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Report of the Sixth IOTC CPUE Workshop on Longline Fisheries

San Sebastian, April 28th – May 3rd, 2019.

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ACRONYMS

ALB	Albacore Tuna
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.

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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 San Sebastian from April 28th to May 3rd, 2019. The aim of the meeting was to validate and improve the methods of collaborative CPUE analysis for tropical tuna species for main longline distant water fishing fleets operating in the Indian Ocean, to develop joint standardised CPUE indices for bigeye and yellowfin tuna, and to develop standardised indices for the national fleet, including Japanese, Taiwanese, Korean, and Seychelles Longline fleet. The workshop carried out a range of analyses including the preparation of the data, characterization of the fisheries, clustering analysis, and the CPUE standardizations for individual fleet. The 2019 Joint CPUE analysis included the data from the Japanese (1952-2018), Korean (1971-2018), Taiwanese (2005-2018), and Seychelles (2000-2017).

OPENING OF THE MEETING AND INTRODUCTORY ITEMS

1. A small Working group (CPUEWG) was held in San Sebastian from April 28th to May 3st 2019, 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, Taiwanese, and Seychelles 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 2019 (SC21), as well as the 5th CPUE Workshop held in Keelung in 2018 (IOTC–2018–CPUEWS05–R). The CPUEWG was chaired by Dr. Gorka Merino, the Chair of Working Party on Tropical Tunas.
3. Dr. Gorka Merino opened the meeting and informed the participants of the scope and expected outcomes of the workshop. The main priority was to develop joint standardized CPUE for bigeye and yellowfin tuna, as well as indices for individual fleets. The joint standardised indices to be developed during the workshop are expected to be used in the 2019 assessment of bigeye and yellowfin tuna. 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. Matsumoto, Dr. Yeh, Ms. Chang, Dr. Lee, Dr. Kim) for the excellent work and effort put into the joint analysis produced so far (Appendix IV). IOTC would also like to thank the colleagues from AZTI for their hospitality in organizing and providing facilities for the meeting.
5. The report of the collaborative study of bigeye and yellowfin tuna CPUE from Indian Ocean longline fleets, as well as reports of analyses for individual longline fleets will be finalized after this workshop and presented at the IOTC WPM, WPTT (October 2019).

Review of past recommendations on CPUE standardization within IOTC Scientific Committee

6. The IOTC Secretariat summarised the requests and recommendations from WPM07, WPTT20, and SC21. The Scientific Committee recommended the Joint CPUE analysis to continue and also made a number of requests for the analysis, including (a) to create maps showing areas covered by the joint STD CPUE, (b) to produce STD CPUE by fleet to evaluate plausible ones, (c) to produce tempo-spatial aggregated joint CPUE, and (d) to complete technical transfer for national scientists to be able to produce joint CPUE by themselves.
7. The CPUEWG **NOTED** that the spatially aggregated CPUE can be obtained by combining region-specific CPUE indices using regional scaling factors. The CPUEWG **RECALLED** presently the regional scaling factors were derived from aggregated catch effort data using a standardisation model (Hoyle & Langley 2018). Progress has been made in developing regional scaling factors from operational-level data instead that can account for vessel and target effects. The proposed model shall include data from all regions with the target variable defined across fleets/regions (rather than the region/fleet specific target in the joint standardation model).

Review of recent direction on CPUE standardization in IOTC and experiences in other t-RFMO:

8. Dr Hoyle introduced the historic development of the Joint CPUE analysis at IOTC and summarised aspects of the analytic framework, including data preparation, fishery characterizations, clustering analysis, and index standardisation. He also provided a brief review of the lessons and experiences gained from similar analyses that were undertaken in other t-RFMOs. The CPUEWG **NOTED** that the recent peer-review of the ICCAT bigeye tuna assessment has recommended the use of simulations to assess the effectiveness and performance of the clustering analysis in identifying targeting strategies.

National operational catch-effort data and analysis to-date

9. Japanese, Taiwanese, and Korean participants provided overviews of their national longline fleets operating in the Indian Ocean.

10. Dr. Matsumoto gave an overview of Japanese longline fishery and approaches used in the standardization of CPUE. The following summary is provided by the author: "*Japanese longline fishery is operating in the Indian Ocean since 1952. During the initial period, operations were made almost only in the tropical area, and then spread to almost entire area. Amount of fishing effort (number of hooks) fluctuated, and recently it is in a low level with few efforts in the northwest area due to the effect of piracy activities. There are historical changes of species composition of the catch, indicating changes of targeting. Recently albacore is dominant in the catch in number, but not the case for the catch in weight. In the logbook data for Japanese longline, in addition to the information of 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 catch only in number for each set is available up to 1993, and information on both number and weight is available from 1994. The information on bait is available up to 1993. The proportion of deeper longline and nylon material increased over the historical period especially in the 1990s. In recent years, standardization for Japanese longline CPUE for bigeye, yellowfin and albacore by national scientists' own method is conducted with GLM lognormal model by using operational data. The effects of fishing season (quarter or month), fishing ground, fishing gear (material and number of hooks per basket) and environmental effect (sea surface temperature) are used with several interactions. Regarding the effect of fishing ground, five degree latitude and longitude blocks or subareas are used. There are some differences of the trend between Japanese longline and other longline or joint CPUE indices. Some slight difference of CPUE trend was also observed for Japanese longline CPUE between 'traditional' and new method (the method in joint CPUE analysis).Size data for Japanese longline fishery were collected based on on-board measurement by the fishermen, training vessels, and scientific observers. Main component of data source differs depending on period. Recently most of the data are by scientific observers, and the number of samples are low especially for yellowfin tuna. There is no obvious difference of fish size among sampling methods.*."

11. The CPUEWG **NOTED** that the project is still under way to retrieve vessel identity information for the Japanese fleets for the period prior to 1979 from the original logbook data or other sources and was informed that the license number could potentially be used as a proxy for vessel ID before 1979. The CPUEWG **AGREED** that this information is important as it allows the estimation of changes in catchability during this period and to permit cluster analysis to be conducted at vessel level.

12. The CPUEWG **NOTED** that there has been a large increase in albacore catches by the Japanese LL vessels in areas off the west coast of Australia since 2010. The reason is not clear and it may have been a result of changes in fishing strategy by vessels operating in this area.

13. The CPUEWG **NOTED** that there were large fluctuations of fishing effort by the Japanese LL fleets. The effort was reduced significantly through the late 60s to the 70s as fishing vessels moved to other oceans. The large reduction in effort since the late 2000s was due to the threat of piracy activities in the western Indian Ocean.

14. The CPUEWG **NOTED** that the bait usage by the Japanese LL fleet has changed overtime and there was a transition from saury to squid bait from the 1960s to the 1990s. The CPUEWG **RECOMMENDED** the information on bait be made available to the joint analysis for better interpreting the results of the standardisation.

15. The CPUEWG **NOTED** that catches have been recorded in both numbers and weight at set level since 1994 for the Japanese LL fleets. This information can be used to derive average fish length per set, and to inform the spatial and temporal trend in length distributions where the size samples are not available.

16. The CPUEWG **NOTED** that the change of the line material to Nylon for both the main and branch lines since the mid-1990s may confound the interpretation of hooks between floats (HBF) as the fishers may have to reconfigure the HBF for different line materials in order to maintain a similar level of fishing efficiency.

17. The CPUEWG **NOTED** that historic size data submitted to IOTC by Japan was not separated between commercial and training vessels. Size samples from spatial temporal strata (i.e. month, 5 x 5 grid) for which there is no reported catch were likely to have been taken from training vessels.

18. The CPUEWG **NOTED** that the Japanese LL observer program started in the 1990s but the observer data in the IOTC database is only available from the late 2000s. It is possible that the early commercial LL length data in the IOTC database may have included some observer samples.

19. Dr. Lee presented overviews of Korean longline fisheries in the Indian Ocean and the data for CPUE standardization. The following summary is provided by the author: "The number of active fishing vessels of Korean longline fisheries in the Indian Ocean showed the highest in the mid-1970s, but it decreased thereafter and reduced to 7 vessels in 2011. In 2013, it has somewhat of increasing, and was 13-14 vessels in recent years. The total catch peaked at about 70 thousand tons in 1978 and then decreased significantly. Since 2013 the catch of yellowfin tuna has shown an increasing trend, and since 2009 bigeye tuna has been stable at low level and is showing a slight increasing in recent years. In the 1970s and 1980s, the fishing ground of Korean longline fishery was formed at tropical area between 10°N and 10°S in the Indian Ocean, but after that it gradually moved to the southern Indian Ocean, and was formed mainly between 15°S and 40°S of the western and eastern Indian Oceans in recent years. Recently, some vessels have operated at the tropical area to fish for yellowfin and bigeye tunas."

20. The CPUEWG **NOTED** that since around 2002 the distribution of HBF for the Korean fleet exhibited two modes – one at about 10 (shallow sets), and the other higher than 15 (deep sets). Recently most vessels were fishing in the temperate region for southern bluefin tuna and moved to the tropical region to catch bigeye and yellowfin after the end of the bluefin season. There were a few vessels that had no bluefin quota and were mostly fishing in the tropical region.

21. Dr. Yeh presented an overview of the Taiwanese large scale (vessels over 100 GT) longline fishery data in the Indian Ocean. The following summary is provided by the author: "*Taiwanese deep-water longline fleet has been mainly targeting bigeye in the tropical area of the Indian Ocean since the 1980s. The total bigeye catch was significant increasing to 5 ,6800 mt in 2003. And then after 2005, the total bigeye catch was decreasing to 10,300 mt in 2017. The total yellowfin catch was significant increasing from 8,000mt in1985 to 57,800 mt in 2005. And then after 2006, the total yellowfin catch was decreasing to 4,629 mt in 2017. The major reduction of the tropical tuna catch was partly due to Taiwanese vessel reduction program in 2005. After 2014, for the first and fourth quarter, the ratio of set with nhb >= 20 was much higher than the usual cases in the previous years. The phenomenon might be related to the introduce of a new fishing equipment by some vessels. The influence of the change in nhf on the interpretation of CPUEs will be further explored. Standardized CPUE series for bigeye and yellowfin 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*."

22. The CPUEWG **NOTED** that the Taiwanese large-scale longline vessels mainly targeted albacore tuna in the early years, and bigeye tuna has become the main target species since the 1990s with the development of deep freezing capacity. A oil fish targeted fishery was also developed in the western-southern Indian Ocean after 2006 with the oil fish being recorded as a separate species in the logbook since 2009.

23. The CPUEWG **NOTED** that the Taiwanese small-scale (vessels under 100GT) longline has not been included in the standardation dataset. The fleet was developed in the early 2000s and the logbook coverage was very low and has become more complete after 2014 when the E-Logbook system was established. The CPUEWG **RECOMMENDED** that the usefulness of the Taiwanese small-scale longline fishery data for developing abundance indices be explored in the future.

24. The CPUEWG **NOTED** that the deeper sets (HBF >= 20) deployed by the Taiwanese large-scale longline fleet has increased significantly since 2014 in most areas including the temperate region where the albacore tuna were traditionally targeted. The reason for this change is unknown and needs further investigations (e.g. it is not clear whether

the introduction of a new type of hauling machine during this period has prompted more deeper sets to be deployed). The distribution of deeper sets also showed a very distinctive seasonal pattern – as vessels usually targeted bigeye tuna in the first and fourth quarter, and moved southward in the second and third quarter for catching southern bluefin.

25. The CPUEWG **NOTED** that the nominal CPUE for bigeye has declined sharply since 2011, and was at the lowest in the last two years. Information from fishers appeared to indicate that the stock condition for bigeye is deteriorating. The nominal catch rate for yellowfin also remained low in the last few years. However, the quota limitation of yellowfin imposed since 2017 may undermine the interpretation of catch rates if some vessels have tried to avoid areas with high yellowfin catch rates.

26. The CPUEWG **NOTED** that catch and effort for the Seychelles deep-water longliners from 2000 to 2017 have been provided by Seychelles Fishing Authority (SFA) to be included in the joint analysis. An R markdown script was developed for preparing the data to be in a format ready for the standardisation. The CPUEWG thanked Seychelles scientists for their efforts to make their data available in time for the analysis.

Exploring the causes for potential mis-reporting of length samples by longline fleets.

27. Miguel Herrera presented the preliminary results of a review of the time-series of length frequency data reported from the main Asian longline fleets in the Indian Ocean, over the period 1980-2017. The review used length frequency samples reported by Japan, Taiwan, Korea, Seychelles and China over that period. The aim of the ongoing review is to evaluate if high-grading is occurring on longline fleets and, if confirmed, to which extent it may lead to underreporting of fish in logbooks and introduce bias to indices of abundance derived from such data. Preliminary results show that small fish have vanished from the samples reported by the fleets of Taiwan and Seychelles, especially since the early 2000's, with a trend showing larger fish in the samples since then. In the case of Taiwan this has led to changes in average weights derived from samples of about 15-20kg during this period. This is also in contradiction with length data collected by observers in recent years (2010-17), for all fleets combined, which contain small fish, as opposed with lengths collected by the crew over the same period. The review identified as well significant discrepancies in the length distributions reported for the same fleet and among the different fleets for many of the strata under consideration, which will need to be clarified. Considering that lengths and numbers of fish are collected by longline crews, it is assumed that underreporting of lengths might lead to underreporting of numbers of fish, meaning that some of the fish caught by longliners may not be recorded in logbooks. However, the extend to which such underreporting has affected reports of numbers of fish in logbooks is still unknown and needs to be further explored. The aim of future work is to be able to estimate the amount of fish that may have not been recorded in logbooks each year, in particular in recent years, where discarding may have increased as a consequence of regulations. This will assist in building alternative scenarios of numbers of fish that account for high-grading in estimates of indices of abundance derived from operational data reported by these fleets, which do not contain the numbers of fish discarded.

28. The CPUWG **RECALLED** that that Taiwanese length composition data after 2003 have not been included in the recent assessment (SS3) of bigeye and yellowfin tuna following the recommendation by Geehan & Hoyle (2014), and further **NOTED** that the WPTmT07 meeting in January (IOTC–WPTmT07(DP) 2019) advised to exclude the early Taiwanese size data as well due to concern of its quality. The national scientists suggested that the length data collected by observers (available from 2002), and the weight information of sampled fish from commercial logbooks (available from 2009) are likely to be more reliable.

29. The CPUEWG discussed possible causes for the decline in the proportion of smaller fish sampled for lengths from the Taiwanese commercial logbooks that have resulted in the increase of average length/weight since 2002/03, and **NOTED** a number of contributing factors that could potentially degrade the quality of the size data: (1) a number of fishers may have recorded the fish length inaccurately, leading to misreporting of length measurements; (2) sampling protocols may not always be followed – for example sorting or grading of fish for market purposes could result in non-random or biased samples being taken; (3) between 2000 and 2004, many vessels were reflagged as Taiwanese vessels (as part of the Taiwanese fleet reduction program). These vessels were mostly fishing in the tropical regions for bigeye tuna and were more likely to catch/report larger fish; (4) discarding and high grading is also likely to explain the vanishing of small fish in the length samples. The CPUEWG **AGREED** that trends in the Taiwanese length data were likely to be related to a combination these factors.

30. The CPUEWG **NOTED** that discarding occurs for many reasons. The regulations of catch limit and market conditions can create incentives for the longline fleets to retain larger, high value fish and to discard smaller ones. The catch limit of 35 000 mt for bigeye tuna in the Indian Ocean introduced by the Taiwanese government since 2005 has not been exceeded due to the reduced fleet size and lower catch rates, therefore the incentive to discard bigeye tuna for quota reasons was considered small. Taiwanese vessels fishing in the tropical region often unload small bigeye tuna with little or no value for the sashimi market at local port (e.g. Mauritius) to sell for local market. However, the discard for yellowfin may have been increased since 2017 following the introduction of the catch quota (Res. 17/01 and 18/01).

31. Discards rates of yellowfin and bigeye tuna for 2002 – 2018 were estimated from the Taiwanese longline commercial logbooks (Table 1 & 2). Two discard rate scenarios were calculated (i) total discards/total retained catch using all vessels and (ii) only using vessels that have reported discards at least in one year of the whole time series. The latter attempted to recognize differential discarding practices between vessels: accounting for those vessels that are assumed to report discards routinely and discounting those vessels that have not reported any discard. The discard number/rate for bigeye tuna was very low except for 2005 when the catch limit (35000 t) was imposed (scenario 2, see Table 2). There were very little discards for yellowfin in the logbooks before 2017, but the discards rates were high in 2017 and 2018 (e.g. 8.7% and 9.6% in the western tropical and temperate region respectively in 2018, scenario 2, see Table 2).

32. The CPUEWG **NOTED** that Huang & Liu (2010) estimated discard rates for the Taiwanese deep longline fleet using observer data from 2004 to 2008. The overall discard rate was estimated 4.74% for bigeye and 2.32% for the yellowfin. It was estimated that the discard rate for bigeye tuna could be as high as 38% from the fleet that targeted albacore.

33. The CPUEWG **NOTED** that the Japanese and Korean longline fleet are currently not subject to the yellowfin catch limit, and the reported discards of yellowfin and bigeye tuna were low historically. The JPN LL observer data submitted to IOTC show an overall discard rate 1.8%–2.7% for tropical tuna. However, it was noted that the observer monitoring was poor in tropical areas.

34. The CPUEWG **NOTED** that unaccounted discards can introduce bias to length samples and nominal catches, and undermine the interpretation of CPUE. The CPUEWG suggested that a number of data sources can be used to explore the extent and trend of discards of tropical tuna in the longline fisheries, including (1) commercial logbook reports of discarding (however, the changes in reporting behavior over time need to be accounted for), (2) observer data, (3) weight category data in the Taiwanese commercial logbooks (since 2009), e.g. changes in the weight distribution overtime may reveal possible trend in discarding.

Table 1: Summary of retained yellowfin catches and discards (both in numbers) by region from the Taiwanese commercial logbook based on senario2 which excluded vessels that did not report any discards.

	Region 2			Region 3		
Year	Retained	Discards	Rate	Retained	Discards	Rate
2002	138374	0	0.000%	20638	12	0.058%
2003	252060	158	0.063%	18521	15	0.081%
2004	287230	363	0.126%	26179	0	0.000%
2005	301118	545	0.181%	31879	34	0.107%
2006	108223	123	0.114%	5652	5	0.088%
2007	54561	21	0.038%	6155	111	1.771%
2008	16627	15	0.090%	4410	8	0.181%
2009	14355	4	0.028%	6396	0	0.000%
2010	20246	12	0.059%	12510	0	0.000%
2011	45990	11	0.024%	5164	0	0.000%
2012	79347	6	0.008%	7540	0	0.000%
2013	48280	0	0.000%	11117	1	0.009%
2014	54468	0	0.000%	5649	0	0.000%
2015	72419	50	0.069%	12858	24	0.186%
2016	110494	222	0.201%	23337	0	0.000%
2017	67637	3265	4.605%	13670	1795	11.607%
2018	79985	7639	8.718%	22910	2428	9.582%

	Region 4			Region 5		
Year	Retained	Discards	Rate	Retained	Discards	Rate
2002	13015	0	0.000%	16865	1	0.006%
2003	12857	37	0.287%	21887	95	0.432%
2004	28015	1	0.004%	30798	357	1.146%
2005	12736	79	0.616%	10011	81	0.803%
2006	6099	7	0.115%	6984	31	0.442%
2007	5350	1	0.019%	16556	12	0.072%
2008	2993	0	0.000%	8407	0	0.000%
2009	1656	0	0.000%	14958	6	0.040%
2010	6143	4	0.065%	9246	0	0.000%
2011	1235	0	0.000%	18387	2	0.011%
2012	941	0	0.000%	6126	0	0.000%
2013	4394	1	0.023%	2014	0	0.000%
2014	883	0	0.000%	1846	0	0.000%
2015	4417	0	0.000%	1922	0	0.000%
2016	4423	0	0.000%	1831	0	0.000%
2017	1151	12	1.032%	1934	0	0.000%
2018	5169	108	2.047%	3117	230	6.872%

Table 2: Summary of retained bigeye catches and discards (both in numbers) by region from the Taiwanese commercial logbooks based on senario2 which excluded vessels that did not report any discards.

	Region 1			Region 2		
Year	Retained	Discards	Rate	Retained	Discards	Rate
2002	339616	15	0.004%	73633	7	0.010%
2003	464281	134	0.029%	108896	247	0.226%
2004	535017	472	0.088%	116891	711	0.605%
2005	339256	4125	1.201%	26566	140	0.524%
2006	195528	1111	0.565%	19441	93	0.476%
2007	248648	285	0.114%	84701	69	0.081%
2008	143605	177	0.123%	46415	10	0.022%
2009	127561	53	0.042%	116830	17	0.015%
2010	124589	45	0.036%	53601	13	0.024%
2011	139459	45	0.032%	88283	5	0.006%
2012	369228	23	0.006%	13797	0	0.000%
2013	174367	0	0.000%	14330	0	0.000%
2014	96411	304	0.314%	10626	0	0.000%
2015	119661	306	0.255%	11036	0	0.000%
2016	140360	411	0.292%	9404	0	0.000%
2017	111219	260	0.233%	6508	0	0.000%
2018	102403	63	0.061%	4720	0	0.000%

	Region 3			Region 4		
Year	Retained	Discards	Rate	Retained	Discards	Rate
2002	52758	21	0.040%	21990	0	0.000%
2003	30108	36	0.119%	34567	2	0.006%
2004	38030	0	0.000%	27483	5	0.018%
2005	23640	177	0.743%	6954	80	1.137%
2006	10870	30	0.275%	5280	0	0.000%
2007	3390	47	1.367%	5918	7	0.118%
2008	3345	2	0.060%	6155	0	0.000%
2009	4844	0	0.000%	3636	0	0.000%
2010	2812	0	0.000%	7438	0	0.000%
2011	1580	0	0.000%	6160	0	0.000%
2012	1818	2	0.110%	1418	1	0.070%
2013	10103	21	0.207%	5034	0	0.000%
2014	5910	0	0.000%	10056	0	0.000%
2015	7400	27	0.364%	4449	0	0.000%
2016	9739	15	0.154%	3935	0	0.000%
2017	17569	83	0.470%	7478	0	0.000%
2018	14528	3	0.021%	2902	0	0.000%

Preliminary CPUE Standardization for national fleets

35. Maps showing spatial distributions of fishing effort by 5 year period for the Japanese, Taiwanese, and Korean fleets are given in Appendix IV. Example results from preliminary standardisation analyses are shown in Appendix V for yellowfin, and Appendix VI for bigeye.
36. The CPUEWG **NOTED** that the HBF was not included in 2018 standardisation of the Japanese fleet, but was included in 2019. The CPUEWG discussed whether it is appropriate to include both HBF and cluster in the model as both variables are used to indicate targeting. As the cluster variable is derived from separate sources, using both HBF and cluster in the standardisation may offer more explanatory power for changes in fishing strategy, especially in the temperate region.
37. The CPUEWG **NOTED** that for the Korean fleet, the standardized catch rates of yellowfin increased with HBF in the tropical region, but decreased with HBF in temporal region. This is possible as differences in thermocline and/or other oceanic conditions can cause the relationship between catch rates and HBF vary among regions.
38. The CPUEWG **NOTED** that for both Japanese and Taiwanese fleets, using either HBF or cluster did not have an appreciable impact on the trend in the standardized CPUE indices for both bigeye and yellow in the tropical region.
39. A comparison of the standardized CPUE indices for the Japanese, Taiwanese, and Korea Fleets are shown in Figure 1 (western equatorial region only).

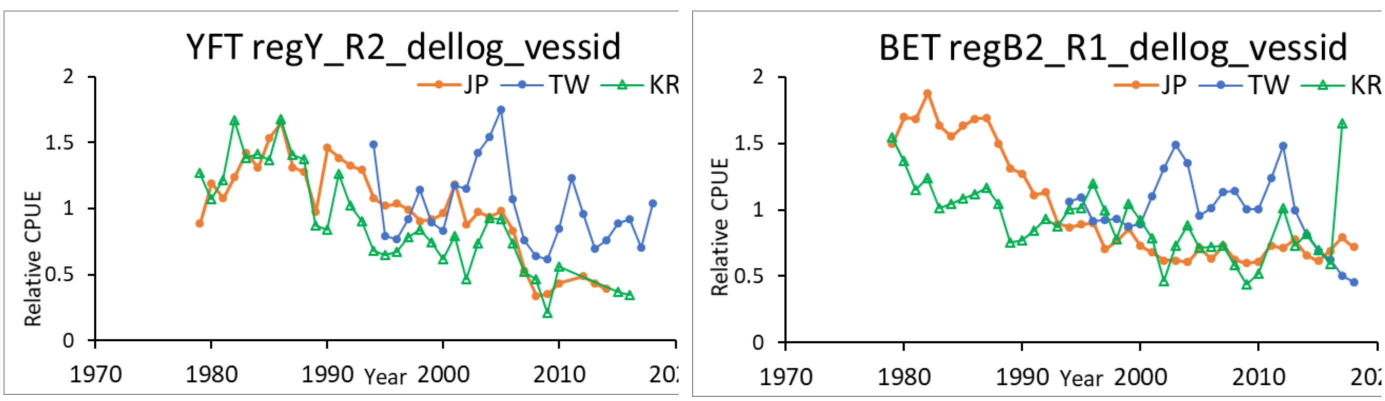

Figure 1: A comparison of the standardized CPUE indices for the Japanese, Taiwanese, and Korea Fleets (left, yellowfin; right, bigeye).

Joint CPUE Standardization

40. The CPUEWG **NOTED** that the 2019 Joint CPUE analysis included the data from the Japanese (1952-2018), Korean (1971-2017), Taiwanese (2005-2018), and Seychelles (2000-2017). Seychelles data were not included in analyses that used hooks between floats (HBF) as data on HBF only became available from 2009 and only in a subset of the effort.

41. The regional structures considered for the analysis are shown in Figure 2 for yellowfin (regY and regY2) and Figure 3 for bigeye (regB2 and regB3). The CPUEWG **NOTED** that the current assessment used the “regY” regional structure yellowfin (Fu et al. 2018) and ‘regB3’ for bigeye (Langley 2016). The split of the western tropical region into north and south (regY2 and regB2) was intended to the account for potentially incomplete tag mixing in the assessment model.

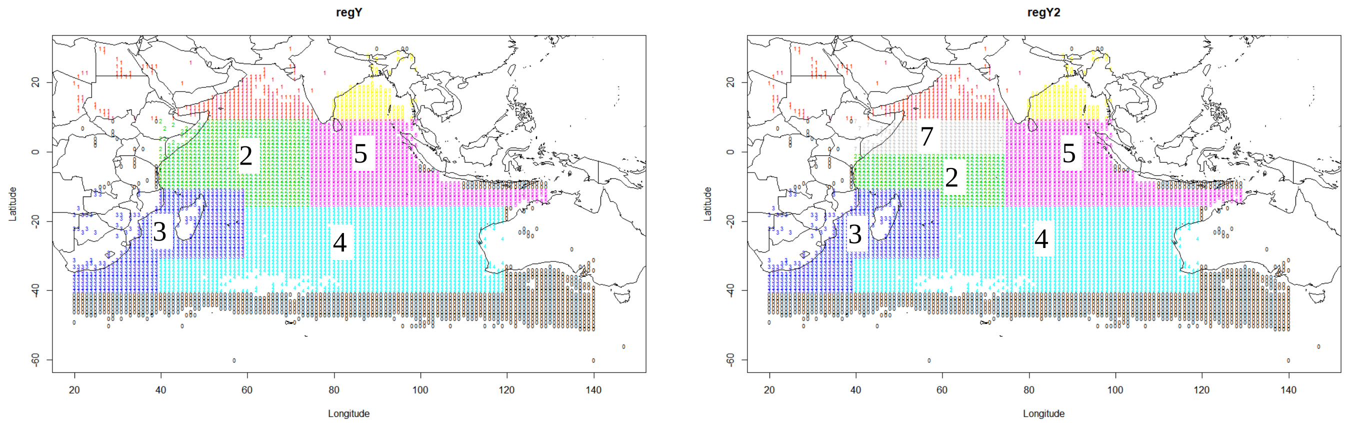

Figure 2: Regional structure “regY” (left) and “regY2” (right) for yellowfin tuna.

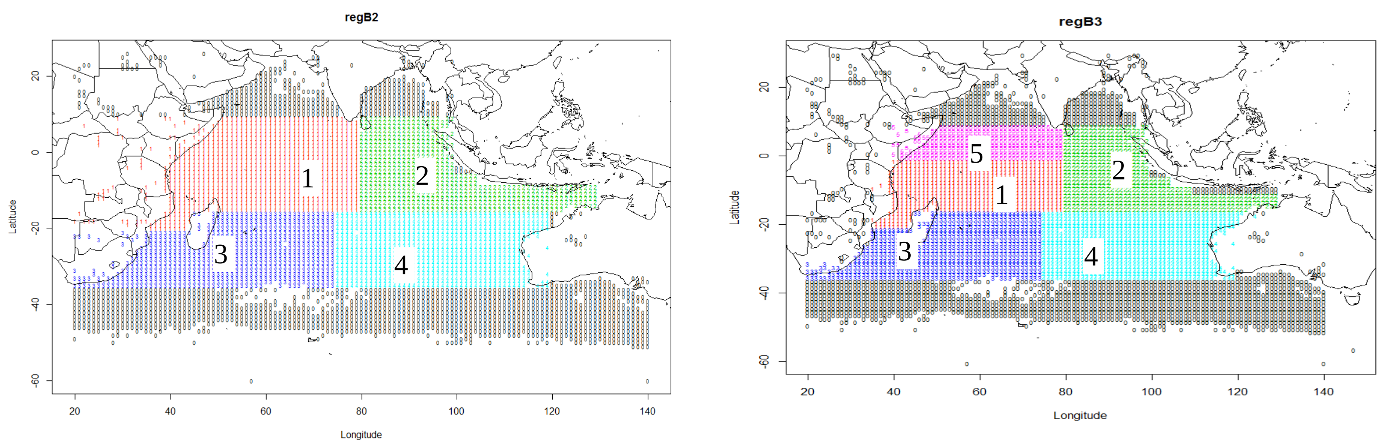

Figure 3: Regional structure “regB2” and “regB3” for bigeye tuna.

42. For both yellowfin and bigeye tuna and for each region in the joint analysis, a set of standardation model runs were conducted based on alternative data/model configurations relating to treatment of vessel effects, targeting strategy, and discards:

- Three options relating to vessel effects: a long time series 1952 – 2018 without vessel ID, a short time series 1952-1978 without vessel ID; and a short time series 1979 to 2018 with vessel ID.
- Three options relating to targeting strategy: one with the HBF only, one with cluster only, and one with both cluster and HBF (the option with cluster only was not considered for the tropical region).
- Three options relating to discards:
    - one did not account for discards,
    - one adjusted the Taiwanese catches with the discard rates using 2 discard rate scenarios. The two discards rates scenarios tried to account for differential discarding practices between vessels: (i) total discards/total retained catch using all vessels and (ii) only using vessels that have reported discards at least in one year of the whole time series (see Table 1 & 2).
    - one adjusted the Taiwanese catches using the discard rates (using discard rates scenarios 1 only) and also extend the Taiwanese data series back to 1995.

43. In each model run, hooks are used as both a measure of effort (on the left hand side of the model equation) and also an explanatory variable indicating targeting.

44. The CPUEWG **NOTED** that previous Joint analysis also developed a long time series with vessel ID (a dummy vessel ID was assigned to all vessels 1950 –1979. Diagnostics showed that the effect for the dummy vessel relative to the other vessels (and vice versa) were likely to be poorly estimated given that there was no overlap between them, which may have led to the apparent the discontinuities in the standardized time series in the late 1970s. This option is not considered in the current Joint analysis.

45. The CPUEWG **NOTED** the following criteria were used for sub-setting data for each region in the 2018 standardisation analyses: vessels were included if they had fished for sufficient quarters in the equatorial regions; similar rules were applied to vessels, 5° cells, and year-quarters (the actual thresholds could be adjusted depending on the amount of data available in the analysis). The CPUEWG **NOTED** that the analysis that used the cluster variable in the model removed clusters that have zero catches of the species of interest, and the analysis that did not use the cluster variable removed clusters that have a very low proportion of the species of interest.

46. The CPUEWG **NOTED** that the cluster analysis on species composition was used to identify effort associated with different fishing strategies. 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. For *cluster* to be considered as the targeting variable for the tropical region, it might be more appropriate to combine the BET and YFT clusters as a single cluster, as the two species are usually targeted together. The CPUEWG **RECOMMENDED** this approach be explored in future iterations.

47. Examples of the standardized CPUE indices for yellowfin (region 2) and bigeye (region 3) are shown in Figure 3.

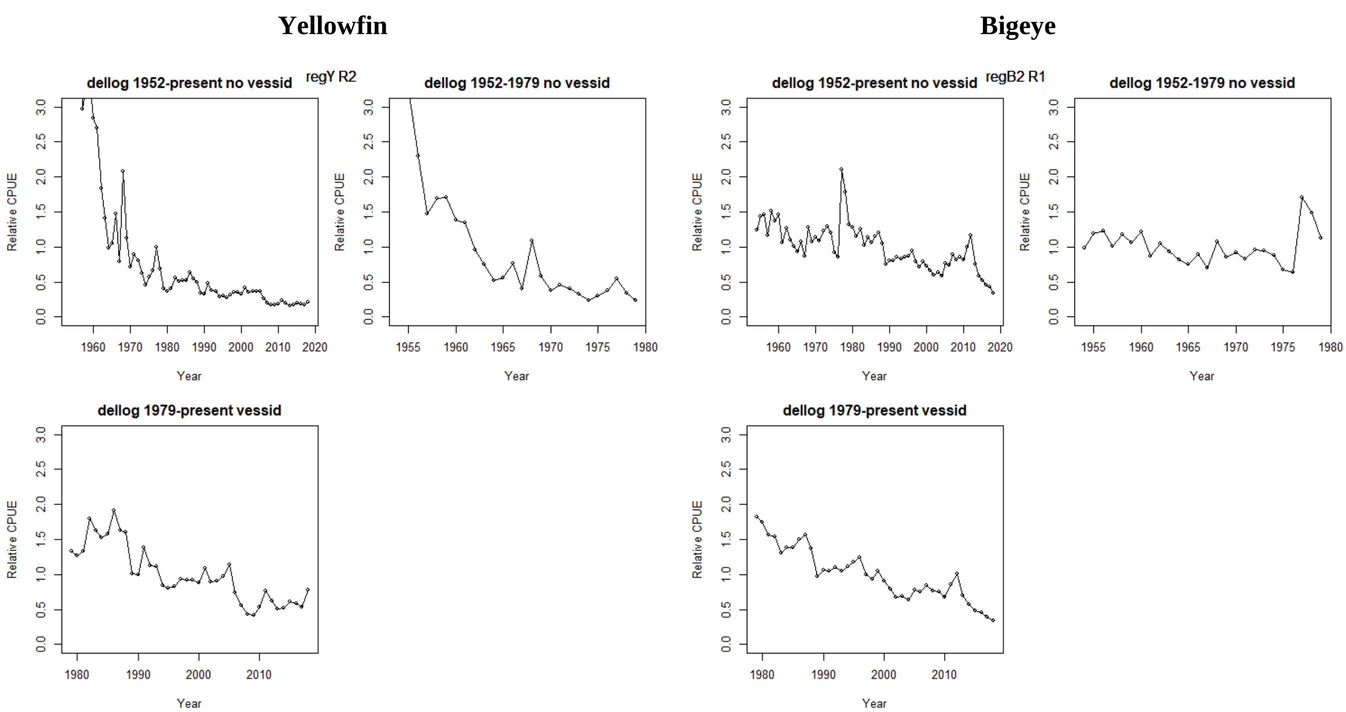

Figure 4: An example of standardized indices (annual) for yellowfin in region 2 (left) and bigeye in region 1 (right). For each species, 3 sets of indices are shown: full series 1952-present with no vessel id; full series 1952-present with vessel id; series 1952-1978 with no vessel id; series 1979-present with vessel id. All models are based on the option of adjusting the Taiwanese catches with the discard rates estimated from senario2.

FUTURE WORKPLAN

48. The CPUEWG **RECOMMENDED** that the Taiwanese small-scale longline fishery data be examined in future iterations of the Joint analysis.

49. The CPUEWG **RECOMMENDED** to further develop the R code for the Joint analysis (currently written as a R library hosted in www.GitHub.com) to make it easier to use.

50. The CPUEWG **RECOMMENDED** to improve the methods of estimating regional scaling factors through the use of operational-level catch effort data (instead of aggregated data) that can account for vessel and target effects.

ADOPTION OF THE REPORT

51. The Report of the 6th IOTC CPUE Workshop on Longline fisheries was adopted on 3rd May 2019. The Chair thanked all the participants for their dedicated work and discussions, and thanked the rapporteurs for producing the report in a timely manner. IOTC thanked the Chair for facilitating the meeting and leading the discussions.

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APPENDIX I: List of Participants

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APPENDIX II: Agenda for the 6th IOTC CPUE Standardisation Working group Meeting

1. Introductory items
    - 1.1 Opening remarks
    - 1.2 Appointment of chair and rapporteurs
    - 1.3 Review of available documents/data/software
2. Review of past recommendations on CPUE standardization within IOTC Scientific Committee
3. Review of recent experiences and direction on CPUE standardization in other t-RFMO
4. General review of methods available
    - 4.1 Conventional GLM and GAM approaches
    - 4.2 Spatial-temporal modelling
    - 4.3 Methods accounting for targeting
    - 4.4 Methods for joint CPUE
    - 4.5 Others
5. Background information on bigeye fishery
    - 5.1 Spatial and temporal distribution of efforts
    - 5.2 Nominal and standardized CPUE
    - 5.3 Size composition
    - 5.4 Others
6. Toward update of national CPUE standardization for bigeye tuna
    - 6.1 Issues/lessons arising in the past analyses specific to bigeye tuna
    - 6.2 Testing clustering procedures
    - 6.3 Specification of the analysis
7. Toward development of joint CPUE standardization
    - 7.1 Issues/lessons arising in the past analyses specific to bigeye tuna
    - 7.2 Technical issues on development of joint CPUE
    - 7.3 Specification of the analysis
    - 7.4 Methods for diagnostics of joint CPUE
    - 7.5 Code sharing with github
    - 7.6 Manual of joint CPUE analyses

8. Review progress in analyses
    - 8.1 Development of CPC's standardized CPUE
    - 8.2 Development of joint CPUE

9. Review outcomes of analyses
    - 9.1 CPC's standardized CPUE
    - 9.2 Joint CPUE
10. Workplan
    - 10.1 Plan until 2019 WPTT (if necessary)
    - 10.2 Plan beyond 2019
    - 10.3 Plan for developing a manual of joint CPUE analyses

11. Adoption of report

APPENDIX III: TERMS OF REFERENCE

Food and Agriculture organization of the United Nations
Terms of Reference for Consultant/PSA

General Description of task(s) and objectives to be achieved

The Indian Ocean Tuna Commission (IOTC) is an intergovernmental organization responsible for the management of tuna and tuna-like species in the Indian Ocean. The IOTC was established in under Article XIV of the FAO constitution. One of the Commission's key science-based functions and responsibilities is to undertake assessments of the status of the IOTC species.

Methods for joint standardisation of catch and effort that incorporate an innovative approach on identifying changes in the targeting of particular fish stocks were developed and incorporated in IOTC stock assessments in 2015 and 2016. Standardised CPUE outputs have been used as abundance indices in the most recent bigeye, yellowfin, and albacore tuna stock assessments in the Indian Ocean. The IOTC Scientific Committee has recommended that the standardized CPUE methods be further developed and CPUE indices to be included in the 2019 stock assessment of bigeye tuna

Based on the recommendations of the IOTC Working Parties, and endorsed by the IOTC Scientific Committee, the IOTC requires a short-term consultant to undertake the following activities:

COLLABORATIVE ANALYSES TO PREPARE CPUE INDICES

1. Validate and improve current methods for developing indices of abundance for bigeye tuna, using up-to-date fishery catch effort data
2. Provide indices of abundance for selected IOTC species to be presented at the IOTC Working Parties in 2019.
3. The analyses will consider data to be provided by key industrial fisheries operating in the Indian Ocean, including data from Japanese, Taiwanese, Korean, Seychelles longline fleets.
4. Analyses will be carried out in a meeting scheduled in April 2019. After the preliminary discussions between the consultant and participating data providers, the joint standardisation analysis will be carried out combining datasets from key fleets. The consultant is expected to undertake any analyses deemed relevant or necessary during the meeting.

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

5. 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.
6. Apply cluster analyses or alternative methods for identifying targeting. Develop CPUE standardizations for bigeye tuna using reliable data from each CPC. Continue to explore residual patterns spatially and among clusters, fleets and vessels through time, and change models where necessary to address any problems identified
7. Develop maps showing the spatial coverage by the CPUE data used in the joint analysis over-time with emphasis on the most recent years, as requested by the IOTC Scientific Committee during its 21th session.
8. 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 provide draft reports to the IOTC Secretariat no later than 60 days prior to the relevant IOTC Working Party meeting.

All work is subject to the agreement of the respective fisheries agencies to make the data available.

V2 09/10

APPENDIX IV: Maps of fishing effort by 5-year period for the Japanese, Taiwanese, and Korean fleets

The figures below are maps showing spatial coverage of fishing effort by 5-year period for the Japanese, Taiwanese, and Korean fleets (A1-A3), as well as the the distribution of fishing effort for all fleets combined (A4).

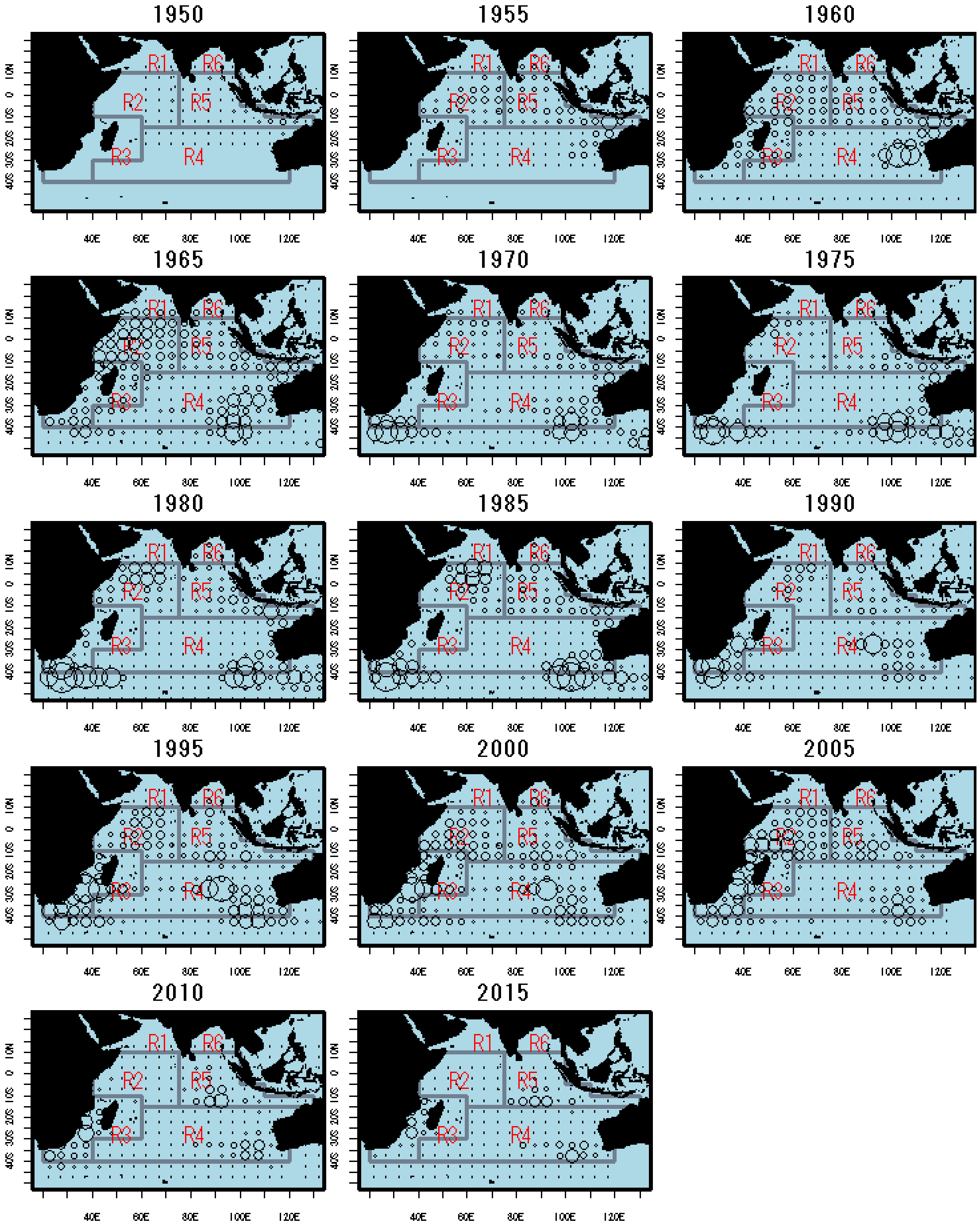

Figure A1: Distribution of fishing effort for the Japanese LL fleet 1952-2018 (aggregated for each 5-year period).

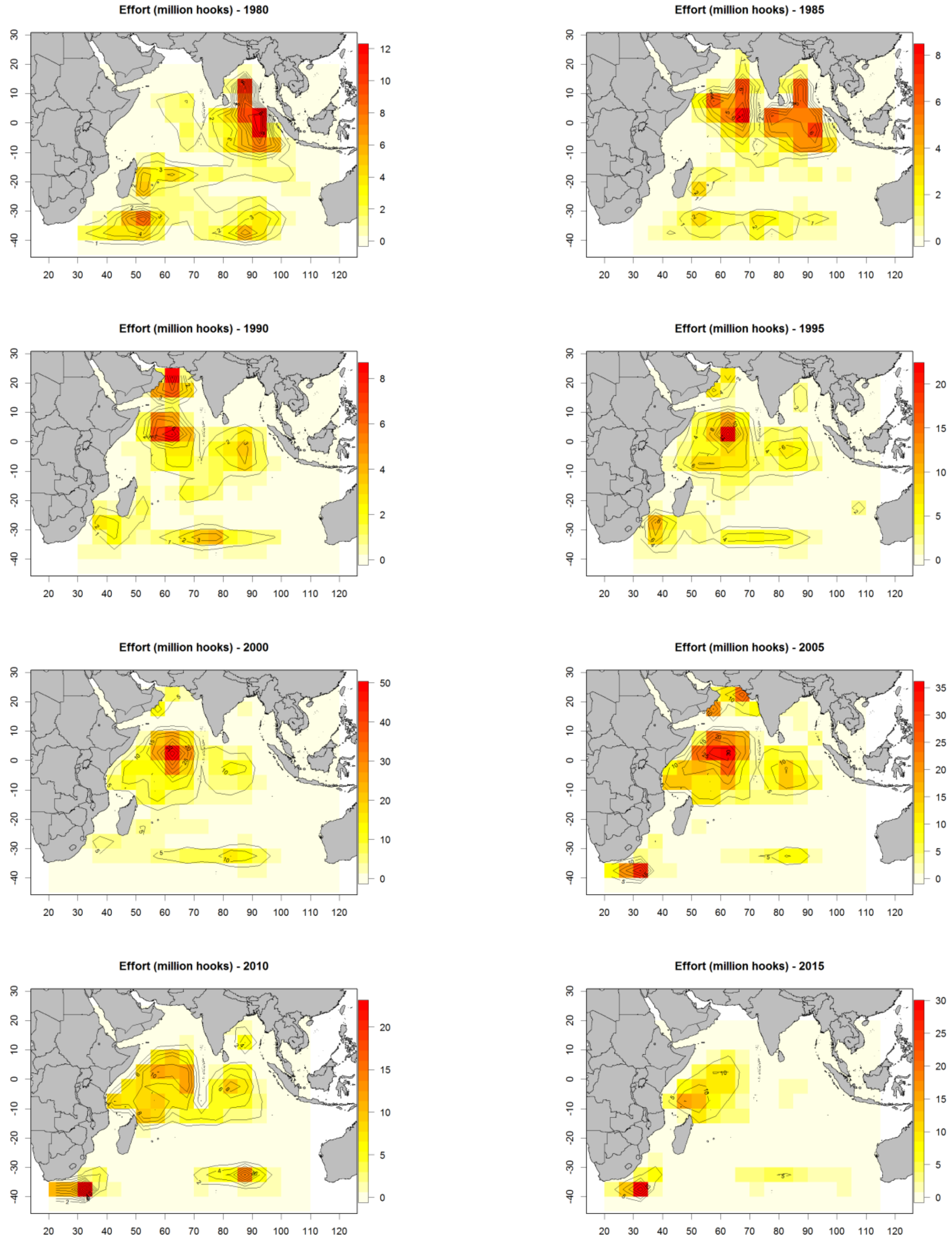

Figure A2: Distribution of fishing effort for the Taiwanese LL fleet 1979-2018 (aggregated for each 5-year period).

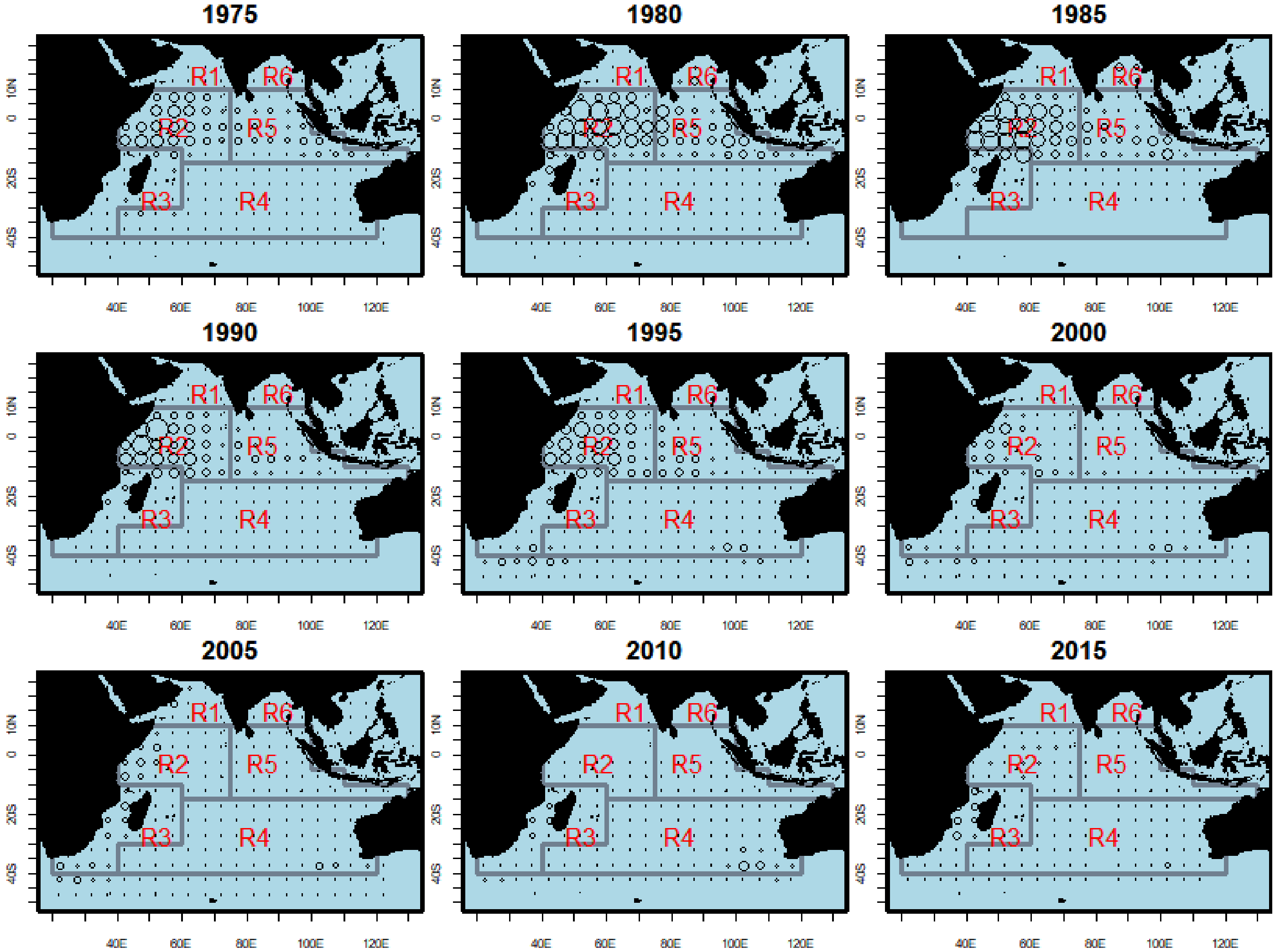

Figure A3: Distribution of fishing effort for the Korean LL fleet 1977-2018 (aggregated for each 5-year period).

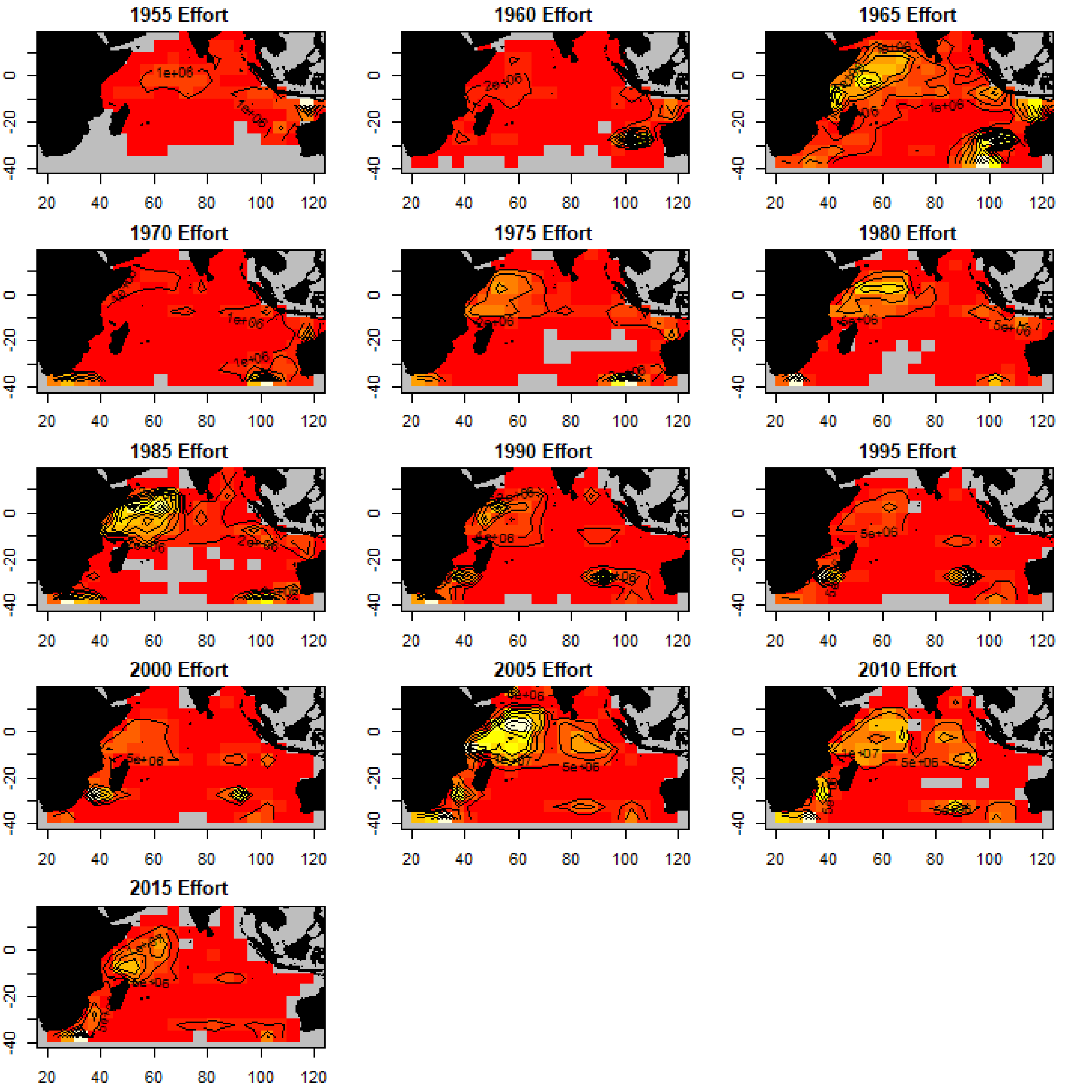

Figure A4: Distribution of fishing effort for the Japanese, Taiwanese, and Korean LL fleet combined 1955 – 2018 (aggregated for each 5-year period). Yellow indicates areas with high level of effort.

APPENDIX V: Examples from Preliminary Standardisation Analysis on Yellowfin tuna

The figures below (B1-B3) are examples from the preliminary clustering and standardisation analysis on yellowfin in the western equatorial region (region 2 with regional structure “regY) from Japanese, Taiwanese, Korean. Each figure includes (a) a tree plot showing the selection of the final clusters; (b) maps showing the spatial distribution of clusters; (c) boxplot showing the distribution of species composition by cluster; (d) standardised CPUE indices.

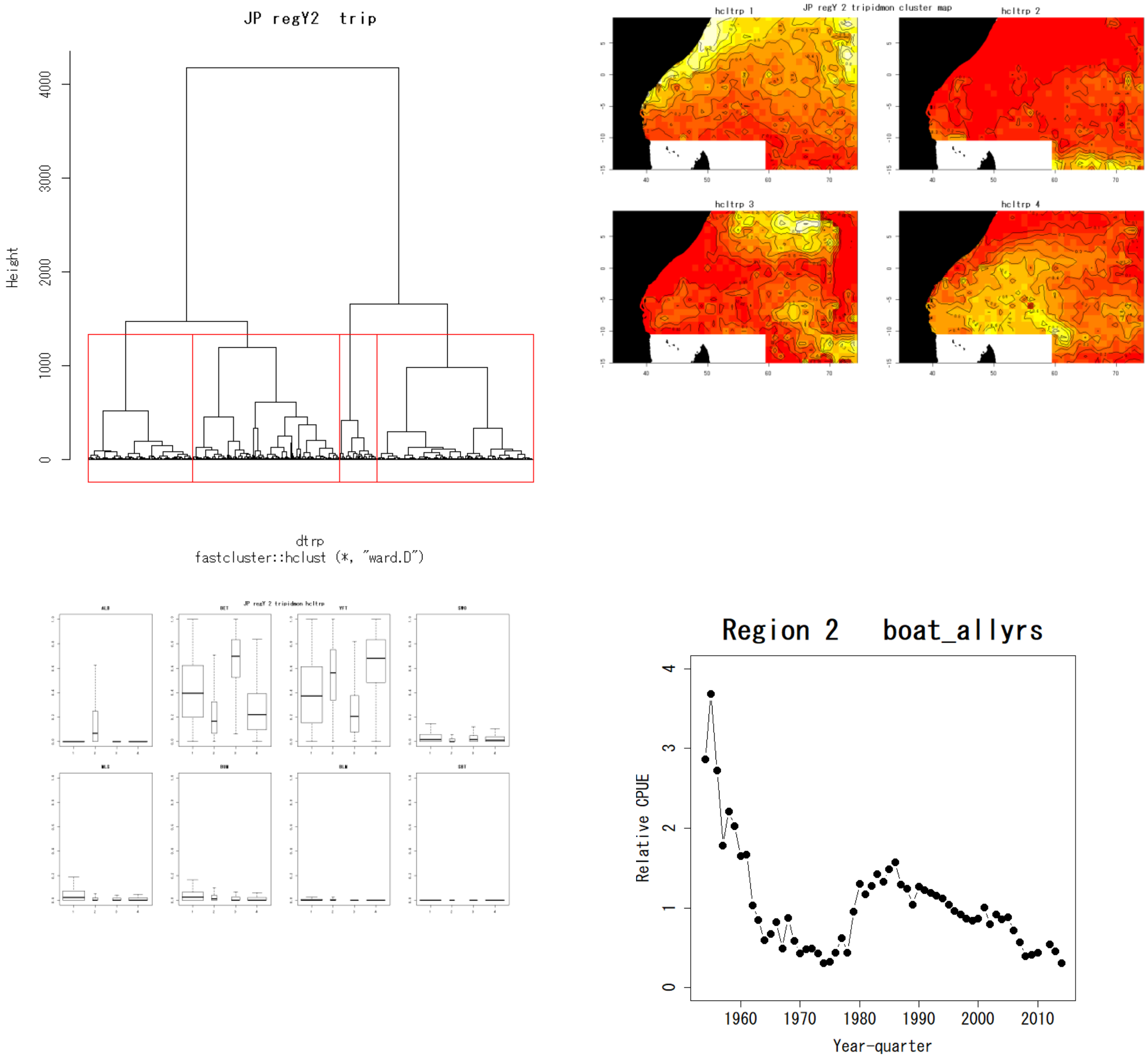

Figure B1: Examples from Japanese fleet on analysis on yellowfin in the western equatorial region (region 2 in “regY”)

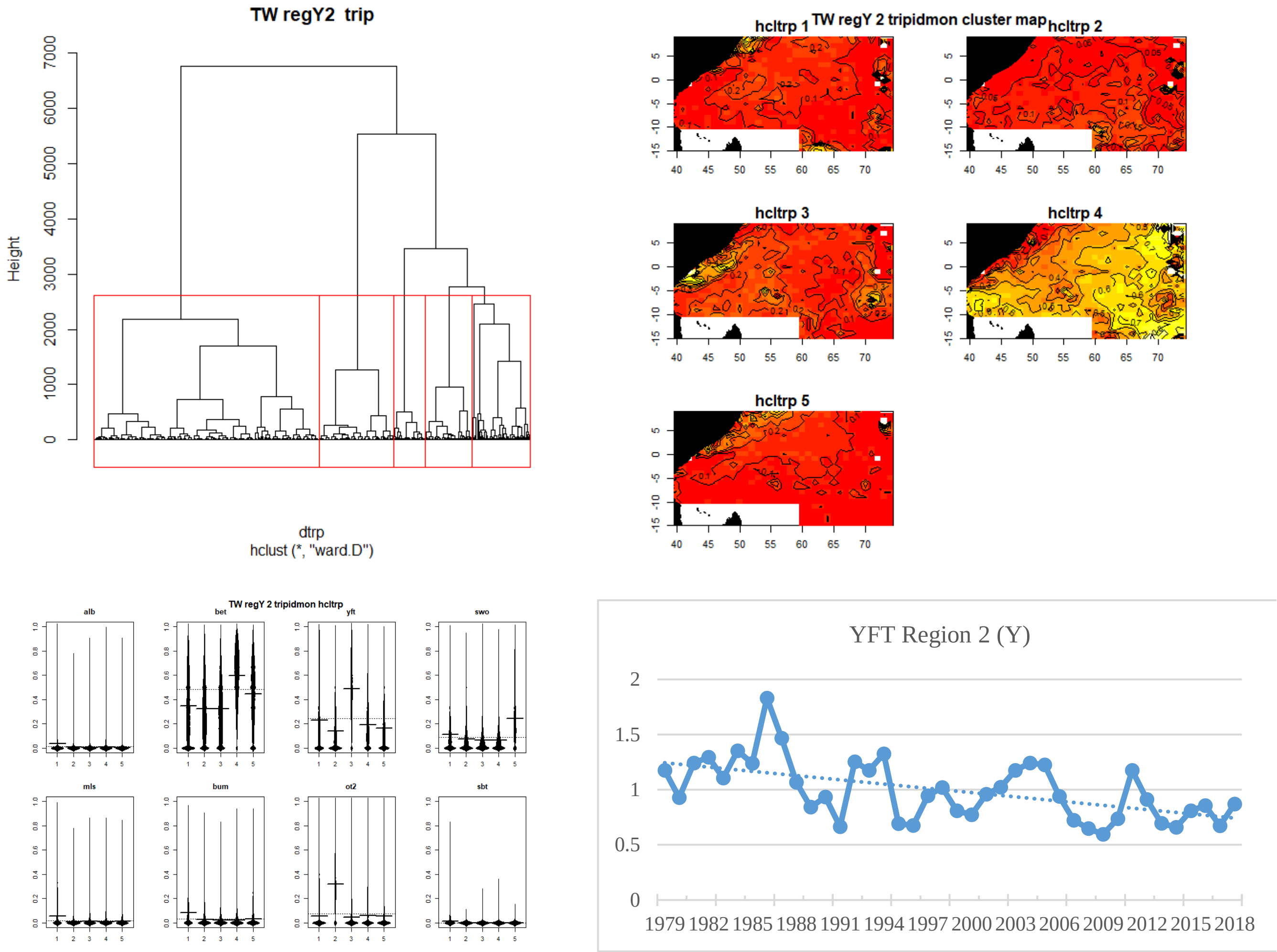

Figure B2: Examples from Taiwanese fleet on analysis on yellowfin in the western equatorial region (region 2 in "regY")

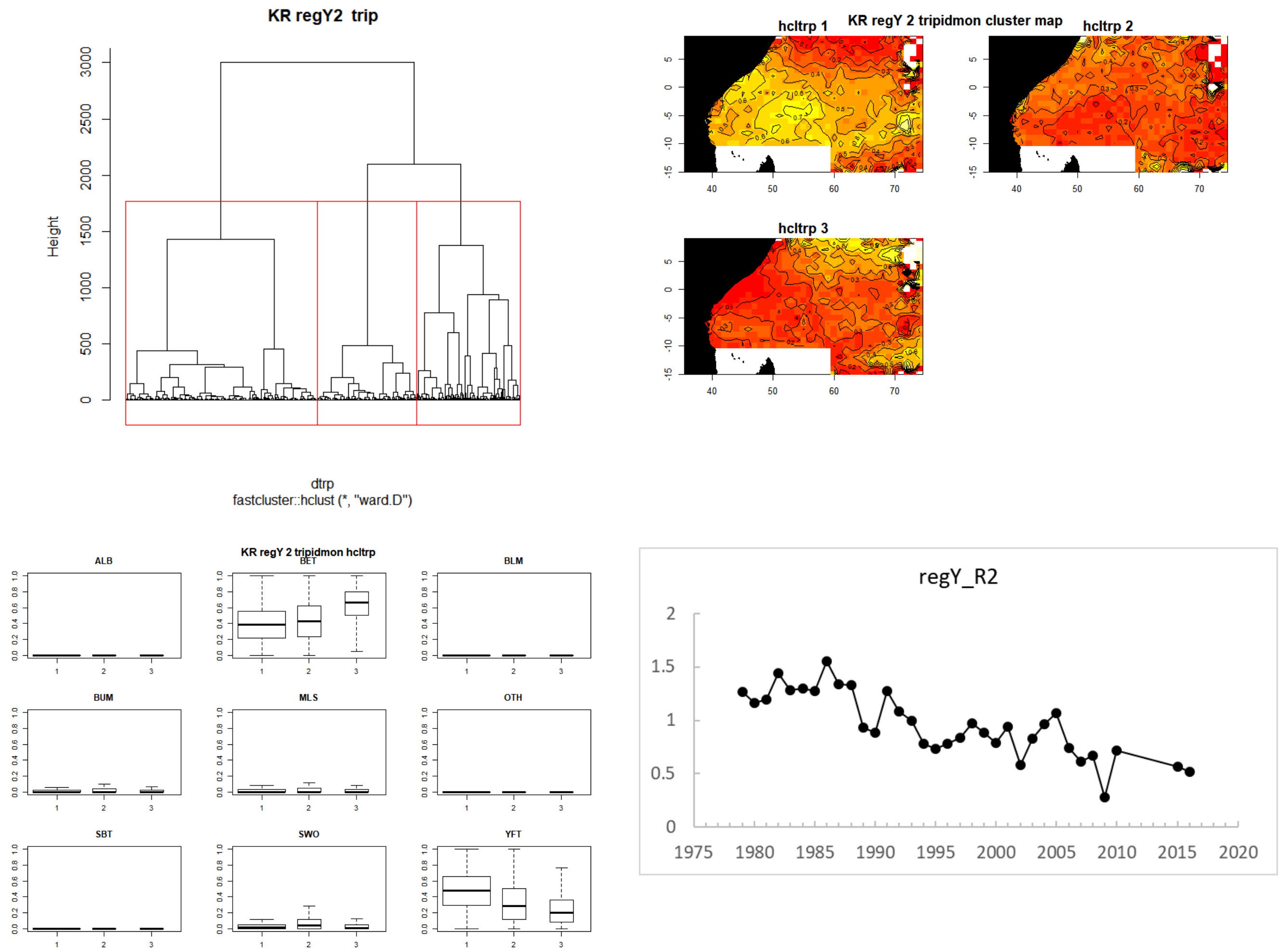

Figure B3: Examples from Korean fleet on analysis on yellowfin in the western equatorial region (region 2 in "regY")

APPENDIX VI: Examples from Preliminary Standardisation Analysis on bigeye tuna

The figures below (C1-C3) are examples from the preliminary clustering and standardisation analysis on bigeye tuna in the eastern tropical region (region 2 with regional structure "regB2") from Japanese, Taiwanese, and Korean fleets. Each figure includes (a) a tree plot showing the selection of the final clusters; (b) maps showing the spatial distribution of clusters; (c) boxplot showing the distribution of species composition by cluster; (d) standardised CPUE indices.

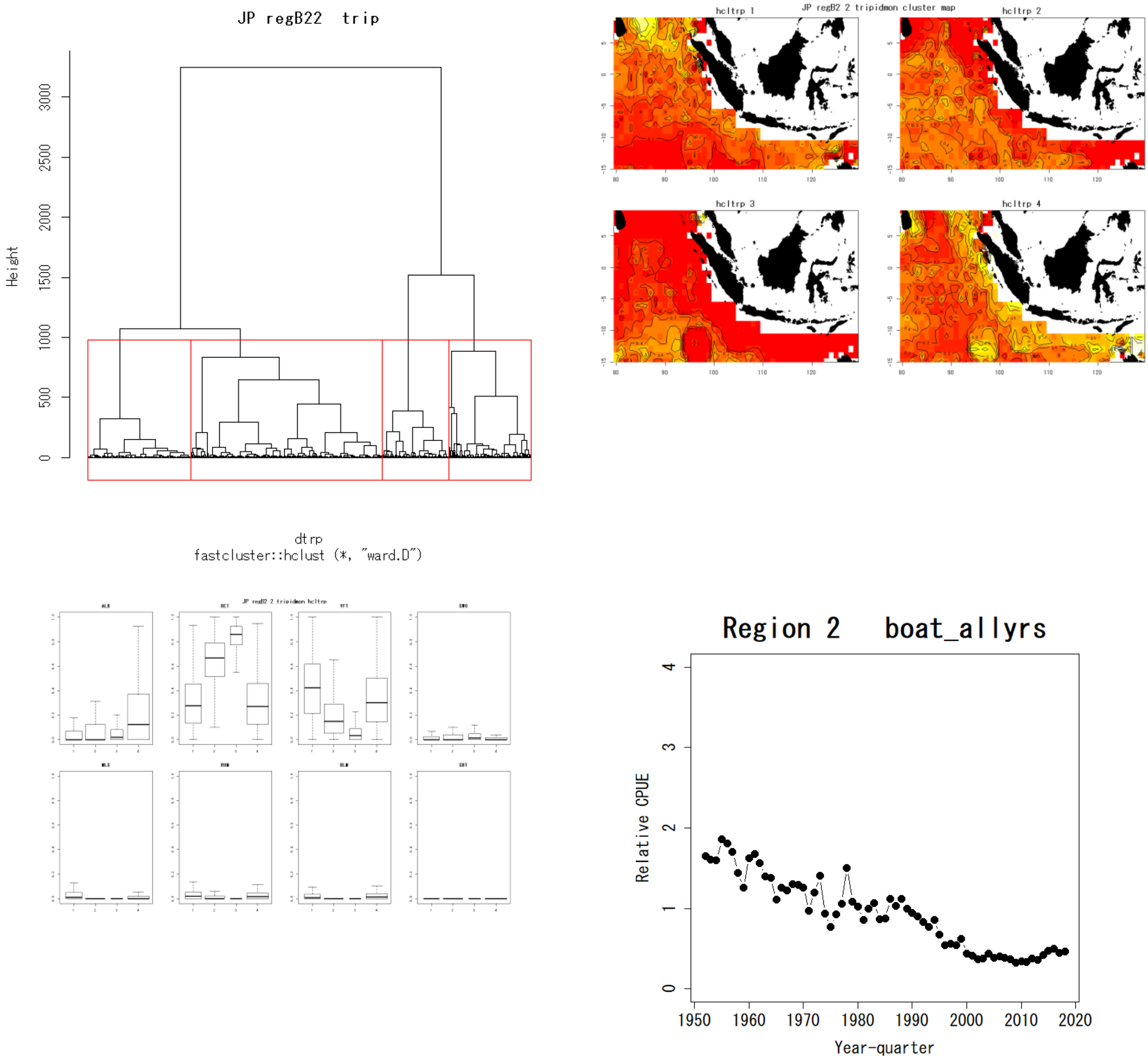

Figure C1: Examples from Japanese fleet on analysis on bigeye in the eastern tropical region (region 2 in "regB2")

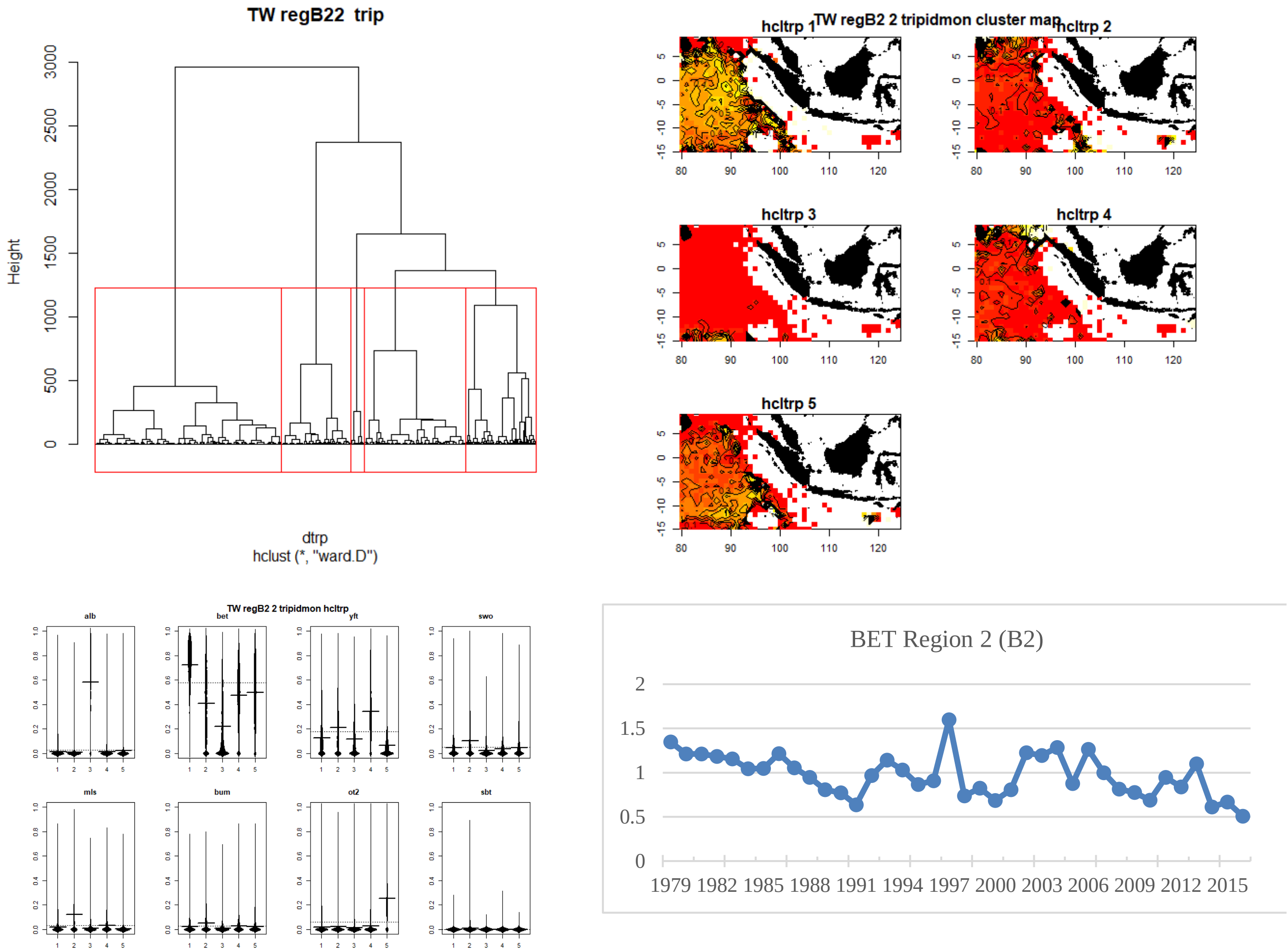

Figure C2: Examples from Taiwanese fleet on analysis on bigeye in the eastern tropical region (region 2 in “regB2”)

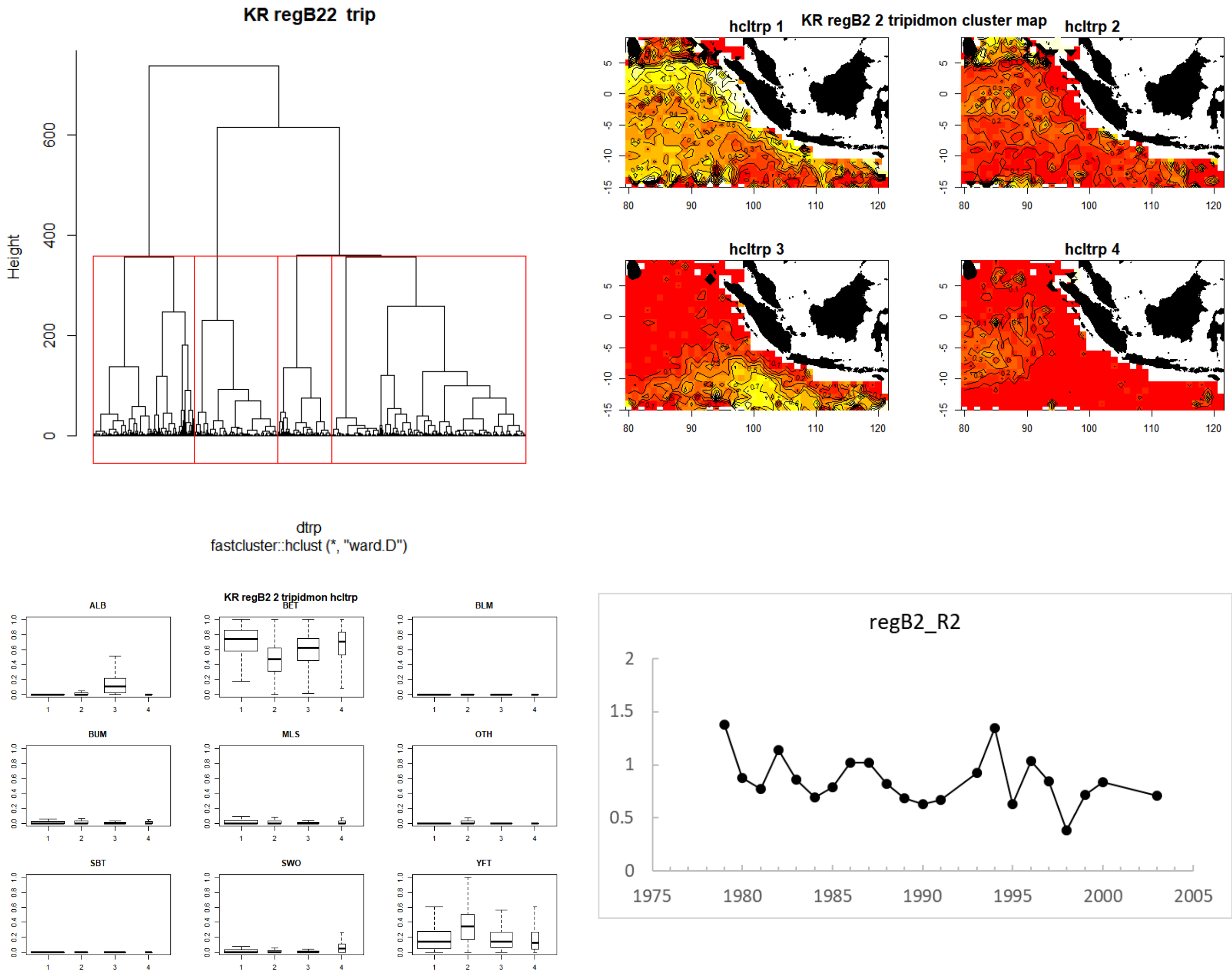

Figure C3: Examples from Korean fleet on analysis on bigeye tuna in the eastern tropical region (region 2 in "regB2")