012 to ONT Capelin Mallotus villosus Canadian Arctic otoliths 2012 to ONT Pacific Sand Lance Ammodytes personatus Canadian Arctic otoliths 2012 to ONT Banded Gunnel Ammodytes personatus Canadian Arctic otoliths 2012 to ONT Greenland Cod Gadus ogac Western Canadian Arctic otoliths 2012 to ONT Saffron Cod Eleginus gracilis Canadian Arctic otoliths 2012 to ONT Arctic Cod Boreogadus saida Canadian Arctic otoliths 2012 to ONT Polar Cod Arctogadus glacialis Canadian Arctic otoliths 2012 to ONT Channel Catfish Ictalurus punctatus Manitoba otoliths 2022

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Region Common name Scientific name Stock Type of structure Years co

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ONT | Freshwater Drum | Aplodinotus grunniens | Unknown | otoliths |  |
| ONT | Deepwater Redfish | Sebastes mentella | NAFO 0B | otoliths | 2019 to |