Food and Agriculture Organization of the United Nations

Indian Ocean Tuna Commission
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Report of the Fourth IOTC CPUE Workshop on Longline Fisheries

Busan, July 3th – 7th, 2017.

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ACRONYMS

BET	Bigeye Tuna
CPCs	Contracting parties and cooperating non-contracting parties
CPUE	Catch per unit of effort
HBF	Hooks between Floats
IOTC	Indian Ocean Tuna Commission
GLM	Generalized Linear Model
LL	Longline
NBF/NHBF	Number of Hooks between Floats
R	R Package for Statistical Computing
SAS	Software for Analyzing Data
SC	Scientific Committee of the IOTC
STD	Standardized
SWO	Swordfish
WP	Working Party of the IOTC
WPB	Working Party on Billfish of the IOTC
WPM	Working Party on Methods of the IOTC
WPTmT	Working Party on Temperate Tunas of the IOTC
WPTT	Working Party on Tropical Tunas of the IOTC
YFT	Yellowfin Tuna

HOW TO INTERPRET TERMINOLOGY CONTAINED IN THIS REPORT

Level 1: ***From a subsidiary body of the Commission to the next level in the structure of the Commission:***
RECOMMENDED, RECOMMENDATION: Any conclusion or request for an action to be undertaken, from a subsidiary body of the Commission (Committee or Working Party), which is to be formally provided to the next level in the structure of the Commission for its consideration/endorsement (e.g. from a Working Party to the Scientific Committee; from a Committee to the Commission). The intention is that the higher body will consider the recommended action for endorsement under its own mandate, if the subsidiary body does not already have the required mandate. Ideally this should be task specific and contain a timeframe for completion.

Level 2: ***From a subsidiary body of the Commission to a CPC, the IOTC Secretariat, or other body (not the Commission) to carry out a specified task:***
REQUESTED: This term should only be used by a subsidiary body of the Commission if it does not wish to have the request formally adopted/endorsed by the next level in the structure of the Commission. For example, if a Committee wishes to seek additional input from a CPC on a particular topic, but does not wish to formalise the request beyond the mandate of the Committee, it may request that a set action be undertaken. Ideally this should be task specific and contain a timeframe for the completion.

Level 3: ***General terms to be used for consistency:***
AGREED: Any point of discussion from a meeting which the IOTC body considers to be an agreed course of action covered by its mandate, which has not already been dealt with under Level 1 or level 2 above; a general point of agreement among delegations/participants of a meeting which does not need to be considered/adopted by the next level in the Commission's structure.

NOTED/NOTING: Any point of discussion from a meeting which the IOTC body considers to be important enough to record in a meeting report for future reference.

Any other term: Any other term may be used in addition to the Level 3 terms to highlight to the reader of and IOTC report, the importance of the relevant paragraph. However, other terms used are considered for explanatory/informational purposes only and shall have no higher rating within the reporting terminology hierarchy than Level 3, described above (e.g. **CONSIDERED**; **URGED**; **ACKNOWLEDGED**).

Executive Summary

A Workshop assessing CPUE trends and techniques used by the IOTC was held in Busan, Republic of Korea from July 3rd to 7th, 2017. The aim of the meeting is to validate and improve the methods of developing joint standardized CPUE for tropical tuna species for main longline distant water fishing fleets operating in the Indian Ocean, and provide training to participants to develop standardised indices for the national fleet. The following main conclusions were drawn from the workshop:

- Cluster analysis and related approaches to identify effort associated with different fishing strategies, should be used when direct measures of directed effort (e.g. HBF) are unavailable or less effective. But clustering can compromise the time trend if the clusters actually represent differences in density rather than catchability / fishing strategy.
- Area * time interactions are investigated in the joint standardisation. The area in the interaction terms are defined as a 5-degree latitude band and that the interactions include both year * latitude and quarter * latitude terms. The combined indices are obtained by summing up the predicted indices in 5x5 grid cells, as weighted by the area of each cell.
- The size data from the Japanese longline did not explain the discontinuity in the Japanese CPUE 1976-1977. The discontinuity is possibly to do with how the data was entered into the database, and not likely to do with what happened in the fishery or population.
- Seychelles logbook data provide an important independent source of information and should be incorporated in developing the joint indices. The addition of Seychelles data shall lead to a more representative sample covering the broadest areas in the Indian Ocean.
- National scientists should prepare and cluster their own datasets before future joint meetings, and prepare National indices using the same generic R code.
- Approaches should be developed to thoroughly test methods outside the workshops, in order to reduce both risks and costs. Scientists from member countries are requested to explore the following complementary strategies:
    - Data access agreements that specify the scientists who may access the joint data, the purpose it may be used for, the access period, and the required security provisions.
    - To develop new and improve existing simulators to create pseudo-operational datasets for model development and testing. Simulators should be designed to replicate issues that commonly affect analyses, such as dataset sizes, spatial distributions, and variable distributions.

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OPENING OF THE MEETING AND INTRODUCTORY ITEMS

1. A small Working group (CPUEWG) was held in Busan, from July 3rd to 7th 2017, to validate and improve the methods of developing joint standardized CPUE for tropical tuna species from main distant water longline fisheries operating in the Indian Ocean, including the Japanese, Korean, Seychelles, and Taiwanese fishing fleets. The meeting was attended by scientists of the main longline fleets in the Indian Ocean, as well as the IOTC Secretariat (see list of participants in Appendix I).
2. The organization of this workshop was recommended based on the SC 2016 (SC19.38), as well as the 3rd CPUE Workshop held in Shanghai in 2016 (IOTC–2016–CPUEWS03–R). The CPUEWG selected Dr. Toshihide Kitakado, the Chair of Working Party on Methods, to chair the meeting.
3. Dr. Toshihide Kitakado opened the meeting and informed the participants of the scope and expected outcomes of the workshop. The main goal of the workshop was to develop joint standardized CPUE for bigeye and yellowfin tuna, as well as indices for individual fleets, by applying cluster analysis to derive targeting strategies using reliable data for each CPC. The agenda was adopted (Appendix II), and the CPUEWG participants agreed on the TOR of the meeting (Appendix III).
4. IOTC would like to thank the lead Principal Investigator, Dr. Simon Hoyle and the CPCs (Dr. Kitakado, Dr. Matsumoto, Dr. Yeh, Mrs. Chang, Dr. Lee, Dr. Kim, Mr. Rodney, Mrs. Lucas, and Mrs. Assan) for the excellent work and effort put into the report produced so far (Appendix IV).
5. The report of the collaborative study of bigeye and yellowfin tuna CPUE from Indian Ocean longline fleets, presented at the IOTC Working Party on Tropical Tunas, held in Seychelles from October 17th to 22st 2017, is also attached in Appendix IV (to be appended).

Current status of joint CPUE STD

6. Dr. Hoyle summarised the progress towards the development of collaborative CPUE indices. The joint CPUE standardisation was initially developed to resolve the inconsistent trends between JP and TW CPUE, particularly for bigeye tuna, and indices developed under this framework have been incorporated into the most recent stock assessments for bigeye, yellowfin, and albacore tuna. The Working group **RECALLED** that differences between Japanese and Taiwanese BET CPUE series for a series of years were examined, and attributed due to either (i.) low sampling coverage of Taiwanese logbook data (between 1982-2000), or (ii.) misreporting across oceans (e.g., Atlantic and Indian oceans) for bigeye catches between 2002-2004. In the first case, the Working group **RECOMMENDED** the development of minimum criteria (e.g., 10% using a simple random stratified sample) for logbook coverage to use data in standardization process, while in the second case, the Working group **RECOMMENDED** identifying vessels through exploratory analyses that were likely misreporting catches, and excluding them from the dataset in the standardization analysis.
7. The CPUEWG **NOTED** that the current analytical framework of joint CPUE standardisation involves the following components:
    - Exploratory plots to improve understanding of the data.
    - Analyse data by fleet, species, and regional structure.
        - Targeting: Cluster analyses to separate fishing strategies.
        - Select useful clusters from each data subset, then combine all fleets.
        - Standardize data using generalized linear models to derive CPUE indices.
8. The IOTC Secretariat summarised the recommendations from previous IOTC Joint-CPUE workshops. The CPUEWG **WELCOMED** the effort made by Japan to retrieve vessel identity information for the Japanese fleets for the period prior to 1979 and **NOTED** this is still work-in-progress. The Working group **ENCOURAGED** that this information should be obtained either from the original logbooks, or from other sources, to allow the estimation of changes in catchability during this period and to permit cluster analysis using vessel level data, particularly as there was significant technological change (e.g., introduction of deep freezers) and changes in targeting (e.g., yellowfin to bigeye) during this period.

Background Introduction

9. Japanese, Taiwanese, Korean, and Seychellois participants provided overviews of their national longline fleets operating in the Indian Ocean, the associated data collection, as well as CPUE analyses conducted to-date. Various aspects of methodologies used are summarised in Table 1.

10. Dr. Matsumoto presented an overview of Japanese longline fishery and logbook data collection system. The Japanese longline fishery has operated in the Indian Ocean since 1952. During the initial period, operations were made almost exclusively in the tropical area, and then spread to almost the entire area. The amount of fishing effort (number of hooks) fluctuated, and recently it has been at a low level with little effort in the northwest area due to piracy. There have been historical changes in the species composition of the catch, indicating changes of targeting. In the logbook data for Japanese longline, in addition to the information on catch and effort, information on fishing gear (number of hooks per basket and gear material) is available, although gear material is available only from 1994. The proportion of deeper longline and nylon material has increased through time.

11. Dr. Matsumoto gave an overview of approaches used in the standardization of Japanese CPUE. In recent years, standardization for Japanese longline CPUE for bigeye, yellowfin and albacore has been conducted with GLM lognormal models using operational data. The effects of fishing season (quarter or month), fishing ground, fishing gear (material and number of hooks per basket) and so on are used with several interactions. Regarding the effect of fishing ground, either latitude and longitude blocks (one or five degree) or subareas are used. For the former approach, so far interactions for area and other effects (e.g. time-area) have not been incorporated. There are some differences of the trend between Japanese longline and Taiwanese longline or joint CPUE indices especially for albacore, which requires more investigation.

12. Dr. Yeh presented an overview of the Taiwanese longline fishery and data collection in the Indian Ocean. The Taiwanese longline fleet consists of large-scale (>= 100 GT) and small-scale (<100 GT) fishing vessels. The operation-level data used for CPUE STD are all from the large-scale fishing fleet, as the logbook coverage of the small-scale fleet was low until 2002. There are three target species/species groups used for the logbooks for the large-scale longliners: bigeye, albacore, and bigeye & albacore. Two additional target species are currently used in the observer records: yellowfin and southern Bluefin tuna. Yellowfin is not considered as a target species for the logbook because only a few vessels target yellowfin in some years; Southern Bluefin tuna is not considered as a target species because a license is required for capturing/landing SBT.

13. Dr. Yeh gave an overview of approaches used in the standardization of Taiwanese CPUE. Standardized CPUE series for bigeye, yellowfin, albacore and swordfish were provided to IOTC annually by Taiwanese scientists. The standardisation for the Taiwanese operation-level data are based on the generic scripts/methods developed for the joint analysis, which include the use of cluster analysis to identify fishing strategy.

14. Dr. Lee presented overviews of the Korean longline fishery and analysis for standardization for Korean CPUE data. The number of active fishing vessels showed the highest in the mid-1970s, since then it has reduced to 14 vessels in 2015. The total catch peaked at about 70 thousand mt in 1978 and decreased significantly thereafter. Since 2014 the catch of yellowfin tuna has shown an increasing trend, but bigeye tuna has been still at low level. In the 1970s and 1980s, the main fishing ground of Korean longline fishery was formed at tropical area between 10°N and 10°S of the western Indian Oceans, but it gradually moved to the southern of the Indian Ocean thereafter, and was formed mainly between 15°S and 40°S of the western and eastern Indian Oceans in recent years. Standardization for Korean longline CPUE for bigeye conducted with GLM lognormal model using operational data, 1977-2016. The CPUE of bigeye tuna showed a decreasing trend since 1977, and recently, it has a steady trend.

15. The Seychelles delegation presented an overview of the Seychelles industrial longline fishery. The Seychelles industrial longline fleet started operating in 1999 and on average the fleet comprised of around 39 vessels targeting mostly bigeye tuna, yellowfin tuna and swordfish. The main data for the fishery are collected via logbook with an average of over 90% logbook coverage after 2005. Length frequency data are also collected under a sampling protocol that started in 2007, where the first 20 fish hauled per set are measured by the vessel's crew. The data is thoroughly verified and validated following which missing hooks and catches in number are estimated, catches in weight are

converted to round weight and the data are extrapolated to take into account data that has been flagged during verification and validation. It was noted that no data analysis has been previously performed on the dataset.

Discussion of common issues/lessons arising

16. Prior to the workshop, the data were cleaned and filtered for obvious errors, including removal of missing values. Unlikely, but potentially plausible, values (e.g., sets with very large catches of a species) were retained. Each set was allocated to a fishery region (consistent with the definitions in the respective IOTC stock assessments), and data outside these areas ignored. A standard dataset was then produced for each fleet.

17. The CPUEWG **NOTED** that new main and branch-line material (Nylon mono-filament) has been used since early 1990s in Japanese LL in the Indian Ocean and this material is lighter than the traditional material. The deployment characteristics of a monofilament longline are different from the traditional longline and this may have prompted fishermen to change the configuration of the gear (e.g. HBF) to achieve similar fishing performance (e.g. depth/target species) with the new gear.

18. The CPUEWG discussed whether a combined whole-ocean model might be able to produce more robust regional indices than analysis conducted for each region separately, as the combined model allows regions to share information on parameters. The sample size of the dataset used in the joint analysis is usually large enough to allow each region to estimate parameters with adequate statistical power. The working group **NOTED** that whole-ocean analyses are problematic for various reasons. The number of interactions involved results in a very complex model. Variable selection is difficult/impossible due to pseudo-replication. There is rarely any benefit from sharing parameters, because a) there is so much data in most areas that parameters are well estimated, and b) parameters often have different values in different regions so it is inappropriate to share them, e.g. HBF effects vary with latitude and longitude, thermocline depth. Error distributions may vary between regions which adds another complication.

19. Questions were raised as to what is the appropriate area/regional definition for CPUE standardisation. The CPUEWG **AGREED** that regional definition should take into an account differences in population structure and/or fleet dynamics. The working group **NOTED** that regional structure in stock assessments may also need to take into consideration other data requirements. The CPUEWG **AGREED** that there is the need for consistency in defining regional structures to allow for comparisons of indices amongst different analyses/fleets.

20. The CPUEWG **NOTED** that the error checking procedure employed for the Seychelles logbook database involves flagging of suspicious values and the data is then extrapolated to take into account such flagged data. The working group **NOTED** that this may introduce unwanted bias for the standardization and the flagged values should be omitted from the CPUE analysis.

21. The CPUEWG **NOTED** the Seychelles longline vessels currently sample the first twenty fish during hauling for each set, and **SUGGESTED** that a more randomized sampling scheme should be used to avoid bias.

22. The CPUEWG **RECOMMNEDED** that cluster analysis and related approaches to identify effort associated with different fishing strategies, should be used when direct measures of directed effort (e.g. HBF) are unavailable or less effective. The working group **NOTED** that clustering can compromise the time trend if the clusters actually represent differences in density rather than catchability / fishing strategy. The working group **NOTED** that for pelagic longline fisheries, such approaches appear helpful in subtropical areas, but may introduce bias if applied in tropical areas – with the exception of where fisheries are clearly distinct. Therefore models in equatorial regions should consider not using the cluster variable or using HBF instead.

Table 1: Summary of fisheries and CPUE standardisation work done so far for the main longline fleet operating in IO

	JPN	KOR	SEZ	TWN	General note
Fishery (LL)					
Target species in IO (including historical ones)	ALB, YFT, BET, SBT	ALB, YFT, BET, SBT	YFT, BET, SWO	ALB, YFT, BET, SBT, SWO, oilfish etc.	See Figure 1.
Coverage year for STD	Mostly since 1950's	Since 1977	Since 2001 (TWN industrial vessels)	Since 1979	
Spatial coverage	Less/no coverage in Central south	Less/no coverage in Central south	Western equatorial region	Whole IO	
Change in target	Historical change	Historical change	Always YFT/BET	Historical change (from ALB to BET)	This change is addressed by clustering approach for both of CPC and joint analysis
Change in gear materials	Yes	No clear information for use	No clear information for use	No clear information for use	Considered only in JPN analysis
Change in Hooks/basket or between floats	Yes	Yes	Information on HBF only available recently	Yes (not used for CPUE STD)	Considered in CPC/joint analysis
Size data	In the past, up to 50 fish per operation. Recently (after around 2005) almost only in observer vessel	Since 2002, observer data (5% of coverage)	First 20 fish per operation	Checked length composition before analysis	Sampling protocol is important (randomized as much as possible) More size information should be used?
Analysis (so far)					
Probability distribution	Log-normal	Log-normal	Delta-lognormal (YFT) & Log-normal (BET)	Delta-lognormal & Log-normal	Agreed approach Delta-LN/LN in a common R code (may consider count models such as NB, Tweedie, ZINB in future)
Zero-catch proportion	58% overall for ALB Low for YFT and BET (see Figure 2)	About 20% in average (BET and YFT)	1% for BET	On average 30% for YFT; 20% for BET	
For region-specific CPUE_STD (Should be consistent over fisheries when extracting the CPUE trends…)	CPUE was analyzed by region	CPUE was analyzed by region	NA	CPUE was analyzed by region	Agreed approach: estimation by region (Pros: Gear effects might different by location Cons: Vessel effects can be shared but estimated by regional data)
Area effect	Large regional scale, 5*5 and 1*1	Large regional scale, 5*5	NA	5*5	Agreed approach (5*5) In future, 2-dim spatial modelling with smoothing effect, such as

	JPN	KOR	SEZ	TWN	General note
					GAM, GRF, …
Year-area interaction (*)	Considered only for combined analysis with "Region" effects	No	NA	No	"Area in interaction" can be larger than the scale of size for 5*5 Joint analysis By only lat (5 degree) or Lat*qrtr+ Lat*year Options for possible approach for CPC analysis (in future) 10*10, 15*15, Different scaling by period (JPN)
Quarter-area interaction or Year/quarter	With month or quarter	Not considered	NA	Not considered	Agreed approach: Joint analysis Lat*qrtr CPC analysis Same as in year-area interaction
Vessel effect	None	Yes (#vessels not so many now!)	NA	Yes (many!!)	Agreed approach = by vessel
Predicting year effect and year-quarter effect	LS mean in SAS	Function "predict" in R	NA	Function "predict" in R	Agreed approach For year-quarter effect: three-step approach 1) Calculate median of each covariate 2) Predict year-quarter effect for 5*5 cells at the median 3) sum up the area*predicted density For year effect: same as above (note: if there are no interactions, just predicting with median of covariates)
Statistical down-weighting for accounting spatial distribution of	No weighting	Weight to the inverse of sample size for time-cell stratum		Weight to the inverse of sample size for time-cell stratum	Agreed approach (after checking the original paper XXX)

	JPN	KOR	SEZ	TWN	General note
effort					Beyond LS means (not simply area weight), weighting considering sample size
Size information	Not used	Not used	NA	Considered for clustering	Regarded as a future work to incorporate in the model as covariates?
Diagnosis and model selection (so far)					
Residual plots against responses	Yes	Yes		Yes	Agreed to use
QQ plot for residuals	Yes	Yes		Yes	Ditto
ANOVA table for comparison of models	Yes	Yes		Yes	Ditto
Residual plots against covariates					Ditto
Influence plots for different parameters					Ditto

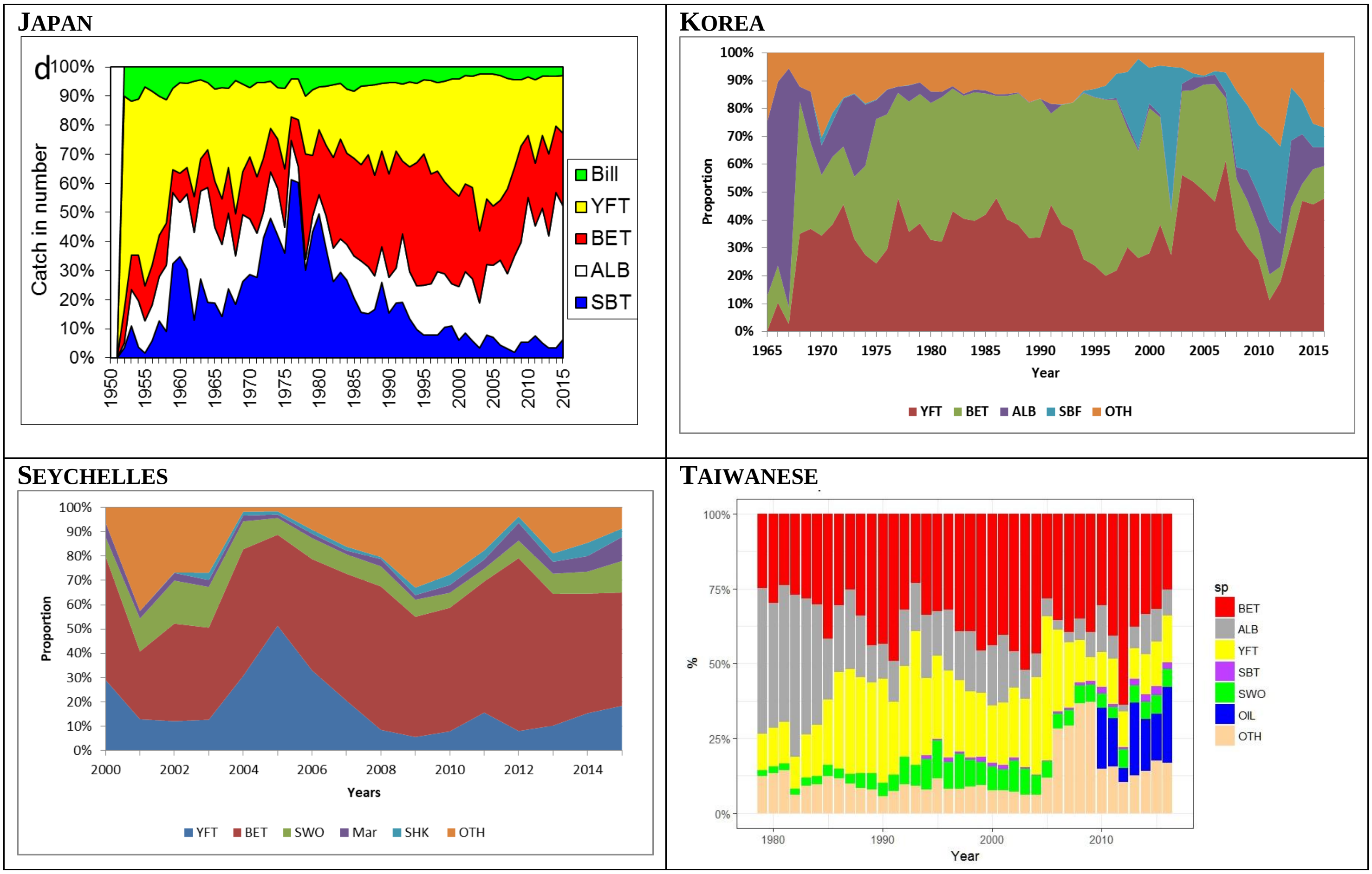

Figure 1: Proportions of main commercial species for Japanese, Korean, Taiwanese, and Seychelles longline fleet.

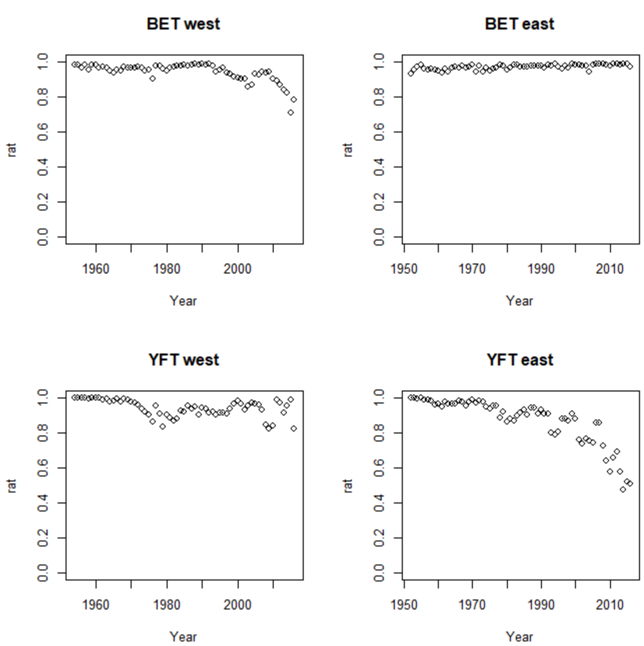

Figure 2: Proportions of nonzero catches for BET and YFT in the equatorial regions for the Japanese LL fleet.

Towards Joint CPUE Analysis

23. The CPUEWG **AGREED** that the current regional structures for bigeye and yellowfin joint standardisation need to be adapted to be aligned with those of the most recent stock assessments of bigeye and yellowfin tuna (Langley 2016a, b).

24. The CPUEWG **NOTED** that the Seychelles industrial longline fleet has a shorter history and a smaller geographic range than other DWLN fleets, but with a reasonably consistent fishing pattern and targeting strategies. The CPUEWG **AGREED** that Seychelles logbook data provide an important independent source of information and should be incorporated in developing the joint indices. The working group **NOTED** that as the HBF have become available only recently in the logbooks, some models for the equatorial regions that used HBF instead of cluster shall not include the Seychelles data.

25. The WG **RECOMMENDED** that examining operation level data across all LL fleets (Korea, Japan, Seychelles and Taiwanese) will give us a better idea of what is going on with the fishery and stock especially if some datasets have low sample sizes or effort in some years, and others have higher sample sizes and effort. The addition of Seychelles data shall lead to a more representative sample covering the broadest areas in the Indian Ocean.

26. The CPUEWG **NOTED** that assessments based on aggregated biomass dynamics models often require the use of area-combined annual indices. The CPUEWG **RECOMMENDED** the use of appropriate regional weighting approach to derive the indices across fisheries with a regional structure. One option involves summing up CPUE indices on fine-spatial grids as weighted by the area of the grid to obtain the weighting for a region.

27. The CPUEWG **NOTED** that area * time interactions are investigated in the joint standardisation. The area can be defined as a 5-degree latitude band and that the interactions include both year * latitude and quarter * latitude terms. The working group **NOTED** that the combined indices are obtained by summing up the predicted indices in 5x5 grid cells (using glm.predict function assuming median values for covariates), as weighed by the area of each cell.

28. The CPUEWG **NOTED** the use of statistical effort weighting (Campbell et al. 2004, 2014) to avoid the potential bias in standardized CPUE due to shifting effort concentration by giving equal weight to data from each time-area stratum, or by a combination of adjusting the statistical weights in the model, and/or randomly sampling an equal number of sets from each stratum. The working group **AGREED** that investigations should be conducted to explore the potential bias if the statistical effort weighting is not applied.

29. The CPUEWG **NOTED** that area effects can be modelled using two-dimensional spline/smoother instead of 5x5 latitude and longitude grid cells. There former approach could perform better in situations where there are strata with only positive catches, with no zeros.

30. Taiwanese longline fleet developed the oilfish fishery in the south-west Indian Ocean since 2006. Before 2010, the oilfish catch were combined with other fish catch recorded in other fish catch column in logbook dataset. But the oilfish catch column was available in the logbook dataset from 2010. The information can be used to verify whether the cluster analysis is able to distinguish between different fishing strategies. An exercise conducted by Dr. Yeh found very low false negative (or type I errors) and false positive rates (type II errors), suggesting that the cluster analysis was be able to distinguish the oilfish fishery from other fishing strategies.

31. The CPUEWG **NOTED** that the size data from the Japanese longline data did not explain the discontinuity in the Japanese CPUE 1976-1977. The working group **NOTED** that the discontinuity also exists in the Atlantic and Pacific Oceans. The discontinuity is possibly to do with how the data was entered into the database, and not likely to do with what happened in the fishery or population. A peak of catch rates occurs at the same time in Korean CPUE but might have a different cause, as it occurred at the beginning of the time series and the logbook coverage was lower during that time period (less than 20% in 1977).

32. The CPUEWG **NOTED** that the spike in the CPUE indices around 2012 in the west equatorial region for both bigeye and yellowfin was evident for most fishing fleet. Examination of the Taiwanese observer data did not reveal any anomalies in the size distribution in 2012 although the size data were very limited for that period. The CPUEWG discussed various hypotheses for what could have happened to CPUE with new fishing in areas, such as those affected

by piracy. For example, this could be due to an increase in catchability as a result of changes in population density, fishing effort, and/or fish behavior.

TECHNICAL INSTRUCTIONS BY HOYLE

33. Dr. Hoyle introduced the general statistical and modelling approach for the joint analysis, and provided technical training to participants on the clustering and standardisation methods for individual fleets with a focus on the use of the generic R code developed for the joint analysis.

FUTURE STEPS FOR FURTHER ANALYSIS

34. It was **NOTED** that clustering approaches and other ways to define targeting should be further explored. The effect of these analyses in defining a subset of operational data (e.g., sets/hauls) and its effects on the standardization should be tested. Alternative cluster aggregations (e.g., vessel-week / vessel-month-HBF / month-HBF-cell) should also be examined. The SBT fishery open/close dates may be useful as additional aggregation boundaries.

35. It was **NOTED** that time-area interactions within regions and among clusters needs further examination, particularly for the delta-lognormal model. The working group **AGREED** that appropriate scale for subareas should be explored by finding a scale that reduces variability and improves the fit to the data.

36. It was **NOTED** that using a subset of vessels to examine Vessel-Year interactions over time would be important to understand vessel-dynamics, and the reasons for their change in efficiency over time.

37. It was **NOTED** that improved modelling approaches should be explored with respect to alternative error distributions and data transformation (e.g. power transformation) to normalise the residuals and to accommodate strata with no zero catch.

38. It was **NOTED** that potential methods to account for target change, particularly the ability to target bigeye vs yellowfin should be explored.

39. It was **NOTED** size data should be explored for each fleet, if possible at the set level. Options for utilising size data in the standardisation or cluster analysis should be investigated.

40. The CPUEWG **RECOMMENDED** that examining operation level data across the main LL fleets (e.g., Korean, Japanese, Taiwanese, and Seychelles fleets) be continued in 2018. The CPUEWG **RECOMMENDED** a further workshop in 2018, to be led by an external consultant with expertise in CPUE standardization and R development, with dates (and venue) to be decided.

41. The CPUEWG **RECOMMENDED** that National scientists should prepare and cluster their own datasets before future joint meetings, and prepare National indices using the same generic R code.

42. The CPUEWG **CONSIDERED** that approaches should be developed to thoroughly test methods outside the workshops, in order to reduce both risks and costs. The CPUEWG **REQUESTED** scientists from member countries to explore the following complementary strategies:

    <u>Strategy 1</u>: Data access agreements that specify the scientists who may access the joint data, the purpose it may be used for, the access period, and the required security provisions. For example, this arrangement may be coordinated by an independent organisation.

    <u>Strategy 2</u>: To develop new and improve existing simulators to create pseudo-operational datasets for model development and testing. Simulators should be designed to replicate issues that commonly affect analyses, such as dataset sizes, spatial distributions, and variable distributions. For example, vessel codes will be changed, fishing locations changed to 5 degree squares, and catches altered.

ADOPTION OF THE REPORT

21. The Report of the 4nd IOTC CPUE Workshop on Longline fisheries was adopted on 7th July 2017.

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APPENDIX I: List of Participants

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APPENDIX II: Agenda for IOTC CPUE Standardisation Working group Meeting July 3rd -7th, 2017.

1. Introductory items and Terms of References

2. Current status of joint CPUE STD

3. Background presentations

   a. Longline Fleets (LL) : Japan
   b. Longline Fleets (LL) : Taiwanese Fleets
   c. Longline Fleets (LL) : Korea
   d. Longline Fleets (LL) : Seychelles

4. Discussion of common issues/lessons arising

5. Toward joint CPUE analysis

6. Technical instructions by Hoyle

   - General statistical approaches
   - Advice on R code

7. Organization of remaining days

   - Testing of clustering procedure
   - Developing national indices and working papers (JPN, KOR, SEZ and TWN)
   - Developing joint indices and a working paper (Hoyle)

8. Wrap-up discussion

9. Workplan until 2017 WPTT

10. Adoption of report

APPENDIX III: TERMS OF REFERENCE

Food and Agriculture organization of the United Nations

Terms of Reference for Consultant/PSA

Name:	
Job Title: INTERNATIONAL CONSULTANT (Stock assessment) (Category A)	
Division/Department: FIDT/FI	
Programme/Project Number: GCP/INT/258/EC – TF/FIDTD/TFEU110016382; MTF/INT/661/MUL – TF/FIDTD/TFAA970097099	
Location:	
Expected Start Date of Assignment: 01 June 2017	**Duration:**
Reports to: ***Name:*** Dr Alejandro Anganuzzi	***Title:*** EXECUTIVE SECRETARY (Interim)

Expected Outputs:	Required Completion Date:

TERMS OF REFERENCE FOR THE PROVISION OF SCIENTIFIC SERVICES TO THE IOTC: COLLABORATIVE ANALYSIS TO PREPARE CPUE INDICES

Scientific Services to be provided:

Methods for standardisation of joint catch and effort from DWFNs that incorporated an innovative approach on identifying target changes were developed in 2015 and 2016. Standardised CPUE indices have been used as abundance index in the most recent Indian Ocean bigeye and yellowfin tuna stock assessments. The working party on tropical tuna (WPTT) has recommended the method to be further developed in 2017. Following the suggestions of WPTT19, the IOTC requires a short-term consultancy for the following activities:

COLLABORATIVE ANALYSES TO PREPARE CPUE INDICES

- Validate and improve methods for developing indices of abundance for tropical and albacore tunas.
- Provide indices of abundance for bigeye and yellowfin tunas and draft working papers to be presented at the WPM09 (13-15 October 2017) and WPTT19 (17-22 October 2017).
- Provide support and training to national scientists in their analyses of catch and effort data.
- The analyses will consider data to be provided by Japanese, Taiwanese, Korean, and Seychelles research agencies.
- Analyses will be carried out in a series of meetings in March and April. After preliminary meetings between the consultant and some of the participating data providers to prepare each dataset and develop methods, there will be a joint meeting between all participating countries and the consultant.

Tasks will include the following, to the extent possible in the available time:

- Work with the Stock Assessment Officer to coordinate a series of meetings between data holders and the consultant.
- Prepare and test computer hardware and software that will facilitate the fast and efficient running of large numbers of computer-intensive analyses.
- Load, prepare, and check each dataset, given that data formats and pre-processing often change between years and data extracts, and important changes to fleets and reporting sometimes occur in new data. The Seychelles data have not previously been included in the analyses and will require additional preparation.

- Conduct the following analyses to improve CPUE methods:
  - Apply cluster analyses and bigeye and yellowfin CPUE standardization using reliable data from each CPC. Prepare separate indices for each fleet, and joint indices. Thoroughly check all code and results in order to validate indices.
  - Develop a simulator to test methods for standardizing CPUE, and to allow the development and testing of new code during periods when the joint data are unavailable
  - Explore alternative modelling and data transformation methods in order to normalise residuals and to accommodate strata with no zero catches.
  - Explore spatial and temporal patterns in residuals by fleet and cluster, in order to better understand the factors driving CPUE changes, to explore potential confounding effects and and possible seasonal catchability changes
  - Identify appropriate subareas for modelling time-area interactions within regions, by region and species. Explore adding subarea-time interactions in the standardization models, to address differences in trends among areas.
  - Explore residual patterns spatially and among clusters, fleets and vessels through time, and change models where necessary to address any problems identified.
  - Investigate the 1976-80 discontinuity in the tropical CPUE of bigeye and (to a lesser extent) yellowfin
  - Explore options for extending the Japanese time series of vessel effects into the pre-1979 period.
  - Increase understanding of the fisheries that provide the CPUE by a) exploring the size data associated with each fleet, if possible with size data at the vessel set level (including using standardizing method to identify spatial and temporal patterns); and b) exploring vessel movement patterns through time. This task involves using data held by the IOTC Secretariat.
  - Develop standard methods for estimating relative reginal weights so as to apportion relative abundance among regions
- All work is subject to the agreement of the respective fisheries agencies to make the data available.
- To document the analyses in accordance with the IOTC "*Guidelines for the presentation of CPUE standardisations and stock assessment models*", adopted by the IOTC Scientific Committee in 2014; and to provide draft reports to the IOTC Secretariat no later than 60 days prior to the meeting of the WPTT19, i.e. **17 August 2017**, and the final report no later than 15 days prior to the meeting of the WPTT19, i.e. **2 October 2017**.
- To undertake any additional analyses deemed relevant by the WPTT19 or the IOTC Secretariat up to 60 days after the start date of the contract.

Expected Outputs:	Required Completion Date:
• To provide an updated draft report of the joint CPUE meetings to the IOTC Secretariat no later than 60 days prior to meeting of the WPTT19, i.e**. 17 August 2017**.	• 30 August 2017
• To provide the final report of the joint CPUE meetings to the IOTC Secretariat no later than 15 days prior to the meeting of the WPTT19, i.e. **2 October 2017**.	• 2 October 2017

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