CODEX ALIMENTARIUS COMMISSION

Food and Agriculture Organization of the United Nations

World Health Organization

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JOINT FAO/WHO FOOD STANDARDS PROGRAMME

CODEX COMMITTEE ON CONTAMINANTS IN FOODS

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DISCUSSION PAPER ON MAXIMUM LEVELS FOR METHYLMERCURY IN ADDITIONAL FISH SPECIES

(Prepared by the Electronic Working Group chaired by New Zealand and co-chaired by Canada)

BACKGROUND

1. The full history of the discussion on methylmercury dating back to 1992 is contained in Information document CF/14 INF/1. A summary of the background leading up to the current discussion paper is given below.

CCCF11 (2017)

2. The 11th Session of the Codex Committee on Contaminants in Foods (CCCF11) (2017) agreed to the concept of establishing maximum levels (MLs) for methylmercury in fish species based on the principle of as low as reasonably achievable (ALARA), in line with the criteria for establishing MLs in the General Standard for Contaminants and Toxins in Food and Feed (GSCTFF) (CXS 193-1995)[1]. The Committee agreed to establish an Electronic Working Group (EWG), chaired by The Netherlands, and co-chaired by New Zealand and Canada, to prepare proposals for MLs for tuna as a group, alfonsino, kingfish/amberjack, marlin, shark, dogfish and swordfish.

3. As part of the recommendations[2] presented to CCCF11 by the previous EWG, other species were identified where further data collection was advised to establish if MLs were needed. Additionally, a recommendation[3] was made that discussion could be commenced on considering MLs for other species in the Global Environment Monitoring System (GEMS) database, with a preliminary analysis presented in the supporting discussion paper.

CCCF12 (2018)

4. CCCF12 (2018) agreed that consistent with the approach taken for the establishment of MLs for lead, the methylmercury ML proposal that would be agreed upon would be those based on the next higher ML resulting in a trade rejection rate lower than 5%. The Committee agreed upon MLs for tuna species[4] (1.2 mg/kg), alfonsino[5] (1.5 mg/kg;), marlin[6] (1.7 mg/kg) and shark[7] (1.6 mg/kg). No consensus was achieved for an ML for swordfish and it was agreed to discontinue[8] work on an ML. Based on the new dataset used by the EWG it was established that mean and median concentrations of total mercury and methylmercury in amberjack all fell below 0.3 mg/kg, the agreed selection criteria for selecting fish species for setting MLs, and therefore it was agreed to discontinue[9] work on the ML for amberjack.

[1] REP 17/CF, para. 126
[2] CX/CF 17/11/12
[3] CX/CF 17/11/12, para. 15
[4] REP 18/CF, para. 75
[5] REP 18/CF, para. 77
[6] REP 18/CF, para. 77
[7] REP 18/CF, para. 77
[8] REP 18/CF, para. 83
[9] REP 18/CF, para. 78

5. CCCF12 also noted[10] that for future ML development, data on both methylmercury and total mercury would need to be available, as it was shown that for certain fish species the ratio of methylmercury to total mercury was very low and for the data analysis it could not always be assumed that total mercury would be mostly present as methylmercury.
6. With the agreement of the MLs for tuna, alfonsino, marlin and shark, there was an established framework to apply an ALARA approach in the setting of future MLs for methylmercury in fish.
7. Noting the recommendation made in CX/CF 17/11/12 for discussion on considering MLs for other species CCCF12 agreed[11] to establish an EWG chaired by New Zealand and co-chaired by Canada to prepare a discussion paper presenting a proposal for establishment of MLs for additional fish species. The paper was to clearly identify the fish species for which MLs should be established.

CCCF13 (2019)

8. The resulting discussion paper[12] from the EWG was considered by CCCF13. The limited availability of methylmercury concentration data for additional fish species precluded establishing appropriate MLs. However a number of species or taxonomic groups were identified where further data collection would be necessary to confirm ALARA or exceedance of the selection criteria.
9. CCCF13 considered[13] a staggered timeline for ML derivation of species or taxonomic groups identified for further data collection, however it was recognized that the recommended program was ambitious and contingent on data submission.
10. CCCF13 agreed[14] to request the FAO/WHO Secretariats of the Joint Expert Committee on Food Additives (JECFA) to issue a call for new data to be submitted to GEMS/Food that would support revision of the discussion paper to consider whether it is feasible to proceed with establishment of MLs for additional fish species.
11. CCCF13 also agreed to consider issues related to sampling plans for methylmercury in fish as part of the re-established EWG examining the feasibility of MLs for additional fish species.
12. Following the agreements at CCCF13, an EWG was established, the participants of which are listed in Appendix V.
13. The recommendations of the EWG for consideration by CCCF14 are described in paragraphs 40 to 44 below. A project document on proposals for new work based on these recommendations is provided in Appendix II.
14. The full discussion paper on establishing MLs for additional fish species is provided in Appendix III. The full discussion paper on developing a sampling plan is provided in Appendix IV. The discussion papers detail the work process followed as well as all the data and information considered by the EWG to arrive at the recommendations in paragraphs 40-44.

Discussions and conclusion - Establishing MLs for additional fish species:

Use of total mercury datasets

15. The EWG provided comments on the interpretation of selection criteria and potential ML options based on total mercury. Although CCCF12 had confirmed[15] that both methylmercury and total mercury were necessary for future ML development, the role both datasets would present in establishing the ML was not specifically defined, particularly where paired analysis was available to confirm the proportion of methylmercury present.
16. Options were presented to the EWG applying both total mercury and methylmercury datasets to the selection criteria and potential MLs. There was support from members of the EWG for either dataset being used to elucidate the need for MLs and the potential values.

[10] REP 18/CF, para. 88
[11] REP 18/CF, para. 93
[12] CX/CF 19/13/13
[13] REP 19/CF para. 116
[14] REP19/CF para. 127
[15] REP18/CF para. 88

17. One member recommended the use of the ratio of methylmercury to total mercury to inform the interpretation. Taking on board this recommendation the datasets were re-reviewed to consider an option for combining methylmercury and unpaired total mercury data. Where paired analysis was deemed to be significantly correlated a regression equation was calculated to model the relationship between methylmercury and total mercury. By applying this equation to any unpaired total mercury for that species it was possible to adjust the data from which it can be modelled with the methylmercury dataset. This approach has the benefit of generating a larger dataset giving greater confidence in the interpretation against the selection criteria and the ML options available.

Interpretation of anglerfish dataset

18. The EWG were asked to consider how the anglerfish dataset should be interpreted and whether it should remain a species targeted for further data collection. The mean for total mercury falls below the selection criteria, however the mean of the much smaller methylmercury dataset exceeds the selection criteria. Members commented that use of the larger total mercury dataset would be beneficial, and that substantial numbers of methylmercury results may be necessary to resolve the difference seen. One member also noted that additional data collection for anglerfish was underway and would be submitted in 2020.

19. To enable the anglerfish datasets to be reconciled will require paired total mercury and methylmercury to be available to confirm the ratio. A conservative calculation indicates that it is unlikely the selection criteria would be exceeded with a combined dataset.

Minimum sample numbers

20. The previous discussion paper[16] had used a simple screening method to identify minimum sample numbers to have confidence in identifying the need for MLs and the potential ML value that could be established. One member provided information on a statistical test to identify the sample number required to have confidence in certain rejection rates. The outputs of this model were incorporated to identify that a minimum of 74 samples were necessary to establish a 4% rejection rate.

Trade information

21. One member noted the need to identify the significance of the species in trade. Export tonnage and monetary value recorded for each identified species for 2017 were extracted from the FAO yearbook Fishery and Aquaculture Statistics 2017. For reference, export tonnage and monetary value were also obtained for tuna, marlin and shark, these data were not available for alfonsino.

Selection criteria

22. One member noted that the selection criteria (of 0.3 mg/kg) should not be relied upon to identify additional fish species for ML setting as fish containing methylmercury below this concentration could contribute to overall dietary exposure. As a result, MLs should be established for all species where the data are sufficient.

23. The present discussion paper has been developed through aligning with the selection criteria accepted by CCCF12 to identify species where ML setting was not required[17]. Review of this selection criterion has been considered out of scope of identifying whether it is feasible to proceed with establishment of MLs for additional fish species.

Proposed MLs

24. One member noted that the Committee has previously used a violation rate of 2-3% in developing MLs. As minor fish species are expected to have an insignificant impact on health and could have limited fishing quotas available to enter into trade a lower violation rate would ensure no unnecessary economic loss. Violation rates of lower than 5% would require larger datasets to ensure confidence in the ML value being established.

25. For fish species/grouping identified to exceed the selection criteria the present discussion document identifies hypothetical MLs covering a range of violation rates. For those species identified to be appropriate to proceed with establishment of MLs the specific violation rate applied could form part of the proposed new work.

[16] CX/CF 19/13/13
[17] REP18/CF para. 78

Discussions and conclusion – Sampling plan:

Variation of methylmercury within fish sampled at the same time

26. The EWG was asked to consider information presented to define methylmercury variation in the lot as a function of fish size (length or weight) and recommend samples drawn be representative of the size range in the lot. It was noted that the data had only been considered for orange roughly and pink cusk-eel and the extent of variability in other species could be different.

27. While members agreed that size was a factor in variation of methylmercury levels they noted the difficulty an approach to draw representative samples might have, notably in processed portions where inherent variation may not be controlled by size. One member commented that applying this criterion would likely require further information to define how to draw size representative samples. Two members recommended an approach to focus only on larger fish in a lot to establish ML compliance. Another member suggested that if the samples are truly representative of the size range then it would be likely that the methylmercury concentration from a size representative sample would reflect the midpoint of the range of methylmercury concentrations given the relationship with size. One member noted that fish traded internationally would be graded by size so variation would already be addressed.

28. The differences in sizes amongst the four species/groupings of fish for which MLs have been established is considerable (alfonsino typically <50 cm; Atlantic blue marlin up to 500cm) and even within the groupings the variability in size may also be large (bullet tuna: ~50 cm; bluefin tuna ~ 200 cm). Defining typical size variation of the lot to encompass the species with MLs would therefore be difficult. Because of these differences using a general sampling plan to encompass the four species/groupings of fish with MLs may not be fit for purpose. An approach to develop specific annexes for each of the four species/groupings of fish with MLs is proposed to ensure that the species specific variation is captured. The annexes would also consider sampling of processed portions of the fish species with MLs, where there is evidence for these in trade.

29. A member noted that for farmed fish the control of methylmercury in the feed would be more consistent than that for wild caught fish thus there would be reduced variation in the content of methylmercury.

Should the whole fish be analyzed or only specific fractions of edible portions

30. The EWG was asked to consider information presented on total mercury and methylmercury concentrations in different lateral fractions of fish and the options to take a representative sample for a large fish. Two members provided further scientific studies around bluefin tuna which were added to the interpretation (Appendix IV: Paragraphs 18-20). One member provided a scientific study on Atlantic halibut (Appendix IV: Paragraph 24)

31. There was support from most members for using a fraction of a large fish for sampling, one member noted that further data should be collected before agreeing on this point. Two members noted variability in the distribution of methylmercury in the carcass was minimal and any fraction could be used, which would limit economic loss. One member supported a composite of head and tail fractions. One member noted that additional information to support the sampling would be beneficial, such as presence/absence of skin and sample depth; as well as clarifying the exact location on the fish carcass the cuts would be made.

32. One member also noted that information on methylmercury distribution in small fish would also be useful.

33. As per paragraph 28 the use of a single approach to cover all of the fish species with MLs is unlikely to be fit for purpose. Development of a database to support identification of the most appropriate sampling fraction based on the properties of each of the species with MLs would be beneficial. The capture of such data would support the development of species specific annexes of the sampling plan.

Draft sampling plan

34. The EWG was invited to comment on a draft of a sampling plan presented to the 13th CCCF (CF13/CRD15) reformatted to ensure harmonization with other sampling plans in the *General Standard for Contaminants and Toxins in Food and Feed.*

35. Members commented that the language in the sampling plans for mycotoxins, which was used as a reference to develop the sampling plan for mercury in fish, would need changing to better reflect terminology around trade in fish. There was agreement from members that sampling at retail was not appropriate within the sampling plan, as a result this section was removed.

Further work

36. Three members noted that further scientific interpretation or collection of a valid database to inform the sampling plan should be undertaken. One member noted that obtaining the evidence base and findings of sampling plans adopted by national authorities would also be of value.

37. It is concluded that further data collection will be essential to develop a robust sampling plan that covers the requirements of all of the fish species/groupings with MLs. A recommendation over the specific aspects required is recorded in paragraph 44 below.

Other discussions

38. A member questioned whether focusing testing on larger fish in the lot would be consistent with reconditioning a lot by removing the larger fish rather than discarding the entire lot. This aspect could be considered within the species specific information as it may not be feasible for some fish species if the larger fish were not easily identifiable in the lot.

39. It has also been noted that there is no consolidated source of risk management recommendations at the catch, sorting, and processing for methylmercury in fish, for example to cover reconditioning options. A cursory literature review suggested that there may be benefit in considering if a guidance paper would be feasible to develop. A note in the General Standard recommends that countries should consider developing nationally relevant consumer advice for women of childbearing age and young children to supplement the ML. Although specific risk communication guidance is therefore not necessary there may be benefit in providing case studies on how consumer advice has been developed, to support countries in implementing this recommendation.

Recommendations:

CCCF is invited to focus its discussions in the recommendations below taking into account the discussion and conclusions on MLs, sampling plans and other risk management recommendations as summarized above and fully described in Appendices III and IV.

Establishing MLs for additional fish species

40. An updated analysis of total mercury and methylmercury data in GEMS/Food for orange roughy and pink cusk-eel identifies the average methylmercury concentration in these species exceeds the selection criteria. Consequently new work could commence to establish MLs for methylmercury in these two species. A new work proposal document is presented in Appendix II to support this program of work.

41. Analysis of the updated total mercury and methylmercury data in GEMS/Food for other species indicates there may be further species or taxonomic groups for which MLs could be derived, specifically anglerfish, snake mackerel, toothfish, sablefish, catfish and greenling. Continued data collection for these species would be beneficial to elucidate the need for MLs

42. A summary table of the recommendations for each species from the present analysis and CX/CF 19/13/13 is presented in Appendix I.

Sampling Plan

43. The consideration of the issues related to sampling plans for methylmercury in fish has identified that species specific consideration could be a preferred approach to ensure the utility of the sampling plan However, generation of databases is required to support species specific annexes in the sampling plan. It is recommend to continue development of the sampling plan at the EWG and present a draft to the plenary in 2021. A proposed draft format for the sampling plan is presented in Appendix IV.

44. A call for data would be necessary to support generation of the database on species specific considerations for methylmercury, aspects to include in the call for data would be:

    a. Results of national sampling plans for tuna, shark, alfonsino and marlin, including, where possible, indication on how the material has been sampled.

    b. Data on correlation of fish length or weight with methylmercury concentration for shark, alfonsino, marlin; and tuna species aside from bluefin.

    c. Data on tissue distribution of methylmercury for shark, alfonsino and marlin

Other Matters: Risk management recommendations

45. The Committee is invited to consider the following additional matter in relation to methylmercury in fish.

46. At present it has been noted that there is no consolidated source of guidance for methylmercury to capture risk management recommendations at the catch, sorting, and processing level. A thorough review of the available literature could be undertaken to identify if there is sufficient information available to support the development of such a guidance paper and provide a scope for what it might contain.

APPENDIX I

SUMMARY TABLE OF RECOMMENDATIONS (FOR CONSIDERATION BY CCCF)

Common name	Scientific name	Taxonomic grouping	FAO taxonomic code	Mean methylmercury [total mercury] concentration (mg/kg)	Date of review and recommendation
Anchovies	*Engraulidae sp.*	Family	1,21(06)xxx,xx	0.05 [0.07]	2019: No ML required
Anglerfish	*Lophius sp.*	Genus	1,95(01)001,xx	0.60 [0.18]	2020: Data collection- low sample numbers and wide disparity between methylmercury and total mercury
Barracuda	*Sphyraena sp.*	Genus	1,77(10)001,xx	[0.69]	2019: Data collection – low sample numbers and no methylmercury results
Blue moki	*Latridopsis ciliaris*	Species	1,70(71)309,01	[0.12]	2019: No ML required
Butterfish	*Odax pullus*	Species	1,70(64)003,01	[0.02]	2019: No ML required
Cardinalfish	*Epigonus telescopus*	Species	1,70(96)373,01	[1.27]	2019: Data collection– no methylmercury results
Carp	*Cyprinidae*	Family	1,40(02)xxx,xx	0.03 [0.13]	2019: No ML required
Catfish	*Siluriformes sp.*	Order	1,41(xx)xxx,xx	[0.41]	2020: Data collection – wide disparity in means for species, low sample numbers and no methylmercury results
Codfish	*Gadinae sp.*	Sub-family	1,48(04)xxx,xx	0.05 [0.07]	2019: No ML required
Cusk-eel	*Ophidiidae*	Family	1,58(02)xxx,xx	0.46 [0.46]	2020: Average methylmercury exceeds selection criteria; proposed for ML setting
Cutlassfish	*Trichiuridae sp.*	Family	1,75(06)xxx,xx	[0.16]	2019: Data collection – wide disparity in means for species, low sample numbers and no methylmercury results
Eels	*Anguilliformes sp.*	Order	1,43(xx)xxx,xx	0.18 [0.19]	2019: No ML required
Greenling	*Hexagrammidae*	Family	1,78(07)xxx,xx	[0.28]	2020: Data collection – low sample numbers and no methylmercury results
Grouper	*Epinephelus sp.*	Genus	1,70(02)042,xx	[0.27]	2019: No ML required Data collection – limited geographic distribution and average approaching the selection criteria
Hapuku	*Polyprion oxygeneios*	Species	1,70(05)058,02	[0.33]	2019: Data collection – low sample numbers and no methylmercury results
Herring	*Cupeidae sp.*	Family	1,21(05)xxx,xx	0.04 [0.04]	2019: No ML required

Common name	Scientific name	Taxonomic grouping	FAO taxonomic code	Mean methylmercury [total mercury] concentration (mg/kg)	Date of review and recommendation
Kahawai	*Arripis trutta*	Species	1,70(29)051,02	[0.24]	2019: No ML required
Ling	*Lotidae sp.*	Sub-family	1,48(04)xxx,xx	[0.28]	2019: Data collection for individual species – cusk and blue ling
Mahi-mahi	*Coryphaena hippurus*	Species	1,70(28)071,01	[0.23]	2019: No ML required
Medusafish	*Centrolophidae sp.*	Family	1,769(08)xxx,xx	[0.11]	2019: No ML required
Merluccid hake	*Merlucciidae sp.*	Family	1,48(05)xxx,xx	0.20 [0.13]	2019: No ML required
Mullet	*Muglidae sp*	Family	1,65(01)xxx,xx	0.02 [0.14]	2019: No ML required
Orange Roughy	*Hoplostethus atlanticus*	Species	1,61(05)002,02	0.43 [0.56]	2020: Average methylmercury exceeds selection criteria; proposed for ML setting
Pacific red gurnard	*Chelidonichthys kumu*	Species	1,78(02)003,01	[0.11]	2019: No ML required
Perch	*Percidae sp.*	Family	1,70(14)xxx,xx	[0.20]	2019: No ML required
Phycid hake	*Phycidae*	Sub-family	1,48(04)xxx,xx	[0.13]	2019: No ML required Data collection for individual species – white hake
Pike	*Escoidae sp.*	Family	1,24(03)xxx,xx	[0.29]	2019: No ML required Data collection – limited geographic distribution and average approaching the selection criteria
Pomfrets	*Brama sp.*	Genus	1,70(27)003,xx	[0.07]	2019: No ML required
Porgies	*Sparidae sp.*	Family	1,70(39)xxx,xx	[0.17]	2019: No ML required
Rays and skate	*Rajiformes sp.*	Order	1,10(xx)xxx,xx	[0.18]	2019: No ML required
Red cod	*Pseudophycis bachus*	Species	1,48(02)014,01	[0.06]	2019: No ML required
Redbait	*Emmelichthys nitidus*	Species	1,70(30)010,01	[0.15]	2019: No ML required
Right eyed flounder & sole	*Pleuronectidae sp./ Soleidae sp*	Family	1,83(02)xxx,xx and 1,83(03)xxx,xx	0.11 [0.21]	2019: No ML required

Common name	Scientific name	Taxonomic grouping	FAO taxonomic code	Mean methylmercury [total mercury] concentration (mg/kg)	Date of review and recommendation
Rockfish	*Sebastes sp.*	Genus	1,78(01)001,xx	[0.19]	2019: No ML required
Sablefish	*Anoplopoma fimbria*	Species	1,78(08)004,01	[0.43]	2020: Data collection– no methylmercury results
Salmonids	*Salmonidae sp.*	Family	1,23(01)xxx,xx	0.03 [0.04]	2019: No ML required
Sea bass	*Unknown*	Unknown	Unknown	[0.21]	2019: No ML required Data collection – species not clearly identifiable
Short nosed chimera	*Chimaeridae sp.*	Family	1,12(01)xxx,xx	[0.38]	2019: Data collection – no methylmercury results
Snake mackerel	*Gempylidiae sp.*	Family	1,75(05)xxx,xx	[0.39]	2020: Data collection– no methylmercury results
Snapper	*Lutjanus sp.*	Genus	1,70(32)xxx,xx	[0.30]	2019: Data collection– low sample numbers and no methylmercury results
Sturgeon	*Acipenseridae sp.*	Family	1,17(01)xxx,xx	[0.08]	2020: No ML required
Temperate bass	*Moronidae sp.*	Family	1,70(04)xxx,xx	0.04 [0.18]	2019: No ML required
Tilapia	*Oreochromis sp.)*	Genus	1,70(59)051,xx	[0.01]	2020: No ML required
Toothfish	*Dissostichus sp.*	Genus	1,70(92)015,xx	[0.41]	2020: Data collection– no methylmercury results
Turbot	*Psetta maxima*	Species	1,83(05)092,01	[0.08]	2019: No ML required
Typical smelt	*Osmeridae sp.*	Family	1,23(04)xxx,xx	0.07 [0.06]	2019: No ML required
Wolffish	*Anarhichas sp*	Genus	1,71(02)001,xx	0.12 [0.10]	2019: No ML required

APPENDIX II

PROJECT DOCUMENT FOR NEW WORK ON
MAXIMUM LEVELS FOR METHYLMERCURY IN CUSK-EEL AND ORANGE ROUGHY

(For consideration by CCCF)

1. **Purpose and Scope of the new work**

This work aims to establish Maximum Levels (MLs) for methylmercury in cusk-eel and orange roughy.

2. **Relevance and timeliness**

The current MLs for methylmercury in fish (tuna: 1.2 mg/kg, alfonsino: 1.5 mg/kg, marlin: 1.7 mg/kg and shark: 1.6 mg/kg) were adopted[1] by the 41st Session of the Codex Alimentarius Commission (CAC41) in 2018 and included in the General Standard for Contaminants and Toxins in Food and Feed (GSCTFF) (CXS 193-1995). These MLs replaced Guideline Levels (GLs) encompassing all predatory and non-predatory fish species, in line with the recommendation of CAC that consideration should be given to establishment of MLs rather than GLs[2]. Discussion could be commenced on considering MLs for other species in the GEMS database, with a preliminary analysis contained in the supporting discussion papers[3] submitted to the Committee. With the establishment of an agreed upon framework at CCCF12 to apply the Principle of As Low As Reasonably Achievable (ALARA) in the establishment of MLs for methylmercury in fish, it is timely to undertake work to derive MLs for additional fish species.

3. **Main aspects to be covered**

ML(s) for methylmercury in additional fish species, taking into account the following:

a. Results of discussions at CCCF on the establishment of MLs for methylmercury in fish species
b. Risk assessments by the Joint Expert Committee on Food Additives (JECFA)
c. Conclusions of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption
d. Achievability of the MLs

The following species of fish have been identified as having average levels of methylmercury sufficient to exceed the selection criterion of 0.3 mg/kg.

Orange roughy
Cusk-eel

4. **Assessment against the criteria for the establishment of work priorities**

Consumer protection from the point of view of health, food safety, ensuring fair practices in the food trade and taking into account the identified needs of developing countries.

The new work will derive Maximum Level(s) for methylmercury in fish species identified as having average levels of methylmercury sufficient to exceed the selection criterion of 0.3 mg/kg.

Diversification of national legislation and actual or potential impediments to international trade.

The international trade of fish and fishery products is increasing, and the new work will provide internationally-harmonized standards.

Work already undertaken by other international organizations in this field and/or suggested by the relevant international intergovernmental body(ies).

The proposed work to establish MLs for methylmercury in the identified fish species globally has not been undertaken by any other international organizations nor suggested by any relevant international intergovernmental bodies.

Consideration of the global magnitude of the problem or issue

The consumption and international trade of fish and fishery products are increasing globally, thus this work is of worldwide interest and becoming increasingly significant.

[1] REP18/CAC, Appendix III
[2] REP18/CF para. 81; CXS 193, Footnote 1
[3] CX/CF 17/11/12, para. 15; CX/CF 19/13/13

5. Relevance to Codex Strategic Goals

The proposed work falls under the following Codex Strategic Goals of the Codex Strategic Plan 2020-25

Strategic goal 1: Address current, emerging and critical issues in a timely manner

This work was proposed in response to needs identified by Members in relation to food safety, nutrition and fair practices in the food trade. There is already significant trade in fish species which potentially have methylmercury levels that exceed the selection criterion of 0.3 mg/kg.

Strategic goal 2: Develop standards based on science and Codex risk-analysis principles

This work will use the scientific advice of the joint FAO/WHO expert bodies to the fullest extent possible. Also, all relevant factors will be fully considered in exploring risk management options.

Strategic goal 4: Facilitate the participation of all Codex Members throughout the standard setting process

Due to the international interest in the trade and consumption of fish, this work will support and embrace all aspects of this objective by requiring participation of both developed and developing countries to conduct the work.

6. Information on the relationship between the proposal and other existing Codex documents

This new work is recommended following the criteria for establishing MLs in food and feed as outlined in the General Standard for Contaminants and Toxins in Food and Feed (GSCTFF).

7. Identification of any requirement for and availability of expert scientific advice

Expert scientific advice has been already provided by JECFA and the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption.

8. Identification of any need for technical input to the standard from external bodies

A need for additional technical input from external bodies has not been identified.

9. The proposed timeline for completion of the new work(timeframe for developing a standard should not normally exceed 5 years)

Grouping (identified species)	Timeframe
Cusk-eel Orange roughy	Final adoption by CAC in 2023 or earlier

APPENDIX III

DISCUSSION PAPER ON
ESTABLISHING FURTHER MAXIMUM LEVELS FOR METHYLMERCURY IN FISH
(For information)

Introduction

1. The current maximum levels (MLs) for methylmercury in the General Standard for Contaminants and Toxins in Food and Feed (GCSTFF) (CXS 193-1995) are 1.2 mg/kg for tuna, 1.5 mg/kg for alfonsino, 1.7 mg/kg for marlin and 1.6 mg/kg for shark. These MLs address the majority of the species of concern identified by the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption[1]. An As Low As Reasonably Achievable (ALARA) approach was used for deriving these MLs, with the established limits set at the concentration value, reported to one significant figure, where the rejection rate was less than 5% (REP18/CF para 71).
2. The agreed upon framework for identifying the selected species for possible ML elaboration was to use a screening concentration of 0.3 mg/kg average methylmercury (CX/CF 17/11/12).
3. For species with average methylmercury concentrations below this screening concentration, the benefits of fish consumption are expected to outweigh the risks when the fish was consumed (CX/CF 17/11/12). Using this screening concentration, CCCF agreed on a recommendation that amberjack did not require an ML (CX/CF 18/12/7).
4. A review of the GEMS/Food database was undertaken in November 2018 of total mercury and methylmercury for those fish species for which MLs were not adopted by CAC41 (2018). The review was to identify further species that would meet the criteria for ML establishment. The full findings of the review were recorded in CX/CF 19/13/13. In brief, the limited availability of methylmercury concentration data for these fish species precluded establishing appropriate MLs. However, a number of species or taxonomic groups were identified where further data collection would be necessary to establish whether ML setting may be necessary (Table 1). Additionally, based on total mercury data falling below 0.3 mg/kg a broader range of fish species and groupings were confirmed to be unlikely to require MLs (CX/CF 19/13/13, Appendix I).

Table 1: Identified fish species or taxonomic groupings for further data collection
(*As presented in* CX/CF 19/13/13).

Grouping (identified species)	
Anglerfish	Pike
Barracuda	Sablefish
Cardinalfish	Seabass
Catfish (Channel catfish)	Short nosed chimera (Rat fish)
Cusk-eel (Pink Cusk-eel, Kingklip)	Snake mackerel (Escolar)
Cutlassfish (Scabbardfish)	Snapper (Russell’s snapper, unspecified)
Grouper (Yellowfin)	Sturgeon
Hapuku	Toothfish (Patagonian toothfish)
Ling (Cusk, Blue ling)	White hake
Orange roughy	

5. CCCF13 considered a staggered timeline for ML derivation of species or taxonomic groups identified for further data collection, however it was recognized that the recommended program was ambitious and contingent on data submission (REP 19/CF para 116).
6. As a result, CCCF13 agreed to request that JECFA issue a call for new data to be submitted to GEMS/Food that would support revision of the discussion paper to consider whether it is feasible to proceed with establishment of MLs for additional fish species (REP19/CF para 127).
7. With an agreed framework for selecting and deriving methylmercury MLs for fish species established, the GEMS/Food database was examined for new data for total mercury and methylmercury in fish to consider whether it is feasible to proceed with establishment of MLs for additional fish species.

[1] Report of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption. Rome, Food and Agriculture Organization of the United Nations; Geneva, World Health Organization

Work Process

Selection criteria

8. A process to derive selection criteria for fish species of concern requiring MLs for methylmercury was reported on in CX/CF 17/11/12.

9. The selection criterion was derived through consideration of weekly fish consumption amounts, in g/person per week, that would be required to reach the PTWI of 1.6 µg/kg bw/day (Table 2).

Table 2: Weekly fish consumption amounts required to reach PTWI of 1.6 µg/kg bw/day at various methylmercury concentrations (As presented in CX/CF 17/11/12).

Methylmercury concentration (mg/kg)	Fish consumption to reach PTWI (g/person per week)	GEMS Cluster Diets potentially exceeding PTWI (fresh/frozen fish)
0.1	960	0
0.2	480	0
0.3	320	0
0.4	240	G14, G17
0.5	192	G10, G14, G17
0.6	160	G10, G14, G17
0.7	137	G10, G11, G14, G17
0.8	120	G04, G07, G08, G10, G11, G14, G17
0.9	107	G02, G03, G04, G07, G08, G10, G11, G14, G15, G17
1.0	96	G02, G03, G04, G07, G08, G09, G10, G11, G12, G14, G15, G17

10. Through comparison of the calculated fish consumption amounts to the 95th percentile fresh fish consumption rate of 285 g/person per week for all GEMS/Food, and to fish consumption amounts in the individual WHO GEMS cluster diets, it was considered that a methylmercury concentration of greater than 0.3 mg/kg would be required to present a risk of exposures exceeding the PTWI (CX/CF 17/11/12). As a result, an average methylmercury concentration of 0.3 mg/kg was adapted as the selection criteria for identifying fish species that would present a concern for methylmercury (REP 17/CF).

11. It is important to note that fish containing an average of less than 0.3 mg/kg methylmercury may still contribute to overall dietary exposure to methylmercury and therefore contribute to a cumulative exceedance of the PTWI if fish with high methylmercury concentrations are also consumed.

12. The 0.3 mg/kg selection criterion for methylmercury has been used in the present consideration to identify further species or taxonomic groupings where MLs could be established.

Review of new data submitted to GEMS/Food (November 2018 – November 2019)

13. The GEMS/Food dataset for total mercury and methylmercury were reviewed to identify results uploaded in the period of 01 November 2018 to 15 November 2019, these being the results newly uploaded since the previous consideration of the data (CX/CF 19/13/13).

14. The review of new data identified a total of 35,636 mercury results for seafood, 1291 of which were for methylmercury. The new results covered a sampling period of 2008-2019 and were representative of data from Australia, Canada, New Zealand and Norway; as well as from the broader European region.

15. Data were excluded that were not for fish species[2], were aggregated data, were unspecific categories, or were not for whole fish or muscle[3]. To ensure the data analysis remained consistent with that of CX/CF 19/13/13, data points for cooked fish were included, with the exception of fish cooked with other ingredients (including batter, breading, glazes, salting and use of spices/herbs) or stored/marinated in oils or sauce. All data from tuna and bonito, alfonsino, kingfish/amberjack, sharks and selachoidae, marlin, dogfish and swordfish were excluded as the conclusions on these species were not being reconsidered.

16. Data were only considered if they were clearly identifiable to a species or taxonomic grouping of fish, either through provision of a binomial name or a sufficiently unique common name[4]. Aligning with the grouping of “all tuna” and “all shark” results to generate group MLs for these species, where possible results for species were grouped within appropriate taxonomic groups (CX/CF 18/12/7).

17. Data for species/taxonomic grouping of fish for which CX/CF 19/13/13 had identified that MLs were not required, were also excluded as they were outside of the scope of the present consideration, namely the suitability to proceed with establishment of MLs for additional fish species.

18. New data for each species was combined with the results considered previously within CX/CF 19/13/13 to provide an updated dataset for each fish species. Species[5] where previously insufficient sample size (≤10 results) existed for analysis (CX/CF 19/13/13) were re-examined to determine if new data resulted in the total dataset meeting the criterion for further evaluation of 10 results or more. The previous results were combined with the newest data to generate a dataset with as many samples as possible for each fish species or taxonomic grouping.

19. To avoid any potential for duplication where samples in a survey have been analyzed for both methylmercury and total mercury, survey results for mercury and methylmercury were analyzed separately.

20. Where available paired data were considered to confirm the ratio of methylmercury to total mercury. To establish if there was confidence in the calculated ratio the paired datasets were analyzed for correlation (Pearson Correlation Coefficient) and confirmed for statistical significance (p= <0.05). Where the ratio of methylmercury to total mercury was statistically correlated, the unpaired total mercury dataset was adjusted by the calculated linear regression equation from the paired data to estimate the methylmercury concentration.

21. All datasets were statistically analyzed for each fish species, with mean, standard deviation, 95th percentile and maximum results calculated.

22. The summary statistics were interpreted to provide recommendations as for which species/groups of fish MLs could potentially be set. To ensure the dataset used to establish an ML was sufficiently robust, a minimum sample number of 74 was required. This was determined based on a binomial distribution, where at a probability of detection of 95%, the required sample size to obtain one analytical value above the 96%ile (i.e. a 4% rejection rate) was 74 samples.

23. Determination of a clear exceedance of the selection criterion was determined only from average methylmercury concentrations. If the average total mercury value fell below the selection criterion it was considered sufficiently indicative to establish that the average methylmercury concentration would not exceed the selection criteria.

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[2] Clams, Crabs, Crustaceans, Lobsters, Marine Mammals, Molluscs, Mussels, Octopi, Oysters, Scallops, Shrimp and Prawns, Squid, Urchins and Sea Cucumber.

[3] For example fish paste, fish roe and fish livers.

[4] For example “Snapper- Unspecified species” was excluded as being generic of fish from multiple families, while “catfish –unspecified species” was incorporated into the consideration of catfish

[5] Atlantic smelt (1 sample) Barracudina (2 samples), Barramundi (4 samples), Black crappie (2 samples), Black sea bass (1 sample), Bluegill (1 sample), Buffalofish (1 sample), Chela pata (2 samples), Climbing perch (1 sample), Croaker (3 samples), Dories and allies (Zeomorphii; 6 samples), Featherback (1 sample), Goldeye (2 samples), Large-mouth bass (3 samples), Lingcod (9 samples), Lumpfish (2 samples), Nile perch (2 samples), Sailfish (1 sample), Snakehead (2 samples), Spearfish (1 sample), Tigerfish (2 samples), Tilapia (4 samples), Tilefish (2 samples) and White sucker (4 sample).

24. To appraise the significance in trade of the additional species under consideration, their FAO export quantity and value for 2017 were obtained[6]. As a reference, the 2017 export quantity and values for whole fresh, chilled and frozen fish of the species currently assigned a methylmercury ML are recorded in Table 3. Alfonsino is not recorded as is not individually listed in the export statistics, however the total catch tonnage was 9996 tonnes for 2017. Whole fresh, chilled and frozen fish data were used as these offered the best comparability between the species and avoided any potential for double counting of whole fish being processed and then re-exported. Exports of prepared forms of shark and tuna were also noted as being appreciable. This approach differs from the use of the 9000 tonne selection criteria applied in CX/CF 19/13/13 by using the export tonnage rather than production tonnage, given the former is more reflective of the trade in the species.

Table 3: 2017 Global export quantity and values for whole fresh, chilled and frozen fish of the species with methylmercury MLs

Species	Export quantity (tonnes)	Export value (US$,000,000)
Marlin	4753	9
Tuna	1,872,517	5,018
Shark	78,635	178

ML options

25. The currently established MLs for fish species have been set at the concentration value, reported to one significant figure, where the rejection rate was less than 5% (REP18/CF para 71, 74 and 77). MLs were established for closely related groupings of species (e.g. all tuna, all marlin, all shark).

26. Hypothetical MLs were calculated applying the above principle to the total mercury and methylmercury datasets. A third option using the combined dataset of methylmercury values and regression equation-adjusted unpaired total mercury values was also calculated to derive options for methylmercury MLs.

Species for which MLs could be established

27. Analysis identified two species or taxonomic groupings of fish, orange roughy (a species in the slimehead family; *Trachichthyidae*) and cusk-eel (*Ophidiidae*; a family grouping containing the species pink cusk-eel and kingklip), for which there was sufficient confidence that average methylmercury concentrations would exceed the 0.3 mg/kg selection criteria.

28. Data for a number of other species had total mercury concentrations exceeding 0.3 mg/kg but the methylmercury data for these species were lacking, and as a result, there was insufficient information on the ratio of methylmercury to total mercury for these species to identify if the screening criteria for methylmercury would be exceeded.

Orange roughy (*Hoplostethus atlanticus*)

29. Data for orange roughy were extracted from GEMS/Food (Table 4). No other species in the slimehead family (*Trachichthyidae*) were identified, as a result no grouping along taxonomic lines was possible.

30. Total mercury results for orange roughy (47 results) had been considered previously within CX/CF 19/13/13. Although the average total mercury result for orange roughy exceeded the selection criteria for establishing an ML, the limited sample numbers and absence of methylmercury data meant an ML could not be identified at that time.

31. The review of new data in GEMS/Food identified that an additional 202 total mercury and 101 methylmercury results were available for orange roughy. These encompassed sampling results from 2017 (101 results, total mercury only) and 2019 (101 results, paired total mercury and methylmercury). Samples were recorded as total (edible + inedible) when the fillets were not deboned.

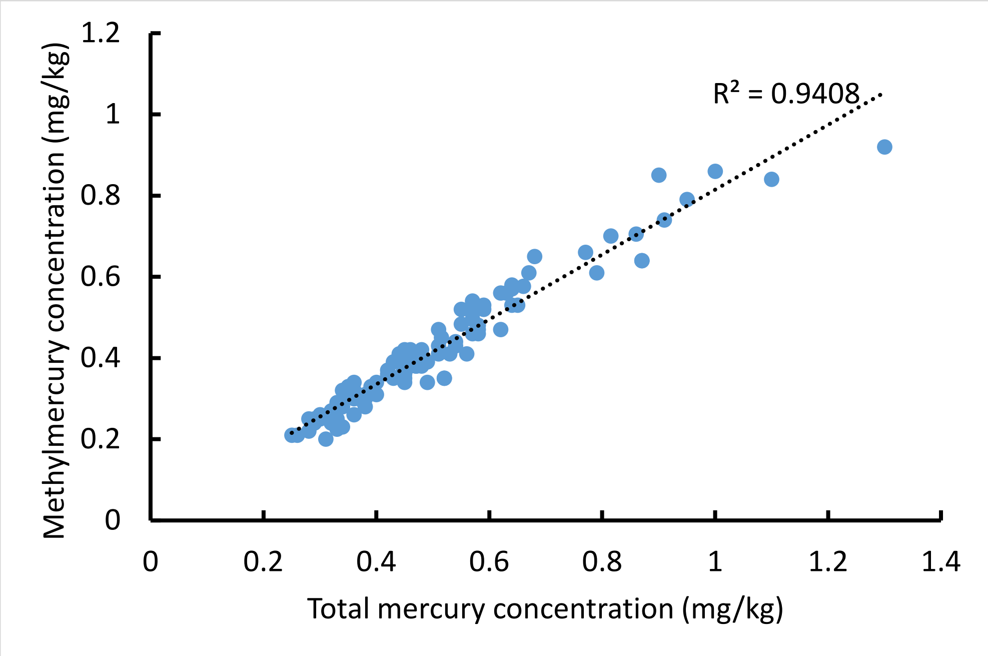
[6] FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire. Statistiques des pêches et de l'aquaculture 2017/FAO anuario. Estadísticas de pesca y acuicultura 2017. Rome/Roma.

Table 4: Updated summary of occurrence data on total mercury and methylmercury in mg/kg in orange roughy samples, data taken from GEMS/Food.

Common name	***Species***	**Total or methyl mercury**	**Includes data points without LOQs**	**Region**	**Total records**	**Non-detects**	**Mean**	**SD**	**P95**	**Max**
Orange roughy (new data)	*Hoplostethus atlanticus*	Total	No	G10 (201)	202	0	0.57	0.20	0.93	1.30
Orange roughy (all data)	*Hoplostethus atlanticus*	Total	No	G10 (248)	249	0	0.56	0.19	0.92	1.30
Orange roughy (new data)	*Hoplostethus atlanticus*	Methyl	No	G10 (101)	101	0	0.43	0.16	0.74	0.92

32. Samples were confirmed with the submitting country to have been caught from one fishery region within that country and one adjacent fishery region in international waters. The FAO fishing region (81) the samples were caught from represented 92% of the global capture production in 2017[7]. The majority of the findings were supplemented with information on fish length and weight.

Figure 1: Correlation of paired total mercury and methylmercury concentrations in 101 samples of orange roughy.



33. In 101 paired orange roughy samples the average concentration ratio of methylmercury to total mercury was 83% (range: 65-96%; Figure 1). The average concentration ratio of methylmercury to total mercury was significantly positively correlated (Pearson Correlation Coefficient: 0.97; $p < 0.05$). A linear regression equation was calculated from the paired dataset of: methylmercury = 0.7983 x total mercury + 0.01603. The regression equation was applied to the unpaired total mercury data (n= 148) to estimate methylmercury. Descriptive statistics for the regression model adjusted total mercury dataset; and a modelled dataset of the methylmercury and unpaired regression model adjusted total mercury dataset are presented in table 5.

[7] FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire. Statistiques des pêches et de l'aquaculture 2017/FAO anuario. Estadísticas de pesca y acuicultura 2017. Rome/Roma.

Table 5: Comparisons of descriptive statistics for methylmercury; regression model-adjusted unpaired total mercury and modelled datasets for orange roughy.

Dataset	Total records	Mean	SD	P95	Max
Methylmercury	101	0.43	0.16	0.74	0.92
Regression model adjusted total mercury	148	0.49	0.15	0.76	0.89
Modelled dataset (Regression model adjusted)	249	0.46	0.16	0.76	0.92

34. The average concentration of methylmercury in orange roughy (0.43 mg/kg) exceeds the selection criteria (0.3 mg/kg). There are sufficient sample numbers (101 samples for methylmercury) to be confident in proposing an ML. Analysis of the modelled dataset gives additional confidence to this decision: 0.46 mg/kg methylmercury (Table 5) for the 249 samples.

35. Based on a less than 5% rejection rate, hypothetical MLs were derived for orange roughy (Table 6).

Table 6: Hypothetical MLs for orange roughy

Hypothetical ML	Total Mercury (n=249)		Methylmercury (n=101)		Modelled dataset* (n=249)	
	Number of samples <ML	% of samples <ML	Number of samples <ML	Number of samples <ML	Number of samples <ML	% of samples <ML
0.7	192	77	93	92	225	90
0.8	219	88	97	96	241	97
0.9	232	93	100	99	248	99
1.0	242	97	101	100	249	100

**Based upon use of methylmercury data points and any non-paired total mercury data points adjusted with a linear regression model to estimate methylmercury.*

36. The FAO recorded that 3246 tonnes of frozen or chilled whole orange roughy were traded internationally in 2017, with a value of US$19.3 million[8].

Pink Cusk Eel/ New Zealand Ling (*Genypterus blacodes*), Kingklip (*Genypterus capensis*), and all Cusk-eels (*Ophidiidae sp.*).

37. Data for pink cusk-eel (New Zealand Ling) were extracted from GEMS/Food (Table 7). Pink cusk-eel are within the cusk-eel family *(Ophidiidae*; taxonomic code: 1,58(02)) and have previously been considered at a grouping level with Kingklip and unspecified cusk-eel (CX/CF 19/13/13).

38. Total mercury results for all cusk-eels (127 results) had been considered previously within CX/CF 19/13/13. Although the average total mercury result for cusk-eel exceeded the selection criteria for establishing an ML, the limited sample numbers and absence of methylmercury data meant an ML could not be identified at that time.

39. The review of new data in GEMS/Food identified 120 new total mercury and 120 new methylmercury results were available for pink cusk-eel. These encompassed sampling results from 2019 (120 results, paired total mercury and methylmercury).

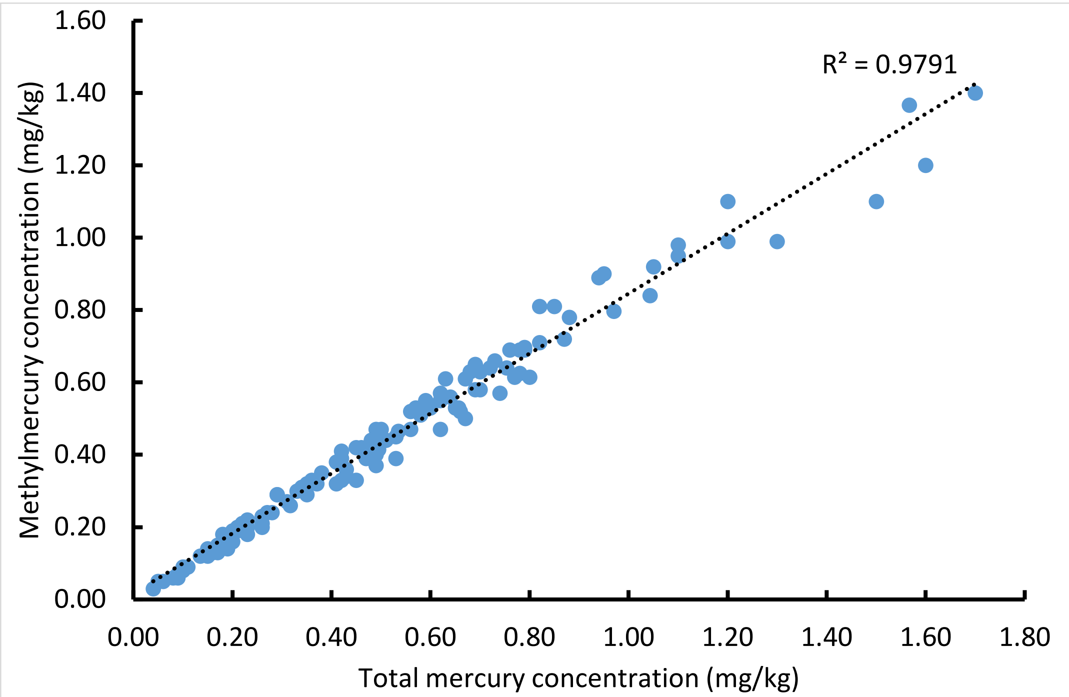
40. Samples were confirmed with the submitting country to have been caught from two fishery regions within that nation. The FAO fishing region (81) the samples were caught from represented 66% of the pink cusk-eel global capture production in 2017[9]. All results were supplemented with information on fish length and weight. Samples were recorded as total (edible+inedible) when the fillets were not deboned.

[8] FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire. Statistiques des pêches et de l'aquaculture 2017/FAO anuario. Estadísticas de pesca y acuicultura 2017. Rome/Roma.
[9] FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire. Statistiques des pêches et de l'aquaculture 2017/FAO anuario. Estadísticas de pesca y acuicultura 2017. Rome/Roma.

Table 7: Updated summary of occurrence data on total mercury and methylmercury in mg/kg in cusk-eel samples, data taken from GEMS/Food.

Common name	*Species*	Total or methyl mercury	Includes data points without LOQs	Region	Total records	Non-detects	Mean	SD	P95	Max
Cusk-eel (unspecified) (all data)	*Ophidiidae sp.*	Total	No	G10 (3)	3	0	0.45	0.23	0.64	0.66
Kingklip (all data)	*Genypterus capensis*	Total	No	G10 (10)	10	0	0.62	0.25	1.07	1.16
Pink cusk-eel (new data)	*Genypterus blacodes*	Total	No	G10 (120)	120	0	0.54	0.34	1.20	1.70
Pink cusk-eel (all data)	*Genypterus blacodes*	Total	No	G10 (234)	234	0	0.45	0.36	1.12	1.98
Pink cusk-eel (new data)	*Genypterus blacodes*	Methyl	No	G10 (120)	120	0	0.46	0.29	0.99	1.40
All cusk-eels (all data)	Ophidiiae sp.	Total	No	G10 (247)	247	0	0.46	0.35	1.14	1.98

Figure 2: Correlation of paired total mercury and methylmercury concentrations in 120 samples of Pink cusk-eel.



41. In 120 paired Pink cusk-eel samples the average concentration ratio of methylmercury to total mercury was 86% (range: 67-100%; Figure 2). The average concentration ratio of methylmercury to total mercury was significantly positively correlated (Pearson Correlation Coefficient: 0.9896; p <0.05). A linear regression equation was calculated from the paired dataset of: methylmercury = 0.82904 x total mercury + 0.01681. The regression equation was applied to the unpaired total mercury data for pink cusk-eel (n= 114); and for all cusk-eel (n= 127) to estimate methylmercury. Descriptive statistics for the ratio adjusted total mercury dataset; and a combined dataset of the methylmercury and unpaired ratio adjusted total mercury dataset are presented in table 8.

Table 8: Comparisons of descriptive statistics for methylmercury; regression equation-adjusted unpaired total mercury and modelled datasets for pink cusk-eel and all cusk-eel.

Dataset	Total records	Mean	SD	P95	Max
Methylmercury – Pink cusk-eel	120	0.46	0.29	0.99	1.40
Regression model adjusted total mercury– Pink cusk-eel	114	0.31	0.29	0.83	1.66
Modelled dataset (Regression model adjusted) Pink cusk-eel	234	0.39	0.30	0.98	1.66
Regression model adjusted total mercury–all cusk-eel	127	0.33	0.29	0.84	1.66
Modelled dataset (Regression model adjusted) All cusk-eel	247	0.39	0.30	0.98	1.66

42. The average concentration of methylmercury in pink cusk-eel (methylmercury: 0.46 mg/kg); exceed the selection criterion (0.3 mg/kg). There are sufficient sample numbers (n=120) to be confident in identifying an ML. Analysis of the modelled dataset gives additional confidence to this decision and indicates it could be applied to all cusk eel: Pink cusk-eel modelled dataset: 0.39 mg/kg (n=234); all cusk-eel modelled dataset 0.39 mg/kg (n = 247).

43. Based on a less than 5% rejection rate, hypothetical MLs were derived for pink cusk-eel (Table 9) and all cusk-eels (Table 10).

Table 9: Hypothetical MLs for Pink cusk-eel

Hypothetical ML	Total Mercury (n= 234)		Methylmercury (n=120)		Modelled dataset* (n=234)	
	Number of samples <ML	% of samples <ML	Number of samples <ML	% of samples <ML	Number of samples <ML	% of samples <ML
0.9	211	90	110	92	218	93
1.0	218	93	116	97	225	96
1.1	220	94	116	97	227	97
1.2	223	95	118	98	229	98
1.3	226	97	119	99	231	99

* *Based upon use of methylmercury data points and any non-paired total mercury data points adjusted with a linear regression model to estimate methylmercury.*

Table 10: Hypothetical MLs for All cusk-eels[#]

Hypothetical ML	Total Mercury (n=247)		Modelled dataset [*] (n=247)	
	Number of samples <ML	% of samples <ML	Number of samples <ML	% of samples <ML
0.9	222	90	230	93
1.0	230	93	238	96
1.1	232	94	240	97
1.2	236	96	242	98
1.3	239	97	244	99

[#] *Methylmercury data were only available for pink cusk-eels.*

[*] *Based upon use of methylmercury data points and any non-paired total mercury data points adjusted with a linear regression model to estimate methylmercury.*

44. The FAO recorded that 5202 tonnes of fresh, frozen or chilled whole cusk-eel were traded internationally in 2017, with a value of US $27.5 million[10]. Four species of cusk-eel (pink, red, black and kingklip) were reported in the FAO capture statistics for 2017, however 80% of the tonnage was pink cusk-eel and 16% kingklip.

Species recommended for continued data collection

45. Analysis of the dataset in GEMS/Food identified that new results were available for six of the species or taxonomic groupings identified for further data collection (Table 1). These were anglerfish, snake mackerel, toothfish, sablefish, sturgeon and catfish. With the exception of sturgeon the updated datasets for these species had insufficient data on methylmercury concentrations for identifying an ML and continued data collection would still be necessary. For sturgeon the updated dataset was sufficient to conclude the average methylmercury concentration was unlikely to exceed the selection criteria and an ML would not be required.

46. One result was available for unidentified snapper. Given snapper is a common name applied across multiple unrelated fish species, without taxonomic information there was insufficient confidence to assign it to the Snapper (*Lutjanus*) family.

47. For other species or taxonomic groupings identified for further data collection (barracuda, cardinalfish, cutlassfish, grouper, hapuku, pike, seabass, short nosed chimera, snapper and white hake), there were no new data submitted to GEMS/Food to allow for an updated review.

Anglerfish/ monkfish (*Lophius sp.*)

48. Data for anglerfish (also commonly termed monkfish) were extracted from GEMS/Food (Table 11). The interpretation of results in CX/CF 19/13/13 had included the broader *lophiiformes* data as only *lophius* species (taxonomic code: 1,95(01)001) were expected to be commercially harvested.

49. Total mercury (92 results) and methylmercury results (18 results) for anglerfish had been considered previously within CX/CF 19/13/13. Although the average total mercury result for anglerfish exceeded the selection criteria for establishing an ML, the absence of methylmercury data meant an ML could not be identified at that time.

50. The review of new data in GEMS/Food identified 105 total mercury results and 1 methylmercury result were available for anglerfish. The new data was recorded in GEMS/Food as being of domestic and imported provenance.

51. Considering the updated dataset the mean for total mercury in anglerfish is below 0.3 mg/kg. However, when the smaller methylmercury dataset is reviewed it can be seen the mean values are greater than double the selection criteria. Interpretation of the methylmercury dataset shows 12 out of the 19 results exceed the selection criteria (range 0.37- 3.0 mg/kg). Although the 3.0 mg/kg results is an outlier from the rest of the data (all < 1 mg/kg) even when this outlier is excluded the average methylmercury concentration (0.46 mg/kg) would exceed the selection criteria.

[10] FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire. Statistiques des pêches et de l'aquaculture 2017/FAO anuario. Estadísticas de pesca y acuicultura 2017. Rome/Roma.

Table 11: Updated summary of occurrence data on total mercury and methylmercury in mg/kg in anglerfish samples, data taken from GEMS/Food.

Common name	*Species*	Total or methyl mercury	Includes data points without LOQs	Region	Total records	Non-detects	Mean	SD	P95	Max
Anglerfish (new data)	*Lophius sp.*	Total	Yes	ER (105)	105	18	0.21	0.35	0.74	3.00
Anglerfish (all data)	*Lophius sp.*	Total	Yes	G07(6) G08 (45) G10 (33) G15(8) ER (105)	197	37	0.18	0.34	0.66	3.00
Anglerfish (new data)	*Lophius sp.*	Methyl	No	ER (1)	1	0	0.17	-	-	-
Anglerfish (all data)	*Lophius sp.*	Methyl	Yes	G08 (3) ER (16)	19	1	0.60	0.66	1.19	3.00

52. As a conservative estimate the datasets could be combined, assuming total mercury would be present as 100% methylmercury. The resulting average for the combined datasets (n= 216) is 0.22 mg/kg which indicates the selection criteria is unlikely to be exceeded.

53. Further data collection for methylmercury occurrence, or ratios of methylmercury to total mercury, in anglerfish would be beneficial to confirm if mean methylmercury concentrations will exceed the selection criteria.

54. The FAO recorded that 40,034 tonnes of fresh, frozen or chilled whole anglerfish were traded internationally in 2017, with a value of US $259 million[11].

Antarctic toothfish (*Dissostichus mawsoni*), Patagonian toothfish (*Dissostichus eleginoides*), and all Toothfish (*Dissostichus sp.*)

55. Data for toothfish (Antarctic and Patagonian) were extracted from GEMS/Food (Table 12). Both species can be grouped to a genus level (*Dissostichus*; taxonomic code: 1,70(92)015) .

56. Total mercury results for Patagonian toothfish (159 results) and all toothfish (201 results) had been considered previously within CX/CF 19/13/13. Although the average total mercury result for Patagonian toothfish exceeded the selection criteria for establishing an ML, the absence of methylmercury data meant an ML could not be identified at that time. The review of new data in GEMS/Food identified an additional 28 total mercury results were available for Antarctic and Patagonian toothfish. The new data were recorded in GEMS/Food as being of domestic and imported provenance.

57. Between the two toothfish species a clear difference continues to be seen in the average total mercury levels, with the level in the Antarctic species being below the selection criteria, and those of the Patagonian species above. As a grouped fish type, which includes any samples not specified between the two species, the average for all toothfish would be above the selection criteria.

[11] FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire. Statistiques des pêches et de l'aquaculture 2017/FAO anuario. Estadísticas de pesca y acuicultura 2017. Rome/Roma.

58. No data on methylmercury was available in GEMS/Food to confirm the ratios of methylmercury to total mercury. However, a study by Yoon and colleagues undertaken on Antarctic toothfish identified the proportion of methylmercury to total mercury was 29.8-51.3% (n=102)[12]. On the assumption that the biokinetics of methylmercury accumulation would be consistent within the genus the methylmercury ratio range could be applied to the dataset for total mercury for Patagonian and all toothfish. This results in average methylmercury concentration estimates of 0.15-0.26 mg/kg and 0.12-0.21 mg/kg, respectively. As both results are below the selection criteria it is indicative that confirmation of the ratios of methylmercury to total mercury in Patagonian toothfish will address whether ML setting may be necessary.

Table 12: Updated summary of occurrence data on total mercury in mg/kg in toothfish samples, data taken from GEMS/Food.

Common name	*Species*	Total or methyl mercury	Includes data points without LOQs	Region	Total records	Non-detects	Mean	SD	P95	Max
Toothfish (Antarctic) (new data)	*Dissostichus mawsoni*	Total	Yes	G07 (15)	15	0	0.13	0.06	0.21	0.25
Toothfish (Antarctic) (all data)	*Dissostichus mawsoni*	Total	Yes	G07 (15) G10 (31)	46	0	0.11	0.06	0.23	0.33
Toothfish (Patagonian) (new data)	*Dissostichus eleginoides*	Total	Yes	G07 (10) G10 (3)	13	0	0.32	0.17	0.64	0.80
Toothfish (Patagonian) (all data)	*Dissostichus eleginoides*	Total	Yes	G07 (10) G10 (162)	172	0	0.50	0.39	1.08	2.52
Toothfish (unspecified) (all data)	*Dissostichus sp.*	Total	No	G10 (11)	11	0	0.34	0.28	0.82	0.82
All Toothfish (all data)	*Dissostichus sp.*	Total	No	G07 (25) G10 (204)	229	0	0.41	0.38	1.05	2.52

59. Further data collection for methylmercury occurrence in Patagonian toothfish would be beneficial to confirm the ratios of methylmercury to total mercury and establish whether ML setting may be necessary.

60. The FAO recorded that 18,407 tonnes of fresh, frozen or chilled whole toothfish were traded internationally in 2017, with a value of US $333 million[13].

Barracouta (*Thyrsites atun*), Escolar (*Lepidocybium flavobrunneum*), and all snake mackerel (*Gempylidiae sp.)*

61. Data for escolar were extracted from GEMS/Food (Table 13). This species and barracouta are within the snake mackerel family (*Gempylidiae*; taxonomic code 1,75(05)) so can be grouped.

62. Total mercury results for barracouta (59 results) and escolar (62 results) had been considered previously within CX/CF 19/13/13. Although the average total mercury result for escolar, and all snake mackerel exceeded the selection criterion for establishing an ML, the limited sample numbers and absence of methylmercury data meant an ML could not be identified at that time.

[12] Yoon, M., Jo, M.R., Kim, P.H. et al. Total and Methyl Mercury Concentrations in Antarctic Toothfish (Dissostichus mawsoni): Health Risk Assessment. Bull Environ Contam Toxicol 100, 748–753 (2018)
[13] FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire. Statistiques des pêches et de l'aquaculture 2017/FAO anuario. Estadísticas de pesca y acuicultura 2017. Rome/Roma.

63. The review of new data in GEMS/Food identified an additional two total mercury results were available for escolar. The new data were recorded in GEMS/Food as being of imported provenance. In the previously considered data all barracouta results had been of domestic provenance and all escolar data of imported or unknown provenance.

64. Between the escolar and barracouta a clear difference can be seen in the average total mercury levels. As a grouping at the snake mackerel family level, the average concentration of total mercury for all snake mackerel indicates the average concentration methylmercury could be above the selection criteria. No data on methylmercury were available to confirm the ratios of methylmercury to total mercury.

65. Certain species of snake mackerel (escolar and oilfish; *Ruvettus pretiosus*) contain high proportions of indigestible wax esters in the flesh, termed gempylotoxin, which can cause adverse gastrointestinal effects in some consumers. The presence of gempylotoxin may limit consumption and consequently the potential methylmercury exposure. Gempylotoxin has not been identified as a hazard in other snake mackerel species[14].

Table 13: Summary of occurrence data on total mercury in mg/kg in snake mackerel samples, data taken from GEMS/Food.

Common name	*Species*	Total or methyl mercury	Includes data points without LOQs	Region	Total records	Non-detects	Mean	SD	P95	Max
Barracouta (all data)	*Thyrsites atun*	Total	No	G10 (59)	59	0	0.18	0.17	0.62	0.70
Escolar (new data)	*Lepidocybium flavobrunneum*	Total	No	G10 (2)	2	0	0.55	0.11	0.60	0.61
Escolar (all data)	*Lepidocybium flavobrunneum*	Total	No	G10 (64)	64	1	0.59	0.26	0.96	1.41
All snake mackerel (all data)	*Gempylidiae sp.*	Total	No	G10 (121)	123	1	0.39	0.30	0.91	1.41

66. Further data collection for methylmercury occurrence in escolar would be beneficial to confirm the ratios of methylmercury to total mercury and establish whether ML setting may be necessary. Data collection for oilfish would also be of benefit as this is another species that represents a notable proportion (28%) of the 2017 total snake mackerel catch tonnage[15].

67. The FAO recorded that 15,605 tonnes of frozen whole barracouta (termed 'snoek') were traded internationally in 2017, with a value of US $24 million[16]. Other species of snake mackerel were not identified in export statistics, however capture production for escolar in 2017 was 1048 tonnes.

Catfish (*Siluriformes*)

68. Data for yellow bullhead (*Ameiurus natalis*), basa catfish/pangasius (*Pangasius bocourti*) and unspecified catfish (*Siluriformes sp.*) were extracted from GEMS/Food (Table 14). The unspecified catfish samples could include fish from a wide number of families in the diverse catfish order (taxonomic code: 1,41), as the previous consideration in CX/CF 19/13/13 had grouped all catfish by order (*Siluriformes*).

69. Total mercury results for brown bullhead (6 results), basa catfish/pangasius (11 results), channel catfish (20 results), walking catfish (1 result) and unspecified catfish (17 results*)* had been considered previously in CX/CF 19/13/13. Although the average total mercury result for all catfish exceeded the selection criteria for establishing an ML, the large disparity between the species and absence of methylmercury data meant an ML could not be identified at that time.

[14] Food and Drug Administration: Fish and Fishery Products Hazards and Controls Guidance Fourth Edition – August 2019
[15] FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire. Statistiques des pêches et de l'aquaculture 2017/FAO anuario. Estadísticas de pesca y acuicultura 2017. Rome/Roma.
[16] FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire. Statistiques des pêches et de l'aquaculture 2017/FAO anuario. Estadísticas de pesca y acuicultura 2017. Rome/Roma.

70. The review of new data in GEMS/Food identified an additional ten total mercury results were available for catfish. The new data were recorded in GEMS/Food as all being of imported provenance.

71. The average total mercury values for all of the individual species, except channel catfish, and for the unspecified catfish samples fell below 0.3 mg/kg indicating the average methylmercury concentration was unlikely to exceed the selection criterion. The mean total mercury for channel catfish was far in excess of the selection criteria, however as noted in CX/CF 19/13/13, the dataset is notably bimodal with 11 out of 20 samples containing less than 0.06 mg/kg and 8 out of 20 samples ranging from 1.59 to 3.66 mg/kg mercury. No data on methylmercury was available to confirm the ratios of methylmercury to total mercury.

Table 14: Summary of occurrence data on total mercury in mg/kg in catfish samples, data taken from GEMS/Food.

Common name	*Species*	Total or methyl mercury	Includes data points without LOQs	Region	Total records	Non-detects	Mean	SD	P95	Max
Brown bullhead (all data)	*Ameiurus nebulosus*	Total	No	G10 (6)	6	0	0.12	0.07	0.23	0.25
Catfish (basa) new data	*Pangasius bocourti*	Total	No	G10 (6)	6	1	0.01	0.01	0.01	0.01
Catfish (basa) all data	*Pangasius bocourti*	Total	No	G10 (11)	17	6	0.02	0.02	0.05	0.05
Catfish (channel) all data	*Ictalurus punctatus*	Total	No	G10 (20)	20	4	0.98	1.22	3.17	3.66
Catfish (walking) all data	*Clarias batrachus*	Total	No	G10 (1)	1	1	0	0	0	0
Yellow bullhead new data	*Ameiurus natalis*	Total	No	G10 (1)	1	0	0.01	-	-	-
Catfish (unspecified) new data	*Siluriformes sp.*	Total	No	G10 (3)	3	2	0.01	0.01	0.03	0.03
Catfish (unspecified) all data	*Siluriformes sp.*	Total	No	G10 (20)	20	2	0.11	0.16	0.56	0.57
All catfish (all data)	*Siluriformes sp.*	Total	No	G10 (65)	65	15	0.36	0.80	2.38	3.66

72. Further data collection of identified species of catfish in trade, in particular channel catfish, would be beneficial to further develop the catfish dataset and support identification and setting of MLs.

73. The FAO recorded that 177,334 tonnes of fresh, frozen or chilled whole catfish were traded internationally in 2017, with a value of US $296 million[17]. Individual species of catfish are not reported on, however total wild catch of channel catfish in 2017 was 1454 tonnes.

Sablefish/ black cod *(Anoplopoma fimbria)*

74. Data for sablefish were extracted from GEMS/Food (Table 15). No other species in the same family (*Anoplopomatidae;* taxonomic code 1,78(08)) were identified; as a result no grouping along taxonomic lines was possible.

[17] FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire. Statistiques des pêches et de l'aquaculture 2017/FAO anuario. Estadísticas de pesca y acuicultura 2017. Rome/Roma.

75. Total mercury results for sablefish (352 results) had been considered previously within CX/CF 19/13/13. Although the average total mercury concentration was indicative that the selection criteria could be exceeded, the absence of methylmercury findings had meant an ML could not be identified.

76. The review of new data in GEMS/Food identified an additional 18 total mercury results were available for sablefish. The new data were recorded in GEMS/Food as being of domestic provenance, although the previously considered dataset for sablefish had also included samples of imported provenance.

77. The average total mercury concentration for sablefish was above the 0.3 mg/kg indicating that the average methylmercury concentration may exceed the selection criterion for ML setting. No data on methylmercury were available in GEMS/Food to confirm the ratios of methylmercury to total mercury. However, a study undertaken in Canada established the proportion of methylmercury to total mercury ranged between 80-94% (n=4)[18]. Applying this methylmercury ratio range to the dataset for total mercury for sablefish results in an estimate of 0.34-0.40 mg/kg. As the estimated methylmercury range is above the selection criteria it is indicative that confirmation of the ratios of methylmercury to total mercury will address whether ML setting may be necessary.

Table 15: Summary of occurrence data on total mercury in mg/kg in sablefish samples, data taken from GEMS/Food.

Common name	*Species*	Total or methyl mercury	Includes data points without LOQs	Region	Total records	Non-detects	Mean	SD	P95	Max
Sablefish (new data)	*Anoplopoma fimbria*	Total	No	G10 (18)	18	0	0.36	0.21	0.69	0.94
Sablefish (all data)	*Anoplopoma fimbria*	Total	No	G10 (370)	370	0	0.43	0.25	0.88	2.33

78. Further data collection for methylmercury occurrence in sablefish would be beneficial to confirm the ratios of methylmercury to total mercury and establish whether ML setting may be necessary.

79. The FAO recorded that 8223 tonnes of fresh, frozen or chilled whole sablefish were traded internationally in 2017, with a value of US $101 million[19].

Sturgeon *(Acipenseridae)*

80. Data for sturgeon (species unspecified) was extracted from GEMS/Food (Table 16).

81. Total mercury results for Atlantic sturgeon (1 result), Shortnose sturgeon (3 results) and unspecified sturgeon (6 results) had been considered previously within CX/CF 19/13/13.

82. Although not prioritized for data collection, further data submission for sturgeon had been seen as beneficial given the limited number of results and potential for a wider inherent variation in the methylmercury levels (CX/CF 19/13/13).

83. The review of new data in GEMS/Food identified 29 total mercury results were available for sturgeon. The new data were recorded in GEMS/Food as being of domestic or unknown provenance.

[18] Canadian Food Inspection Agency. 2003. Draft Sablefish Mercury Report - Investigation of mercury in B.C. Sablefish sampled between October 2002 and November 2003.
[19] FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire. Statistiques des pêches et de l’aquaculture 2017/FAO anuario. Estadísticas de pesca y acuicultura 2017. Rome/Roma.

Table 16: Summary of occurrence data on total mercury in mg/kg in sturgeon samples, data taken from GEMS/Food.

Common name	*Species*	Total or methyl mercury	Includes data points without LOQs	Region	Total records	Non-detects	Mean	SD	P95	Max
Sturgeon (new data)	*Acipenseridae sp.*	Total	No	ER (29)	29	2	0.08	0.13	0.33	0.63
Sturgeon (all data)	*Acipenseridae sp.*	Total	Yes	G07 (1) G08 (3) G10 (6) ER (29)	39	4	0.08	0.12	0.23	0.63

84. The mean values for total mercury for the sturgeon family grouping fell below 0.3 mg/kg indicating that the average methylmercury concentration would not exceed the selection criteria. It can be concluded that no ML is necessary. As a result, sturgeon can be removed from the species for which further data collection would be required.

Newly reviewed species

85. Analysis of the dataset in GEMS/Food identified that new results were available for two fish groupings, greenling (a family grouping containing atka mackerel and lingcod; two new results) and tilapia (11 new results), that would mean the updated dataset was sufficient for consideration (n= ≥10).

86. Two new results were available for dories and allies (*Zeomorphi*), however the updated dataset had only eight results which was too few for consideration.

87. No other fish or taxonomic groups for which CX/CF 19/13/13 had identified as data poor, or were not part of a taxonomic grouping considered in CX/CF 19/13/13, had new data submitted.

Lingcod (*Ophiodon elongates),* atka mackerel (*Pleurogrammus monopterygius*) and all greenling (*Hexagrammidae sp.)*

88. Data for lingcod and atka mackerel were extracted from GEMS/Food (Table 17). Both species are in the greenling family (*hexagrammidae* taxonomic code: 1,78(07)) as a result a grouping to family level was possible. All data points were for total mercury and had the assay LOD/LOQ values recorded.

89. Total mercury (9 results) for lingcod had been insufficient for consideration within CX/CF 19/13/13. The availability of two further results in the new GEMS data meant a review could be undertaken. The data were recorded in GEMS/Food as being of domestic and imported provenance.

Table 17: Summary of occurrence data on total mercury in mg/kg in greenling samples, data taken from GEMS/Food.

Common name	*Species*	Total or methyl mercury	Includes data points without LOQs	Region	Total records	Non-detects	Mean	SD	P95	Max
Atka mackerel	*Pleurogrammus monopterygius*	Total	No	G10 (1)	1	0	0.05	-	-	-
Lingcod	*Ophiodon elongates*	Total	No	G10 (10)	10	0	0.30	0.20	0.58	0.67
All greenling	*Hexagrammidae*	Total	No	G10 (11)	11	0	0.28	0.20	0.57	0.67

90. The average total mercury for lingcod was 0.3 mg/kg indicating that there is potential for the average methylmercury concentration to meet the selection criteria. The single results for atka mackerel did not exceed 0.3 mg/kg indicating that the average methylmercury concentration would not exceed the selection criteria. No data on methylmercury were available to confirm the ratios of methylmercury to total mercury.

91. Further data collection for methylmercury and total mercury occurrence in greenling would be beneficial to confirm the ratios of methylmercury to total mercury and establish whether ML setting may be necessary.

92. The FAO recorded that 40,259 tonnes of frozen whole atka mackerel were traded internationally in 2017, with a value of US $113 million[20].

Tilapia (*Oreochromis sp.)*

93. Data for tilapia were extracted from GEMS/Food (Table 18). Commercial tilapia is typically Mozambique or Nile tilapia, however because species were not identified the data were grouped under the broader *oreochromis* genus (Taxonomic code 1,70(59)051). All data points were for total mercury and had the LOD/LOQ values recorded.

94. The dataset for total mercury (4 results) for tilapia had been insufficient for consideration within CX/CF 19/13/13. The availability of 11 further results in the new GEMS/Food data meant a review could be undertaken. The data were recorded in GEMS/Food as being of imported or unknown provenance.

Table 18: Summary of occurrence data on total mercury in mg/kg in tilapia samples, data taken from GEMS/Food.

Common name	*Species*	Total or methyl mercury	Includes data points without LOQs	Region	Total records	Non-detects	Mean	SD	P95	Max
Tilapia (all data)	*Oreochromis sp.*	Total	No	G09 (1) G10 (14)	15	4	0.01	0.01	0.04	0.05

95. The mean value for total mercury for tilapia fell far below 0.3 mg/kg indicating that the average methylmercury concentration would not exceed the selection criteria. As a result, there is confidence no ML is necessary.

[20] FAO. 2019. FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire. Statistiques des pêches et de l'aquaculture 2017/FAO anuario. Estadísticas de pesca y acuicultura 2017. Rome/Roma.

APPENDIX IV

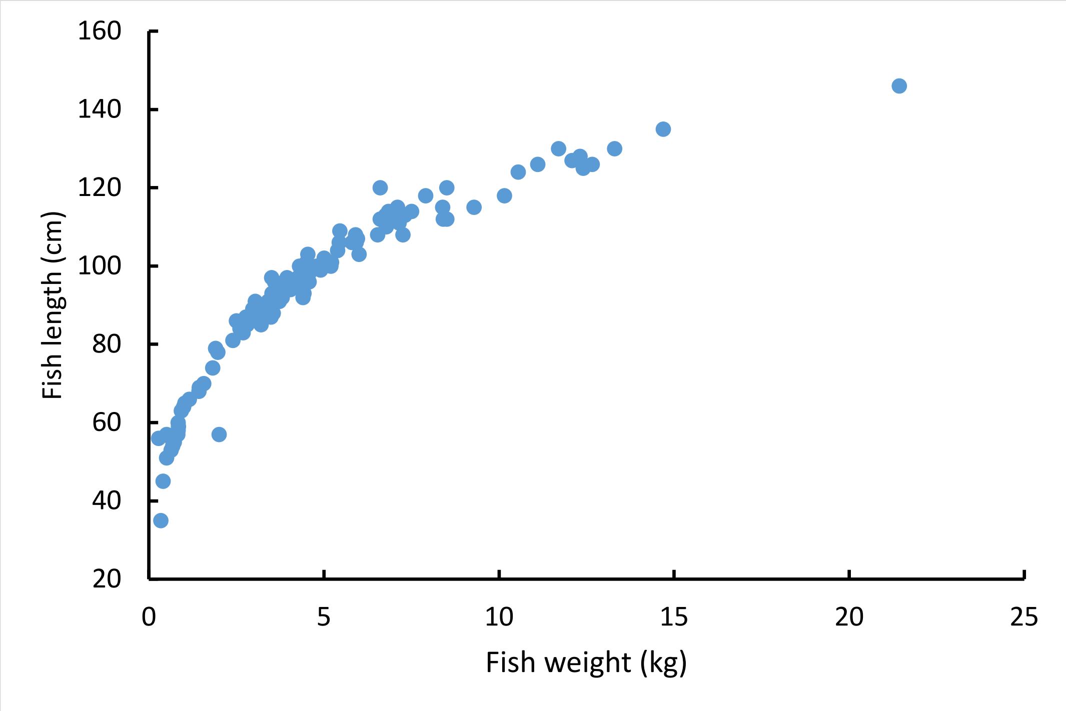
DISCUSSION PAPER ON
ESTABLISHING A SAMPLING PLAN FOR METHYLMERCURY IN FISH
(For information)

1. The conclusions of CCCF11 in terms of progressing MLs for methylmercury in fish identified that MLs should be accompanied by sampling plans (REP 17/CF para 140).
2. A general sampling plan for methylmercury in fish was developed using European Union: Commission Regulation (EC) No 333/2007 as a basis. The draft sampling plan was discussed and presented to CCCF12 accompanying the proposed MLs for various fish species (CX/CF 18/12/7).
3. Following editorial amendments CCCF12 agreed to send the sampling plans to CCMAS for endorsement and to request advice on:
   a. The necessary performance criteria for the MLs;
   b. Whether there is evidence that methylmercury can vary widely between individual fish sampled at the same time. How this would apply to large fish sold as individual units and whether the sampling plan provides enough basis to deal with this; and
   c. Whether the whole fish should be analyzed or only specific fractions of edible portions. Currently only mention is made that the mid-section should be sampled for some large fish (REP18/CF).
4. CCMAS39 was unable to respond to the questions raised in relation to the sampling plan as the questions were outside the remit of CCMAS (CX/CF 19/13/2). CCMAS endorsed the performance criteria for methods of analysis for methylmercury when amended to meet formatting requirements. However, CCMAS39 did not endorse the sampling plan for MLs for methylmercury in fish and agreed to return the sampling plan to CCCF for further consideration.
5. At CCCF13 the chair of the EWG informed the committee that a revised sampling plan would not be presented for approval as there were areas of inconsistency with other sampling plans in the GSCTFF that needed to be addressed. In addition, the two remaining questions CCMAS was unable to respond to were not discussed as further consideration was necessary, these questions had also not been discussed by the EWG in advance of CCCF13. CCCF13 agreed to consider issues related to sampling plans for methylmercury in fish, through the consideration of contemporary scientific literature and national monitoring data, as part of the re-established EWG examining the feasibility of MLs for additional fish species (REP 19/CF). It was agreed that the EWG would present these findings for consideration at CCCF14

Sample plan question 1:
Can methylmercury vary widely between individual fish sampled at the same time?

6. A number of studies have identified that the mercury concentration in freshly caught fish is positively correlated with the fish length (McKinney et al., 2016, Nilsen et al., 2016; Polak-Juszczak, 2017; Vega-Sánchez et al., 2017; Houssard et al., 2019). While other properties such as environmental factors may influence methylmercury concentration broadly across a species' geographical distribution (Nilsen et al., 2016; Azad et al., 2019; Houssard et al., 2019), the impact of this on a traded lot of fish is unlikely if the lot was sourced from catch taken in a single fishery region.
7. As a result, the variation in methylmercury in fish sampled at the same time and from a single fishery area is likely to be contingent on the variation of fish sizes in the lot. Fish that are graded by length (typically whole fish) or weight (for frozen fillets), and are sorted into lots, would be expected to show smaller variations in methylmercury. An exception however could be expected for processed fishery products which being drawn from a broad range of fish sizes and catches from different regions, may have larger variation in the methylmercury concentration.
8. The smaller variation in methylmercury for fish graded by length or weight is demonstrated through the interpretation of the results from the New Zealand survey of pink cusk-eel submitted to GEMS. Although not a species for which an ML is currently established the results provide contextual information on the importance of variation in length and weight. Samples were accompanied with information on capture length and weight. Fish length and weight was positively correlated and ranged considerably across the dataset (Figure 1).

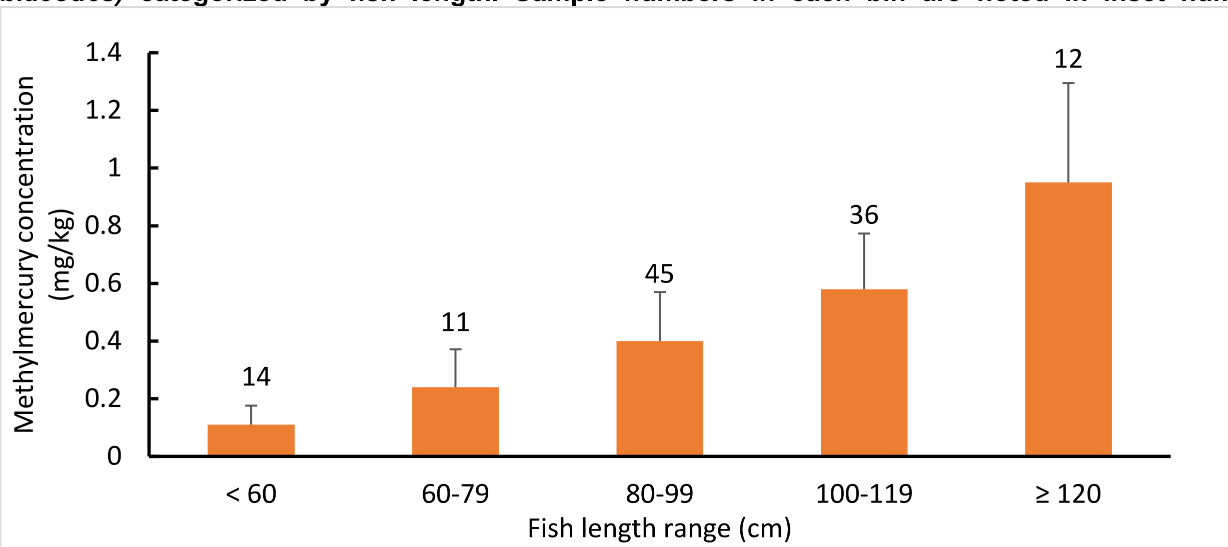
Figure 1: Correlation of capture weight and length of pink-cusk eel (*Genypterus blacodes;* n=118).



9. Consequently with the broad size distribution the range of methylmercury concentrations across the dataset is also large at 0.03-1.4 mg/kg.

10. Unless fish are graded by length or weight it is prudent to assume that the size variations will mean a large variation in the methylmercury concentrations. Analysis of methylmercury average concentrations and standard deviation by length for pink-cusk eel using 20 cm bins suggests variation in methylmercury concentrations within most length ranges is typically within 50% of the mean (Figure 2).

Figure 2: Mean methylmercury concentrations and standard deviation for pink cusk-eel (*Genypterus blacodes)* categorized by fish length. Sample numbers in each bin are noted in inset number.



11. A suggested amendment to the sampling plan at CCCF13 was to define the fish length and weight within a lot (CF13/CRD04). It is noted that the differences in sizes amongst the four species/groupings of fish with MLs is considerable (alfonsino typically <50 cm; Atlantic blue marlin up to 500cm) and even within the groupings the variation may be large (bullet tuna: ~50 cm; bluefin tuna ~ 200 cm).

12. Defining the degree of size variation appropriate within a lot of fish is likely to be highly species dependent differing with the dimensions and growth ranges of the fish, and whether grading is typical for that species when traded. A general approach to draw a representative sample based on length or weight in the lot may not accurately encompass the broad ranges in fish lengths and weights for the fish species/groupings with MLs.

13. There are insufficient data presently to define the influence of size variation for the fish species/ groupings when evaluating exceedance of MLs. Developing the database from which to establish specific recommendations of size variation in the lot for each of the species/fish groupings in relation to the MLs would be necessary to derive robust sampling plans that address potential variation in methylmercury concentrations within the lot. Species-specific information would be better captured in an annex of the sampling plan to supplement more general considerations on sampling. Each annex could also be tailored for the quantities and the type of fishery products in trade for each species/grouping.

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Sample plan question 2:
Should the whole fish should be analyzed or only specific fractions of edible portions?

14. Commercially traded lots of whole fish may involve individual fish of considerable size. For example pink cusk-eel caught in the New Zealand survey recorded a number of individuals greater than 10 kg in weight (Figure 1). The fish groupings with MLs for methylmercury include marlin, tuna and shark both of which contain individual species commonly weighing greater than 100 kg. Alfonsino are the smallest of the species with MLs, typically ranging up to 70 cm in length and up to 4 kg (FAO, 2016).

15. Homogenization of a whole fish to obtain a sample representative of the methylmercury concentration for any of the species/groupings with MLs would be expected to be a significant undertaking for a laboratory, and could result in significant wastage over that required for testing needs. As a result, the question has been raised over whether a fraction of the edible portion could be representative of the methylmercury concentration in the whole fish.

16. A further subset of this question relates to high value fish species for which carcass integrity is important for retail. A representative sample for these species from the centre of the carcass may cause considerable economic loss. There is also value therefore in establishing whether an alternative fraction could be sampled and still be representative of the whole fish methylmercury concentration.

17. A request for information was issued for any studies identifying any distribution of total or methylmercury in muscle sampled from different areas from fish. Three studies considering distribution of mercury concentrations in tuna were identified.

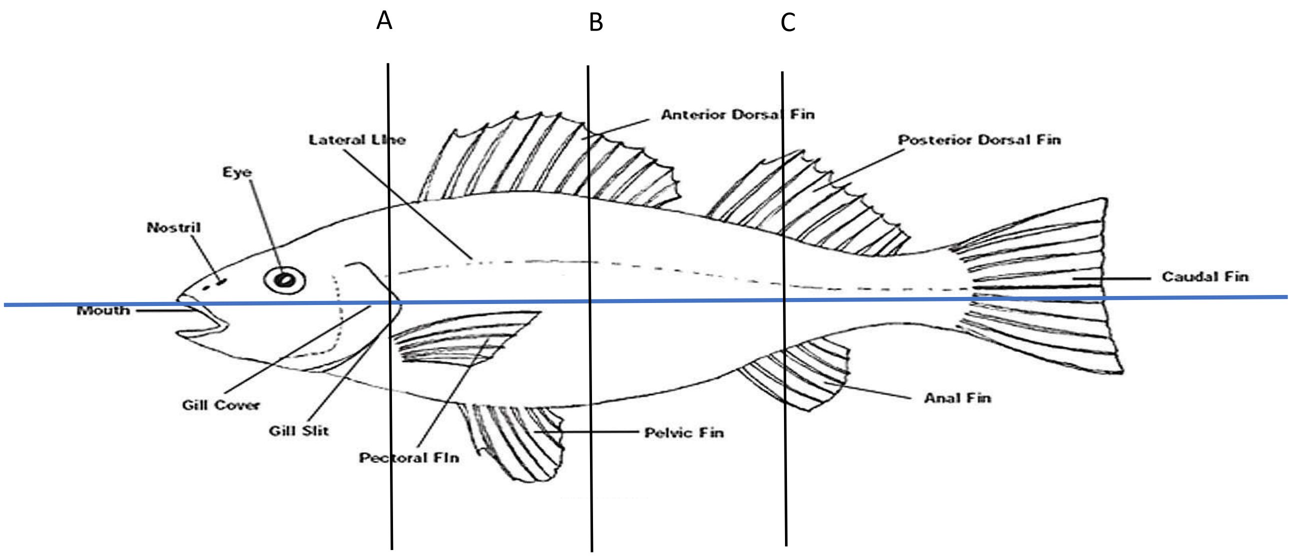
18. Ando and colleagues (2008) reported the statistical analysis of total mercury results for seven different portions of farmed bluefin tuna (dorsal front, middle and rear; ventral front, middle and rear, and tail). Of the averages for the different portions across nine individual fish, the largest difference occurred between the ventral front (0.49 mg/kg) and dorsal front (0.72 mg/kg). The other five tissue portions, fell within these ranges (0.58-0.67 mg/kg) and were not significantly different from each other. Analysis of the tail portion for total mercury across 98 farmed bluefin tuna identified no correlation between the body weight of the fish and the total mercury concentration in either ordinary or dark muscle, although for both male and female fish the concentrations in each muscle type were significantly different. There were no significant differences in the total mercury concentrations between different sexes. As farmed fish the variation between tissues may be less pronounced than might be expected for wild caught fish with more variable dietary sources of methylmercury.

19. A similar analysis of different portions of tuna was reported by Japan's Ministry of Agriculture, Forestry and Fisheries. This used the same sampled portions as Ando and colleagues (2008), with the exception that the tail value was not reported. The mean values across nine individual fish identified little variation between the portions (range: total mercury 0.6-0.75 mg/kg methylmercury 0.52-0.65 mg/kg). For both total mercury and methylmercury the middle portions had marginally higher concentrations than the front or rear (MAFF, 2007; 2008; 2009)

20. A further survey considered the variation in total mercury content between the different tissue cuts of bluefin tuna (akami, chu-toro and o-toro; Balshaw et al., 2008). Composite samples of the different tissue cuts taken from each of the six dorsal and ventral portions in the tuna as per the previous studies, with the exception of o-toro that is only present in ventral front and middle. Akami had consistently higher total mercury (0.36 mg/kg), followed by chu-toro (0.28 mg/kg) and o-toro (0.23 mg/kg). Analysis identified a negative correlation of total mercury with the lipid content of the tissue, with a common linear regression fit of -0.00476 mercury (mg/kg)/% lipid). It was proposed that sub-samples of chu-toro would most accurately represent the mercury and lipid content of the fish white muscle.

21. The lateral variation of total mercury and methylmercury concentrations was investigated in the results from New Zealand surveys of orange roughy and pink cusk-eel submitted to GEMS. Although these are not species for which MLs are currently established the results for these species provide contextual information on lateral tissue distribution of methylmercury. A small proportion of fish weighing greater than 1 kg had been sampled separately at three locations to allow comparison of the methylmercury and total mercury concentrations (Table 1 and 2; Figure 2).

Figure 2. Sampling locations and instructions for determination of lateral variation of total and methylmercury in orange roughy and pink cusk-eel.



Measuring from the mouth to the start of the caudal fin (tail) divide fish lengthwise into four equal parts as depicted by the solid lines A, B and C. Cut ~2 cm either side of the lines A, B and C to obtain sufficient tissue for the analytical method.

Table 1: Analysis of total mercury and methylmercury concentrations in different lateral sampling sites of pink cusk-eel (*Genypterus blacodes).*

Sample	Fish length (cm)	Total mercury (mg/kg) at sample site				Methylmercury (mg/kg) at sample site			
		A	B	C	Mean	A	B	C	Mean
1	100	0.88	0.84	0.65	0.79	0.83	0.73	0.53	0.70
2	113	1.00	0.97	0.94	0.97	0.85	0.83	0.71	0.80
3	104	0.33	0.31	0.31	0.32	0.25	0.28	0.25	0.26
4	115	1.20	1.00	0.93	1.04	0.97	0.85	0.7	0.84
5	115	0.71	0.65	0.61	0.66	0.58	0.54	0.47	0.53
6	114	0.84	0.76	0.66	0.75	0.67	0.67	0.58	0.64
7	128	1.80	1.60	1.30	1.57	1.60	1.40	1.10	1.37
Mean	112	0.97	0.88	0.77	0.87	0.82	0.76	0.62	0.73

Table 2: Analysis of total mercury and methylmercury concentrations in different lateral sampling sites of orange roughy *(Hoplostethus atlanticus)*

Sample	Fish length (cm)	Total mercury (mg/kg) at sample site				Methylmercury (mg/kg) at sample site			
		A	B	C	Mean	A	B	C	Mean
1	41	0.65	0.72	0.61	0.66	0.53	0.69	0.51	0.58
2	38	0.46	0.42	0.47	0.45	0.36	0.32	0.37	0.35
3	40	0.59	0.57	0.49	0.55	0.52	0.54	0.39	0.48
4	37	0.56	0.52	0.51	0.53	0.41	0.35	0.47	0.41
Mean	39	0.57	0.56	0.52	0.55	0.46	0.48	0.44	0.46

22. The relative ratio of the total mercury to methylmercury result for each sampling region to the average whole fish total mercury to methylmercury result was calculated for both species (Table 3).

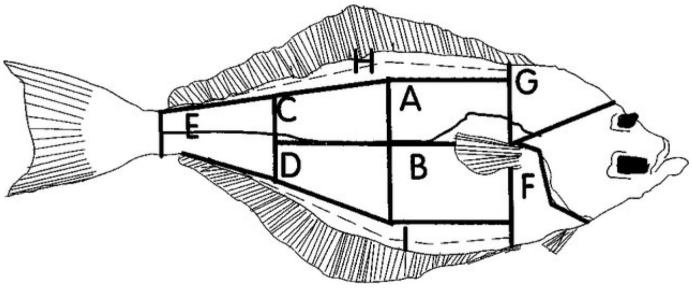
23. Results for both pink cusk-eel and orange roughy support that a sample taken from the lateral centre of the fish is the closest to the concentration of the whole fish total mercury or methylmercury value, although the difference for tail or head cuts is low.

Table 3: Ratios of total mercury and methylmercury concentrations in different lateral sampling sites of orange roughy and pink cusk-eel to whole fish concentrations

Species	Ratio of average total mercury at sample site to whole fish total mercury			Ratio of average methylmercury at sample site to whole fish methylmercury		
	A	B	C	A	B	C
Pink cusk-eel	1.12	1.01	0.89	1.12	1.04	0.85
Orange roughy	1.04	1.02	0.95	1.00	1.04	0.96

24. Additionally for Atlantic halibut (*Hippoglossus hippoglossus*) it was reported that the b-cut (Figure 3) was taken for mercury analysis due its lower lipid content (Nilsen et al., 2016).

Figure 3: Different cuts from Atlantic halibut (Reproduced from Nortvedt and Tuene, 1998)



25. The findings in pink cusk-eel and orange roughy support that, in general, there is only a small variation in the total mercury or methylmercury concentration in different cuts of the fish. For bluefin tuna there was little variation between different sections of farmed fish, although between different muscle tissues that have varying lipid contents there was notable variation. There are limited data for other species so it is not possible to confirm that this would be the case for marlin, alfonsino and shark.

26. Guidance around the analysis of fish is likely to be contingent on the dimensions of the fish species and the specifics around its trade. A general approach applied to both 50 cm alfonsino and 500 cm marlin is unlikely to be fit for purpose. Continued development of a database to support species specific guidance on sampling is considered an approach that would deliver a sampling plan of most utility to national authorities.

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Proposed Sampling Plan

27. In the consideration of the two questions considered by the EWG it has been identified that a best fit approach may be to derive species-specific parameters in the sampling plan. Although at this stage the limited database precludes the development of these for species other than bluefin tuna.

28. To outline how the species-specific aspects would fit in a sampling plan a proposed draft format has been outlined. The general considerations have been retained from the sampling plan presented to CCCF13 (CF13/CRD15), although there may be aspects of this that require species-specific considerations to be included in all or some of the annexes.

29. Development of the sampling plan will require the development of a database for each of the species with an ML established (tuna, shark, alfonsino and marlin). Ideally this would include the following aspects:

    a. Results of national sampling plans for tuna, shark, alfonsino and marlin, including where possible, indication on how the material has been sampled.

    b. Data on correlation of fish length or weight with methylmercury for shark, alfonsino and marlin, and tuna species other than bluefin.

    c. Data on tissue distribution of methylmercury for shark, alfonsino and marlin.

30. Other aspects of value to support the development of the sampling plan would include the evidence, or statistical basis, used by national authorities in the development of national sampling plans.

PROPOSED SAMPLING PLAN FORMAT FOR METHYLMERCURY CONTAMINATION IN FISH

GENERAL CONSIDERATIONS

PACKAGING AND TRANSPORTATION OF SAMPLES

1. Each laboratory sample should be placed in a clean, inert container offering adequate protection from contamination, loss of analytes by adsorption to the internal wall of the container and against damage in transit. All necessary precautions should be taken to avoid any change in composition of the sample which might arise during transportation or storage (for example avoiding excess heat or the sample drying out).
2. Each laboratory sample taken for official use shall be sealed at the place of sampling and identified. A record must be kept of each sampling, permitting each lot, or sublot, to be clearly identified and giving the date and place the sampling occurred, together with any additional information likely to be of assistance to the analyst.

SAMPLE PREPARATION

PRECAUTIONS

3. In the course of sampling, precautions should be taken to avoid any changes which would affect the levels of contaminants, adversely affect the analytical determination or make the aggregate samples unrepresentative.
4. Wherever possible, apparatus and equipment coming into contact with the sample should not contain mercury and be made of inert materials, e.g. plastics such as polypropylene, polytetrafluoroethylene (PTFE) etc. These should be acid cleaned to minimise the risk of contamination. High quality stainless steel may be used for cutting edges.

HOMOGENIZATION – GRINDING

5. The complete aggregate sample should be finely ground (where relevant) and thoroughly mixed using a process that has been demonstrated to achieve complete homogenization. Depending on the equipment available frozen samples may need to be thawed prior to homogenization.

TEST PORTION

6. Procedures for selecting the test portion from the comminuted laboratory sample should be a random process. If mixing occurred during or after the comminuting process, the test portion can be selected from any location throughout the comminuted laboratory sample. Otherwise, the test portion should be the accumulation of several small portions selected throughout the laboratory sample.
7. It is suggested that three test portions be selected from each comminuted laboratory sample. The three test portions will be used for enforcement, appeal, and confirmation if needed.

ANALYTICAL METHODS

8. A criteria-based approach, whereby a set of performance criteria is established with which the analytical method used should comply, is appropriate. The performance criteria-based approach has the advantage that, by avoiding setting down specific details of the method used, developments in methodology can be exploited without having to reconsider or modify the specific method.
9. Refer to The Procedural Manual of the Codex Alimentarius Commission for principles for the establishment of methods of analysis.
10. Possible performance criteria are detailed for the species of fish in each annex. Utilizing this approach, laboratories would be free to use the analytical method most appropriate for their facilities.
11. Countries or importers may decide to use their own screening when applying the ML for methylmercury in fish by analysing total mercury in fish. If the total mercury concentration is below or equal to the ML for methylmercury, no further testing is required and the sample is determined to be compliant with the ML. If the total mercury concentration is above the ML for methylmercury, follow-up testing shall be conducted to determine if the methylmercury concentration is above the ML (REP18/CF).

ANNEX I: ALFONSINO – *proposed sections to be developed with species specific dataset*

Definitions:

Sample selection

to cover: sample fraction, application to processed forms; separation of lots into sublots, and numbers of incremental samples taken per lot/sublot.

Sample preparation (if any species specific measures necessary)

Proposed method criteria

ANNEX II: MARLIN – *proposed sections to be developed with species specific dataset*

Definitions:

Sample selection

Sample preparation (if any species specific measures necessary)

Proposed method criteria

ANNEX III: SHARK – *proposed sections to be developed with species specific dataset*

Definitions:

Sample selection

Sample preparation (if any species specific measures necessary)

Proposed method criteria

ANNEX IV: TUNA – *proposed sections to be developed with species specific dataset*

Definitions:

Sample selection

Sample preparation (if any species specific measures necessary)

Proposed method criteria

APPENDIX V

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