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National Capital Region

Proceedings of the National Peer Review for Science Advice on the Potential of Introducing Live Organisms by the Aquarium, Water Garden, and Live Food Trades in Canada

Meeting Dates: June 1-3, 2020
Location: Virtual Meeting

Chairperson: Marten Koops
Editors: Stephanie Sardelis and Tessa Brinklow

Fisheries and Oceans Canada
200 Kent Street
Ottawa, Ontario, K1A 0E6

August 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 is a record of key presentations and discussion points from the national Canadian Science Advisory Secretariat peer review meeting regarding the potential of introducing live organisms by the aquarium, water garden, and live food trades in Canada. The meeting was held virtually from June 1 to 3, 2020 (*note: the meeting was compressed to three days instead of four due to the pace of discussion*). The purpose of the meeting was to develop and review formal science advice in response to a request from Fisheries and Oceans Canada's Ecosystems Management sector and the federal-provincial-territorial National Aquatic Invasive Species Committee.

The advisory process was informed by a draft Research Document and subsequent presentations by Fisheries and Oceans Canada's Ecosystems and Oceans Science sector researchers. A total of 22 participants (Appendix I) from academia, provincial governments, and Fisheries and Oceans Canada's six administrative regions participated in this advisory process. The Terms of Reference and agenda for this process can be found in Appendices II and III, respectively.

The conclusions and advice resulting from this meeting are provided in the form of a Science Advisory Report and a peer-reviewed Research Document, which are publically available on Fisheries and Oceans Canada's Canadian Science Advisory Secretariat website along with these proceedings.

INTRODUCTION

A national Canadian Science Advisory Secretariat (CSAS) peer review meeting was held virtually on June 1-3, 2020 (*note: the meeting was compressed to three days instead of four due to the pace of discussion*) regarding the invasion risk of aquatic invasive species (AIS) via the aquarium, water garden, and live food trade pathways in Canada. This science advice was requested by provincial and territorial governments and Fisheries and Oceans Canada (DFO)'s Ecosystems Management sector through the Canadian Council of Fisheries and Aquaculture Minsters' National Aquatic Invasive Species Committee (NAISC).

The Terms of Reference (TOR, Appendix II) for this CSAS process were developed in response to the request for advice from NAISC. A draft Research Document was distributed to participants three weeks prior to the meeting and served as the basis for the peer review and subsequent Science Advisory Report (SAR).

The CSAS peer review meeting involved participants with relevant expertise identified by a Steering Committee prior to the meeting, including experts from federal and provincial governments and academia. Discussion focused on the main components of the draft Research Document, particularly regarding estimates of the proportion of Canadian households owning aquaria, water gardens, or purchasing live food, the proportion of end users that release organisms in trade into the wild, and the number of organisms released per event (propagule pressure). With guidance from the meeting chair, participants formulated scientific advice summary bullets and conclusions for the SAR based on their review.

CSAS NATIONAL PEER REVIEW MEETING PROCESS

The meeting was chaired by Marten Koops. The chair provided an overview of the CSAS peer review process and described the role of meeting participants as reviewers. The main objective of CSAS is to provide sound, objective, and impartial science advice in support of government policies, management plans, and decisions. The approach is based on the Scientific Advice for Government Effectiveness (SAGE) principles and guidelines. Participation in the CSAS process is by invitation to those with expertise and knowledge of the subject matter. Scientific working paper(s) and other inputs (e.g., analysis, findings, conclusions) are subject to rigorous review and quality control in a peer-based forum. The resultant peer reviewed documents are published on the DFO CSAS website.

OVERVIEW

PRESENTATION SYNOPSIS

The meeting began with an overview presentation on organisms in trade in Canada and the alignment of the supply chain with the invasion process. It highlighted numerous opportunities for AIS to leave the commercial supply chain and enter natural environments. The research described focused specifically on the intentional release of organisms by end users. Canada's trade distribution network for organisms in trade is poorly understood, so backcasting the movement of organisms was necessary. The aim of this work was to derive spatially-explicit estimates of propagule pressure for each pathway, which could be used to identify logical opportunities for AIS surveillance at critical control points given dominant trade patterns or traceability of organisms in trade. The authors also presented the objectives, scope, analysis framework, and data sources for this work, as well as data gaps and inconsistencies.

DISCUSSION

It was clarified that the process in question was a pathway estimate of propagule pressure and did not constitute a full risk assessment. It did not explore the survival and establishment of AIS crossing Canada's international borders, nor species-specific impacts to Canadian ecosystems. Instead, it examined potential for introduction and release of organisms in trade, specifically the number of organisms released into an environment per release event.

Cultural and vandalistic release as end user behaviours was considered beyond the scope of this work as it is poorly understood and difficult to quantify. Professional and amateur online and hobbyist club sales of organisms were also considered beyond the scope of this work as data does not exist and tracking sales would be a large undertaking, exceeding the timeframe of this process. A participant noted that, in the United States, many organisms popular with hobbyists and in online trade were also captured in federal databases, which suggests that they may have also been captured in this work through the analysis of Canada Border Services Agency (CBSA) data.

Finally, for the live food trade, only invertebrates that were alive at the time of import were considered. Of all invertebrates imported, approximately 25% were labelled as live. An additional 23% were potentially alive as they were not labelled. It was not possible to discern if invertebrates that were labelled as frozen were alive or dead because frozen fresh, live, and chilled organisms all fall under a single label.

METHODS: AQUARIUM TRADE

PRESENTATION SYNOPSIS

Behaviour of aquarium owners was derived from statistics in peer-reviewed literature based on public surveys. With this information, the authors described the modelling approach used to estimate the proportion of Canadian households owning aquaria, the proportion of owners that were releasers, and the number of organisms released per event (propagule pressure). These proportions were used to identify statistically significant areas, or hot spots, at the grid level where releasers tended to aggregate.

DISCUSSION

Participants noted that the peer reviewed literature from which the behaviour of aquarium owners was inferred was outdated (1994). The authors noted that a more recent survey was conducted in 2018 with similar results, but they were not published. However, this information was sufficient to give the authors confidence that the survey results from 1994 were still useable, and the results were used as a baseline for a series of estimates to be generated accounting for uncertainty.

It was suggested that estimates used should be considered a minimum because individuals are unlikely to admit to illegally releasing organisms, while other releasers may be completely unaware that their behaviour is harmful to the environment. A sensitivity analysis was conducted to ensure that the statistics used for modelling included buffers to account for such uncertainties.

A participant pointed out that the rural-to-urban population distribution ratio applied to aquaria owners may not apply universally across all provinces and territories. For instance, using a ratio that applies to Ontario in the prairie provinces where there are a higher proportion of rural residence would skew ownership of aquaria towards larger cities. The authors acknowledged this and suggested it as an area for future analysis if or when more refined provincially or

territorially-disaggregated data becomes available. While this placed a slightly heavier bias towards urban ownership, the bias was deemed not significant, especially given a range of ratios were used in the sensitivity analysis. Census data were also used to adjust the bias. Participants agreed that this made sense, given ownership distribution would likely be correlated with retailer distribution.

Questions were posed regarding the calculation of the average (mode) number of organisms released per event. In urban areas, there may be many releasers with few release sites, which enables the reproduction of organisms even if only one is released per event. Based on the literature, the authors were confident that events where multiple organisms are released are significantly rarer than events where single organisms are released. Further, this work did not consider post-introduction filters to survival and establishment, only release.

METHODS: WATERGARDEN TRADE

PRESENTATION SYNOPSIS

Organisms considered part of the water garden trade included fish, plants, and invertebrates. Similar to the presentation on the aquarium trade, the authors outlined how the behaviour of water garden owners was derived from statistics in peer-reviewed literature based on public surveys. Water garden organisms may be released due to storms or flooding, but these events were not considered as part of the supply chain, nor as an end-user behaviour.

The authors described the modelling approach used to estimate the proportion of Canadian households with water gardens, the proportion of owners that were releasers, and propagule pressure. These proportions were used to identify statistically significant areas, or hot spots, at the grid level where releasers tended to aggregate.

Hot spot estimates were constrained by climate parameters to geographic regions where water gardening is possible in Canada. Based on available data, water gardening was assumed to be more likely in rural than urban areas where available property for gardening was greater.

DISCUSSION

The analysis was conducted at a high resolution and did not consider the survivability of particular species in individual zones, including climatic variation between provinces and territories. This was due to extensive data gaps. It was noted by a participant that the sensitivity analysis does not provide insights into distributional effects. Instead, environmentally tolerant species defined the northern limit of survivability across Canada. Similar to the aquarium trade, these estimates should be considered minimums, but might not apply for all species across all geographic regions.

A participant commented that surveys might not capture non-traditional water garden owners, such as dugouts or other water features used in rural areas. Again, the authors noted that this was captured by the sensitivity analysis.

Once again, questions were raised regarding the calculation of the average (mode) number of organisms released in a single event. In particular, plants may be released in larger quantities (e.g., removing clumps of overgrown plants) than vertebrates (e.g., removing a single fish), which would change the estimates of propagule pressure used in the model depending on the taxa in question. However, without data beyond the grey literature to substantiate this speculation, it was more conservative to make inferences based on the same propagule pressure estimates used for the aquarium trade.

METHODS: LIVE FOOD TRADE

PRESENTATION SYNOPSIS

The authors provided an overview of the live food trade pathway, including the behaviour of live food purchasers derived from statistics in the peer-reviewed literature. A model was used to estimate the proportion of the Canadian population that purchases live food, the proportion of purchasers that were releasers (values adopted from the aquarium trade due to non-existent data), and propagule pressure (values also adopted from the aquarium trade).

Data were collected on existing live food retailers across Canada, to which it was assumed the distribution of purchasers aligned based on supply-and-demand. These proportions were used to identify statistically significant areas, or hot spots, at the grid level where releasers tended to aggregate.

DISCUSSION

Domestic production of live food was not considered; only import records were considered. However, the information on the number of live food purchasers in Canada pulled from the peer-reviewed literature did not distinguish between domestic or international sources. This may have resulted in an overestimation of consumers purchasing internationally imported products, which would subsequently overestimate propagule pressure. Further, no information was provided regarding where freshwater and marine species were being purchased, which would influence propagule pressure. However, the objective of the work was not to determine the risk of successful establishment, but rather risk of introduction. The authors recognized that it is better to overestimate and ensure all potential releasers are captured than to underestimate and report a less-severe risk.

For all three pathways, it was assumed that release behaviour was occurring within 50km of purchase location. In other words, releasers were not likely to travel long distances with live organisms to release them into the wild, which would be considered highly vandalistic. Not enough is known about the motivation of purchasers to release organisms beyond cultural release and potential vandalism, which are both poorly understood.

RESULTS

PRESENTATION SYNOPSIS

The authors provided an overview of the movement of organisms in trade for all three pathways based on available data, including source countries, ports of entry, distribution hubs, and retailers. Results presented also included the number of species imported over the four-month period available from the CBSA's Pathfinder dataset, as well as model results estimating the number of households owning aquaria, water gardens, or purchasing live food in Canada, the number of releasers, and propagule pressure. These results were presented spatially across Canada to identify hot spots and subsequent control points at major nodes along the supply chain where management action to prevent the introduction and spread of AIS could focus. Inter-provincial movement of organisms in trade was also highlighted.

DISCUSSION

While shipments were considered to be direct from the source countries indicated in the CBSA's data, the species may have originated or been native elsewhere. The authors reiterated that

there is a distinction between source country and native range of organisms, which was not considered in this research.

Calgary in particular had a high number of source countries, which the authors explained was because the city has a strong and historic distribution network. Meanwhile, some ports of entry did not include imports from the United States over the four-month study period, which surprised some participants, but this may change temporally throughout the year.

Model overestimation was highlighted by data points generated in Northern Canada. The authors noted that this is likely a result of assuming similar distribution of owners across Canada. The authors reminded participants that the degree of precision decreased with northern latitude as postal code areas used to develop the spatial grid increased in size due to reduced population size and distribution.

One participant raised concerns that the estimate of the number of households in urban areas that own water gardens may be artificially high because it does not consider how many households actually have space for water gardens. For instance, may Ontarians live in condominiums or apartments where owning a water garden would be impossible, but they still contribute to the overall number of households in urban areas in the province used in this study. However, it was pointed out that terrace water gardens are increasing in popularity in urban settings and still pose a risk of owners releasing unwanted organisms. The participant suggested that types of dwellings in urban areas could have been delineated for a more accurate estimate. These data should be available from Statistic Canada as a socio-economic demographic characteristic. This level of detail was considered beyond the scope of this pathway assessment, but could form the basis of future work.

One participant noted that live organisms may arrive at distribution hubs, but may be sent from there to processing plants where they are killed. For example, species are imported into Newfoundland from St. Pierre and Miquelon (France) for processing purposes. Domestic retailers would not list these organisms as live, even though they were imported and are considered in the data as alive. Further, these species are likely native and would not pose an invasion risk. There is a disconnect between the identification of control points along the supply chain and the estimates of end-user behaviour and propagule pressure. This speaks to the lack of end-to-end traceability that exists for the supply chain to end users, which limited this study.

Finally, one participant commented on the confounding effects of advertising on compiling a list of retailers, potentially obscuring smaller shops selling live food. The authors acknowledged that the list of retailers is not complete, but major chains and some smaller shops were captured using social media. This was enough to make inferences about consumer behaviour.

KEY FINDINGS AND CAVEATS

PRESENTATION SYNOPSIS

The authors presented an overview of the key findings while outlining caveats and uncertainties. Key findings included the trade distribution networks assembled for each pathway, estimates of propagule pressure, and predictions of the volume of end-user release behaviour occurring around major cities, consistent with previous studies. The discussion of caveats was focused on the sensitivity analysis results, the limitations of assembling the trade distribution networks due to limited data and assuming that species import records were accurately reported, and modelling uncertainties. The authors concluded the presentation segment of the peer-review meeting by outlining suggestions for additional surveys and follow-up studies.

DISCUSSION

Participants noted the implications of this study regarding gaps in the CBSA tracking and reporting of imports. This study should be used by the CBSA as guidance to improve data collection and resolution. Given import data includes documentation of the release office (which correlates to port of entry), next steps could include identifying high-volume border crossings where enforcement efforts should be directed.

Participants discussed issues surrounding the accuracy of public surveys, such as representation of respondents and social desirability bias, which limit the ability to draw associations between individual behaviours and wider population traits. This influences the robustness of the sensitivity analysis used, as the values may be an underestimate of the actual volume of release. Participants suggested an important area for future work would be delineating ways to reduce bias and accrue more truthful and representative answers from the public.

Another area for future study discussed was the inclusion of species' physiological survival ability compared to geographic climate variables. Narrowing down the estimated propagule pressure based on species characterization could focus management actions spatially and temporally. This could also differ across pathways; for example, aquarium ornamental fish from the tropics would likely have a lower survival risk than hardier water garden species, despite the aquarium pathway having a higher estimated propagule pressure by the model in this study. Similarly, another mechanistic link that could be made would be the overlap between known distribution of AIS from particular pathways and the estimated hot spots of end-user release as a means of ground-truthing the reported results.

REVIEW OF OBJECTIVES

The chair led participants through a discussion regarding the objectives outlined in the TOR (Appendix II) to ensure they were met. In particular, discussion focused on objectives 2 and 5. Overall, consensus was reached that all objectives were met.

For objective 2 (characterize the behaviour of end users that allows propagules to be released), participants clarified that this study did not explore or describe release motivation, but rather quantified the volume of potential end users engaging in release behaviour. With the definition of "characterize" clarified, participants agreed objective 2 was met.

For objective 5 (identify critical control points of each pathway), participants agreed that control points along the supply chain will change in importance based on the objectives of an observer (e.g., if they are looking to intercept particular species or simply optimize general surveillance). Since this is more of a management consideration, ports of entry and distribution hubs were considered as logical control points for this work where the greatest abundance or diversity of organisms could be encountered. It would be a huge undertaking to summarize all species imported at all ports of entry, posing data management issues; setting specific management objectives would enable a more feasible review of available data. Participants encouraged the authors to better define control points and what variables may be considered to parse out critical points to increase applicability for managers. Otherwise, participants agreed this objective was met.

CONCLUSION OF THE SCIENCE ADVISORY PROCESS

In the afternoon of the third day, the skeleton of the Science Advisory Report (SAR) with conclusions in bullet point form were reviewed and agreed upon by the meeting participants.

Due to the timing of the completion of these proceedings, the content reflects the summary prepared by the rapporteur (Tessa Brinklow), which was subsequently reviewed and edited by Stephanie Sardelis.

APPENDICES

APPENDIX I. LIST OF MEETING PARTICIPANTS

Name	Affiliation
Christine Boston	Fisheries and Oceans Canada, Ontario and Prairie Region
Johanna Bradie (Written comments only)	University of Windsor
Tessa Brinklow (Rapporteur)	Fisheries and Oceans Canada, Ontario and Prairie Region
Jeff Brinsmead	Government of Ontario, Ministry of Natural Resources and Forestry
Oscar Casas-Monroy	Fisheries and Oceans Canada, Ontario and Prairie Region
Farrah Chan (Author)	Fisheries and Oceans Canada, Ontario and Prairie Region
Chantal Coomber	Fisheries and Oceans Canada, Gulf Region
Claudio DiBacco	Fisheries and Oceans Canada, Maritimes Region
Andrew Drake (Author)	Fisheries and Oceans Canada, Ontario and Prairie Region
Sophie Foster	Fisheries and Oceans Canada, National Capital Region
Jaclyn Hill	Fisheries and Oceans Canada, Quebec Region
Jeffery Eugene Hill	University of Florida
Len Hunt	Government of Ontario, Ministry of Natural Resources and Forestry
Nicole Kimmel	Government of Alberta, Ministry of Environment and Parks
Marten Koops (chair)	Fisheries and Oceans Canada, Ontario and Prairie Region
James Kristmanson	Fisheries and Oceans Canada, National Capital Region

Name	Affiliation
Mark Laflamme	Fisheries and Oceans Canada, Gulf Region
Jason LeBlanc	Government of Nova Scotia, Department of Fisheries and Aquaculture
Stephanie Sardelis	Fisheries and Oceans Canada, National Capital Region
Philip Sargent	Fisheries and Oceans Canada, Newfoundland and Labrador Region
Thomas Therriault (Author)	Fisheries and Oceans Canada, Pacific Region
Guglielmo Tita	Fisheries and Oceans Canada, National Capital Region

APPENDIX II. TERMS OF REFERENCE

Science Advice on the potential of introducing live organisms by the aquarium, water garden, and live food trades in Canada

National Peer Review - National Capital Region

June 1-4, 2020

Virtual meeting

Chairperson: Marten Koops

Context

Thousands of live aquatic organisms (fishes, vascular aquatic plants, invertebrates) are imported to Canada each year through the aquarium, water garden, and live food trades. The provinces/territories and DFO's Ecosystems Management sector, through the federal/provincial/territorial Canadian Council of Fisheries and Aquaculture Minsters' National Aquatic Invasive Species Committee (NAISC), have requested scientific advice about the invasion risk posed by these pathways across Canada. Previous CSAS processes have evaluated the screening-level risk posed by specific organisms imported to Canada through live trades based on species import volume and estimates of species survival and establishment; however, significant uncertainties remain about: 1) the scope and scale of pathways themselves (i.e. species supply chains) in Canada, including key entry points, distribution hubs, retailers, and consumers, 2) the movement and release behaviour of end-users (i.e. consumers), and, 3) the composition of species associated with each pathway. Overcoming these uncertainties would allow spatially derived statistical estimates of species introduction effort (propagule pressure) to be developed for each pathway, which would help to significantly refine current estimates of invasion risk. Characterizing this component of invasion risk will inform management and policy at regional and national levels by (i) developing a better understanding of key control points, (ii) informing future research priorities, (iii) developing monitoring programs, and (iv) establishing communication strategies for high-risk components.

Objectives

The overarching objective of this National CSAS Advisory Process is to assess the pathway–level introduction risk posed by the aquarium, water garden, and live food pathways in Canada. Working paper(s) will be reviewed and will provide the basis for discussion on the specific objectives outlined below:

- Characterize the movement of species in trade into and within Canada, including components such as the number and spatial distribution of species entry points, distributor hubs, retailers, and end users (consumers).
- Characterize the behaviour of end users (consumers) that allows propagules to be released.
- Based on available data, identify aquatic species-in-trade in Canada.
- Develop spatially-based estimates of propagule pressure, per pathway, including a description of key uncertainties.
- Identify critical control points of each pathway.

Expected Publications

- Science Advisory Report
- Research Document(s)
- Proceedings

Expected Participation

- Fisheries and Oceans Canada (DFO)
- Other government departments, including provincial/territorial governments facilitated through NAISC
- Other invited experts

References

Bradie, J., Chivers, C., and Leung, B. 2013. Importing risk: quantifying the propagule pressure-establishment relationship at the pathway level. Diversity and Distributions 19(8): 1020-1030.

Gantz, C., Mandrak, N.E., and Keller, R.P. 2014. . Application of an Aquatic Plant Risk Assessment to Non-Indigenous Freshwater Plants in Trade in Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/096 v + 31 p.

Mandrak, N.E., Gantz, C., Jones, L.A., Marson, D., and Cudmore, B. 2014. Evaluation of Five Freshwater Fish Screening-Level Risk Assessment Protocols and Application to Non-Indigenous Organisms in Trade in Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/122. V + 125 p.

Schroeder, B., Mandrak, N.E., and Cudmore, B.C. 2014. . Application of a Freshwater Mollusc Risk Assessment to Non-indigenous Organisms in Trade in Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/060. V + 26 p.

APPENDIX III. AGENDA

Note: The meeting was originally intended to last 4 days, but was shortened to 3.

Date	Time	Subject
June 1, 2020	11:00 – 11:30	• Welcome and context • Introduction of participants • Overview of CSAS policies • Review Terms of Reference • Meeting process and agenda

	11:30 – 13:00	• Background
		• Methods: Movement of organisms in trade for all pathways
		  ○ Species import records
		  ○ Components of the supply chain
		• Methods: Spatially explicit estimates of propagule pressure for the aquarium pathway
		  ○ Behaviour of aquarium owners
		  ○ # and spatial distributions of end users and releasers
		  ○ # of aquarium organisms released/year

	13:00 – 14:00	Break

	14:00 – 16:00	• Methods: Spatially explicit estimates of propagule pressure for the water garden trade
		  ○ Behaviour of water garden owners
		  ○ # and spatial distributions of end users and releasers
		  ○ # of water garden organisms released/year
		• Methods: Spatially explicit estimates of propagule pressure for the live food trade
		  ○ Behaviour of seafood consumers
		  ○ # and spatial distributions of end users and releasers
		  ○ # of live seafood organisms released/year

June 2, 2020	11:00 – 13:00	• Recap of day 1
		• Results: Movements of aquarium organisms in trade
		  ○ Flow maps
		  ○ Aquarium species in trade
		• Results: Spatially explicit estimates of propagule pressure for the aquarium trade
		  ○ # and spatial distributions of end users and releasers
		  ○ # of aquarium organisms released/year
		• Results: Critical control points in the aquarium pathway

	13:00 – 14:00	Break

	14:00 – 16:00	• Results: Movements of water garden organisms in trade
		  ○ Flow maps
		  ○ Water garden species in trade
		• Results: Spatially explicit estimates of propagule pressure for the water garden trade
		  ○ # and spatial distributions of end users and releasers
		  ○ # of water garden organisms released/year

Date	Time	Subject
		• Results: Critical control points in the water garden pathway

June 3, 2020	11:00 – 13:00	• Recap of day 2
		• Results: Movements of live food organisms in trade
		  ○ Flow maps
		  ○ Live food species in trade
		• Results: Spatially explicit estimates of propagule pressure for the live food trade
		  ○ # and spatial distributions of end users and releasers
		  ○ # of live food organisms released/year
		• Results: Critical control points in the live food pathway

	13:00 – 14:00	Break

	14:00 – 16:00	• Assumptions and uncertainties for all pathways
		  ○ Knowledge of the system
		  ○ Data relevance and quality
		  ○ Model uncertainty
		• Recommendations

June 4, 2020	11:00 – 13:00	• Recap of day 3 • Science Advisory Report development
	13:00 – 14:00	Break
	14:00 – 16:00	• Science Advisory Report development continued • Meeting wrap-up