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A comparison of stock assessment practices in tuna-RFMOs

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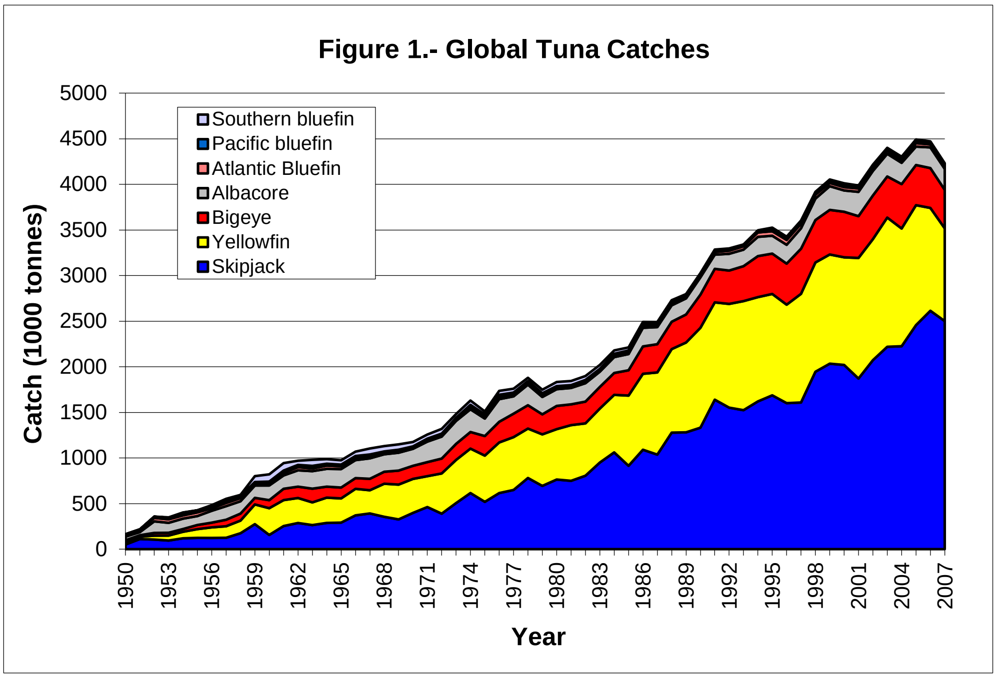
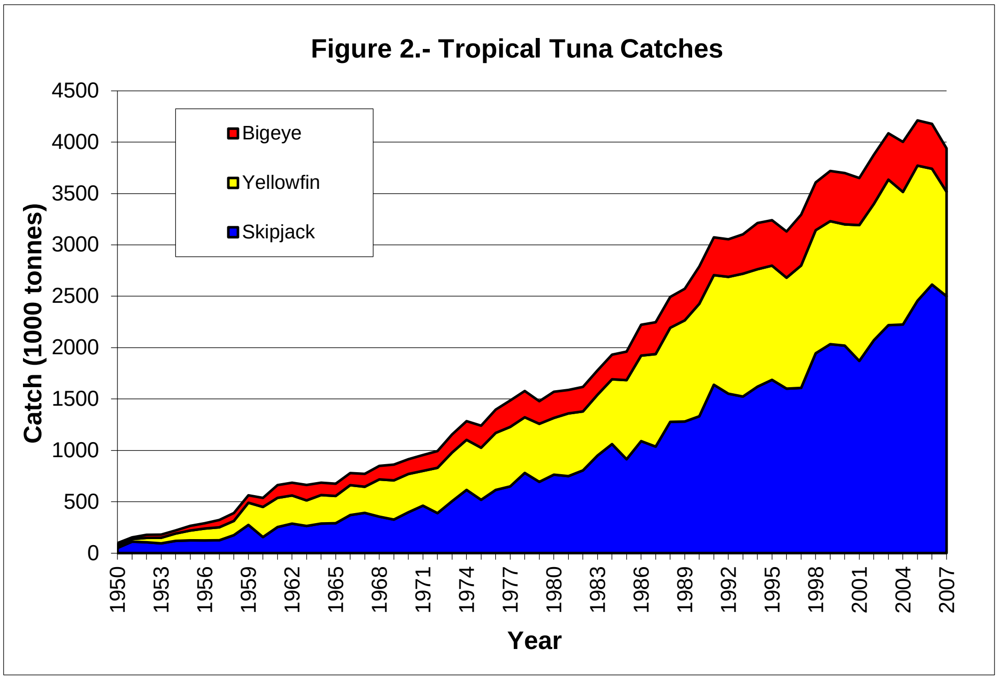
INTRODUCTION

Tuna and tuna-like species are important socio-economic resources as well as a significant source of protein for the society. They include approximately forty species occurring in the Indian, Pacific and Atlantic oceans, with a current global production of almost 6 million tonnes. The most commercially important tuna species are albacore *(Thunnus alalunga,* ALB*)*, bigeye *(Thunnus obesus,* BET*)*, Atlantic bluefin *(Thunnus thynnus,* BFT*)*, Pacific bluefin *(Thunnus orientalis,* PBF*)*, skipjack *(Katsuwonus pelamis,* SKJ*)*, southern bluefin *(Thunnus maccoyii,* SBF*)* and yellowfin *(Thunnus albacares,* YFT*)*. These species perform long migrations and their spatial distribution includes the temperate and tropical regions of all oceans. The total catch of the most important commercially tuna species increased continuously from 1950 to 2007, with the highest level, aroun d 4.5 million tonnes, observed in 2005 (Figure 1). In 2007, their catch was above four million tonnes, which represents around 75 percent of the total catch of all tuna and tuna-like species.



From those species, the tropical tuna species (BET, SKJ, and YFT) are of special interest for the tuna cannery and fresh industry. Tropical tuna species are caught by several industrial fleets of different countries as well as by artisanal fleets of coastal states, landed and processed in many locations around the world, traded in a global market, and finally consumed worldwide. The tropical tunas (BET, SKJ, and YFT) accounted for most of the catches (93 percent), being the total catch around 4.2 in 2005 (2.2 in the Western and Central Pacific, 1.1 in the Indian Ocean, 0.6 in the Eastern Pacific and 0.3 in the Atlantic). The preliminary catch figure for 2009 slightly decreased to 4 million tonnes (Figure 2). The individual contribution to total catch of principal commercial tuna species from 2000 has not significantly varied being around 65 %, 26 % y 9 % for the Pacific, Indian and y Atlantic, respectively. Around 63 % of the tropical catch is composed by SKJ, around 26 by YFT, and 10 percent by BET.



For management purposes, 13 stocks of tropical tuna species are considered. For both bigeye and yellowfin tunas, two stocks are considered in the Pacific Ocean (the eastern and western stocks, respectively), while a single stock is considered in the Atlantic and Indian oceans. Regarding skipjack tuna, two stocks are considered in both the Pacific and Atlantic oceans (the eastern and western stocks, respectively), while a single stock is considered in the Indian Ocean. A number of international tuna Regional Fishery Management Organizations (RFMO) have been created in order to manage these stocks: the International Commission for the Conservation of Atlantic Tunas (ICCAT, www.iccat.int), the Indian Ocean Tuna Commission (IOTC, www.iotc.org), the Western and Central Pacific Fisheries Commission (WCPFC, www.wcpfc.int), the Inter-American Tropical Tuna Commission (IATTC, www.iattc.org) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT, www.ccsbt.org). ICCAT, IOTC, WCPFC and IATTC are responsible for the management of tunas in the Atlantic ocean, Indian ocean, Western Pacific ocean and Eastern Pacific oceans, respectively, while CCSBT is responsible for the conservation of southern bluefin tuna that inhabits the three oceans. In addition, the Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC, http://isc.ac.affrc.go.jp/) and the Secretariat of the Pacific Community (SPC, www.spc.int) conduct or facilitate the assessment of tuna stocks in the North and South Pacific, respectively.

Over the last decades, tuna fleets and their catches have been growing (Allen, 2010), to the extent that some stocks are overexploited or are at risk of being overexploited. The different tuna commissions face with similar situations and problems and they have recently started to cooperate through information sharing and common discussion (see Kobe I and Kobe II reports at www.tuna-org.org). Among other things, the Kobe process has stressed the importance of sound scientific advice as the basis for fishery management decisions and, therefore, considering the critical role of high quality sciences, has agreed to incorporate uncertainty and risk in the assessment, to present the scientific advice as clear as possible, and to exchange information and harmonise methodologies between scientists from different tuna RFMOs. For example, a common use of phase diagrams tool (i.e. “Kobe Plots”) to summarize and communicate the tuna stocks status to the tuna Commissions was agreed; which was further extended to a probabilistic Kobe II strategic matrix (i.e “K2SM”).

In this context, one of the recommendation from the Kobe process is to harmonize the data collections, assessment and management advice which was addressed discussed in the Barcelona Workshop on the scientific process in the RFMOs, which was intended to share best practices and discuss areas for coordination and harmonization that would allow the RFMOs to provide more efficient and fully transparent scientific advice on their tuna stocks and their pelagic ecosystems. Other initiatives have been also taken such as the ISSF Workshop on assessment methods, where similarities, dissimilarities and standardization mechanisms on the assessment process were discussed between different Tuna-RFMO stock assessment experts.

Thus, the objective of this work is to review the similarities and differences observed in the different Tuna-RFMOs in relation to the provision of the scientific advice in support of fishery management of the tropical tunas. Particularly, the focus of this work is on the assessment process between the different Tuna RFMOs dealing with tropical tunas, i.e. IATTC, IOTC, ICCAT, and WCPFC.

OVERVIEW

Tuna RFMOs

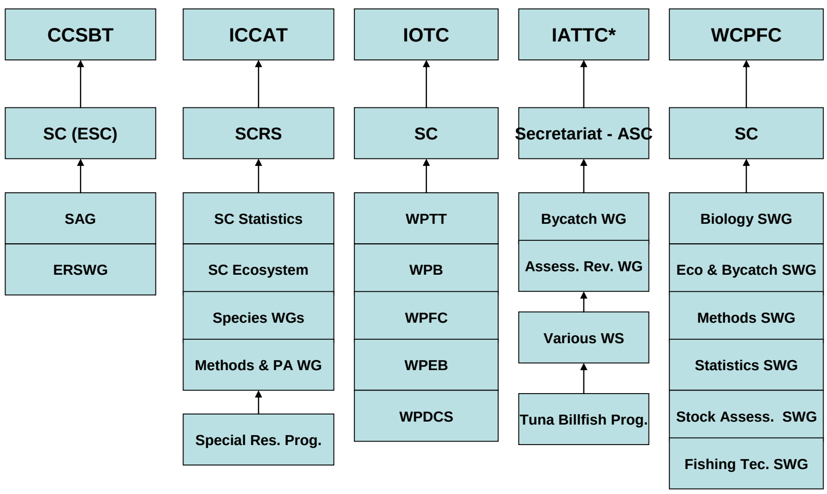
These organisations provide scientific and management support with the mandate of sustainable exploitation of tuna resources in the Pacific, Atlantic and Indian oceans. Chronologically, the first of the tuna RFMOs to be established was the IATTC, which dates from 1949, and the most recent is the WCPFC, which was ratified in 2004. The Attic's Antigua Convention has recently replaced the previous convention in order to better fit the improvements and current tendencies in fisheries management as well as to accommodate the changing political necessities of the member states. In general terms, tuna RFMOs comprise a secretariat and members and cooperating non-members. The WCPFC has a special category of membership named participatory territory which is an insular territory that belongs to an overseas country.

Research and assessment in each RFMO depends on its science structure. The secretariat may have its own scientific capacity such as IATTC or it may rely more on scientific input from its working groups, composed by scientists of Member States, as for example in ICCAT. Data for scientific processes is generally supplied by the member states, including total catch, catch and effort data, and catch at size data. The submission of data is often incomplete or late, and even underreported which may jeopardise data used in sound management advice. Detailed operational data (set by set) is rarely supplied by members and considered highly confidential. Steps are being taken to obtain access to operational data such as in the case of the WCPFC, which aims to be able to access operational data prior to 2005 from their members.

Data on ecosystems, environment, ecological and socio-economic issues are relatively scarce. Initiatives are being taken to gather data on ecological implications of fishing especially the impacts of fishing on non-target species and the impact of Fish Aggregation Devices (FADs) on fish behaviour. Some RFMOs such as ICCAT and IOTC have recently launched working groups on ecologically related issues. Data on socio-economic issues such as value of fish and fish products or employment are collected by member states but little is done within the RFMO framework. Socio-economic aspects are, however, increasingly taken into account within RFMOs, for example, the scientific committee of the WCPFC is considering the creation of a specialist working group on socio-economics.

In the case of ICCAT and IOTC, the science production is organised into working groups where diverse specialists groups (see figure above), comprising of scientists that belong to the different members (and in some cases independent scientists), undertake the research under the coordination of the Commission’s Scientific Committee. Processes under the responsibilities of working groups are compilation of data and coordinated joint efforts with counterparts to collate the information, analyse it, carry out analytical assessments of various tuna stocks and provide scientific support to the decision-makers.

TUNA RFMOs: SCIENTIFIC STRUCTURE



IATTC follows the scientific secretariat model where it carries out research, analysis and advice internally but receiving input and especially revisions from working groups. The WCPFC applies a *sui generis* model where science is produced by the in-house capabilities of the Secretariat of the Pacific Community - Ocean Fisheries Programme (SPC - OFP), which is a contracted provider of scientific advice for southern stocks, whilst the International Scientific Committee (ISC) provides scientific support for northern stocks, following a working group model.

Science drivers generally comprise the need to obtain and use the best available fishery data, biological knowledge and the inclusion of ecosystem considerations. For example, the WCPFC Convention (2004) and the reformed IATTC convention Antigua Convention (2010) mention the need for incorporating ecosystem considerations and socio-economic aspects into fisheries management and, in general, have attempted to incorporate new tendencies in management since they have been signed after the United Nations Fisheries Stocks Agreements (UNFSA). The application of the Precautionary Approach (PA) in the RFMOs has been limited to date. Only IATTC and WCPFC have explicitly included statements to implement the PA in their Convention's text. The former is in the process of implementing the PA from 2010, according to the Antigua Convention. The WCPFC and IATTC are carrying out studies and workshops to discuss and develop reference points. However, this may prove to be difficult due to the diverse interests of the various parties involved. Even though ICCAT/IOTC does not explicitly include the PA in its Convention's text it has acknowledged the importance of the PA and managed to include aspects of it operationally in the Management Advice. For example, in practical terms the SC is taking into account the issues of ecosystem approach to fisheries management and the protection of biodiverstity and, more importantly, the scientific advice for fisheries management is considering biological reference points as well as the precautionary principles. Operational PA in the form of Management Strategy Evaluations (MSEs) is under consideration in the IOTC, WCPFC and ICCAT.

Cooperation amongst tuna RFMOs is a key element for sustainable management because some resources straddle the different geographical areas of competence. CCSBT, for example, maintains close relations with WCPFC, IOTC and ICCAT for the sake of effective management of southern bluefin tuna. However, the burden for science and conservation measures lies entirely on the CCSBT for this species. Another example of cooperation for straddling stocks is seen in the recently signed agreement on data exchange between WCPFC and IATTC.

In addition to the above, cooperation among Tuna-RFMOs is seen as necessary to ensure more effective and efficient management of tuna resources. In the first join tuna RFMO meeting (Kobe 2007), Tuna -RFMOs arrived at 14 commitments, including improvement, sharing and dissemination of data and stock assessments; implementation of the PA and Ecosystem Approach for Fishery Management (EAFM); collection of by catch data; improvement of data collection, assessment and management of shark fisheries; provision of technical capacity (e.g. data collection, assessment and participation) for developing states and enhancement of cooperation among scientists. In addition, the Kobe process required Tuna-RFMOs to undertake independent performance reviews. Kobe established priorities for cooperation in technical work. For example, one of the priorities after Kobe was the coordination and harmonization of the assessment process and standardization of presentation of stock assessment results which was tackled in the San Sebastian Meeting as well as in the Barcelona Workshop on the scientific process in the RFMOs.

The Indian Ocean Tuna Commission (IOTC)

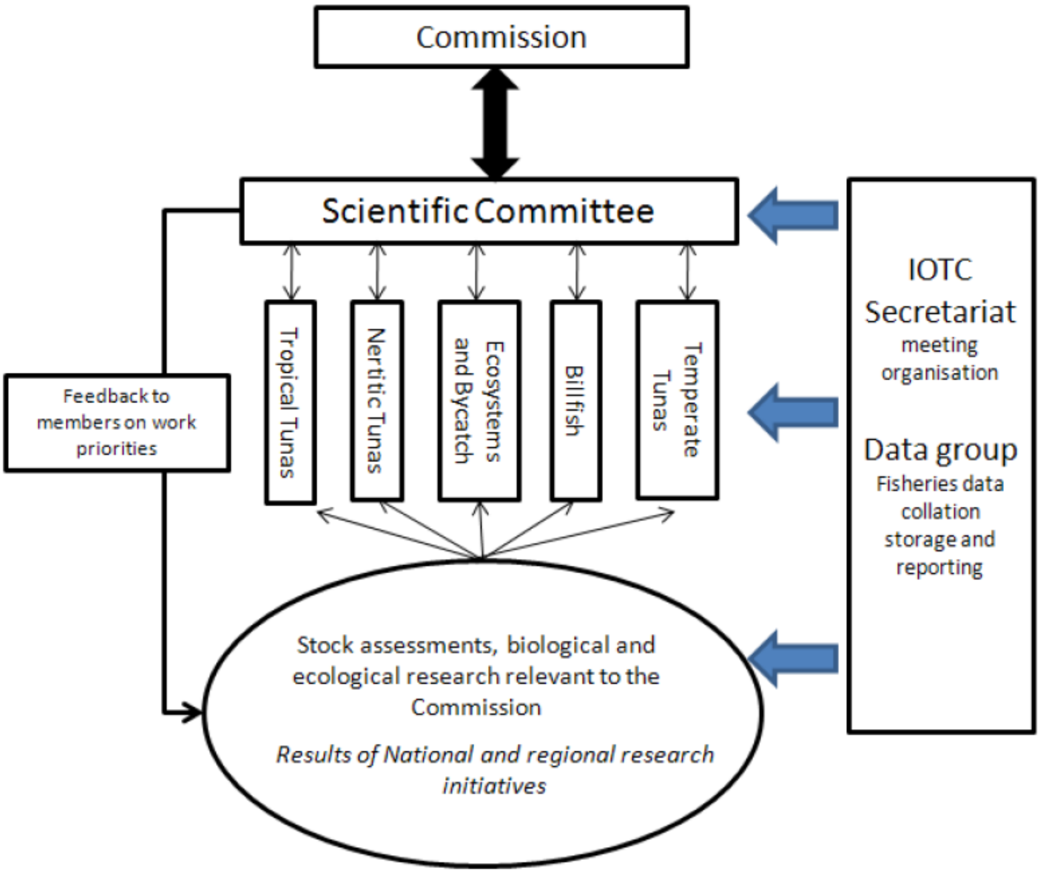
Stock assessments are co-ordinated by the various IOTC SC working group responsible for each species or group of species. Where possible, fully age-structured integrated stock assessment models have been used. For yellowfin tuna, Mutifan-CL (Fournier et al. 1998) has been used for stock assessments since 2008 (Langley et al 2009). Five stock assessment models were applied to bigeye tuna during 2009. These were surplus production models Prodfit, Procean and ASPIC (Chassot et al. 2009), ASPM (Nishida and Rademeyer 2009) and SS3 (Shono et al 2009). The Scientific committee emphasized that tag and release data on bigeye have still be poorly exploited for the assessment and recommended that integrated approaches (SS3, Multifan-CL) that can accommodate tagging data, be developed on this species in the future. The 2009 assessment of bigeye tuna conducted using SS3, did not include tagging data, although a revised model in 2010 did. A range of quantitative modelling methods were applied to the swordfish assessment in 2009, ranging from the highly aggregated ASPIC surplus production model to the age-, sex- and spatially-structured SS3 analysis. A surplus production model has been used to assess albacore tuna stocks in 2008 (Hillary 2008a). Stock assessments have not been conducted for any other species, although investigations into stock indicators for skipjack tuna have been conducted in the past (Hillary 2008b).

Stocks are annually or bi-annually assessed. Over the past years (2008/2009/2010), yellowfin tuna has received priority in terms of assessment, including hiring an independent consultant to conduct the assessment. Bigeye tuna has been assessed during this time by scientists from participating countries and very little work has been conducted to assess the state of skipjack tuna stocks in the IO.

The Working Parties and Scientific Committee typically meet in the final quarter of the year in order to be able to use the most updated fishery statistics for assessment (fishery statistics from the previous year); which is linked to the deadlines of the fisheries data submission requirements. Although the SC meets well in advance of the IOTC Commission plenary, the IOTC Commission meets during the first quarter of the following year to take management decisions which usually enter into force during the next year of the Commission meeting. This means that the Commission receives advice on the status of the stocks that is one and a half year old but that the regulations enter into force after a delay of 2 years in relation to the year for which the management advice is given by SC (Anon 2009).

The IOTC does not carry out retrospective analysis for tuna stocks as the current stock assessment methodology has been used for such a short time. Also projections of future stock status are not conducted due to the large degree of uncertainty around the sources that affect the tuna assessments (IOTC 2009). Regarding reference point estimation has been conducted for bigeye, yellowfin and albacore tunas as well as swordfish. All reference points are target reference points based on Maximum Sustainable Yield (MSY) (IOTC 2009).

Uncertainty is increasingly being included in management advice provided to the Commission. The use of Kobe plots has been initiated and is now fairly standard. In addition, advice is not given as point estimates, but confidence intervals surrounding reference points are included when sufficiently robust assessment models have been developed. At this stage, projections of stocks under different management scenarios have not been included routinely although an exercise has been carried out in the last bigeye assessment (IOTC, 2010). The IOTC is, however, advocating the use of Management strategy evaluation (MSE) in order to incorporate uncertainty in its management advice (IOTC, 2011).


Commission
Scientific Committee
Feedback to members on work priorities
Tropical Tunas
Neritic Tunas
Ecosystems and Bycatch
Billfish
Temperate Tunas
IOTC Secretariat
meeting organisation
Data group
Fisheries data collation storage and reporting
Stock assessments, biological and ecological research relevant to the Commission
Results of National and regional research initiatives

Comparison of assessment approach

The various TunaRFMOs use different assessment s methods to evaluate different tuna populations and within those methods several variables and parameters used in the assessment models are not threated consistently across TunaRFMOs. Similarly, the framework for the management advice can differ from one to other Tuna RFMO. Although a tuna life history characteristic may slightly differ from one Ocean to other (i.e. growth rate), the general life characteristics pattern is expected to be the same (i.e. two stanza growth patterns vs. Von bertalanffy grown pattern) since both are populations of the same species. Similarly, this could be applied to the fleet dynamics, where each fleet will behaviour similarly independent to the Ocean basis (i.e. selectivity curves). Thus, it is important to compare different tuna life history characteristics, inputs for assessment and the assessment framework of the Tuna RFMOs to reconcile the differences and improve consistency.

The table below reviews the data collections methods, assessment methods as well as the framework to generate the science in support of fishery management.

	WCPFC	ICCAT	IATTC	IOTC
DATA COLLECTION				
Fishery data				
Landings data	Total catch, catch and effort data, and catch at size data. CA data lacking for certain fisheries (i.e. artisanal fishery)	Total catch, catch and effort data, and catch at size data. CA data lacking for certain fisheries (i.e. artisanal fishery)	Total catch, catch and effort data, and catch at size data.	Total catch, catch and effort data, and catch at size data. CA data lacking for certain fisheries (i.e. artisanal fishery)
Discards data	Observer programmes Not all fleets (only PS)	Observer programmes Not all fleets.	Observer programmes Not all fleets (only PS)	Regional Observer Programme to start July 2010 (catch data, biological data).
CPUE/effort data	Collected Not all fleets all countries	Collected Not all fleets all countries	Collected Not all fleets all countries	Collected Not all fleets all countries
Spatial distribution data	Tagging programme	Tagging programme	Tagging programme	Tagging programm
Temporal distribution data	Collected	Collected	Collected	Collected
Observer reports data	Collected	Collected by CPCs, not always available to all scientists as is often confidential	Collected and maintained by secretariat	Regional Observer Programme to start July 2010 (catch data, biological data).
Logbooks data	Requested by the Commission. Partially submitted	Submitted for vessels (>24 m)	Requested by the Commission	Requested by the Commission
VMS data	Collected but not yet used in research	Collected but the Secretariat is unable to provide a database for scientists	Collected but not yet used in research	Collected from some members but not yet used in research
Port Sampling data	Done at the member's level but insufficient	Done at the member's level, but insufficient in many countries	Done at the member's level but insufficient in many countries	Done at the member's level but insufficient in many countries
Fisheries Independent data				
Tagging data	Tagging data available from the Pacific-wide Tuna Tagging programe (PTTP). Two large-scale tuna tagging projects in the 70's-90's (SSAP -	Old tagging program	Data from tagging programmes used in stock assessment.	Data from RTTP-IO tagging programme used in stock assessments.

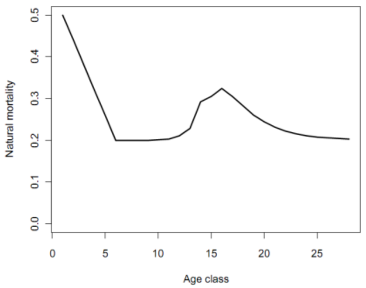
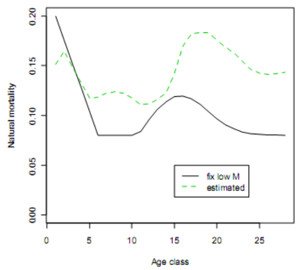
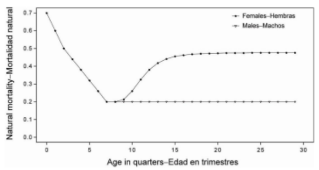
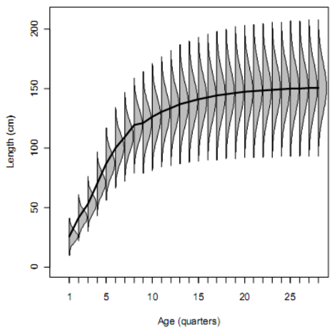
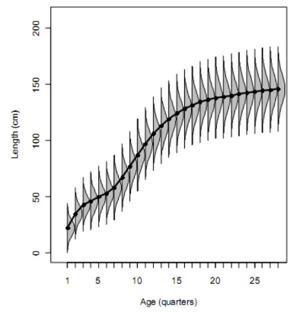
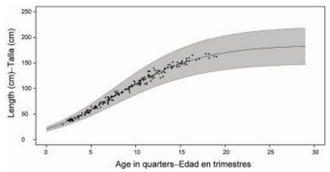
	Skipjack Survey Assessment Program and RTTP-Regional Tuna Tagging Project).			
Key biological parameters				
Length	Yes	Yes	Yes	Yes
Age	Yes	Yes	Yes	Yes
Sex	No	No	No	No
Maturity	Yes	Yes	Yes	Yes
Fecundity	No	Yes (limited)	Yes (limited)	Yes (limited)
Migration	From Tagging	From ongoing Tagging programme	From small-scale tagging	From tagging
Stock structure and genetics	Limited stock structure	Limited stock structure from tagging and genetics	Genetic studies for stock structure as well as limited tagging information.	Limited stock structure from tagging
Natural mortality	Yes	Yes	Yes	Yes
STOCK ASSESSMENT & MANAGEMENT ADVICE				
Key stocks	Single YFT, BET, and SKJ.	Single YFT, BET, west SKJ, and east SKJ.	Single YFT, BET, and SKJ.	Single YFT, BET, and SKJ.
Stock Assessment				
Assessment methods	The preferred stock assessment model and software is MULTIFAN-CL. BET assessments are carried out almost every year.	For YFT, ASPIC and ADAPT-VPA have been used for the last most recent stock assessments. BET has been assessed using ADAPT-VPA and Mutifan-CL in 2007 and are scheduled for another	YFT SS 3 BET SS 3 SKJ are assessed using a simple	For YFT tuna, Mutifan-CL has been used for stock assessments since 2008. Five stock assessment models were applied to BET during 2010. These were surplus production models

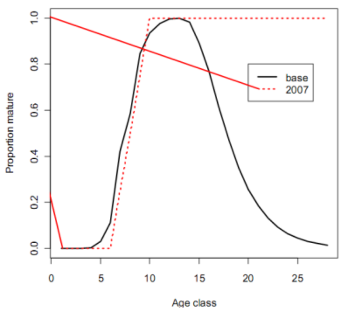
	YFT is also assessed almost every year. SKJ less frequent.	assessment in 2010. The SKJ assessment in 2009 was conducted using a Bayesian extension to a Schaeffer surplus production model.	biomass model with population indicators. The IATTC is changing to a biannual schedule.	Prodfit, Procean and ASPIC, ASPMand SS3. The SC emphasized that tag and release data on BET have still be poorly exploited for the assessment and recommended that integrated approaches (SS3, Multifan-CL) that can accommodate tagging data, be developed on this species in the future. SKJ not assessed yet. Projections of future stock status are not conducted due to the large degree of uncertainty around the sources that affect the tuna assessments.
Timing	Every year	Biannual or triannual	Biannual or triannual	Annual
Projections	No	Yes	Yes	No
Managemente Advice				
Reference points	$F_{current}/F_{MSY}$, $B_{current}/B_{MSY}$ and $S_{Bcurrent}/SB_{MSY}$	$F_{current}/F_{MSY}$, $B_{current}/B_{MSY}$ and $S_{Bcurrent}/SB_{MSY}$	$F_{current}/F_{MSY}$, $B_{current}/B_{MSY}$ and $S_{Bcurrent}/SB_{MSY}$	$F_{current}/F_{MSY}$, $B_{current}/B_{MSY}$ and $S_{Bcurrent}/SB_{MSY}$
Definition overfished	Current B lower than B_{MSY}	Current B lower than B_{MSY}	Current B lower than B_{MSY}	Current B lower than B_{MSY}
Definition overfishing	Current F higher than F_{MSY}	Current F higher than F_{MSY}	Current F higher than F_{MSY}	Current F higher than F_{MSY}
Communication of Management advice				

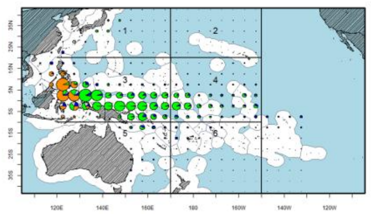
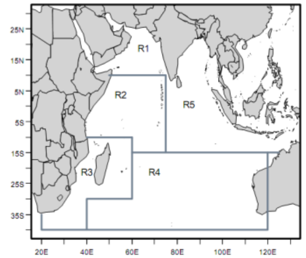
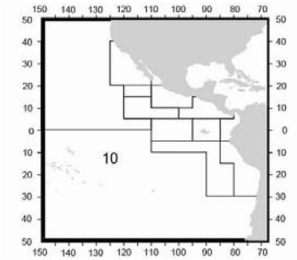
	Kobe plots Kobe II Strategic Matrix	Kobe plots Kobe II Strategic Matrix	Kobe plots: to enable managers to view the evolution of the stock over time with relation to MSY and F at MSY.	Kobe plots: to enable managers to view the evolution of the stock over time with relation to MSY and F at MSY. Kobe II Strategic Matrix
How is uncertainty presented to management	Uncertainty is explicitly presented to managers in the form of summary tables and KOBE I and II plots	Uncertainty is explicitly presented to managers in the form of summary tables and KOBE I and II plots	KOBE matrices and plots have been advocated by the joint working groups on tuna RFMOs	Uncertainty is explicitly presented to managers in the form of summary tables and KOBE I and II plots
Have Management Strategy Evaluation (MSE) methods been used to evaluate the system	Not implemented but under the glance	Not implemented, but under consideration	Not implemented	Not implemented but advocated and being trialled for YFT.
What software and approaches have been used to evaluate management strategies?	Not yet evaluated	FLR is being trialled for use with YFTh	Not yet evaluated	Not yet evaluated, although FLR MSE is being developed
SCIENCE PEER-REVIEW AND RESEARCH PLANNING				
Current research activities and scientific advice				
Scientific advice to management	Executive summaries	Executive summaries	Executive summaries	Executive summaries
Research organisation				
Structures and processes linking science to management and how they facilitate collaboration and coordination.	▪ The specialist WGs are essential in dealing with scientific and technical issues in the Commission. ▪ SC developing the Strategic Research Plan ▪ SPC + CPCs conducted research	▪ Research conducted by CPCs ▪ SCRS developing the species Research Programmes.	▪ Scientific activities are planned and prioritised by Secretariat taking into account recommendations of the scientific committee.	▪ CPCs. ▪ SC developing Research Priorities through Research Recommendations.
Peer review of science	▪ Outcomes from assessments carried out by the SPC and ISC	▪ It is not a formal process of external peer review of stock	▪ Data which are used in analyses are reviewed as part of the	▪ It is not a formal process of external peer review of stock

	are revisited by the SC and the NC respectively. There is no external peer review process. But a review of scientific structure and processes was carried out by an independent contractor in 2008-2009.	assessments. The SC reviews the assessments and management advice given carried out by the different WP. The implementation of an external scientific peer review process as standard practice of WP and SC was recommended by the Performance Review Panel Report.	annual, scientific peer review of IATTC stock assessments held prior to development of final reports or Annual Meetings. Transparency of the information and results on status and trends of stocks and resources presented by the IATTC are documented in the course of the scientific peer-review process followed to obtain the results, and the various public meetings of the IATTC. In addition a scientific committee will review assessments carried out by staff scientists prior to stock assessment meetings.	assessments. The SC reviews the assessments and management advice given carried out by the different WP. The implementation of an external scientific peer review process as standard practice of WP and SC was recommended by the Performance Review Panel Report.
Science drivers	Science drivers are established in the Strategic Research Plan (SRP) 2007-2011 and are drafted by the SC. The SRP consists of (1) Collection and validation of data from the fishery; (2) Monitoring and assessment of stocks; (3) Monitoring and assessment of the ecosystem and (4) Evaluation of management options.	The ICCAT science plan is driven by the SCRS on which each member of the Commission may be represented. The SCRS is responsible for developing and recommending to the Commission all policy and procedures for the collection, compilation, analysis and dissemination of fishery statistics.	▪ The major drivers of science are contained in the Antigua convention: to promote, carry out and coordinate scientific research concerning the abundance, biology and biometry in the Convention Area of fish stocks and dependent species, and the effects of natural factors and human activities on the populations. The major external driver is the desire to comply with the FAO CoC for responsible fisheries. Future research is proposed by the director with support of the scientific staff.	▪ S scientific priorities and research recommendations are reported in annual SC reports for future research. External drivers are the general outstanding questions of fishery assessment/management (FAO's IPOAs and CoC and the UNCLOS, etc. and, particularly, the issues that most of the Tuna RFMOs are facing with.

Table 1.- Stock assessment and management advice framework.

YELLOWFIN (Thunnus albacares)				
	WCPFC	**IOTC**	**IATTC**	**ICCAT**
	MULTIFAN	***MULTIFAN***	***SS3 (sex disaggregated)***	***ADAPT-VPA (ASPIC*)***
Key biological parameters used in the assessment				
Mortality			*Males and females different M* 	*Assumed to be 0.8 for ages 0 and 1, and 0.6 for ages 2+*
Growth	*VB growth* 	*Fix: Fonteneau growth equation (2 stanza)* 	*Richard's growth curve* 	*Gascuel et al 1992:* $FL\ (cm) = 37.8 + 8.93 * t + (137.0 - 8.93 * t) * [1 - \exp(-0.808 * t)]^{7.49}$

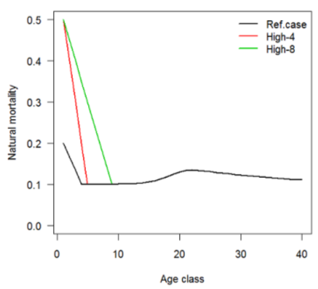
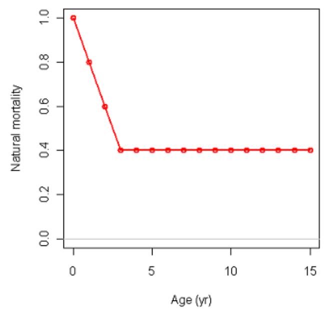
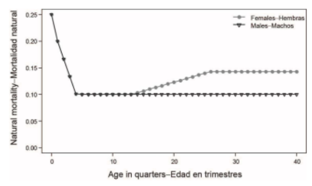
Maturity	*Fix*	*Fix: 0 (ages 0-8), 0.25 (age 9), 0.5 (age 10), 0.75 (age 11), 1 (ages 12-28) (Grande et al., 2010).*	*Fix*	*Fix: assumed to be knife-edge at the beginning of age 3*
Reproductive potential (or SSB)	*% F at age * Maturity * S * BF (Figure 19)*  	*Maturity at age * weight at age*	*Female maturity ogive * BF * S (Schaeffer, 1998)*  	*Maturity at age * Weigth at age (at February 14 mid point of spawning peak).* *Weight of 5 + as the average of weight of age 6-10.*
Steepness	*0.65-**0.8**-0.95* *Beta prior (lower bound 0.20, mode =0.85, se = 0.16)*	*0.6-0.7-0.8-0.9*	*1 (VB)*	*S-R relationship.* *Resampling of observed recruitments.*
Weigth at length	*W = a L^b (a= 2.512e-05, b= 2.9396, source N. Miyabe, NRIFSF)*	*W = aL^b (a=1.585 exp-5, b = 3.045 (Nishida and Shono, 2007).*	$W = 1.387 * 10^{-5} * L^{3.086}$ *Wild (1986)*	$W(kg) = 2.1527 \times 10^{-5} * L(cm)^{2.976}$
Tagging	*Included (PTTP)*	*Included (RTTP-IO)*	*Included*	*No*
Key fishery parameters used in the assessment				
Discards	*No*	*No*	*Yes*	*No*
LL selectivity	*Flat top for one LL fleet (catching bigger individuals) while is slightly dome shape for*	*Estimated*	*Estimated*	*2 runs:* *(1) estimated -> dome shape*

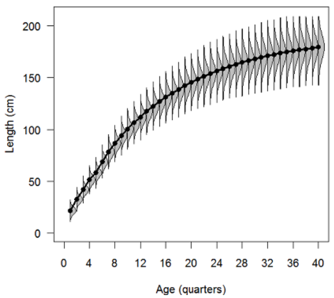
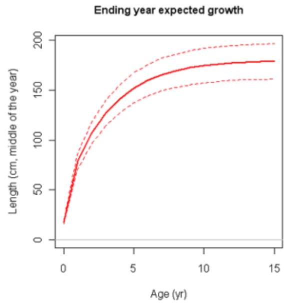
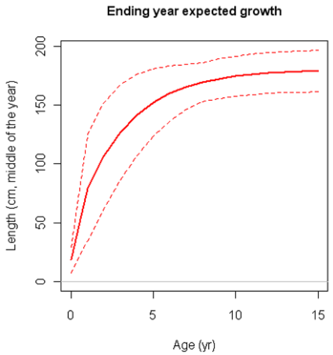
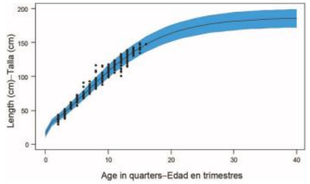
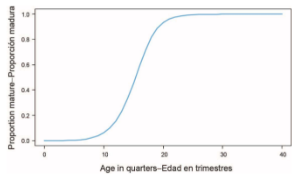
	other LL fleet.	*Cte over time. 4 last ages equal.*		*selectivity.* *(2) fixed to flat top selectlivty (fixed the full selected age of (1) and then using 1).*
LL effort	*Total number of hooks*	*Total number of hooks*	*Total number of hooks*	*Total number of hooks*
PS selectivity	*Dome shape*	*Estimated*	*Estimated*	*Estimated*
PS effort	*Searching or fishing days*	*Searching or fishing days*	*Day fished*	*Searching or fishing days*
Catchability	*Allow to vary over time. Raldom walk in 2 years step.* *Seasonal variation for most of the fleets.*	*Seasonal variation* *Cte among years and regions for LL* *PS random walk*	*Estimated*	*Catchability for all index cte over years.* *PS CPUE estimated with increase in catchability (3 %).*
Spatial stratification	*6 zones* 	*5 zones*  	*13 zones*  	*1 zone*
Temporal stratification	1952-2010 Quarter	1972-2010 Quarter	1975-2010 Quarter	1970-2010 Year
Population dynamics				
Age-classes	*28 quarterly classes (age 0-7+)* *25 mean length year 1 (Lehodey and Leroy*	*28 quarterly classes (age 0-7+)* *22 mean length year 1 (Lehodey and*	*30 quarterly classes*	*Age 0 – 5 + years*

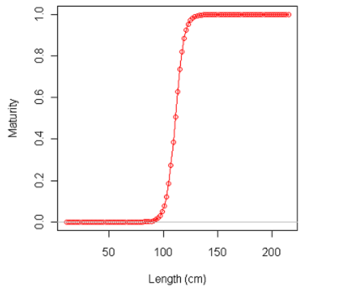
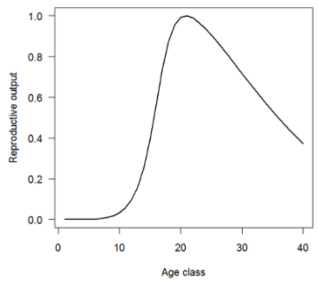
	1999)	*Leroy 1999)*		
Recruitment	*Age 1 quarter* *At the beginning of each quarter*	*Age 1 quarter* *At the beginning of each quarter*	*Age 0* *At the beginning of each quarter*	*Age 0*
Retrospective analysis	*No*	*No*	*Yes*	*Yes*
Management advice				
Projections time frame	*No*	*No*	*10 years*	*15 years*
Years for computing Bcurrent/Fcurrent in relation to reference points	*3 Last years without considering latest year. For example, in 2011 assessment with 2010 last year it was used 2006-2009.*	*Last year*	*3 Last years (2008-2010) for Fcurrent* *Last year for Bcurrent*	*Last year*
Fa to estimate MSY reference points	*Last 3 years*	*Last year*	*3 Last years (2008-2010)*	*Last year*

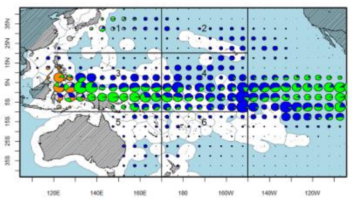
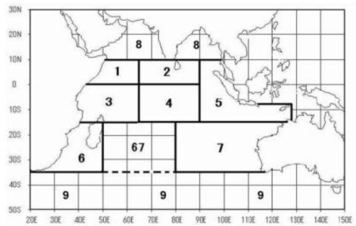
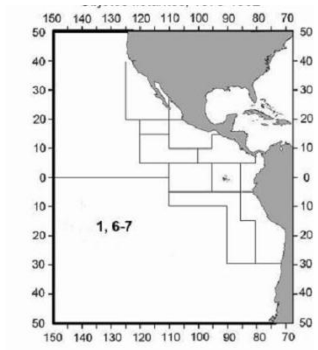
* ASPIC inputs not included for comparison

Table 2.- Life history characteristics and parameters used as inputs in Yellowfin stock assessment of different Tuna RFMOs.

BIGEYE (*Thunnus obesus*)				
	WCPFC	**IOTC**	**IATTC**	**ICCAT**
	MULTIFAN	***SS3 (ASPIC*)***	***SS3 (sex disaggregated)***	***ASPIC***
Key biological parameters used in the assessment				
Mortality	Fix (Base case scenario + an alternative)  	Fix (base case + sensitivity scenarios)  	Fix Sex-specific  	0.8 for ages 0 and 1 0.4 for ages >1
Growth	VB growth except for age classes 2-8 mean length which is estimated	Fix: from IOTC-2009-WPTT-20	Estimated using otolith data (Schaefer and Fuller 2006)	$Lt = 217.3 (1- \exp^{-0.18(t+0.709)})$

		 		
Maturity	Fix	Fix: IOTC-2009-WPTT-20 (50 % at age 2)	Fix (Schaefer et al., 2005) 	Knife edge around 100-110 cm.

				
Reproductive potential (or SSB)	% F at age * Maturity * S * BF (Figure 19) 	Maturity at age * weight at age	Female % * Female maturity ogive * Weigth at age	Maturity ogive * wegith at age
Steepness	0.65-**0.8**-0.95 Estimated- Beta prior (lower bound 0.20, mode =0.85, se = 0.16)	BV with fixed steepnes: 0.55-*0.75*-0.95	1 (BV)	-
Weight at length			$W = 3.661 * 10^{-5} * L^{2.90182}$ Nakamura and Uchiyama (1966)	$RWT = 2.396*10^{-5} *FL^{2.9774}$
Tagging	Included (PTTP)	Included (RTTP-IO)	No	No
Key fishery parameters used in the				

assessment				
Discards	No	No	Yes	No
LL selectivity	Estimated. Time invariant and similar form to all LL.	Estimated	Estimated and dome-shape (except for 2 LL fisheries9	
LL effort	Total number of hooks	Total number of hooks	Total number of hooks	
PS selectivity	Estimated. Time invariant and similar form to all LL.	Estimated	Estimated	
PS effort	Searching or fishing days	Nº of sets	Day fished	
Catchability	Allow to vary over time. Raldom walk in 2 years step. Seasonal variation for most of the fleets.	Estimated and variable.	Two time blocks for catchability: early (before 1990) and late (after 1990) were estimated.	
Spatial stratification	6 zones 	10 zones 	13 zones 	1 zone
Temporal stratification	1952-2010 Quarter	1952-2008 Quarter	1975-2010 Quarter	1950-2009 Year

Population dynamics				
Age-classes	40 quarterly classes 20 mean length year 1 (Lehodey and Leroy 1999)	0-15 + years	40 quarterly classes	-
Recruitment	Age 1 quarter At the beginning of each quarter	Age 0 Estimated yearly	Age 1 At the beginning of each quarter	
Retrospective analysis	No	No	Yes	No
Management advice				
Projections time frame	No	10 years	10 years	10 years
Years for computing Bcurrent/Fcurrent in relation to reference points	3 Last years without considering latest year. For example, in 2011 assessment with 2010 last year it was used 2006-2009.	Last year	3 Last years (2008-2010) for Fcurrent Last year for Bcurrent	Last year
Fa to estimate MSY reference points	Last 3 years	Last year	3 Last years (2008-2010)	Last year

* ASPIC inputs not included for comparison

Table 2.- Life history characteristics and parameters used as inputs in Bigeye stock assessment of different Tuna RFMOs.

DISCUSSION

There are differences in terms of the general approach as well as the life history characteristics used as inputs for the various stock assessment used by the different Tuna RFMO studied. In some cases, the differences in the parameters and variables assumed or estimated can be large (i.e. mortality, growth and/or steepness). This, in turn, in some cases may have a huge implication in the management advice provided by the Tuna RFMO and, hence, ultimately may affect the management recommendations agreed by the parties. As discussed and agreed during Kobe process it would be beneficial to coordinate and harmonize the process of generating the scientific advice in support of tuna fishery management. Although it is also recognized that some issues should be addressed individually by region of concern, it would be a good initiative to investigate whether those differences are real or not in order to be standardized and harmonized. The provision and communication of best quality science, incorporating an assessment of uncertainty and risk, in support of the management of tuna resources is a matter of priority for all Tuna RFMOs and this needs to be tackled in a coordinated manner. Therefore, the issues underlined in this work, amongst others that can be identified in a further revision, would be a good starting point for Tuna RFMOs to start collaborating in order to agree common and standardized approaches and standards.

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