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Proceedings of the Regional Peer Review meeting on the Assessment of the northern contingent of Atlantic mackerel (*Scomber scombrus)*

February 25-26 and March 3, 2021
Virtual meeting

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September 2021

Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

This document outlines the proceedings of the regional peer review meeting on the assessment of the northern contingent of Atlantic mackerel. This meeting, which was held virtually via Zoom on February 25-26 and March 3, 2021 brought together about sixty participants from DFO Science and Management branch, university, indigenous groups, provincial representatives, fishing industry and environmental non-governmental organizations. These proceedings detail the essential parts of the presentations and discussions held during the meeting, as well as the recommendations and conclusions made.

INTRODUCTION

The Quebec Region of Fisheries and Oceans Canada (DFO) is responsible for assessing several stocks of fish and invertebrate species harvested in the Estuary and Gulf of St. Lawrence. Most of these stocks are periodically assessed as part of a regional advisory process that is conducted at the Maurice Lamontagne Institute in Mont-Joli. This document consists of the proceedings of the meeting held on February 25-26 and March 3, 2021 via the Zoom platform (virtual meeting), on the assessment of the northern contingent of Atlantic mackerel.

Canada assesses the northern contingent of Atlantic mackerel every two years. The last assessment of mackerel in Canada took place in March of 2019. The Fisheries Resource Management Branch has requested scientific advice on Atlantic Mackerel for the 2021 and 2022 fishing seasons.

These proceedings report on the main points discussed in the presentations and deliberations stemming from the activities of the regional stock assessment committee. The regional peer review meeting is a process open to all participants who are able to provide a critical outlook on the status of the assessed resources. Accordingly, participants from outside DFO are invited to take part in the committee's activities within the defined framework for this meeting (Appendices 1 and 2). The proceedings also list the recommendations made by the meeting participants.

ASSESSMENT

The chair of the meeting, Martin Castonguay, welcomed participants and briefly went over the peer review process and objectives. He noted the presence of two external reviewers, Kiersten Curti (NOAA) and David Richardson (NOAA). After the participants introduced themselves, Stéphane Plourde presented DFO's national initiative to implement an ecosystem approach for fisheries management by integrating environmental variables into single-species stock assessments to improve fisheries management decisions. This represents a global shift in fisheries management methodology that takes account of the context of climate change and responds to eco-certification requirements and international market standards. The stock assessment biologist, Andrew Smith, opened the meeting by highlighting the contributions of the numerous collaborators. He presented the agenda for the following days (Appendix 3) as well as the terms of reference for the peer review, the objective of which is to provide science advice on the status of the northern contingent of Atlantic mackerel for the 2021 and 2022 fishing seasons. A summary of the previous assessment (March 2019) was presented along with a few aspects of the species' biology.

UPDATE OF KNOWLEDGE

Population structure

Audrey Bourret presented the distribution of Atlantic mackerel, along with the results of genetic studies on the population structure. Recent analyses confirm previous findings that the Northwest Atlantic mackerel stock is distinct from the Northeast Atlantic stock. These analyses also underline the distinction between the northern and southern spawning contingents of the Northwest Atlantic stock. According to the results of the genetic studies, some mixing occurs between the southern and northern contingents while they are in Canadian waters and U.S. waters, respectively.

- It was explained that the F_{st} value measures differentiation rather than mixing.
- Given the data available currently, it could be difficult to detect a new contingent along the east coast of Newfoundland, unless the genetic differences are quite significant. At the moment, there is no evidence of this.
- It was mentioned that obtaining spawners from the United States would be useful in improving our knowledge of the population structure.

Population dynamics and recruitment

Elisabeth Van Beveren presented the results of a study undertaken to better understand recruitment variability in the species (Brosset et al. 2020). According to the authors' fine-scale analysis of recruitment variability, the spatio-temporal correspondence between mackerel larvae and their preferred food as well as optimal population dynamics and structure (maternal condition, spawning biomass, age structure) promote recruitment.

- Given the absence of an egg survey in 2020, the usefulness of this study in informing the assessment model (recruitment prediction) was questioned. Most participants believed that it would not really be useful.
- Van Beveren continued with a synthesis of the biological data on mackerel population dynamics. It is generally accepted that individuals spawn in the southern Gulf in June and then disperse through Atlantic Canada to migrate to the U.S. coast, where they overwinter. However, according to this data synthesis, some eggs and larvae have been found outside the southern Gulf, notably on the Scotian Shelf and around Newfoundland, although densities remain low. In addition, movements by individuals between regions have been observed. Seasonal movements appear to be linked to temperature changes and the growth of zooplankton communities.
- No analyses involving environmental data were performed and it was explained that this was not the objective.
- The contingent's colonization of the northern Gulf seems probable in the future although it is difficult to predict exactly what will occur.
- The results of this synthesis will be published in a research document.
- The egg survey will be conducted again in 2021.

Fishery

The history of the global mackerel fishery was outlined, followed by a portrait of the commercial fishery in the Atlantic Provinces and Quebec. It is primarily an inshore fishery using a variety of gear types (gillnets, mechanical jiggers, seines, weirs, and traps), which vary by region and time of year. Mackerel are also harvested in a food fishery, bait fishery and a popular recreational fishery. While each fishery has its own regional harvest control rules, mackerel are managed on a national level. Representatives from the industry, Indigenous groups, and other stakeholders participate in the Atlantic Mackerel Rebuilding Plan Working Group organized by DFO Fisheries Management.

Updated figures on landings were presented for the years from 2017 to 2020, representing 9,786 t, 10,964 t, 8,623 t and 7,772 t respectively. A TAC of 10,000 t was established for the 2017-2018 period and of 8,000 t for the 2019-2020 period. During these years, landings mainly took place in the Gulf of St. Lawrence (NAFO Region 4RST) and off the northeast coast of Newfoundland (NAFO Region 3K).

The average length at 50% maturity (L_{50}) was recalculated for the 1974-2018 period, and was found to be 262 mm, compared to 266 mm for the 2014-2018 period.

- In 2020, Atlantic mackerel landings in the U.S. totaled 8,025 t, compared to 7,772 t in Canada. In addition, unlike Canada, the United States assesses both contingents, with the last stock assessment taking place in 2017.
- As noted in the previous assessment (March 2019), some data were incomplete or even missing altogether in some certain sectors, including the Gulf region.
- The fact that landings were low in 4R was highlighted.

Egg survey

An egg survey has been carried out in the southern Gulf since 1979. The results are used notably to calculate the total egg production index. A decrease in the length of the spawning season and in the spawning area has been noted over the years. In recent years, spawning has been observed solely in the western part of the survey area.

- It was noted that the egg survey did not take place in 2020, due to the health measures in effect for COVID-19.
- Given that the survey results are used to inform the assessment model, it was emphasized that the lack of a survey in 2020 did not prevent the model from being used to estimate the health of the stock.

ASSESSMENT OF THE RESOURCE STATUS

Assessment model: description and results

Andrew Smith provided an overview of the model used in the assessment (structure, inputs, sensitivity). Spawning stock biomass (SSB), fishing mortality and age-1 recruitment in the northern contingent of mackerel were calculated using a censored statistical catch-at-age model. Data used in the model include recorded landings, an annual egg index, catch-at-age, weight-at-age, the proportion of mature females in the population, and estimated fecundity-at-age. The uncertainty associated with unaccounted-for landings as well as landings by the U.S. fishery are explicitly taken into account in the model by imposing both upper and lower limits on the estimated annual catch.

- The upper limit was reduced (by 25%) in recent years relative to that in the previous assessment mainly to reflect the improved management measures for the recreational fishery as well as industry efforts to reduce the uncertainty associated with unaccounted-for catches.
- In addition, in response to the comments made during the last assessment, data smoothing was performed on the weight-at-age, proportion mature at age and fecundity data.
- The values input in the model come from December 2020 and will be updated.
- Questions arose about the possible explanation for the decline in fecundity in recent years (e.g., sample size, interpolation).
- Participants wondered what the catches represented, with 25% to 50% of the catches occurring in the United States. This is an estimate of the northern contingent caught in the U.S. fishery, which is included in the unreported catches and is taken into account in the model by providing upper and lower limits for the total catch.

- Participants questioned the value used for natural mortality (M), which is 0.27. This value represents the best fit to the model (sensitivity analysis). In addition, in recent years, the value for fishing mortality (F) has been much greater than the value for M, which limits M's impact in the model. According to some participants, using a value of 0.2 for M would be more appropriate; an M of 0.2 is commonly used for the pelagics and seems more accurate from a biological point of view—at least for the past. However, the model appears to be fairly robust. Several participants felt that the value of 0.27 was reasonable. It was noted that the trend for M is much more important than the value itself. The meeting participants ultimately agreed on the value of 0.27 for this assessment. Re-examining this value before the next assessment, which is expected in two years, might be appropriate, although participants were reminded that this had already been done in the past.

Andrew Smith presented the results of the modelling. The northern contingent SSB is the lowest ever observed, corresponding to 58% of the limit reference point (LRP) in 2020. The stock has been near or below the LRP for a decade according to the precautionary approach. The last recruitment event took place in 2015, when the stock was in the critical zone, but, in 2020, this cohort represented no more than 7% of the spawning biomass. There have been no notable signs of recruitment since 2015. The estimated exploitation rate among fully selected age classes (ages 5 to 10 and up) in 2020 was 74%, which exceeds the reference point (51%). The fishery currently focuses on ages 2 to 5, with an annual exploitation rate of 56%. Fish over age 5 currently represent less than 1% of the population.

- The stock has been in the critical zone for a decade. The exploitation rate is considered to be much too high.
- It was explained that the reference points are dynamic and are updated as part of the management strategy evaluation.
- Questions arose over the high exploitation rates in recent years. It would be more appropriate to examine exploitation rates by age, which is done in the Science Advisory Report, in order to provide a better understanding of the results and obtain a more accurate picture of the stock.
- Although there have been fewer fish in the water in recent years, the fishery still seems to be highly efficient.

Projections for 2021-2023

SSB projections for the years 2021 to 2023, based on various TAC scenarios, were presented. Depending on the TAC (0-10,000 t) and the recruitment projections, the probability of the spawning biomass being outside the critical zone by 2023 ranged from 29% (TAC = 10,000 t) to 58% (TAC = 0 t). Furthermore, according to these projections, the probability of the 2023 spawning biomass being greater than the 2021 spawning biomass ranged from 39% (TAC = 10,000 t) to 92% (TAC = 0 t).

- Questions were raised about the use of the Beverton-Holt stock-recruitment relationship in the projections (1969-2020), with participants wondering if an average of recent recruitment years should be used instead. Some participants suggested that an average of recent low recruitment years be used. The average of the last four years (2017-2020) seems to be a feasible option, which would exclude the larger 2015 cohort.
- Once this projection was performed (2017-2020 average), the picture remained essentially the same, although slightly more optimistic. The number of years that should be included in the average to be as realistic as possible was discussed again. Since the stock has been

below the LRP since 2010, it was proposed that the average for the 2011-2020 period be used, which means that the 2015 data would be included. This option was modelled and presented. It appears to be slightly more optimistic than the projections made using Beverton-Holt.

- All removals (TAC and unreported catches) were taken into account in the projections.
- It was decided that both options (or models) should be included in the Science Advisory Report: the one using the Beverton-Holt stock-recruitment relationship (1969-2020) and the other, which uses the 2011-2020 average. The degree of uncertainty must be mentioned in the report.
- It was proposed that a column be added in the table to indicate what the situation was relative to the LRP. However, the possibility of incorporating the upper stock reference point (USR) was excluded, since this point is defined by DFO Fisheries Management rather than DFO Science.
- Some participants were not in favour of the terminology proposed by IPCC to describe the likelihood of an outcome. Using it in the science advice was not advisable.
- Some comments were made on the table's clarity. An effort must be made to ensure that Fisheries Management will be able to correctly interpret what is shown. It was noted that a key point will be drafted on this, and that the information will also be covered in the Science Advisory Report.
- The meeting participants agreed that both models had advantages and deserved to be included in the science advice, while underlining the uncertainty involved.

CONCLUSION

INTERIM YEARS

The participants agreed to assess the stock status of the northern contingent of Atlantic mackerel for two years (Science Advisory Report for the 2021 and 2022 fishing seasons). An update would not be realistic in the meantime, given the short-term availability of data, which appeared problematic. The next science peer review is expected in the winter of 2023. No indices will be reviewed before then.

RESEARCH

Future research topics and issues mentioned include:

- Additional egg surveys (explore and validate what has been done in 4R and explore an area south of Newfoundland);
- Genetic structure of the Northwest Atlantic stock (mixture of southern and northern contingents);
- Mackerel fecundity in the Northwest Atlantic;
- Improving the way total egg production is estimated;
- Certain industry representatives would like the predation issue to be examined in greater depth (notably predation by seals).

HIGHLIGHTS AND RECOMMENDATIONS

The key points were presented, and commented on by participants. Comments involving stylistic changes and rewording are not included here.

- In the key point dealing with the genetic analyses, it must be noted that, as well as the information on the presence of southern contingent mackerel in Canadian waters, the opposite also occurs (presence of northern contingent mackerel in U.S. waters).
- It should be stated that landings mainly occurred in the Gulf of St. Lawrence (NAFO Division 4RST) and off the northeast coast of Newfoundland (NAFO Division 3K).
- Questions arose over the relevance of including a key point on the industry's effort to reduce the uncertainty associated with unaccounted-for catches. It was decided that this point would be addressed in the Science Advisory Report.
- The report would also address the uncertainty linked to environmental changes.
- It should be stated that the stock has been below the LRP for a decade according to the precautionary approach.
- In terms of the 2020 exploitation rate, it was decided that the exploitation rate for mackerel fully recruited to the fishery (5 to 10+) should be presented. It should be explained that the fishery now focuses on ages 2 to 5 and there are few fish over 5 years. The relevant facts and figures will be included in the key point.
- With regard to recruitment, it must be clearly stated that no significant recruitment has occurred since 2015.
- It was decided that the information on peak spawning times would be removed.
- In the key point on the egg survey, along with noting that the 2020 survey did not take place due to the COVID-19 pandemic, it should be added that this did not prevent the assessment model from being used to estimate the stock status.
- A key point on recruitment was added, referring to the study by Brosset et al. (2020).
- With respect to the key point on projections, there were concerns about the message conveyed in the key point. This paragraph was rewritten. Adding the TAC values corresponding to the probabilities ensures a clearer and more accurate message.
- In conclusion, it is important to note that the SSB has been in the critical zone for over 10 years and rebuilding the stock so that it is in the healthy zone will require restoring the age structure, which has been eroded by the overexploitation of the stock.

The participants concluded that:

The SSB is the lowest ever observed and has been in or near the critical zone for 10 years. According to the precautionary approach, catches from all fishing sources must be kept to the lowest possible level to promote the rebuilding of the stock. Rebuilding the stock will also require restoring the age structure, which has been eroded by overfishing.

APPENDIX 1 – TERMS OF REFERENCE

Assessment of the northern contingent of Atlantic Mackerel (*Scomber scombrus*)

Regional Peer Review - Quebec Region

February 25-26 and March 3, 2021
Virtual meeting

Chairperson: Martin Castonguay

Context

Atlantic Mackerel (*Scomber scombrus*) are a highly migratory transboundary species with two distinct spawning contingents in the Northwest Atlantic. The southern contingent has historically spawned in the Mid-Atlantic Bight from April to May whereas the northern contingent spawns primarily in the Southern Gulf of St. Lawrence in June and July. Both contingents overwinter in deeper warmer waters off the continental shelf. The U.S. fishery takes place during the winter along the New England coast and lands both contingents, whereas landings in Canadian waters are thought to consist entirely of mackerel from the northern contingent. Canada evaluates the northern contingent every two years and as of the last assessment in 2019, this stock was still in the Critical Zone according to the Precautionary Approach.

Mackerel are harvested commercially across the Atlantic Provinces and Quebec. It is an open competitive fishery that occurs primarily inshore where a variety of gear types are used (gillnets, mechanical jiggers, seines, weirs, and traps) and which vary by region and time of year. Mackerel are also harvested through a food fishery, bait fishery as well as a popular recreational fishery. While each fishery has its own regional harvest control rules, mackerel are managed on a national level. Representatives from the industry, Indigenous Groups, and other stakeholders participate in “Rebuilding Plan Working Group” organised by Fisheries Management. In 2019 and 2020, the commercial Total Allowable Catch (TAC) was 8000 t and the minimum legal size was 26.8 cm.

In contrast to Canada, the U.S.A. assesses both spawning contingents. Their last full stock assessment occurred in 2017 and DFO scientists were in attendance to contribute to the peer review process. Their stock assessment indicated that the stock was overfished and overfishing was occurring.

The spawning stock biomass, fishing mortality, and recruitment of age-1 northern contingent of mackerel are estimated using a censored statistical catch-at-age model. Data used in the model include recorded landings, an annual egg index, catch and mass-at-age, the proportion of mature females in the population, and an estimate of natural mortality. The uncertainty in unaccounted for landings as well as landings by the fishery in the U.S.A. are accounted for explicitly in the model by imposing both upper and lower bounds on the estimated annual catch.

The last assessment of mackerel in Canada took place in March of 2019. The Fisheries Resource Management Branch has requested scientific advice on Atlantic Mackerel for the 2021 and 2022 fishing seasons.

Objectives

Provide scientific advice on the status of the northern contingent of Atlantic Mackerel for the 2021 and 2022 fishing seasons. This advice will include:

- A summary of mackerel genomics describing the population structure across the Atlantic and within the Northwest Atlantic.
- A synthesis of the data in support of our understanding of mackerel population dynamics.
- A summary of how mackerel recruitment varies with respect to the environment.
- An update on the status of Atlantic mackerel, including:
    - A summary of the commercial fishery statistics up to the 2020 fishing season (Canada and U.S.A.).
    - A summary of the biological data used as input into the stock assessment model.
    - A summary of the egg survey index data up to 2020.
    - A presentation on the results of the stock assessment model (estimates of fishing mortality, spawning stock biomass, catch-at-age, abundance at age, age-1 recruitment, and spawning stock biomass projections for the years 2021-2023 under different TAC scenarios.
    - An update of stock status with respect to the Precautionary Approach's reference points.
- Specific elements related to the update of the relevant data to the management of Atlantic Mackerel such as:
    - The determination of the process to provide advice during the interim years, including a description of conditions that may warrant a full stock assessment earlier than originally planned.
    - Identification and prioritization of research projects to be considered for the future.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Expected Participation

- Fisheries and Oceans Canada (DFO) Science and Fisheries Management
- Fishing industry
- Provincial government representatives
- Aboriginal Communities / Organizations
- Academia
- Environmental NGOs

APPENDIX 2 – LIST OF PARTICIPANTS

Name	Affiliation	Feb. 25	Feb. 26	March 3
Barry, David	Barry group	x	x	x
Barry, Joe	Barry group	x	-	-
Benoit, Hugues	DFO Science	x	x	-
Bonnet, Claudie	DFO Science	x	-	-
Boudreau, Ginny	Guysborough County Inshore Fishermen's Association	x	-	x
Boudreau, Mathieu	DFO Science	x	x	-
Boudreau, Mélanie	DFO Science	x	x	-
Bourbonnière, Jean-Patrick	DFO Science	x	-	-
Bourdages, Hugo	DFO Science	x	-	x
Bourret, Audrey	DFO Science	x	x	-
Brushett, Rebecca	Ecology Action Centre	x	x	x
Carruthers, Erin	FFAW	x	-	-
Castonguay, Martin	DFO Science	x	x	x
Cawthray, Jenness	DFO Fisheries Management – Ottawa	x	x	x
Chamberland, Jean-Martin	DFO Science	x	x	-
Chandler, Alan	Fisheries and Aquaculture, Nova Scotia	x	x	x
Claytor, Ross	COSEWIC	x	x	-
Cogliati, Karen	DFO Science Ottawa	x	x	x
Couture, John	UINR	x	x	-
Curti, Kierten	NOAA	x	x	x
Cyr, Charley	DFO Science	x	x	x
d'Eon, Sherman	Cape Breeze Seafoods Ltd.	x	x	x
Deraspe, Mario	APPIM	x	-	-
Desgagnés, Mathieu	DFO Science	x	-	-
Dubé, Sonia	DFO Science	x	x	x
Duguay, Gilles	RPPSG	-	x	x
Duplisea, Daniel	DFO Science	x	-	-
Dunne, Erin	DFO Fisheries Management – NL	x	x	x
Émond, Kim	DFO Science	x	x	-
Ferguson, Louis	UPM-MFU	x	x	x
Gauthier, Johanne	DFO Science	x	-	-
Giffin, Melanie	PEIFA	x	x	x
Girard, Linda	DFO Science	x	x	-
Huard, David	RPPSG	x	x	-
Hubert, Nicholas	Membertou First Nations	x	-	x
Kelly, Brianne	WWF – Canada	x	x	x
Langelier, Serge	AMIK	x	x	-
MacMillan, Robert	PEI Fisheries	x	x	x
Marancik, Katey	NOAA	x	x	-
McQuinn, Ian	DFO Science	x	x	-
Mitchell, Vanessa	MAPC-MAARS	x	x	x
Munden, Jenna	Herring Science Council	x	x	x
McQuinn, Ian	DFO Science	x	x	x
Nilo, Pedro	DFO Science	x	x	-
Paquet, Frédéric	DFO Science	x	x	x
Pardo, Sebastian	Ecology Action Centre	x	x	x
Parent, Geneviève	DFO Science	x	x	-
Plourde, Stéphane	DFO Science	x	x	x
Rees, Bobbi	Government of NL	x	x	x

Name	Affiliation	Feb. 25	Feb. 26	March 3
Richardson, David	NOAA	x	-	-
Rivierre, Antoine	DFO Fisheries Management – Quebec	x	-	-
Sandt-Duguay, Emmanuel	AGHAMM	x	-	-
Scarratt, Michael	DFO Science	x	x	-
Schleit, Katie	Oceans North	x	x	x
Senay, Caroline	DFO Science	x	x	x
Smith, Andrew	DFO Science	x	x	x
Spingle, Jason	FFAW	x	x	x
Van Beveren, Elisabeth	DFO Science	x	x	x
Vautier, Jeffrey	Southern Gaspesia Processor	x	x	-
Wainwright, Hillary	DFO Fisheries Management – Maritimes	-	x	x
Waters, Christa	DFO Fisheries Management – Maritimes	x	x	x

APPENDIX 3 – AGENDA

Assessment of the northern contingent of Atlantic mackerel (*Scomber scombrus*)
February 25-26 and March 3, 2021 (Virtual meeting)

Président : Martin Castonguay

Time	Subject	Presenter	Duration
Day 1: Thursday, February 25, 2021			
8:30	Introductions	Martin Castonguay	10 min
8:40	Participants presentation	Martin Castonguay	10 min
8:50	Ecosystem approach to fisheries management	Stéphane Plourde	10 min
9:00	Summary of the last science advisory report	Andrew Smith	10 min.
9:10	Terms of Reference	Andrew Smith	10 min
9:15	Genomics and Stock Structure	Geneviève Parent & Audrey Bourret	45 min
10:00	A summary of how mackerel recruitment varies with respect to the environment	Elisabeth Van Beveren	15 min
10:15	A synthesis of the data in support of the current understanding of mackerel population dynamics	Elisabeth Van Beveren	30 min
10:45	Break		15 min
11:00	Fishery statistics	Andrew Smith	30 min
11:30	Egg survey statistics	Andrew Smith	30 min
12:00	Stock assessment model and input data	Andrew Smith	60-90 min
1:30	End of day 1		
Day 2: Friday, February 26, 2021			
8:30	Overflow and/or summary of day 1	Martin Castonguay	10 min
8:40	Stock assessment model and input data - recap	Andrew Smith	10 min
8:50	Model runs and sensitivity analyses	Andrew Smith	90 min
10:30	Break		15 min
10:45	Summary of advice	Andrew Smith and participants	120 min
1:30	End of day 2		
Day 3: Wednesday, March 3, 2021			
8:30	Addendum to the meeting	Andrew Smith and participants	180 min
11:30	End of the meeting		