8.1 YFT – YELLOWFIN TUNA

A stock assessment for yellowfin tuna was conducted in 2016, at which time catch and effort data through 2014 were available. The catch table presented in this Executive Summary (**YFT-Table 1**) has been updated to include reported catches through 2016, including revisions to Ghanaian catches for the period 1973-2014 that have been incorporated since the last assessment. The revisions to Ghanaian yellowfin tuna catches for 2015 and 2016 are still pending review by the SCRS. Readers interested in a more complete summary of the state of knowledge on yellowfin tuna stock status should consult the detailed Report of the 2016 Yellowfin Stock Assessment Session (Anon., 2017a). The Tropical Tunas Work Plan (**Appendix 12**) includes plans to address research and assessment needs for yellowfin tuna.

YFT-1. Biology

Yellowfin tuna is a cosmopolitan species distributed mainly in the tropical and subtropical oceanic waters of the three oceans. The exploited sizes typically range from 30 cm to 170 cm FL. Juvenile yellowfin tuna form mixed schools with skipjack and juvenile bigeye, and are mainly limited to surface waters, while larger fish form schools in surface and sub-surface waters. Spawning on the main fishing grounds, the equatorial zone of the Gulf of Guinea, occurs primarily from December to April. Spawning also takes place in the Gulf of Mexico, the southeastern Caribbean Sea and off Cabo Verde, although the peak spawning can occur in different months in these regions. The relative importance of the various spawning grounds is unknown.

Although the distinct spawning areas might imply separate stocks, or substantial heterogeneity in the distribution of yellowfin tuna, a single stock for the entire Atlantic is currently assumed. This assumption is based upon information such as observed transatlantic movements (from west to east) indicated by conventional tagging and longline catch data that indicates yellowfin are distributed continuously throughout the tropical Atlantic Ocean. However, movement rates and timing, routes, and local residence times remain highly uncertain. In addition, some electronic tagging studies in the Atlantic as well as in other oceans suggest that there may be some degree of extended local residence times and/or site fidelity.

A recent study in the eastern Atlantic Ocean further described the reproductive traits of female yellowfin tuna including, sex-ratio, size at maturity, spawning seasonality, fish condition and fecundity. Size at 50% maturity was estimated at 103.9 cm fork length when cortical alveoli were used as a maturity threshold, however a larger size of around 120 cm at 50% maturity was estimated when more advanced oocytes were used. The conclusions of this research were incorporated in the 2016 stock assessment of yellowfin tuna.

Tagging studies of yellowfin in the Pacific and Indian Oceans suggest that natural mortality is age-specific, and higher for juveniles than for adults. Nevertheless, uncertainties remain as to the exact parameterization of the age-specific natural mortality function. As was applied for the recent bigeye tuna assessment, an age-specific natural mortality function (e.g. Lorenzen) was developed and applied to the 2016 assessment of yellowfin tuna. The most recent stock assessment does not consider sex-specific natural mortality or growth, yet there are disparities in average size by gender. Males are predominant in the catches of larger sized fish (over 145 cm), which could result if large females experience a higher natural mortality rate, perhaps as a consequence of spawning. In contrast, females are predominant in the catches of intermediate sizes (120 to 135 cm), which could result from differential growth (e.g. females having a lower asymptotic size than males). Recent results from studies in the Indian Ocean suggest a combination of the two hypotheses.

It is generally agreed that growth rates are relatively slow initially, increasing at the time the fish leave the nursery grounds. This interpretation is supported by analyses of size frequency distributions as well as tagging data. Regardless, questions remain concerning the most appropriate growth model for Atlantic yellowfin tuna, as analyses of hard part growth increments support somewhat different growth patterns.

Younger age classes of yellowfin tuna (40-80 cm) exhibit a strong association with FADs (natural or artificial fish aggregating devices/floating objects). The Committee noted that this association with FADs, which increases the vulnerability of these smaller fish to surface fishing gears, may also have an impact on the biology and on the ecology of yellowfin due to changes in feeding and migratory behaviors. These uncertainties in stock structure, natural mortality, and growth could have important implications for the stock assessment. The ongoing Atlantic Ocean Tropical Tuna Tagging Programme (AOTTP), if fully successful, will help reduce these uncertainties.

YFT-2. Fishery indicators

Yellowfin tuna have been exploited by three major gears (longline, baitboat and purse seine fisheries) and by many countries throughout its range. Detailed data are available since the 1950s (**YFT-Table 1**). Overall Atlantic catches declined by nearly half from the peak in 1990 (193,600 t) to 109,000 t estimated for 2015, but have since increased to 127,800 t in 2016. The most recent catch distribution is given in **YFT-Figure 1**. However, it should be noted that official reports are not yet available from several Contracting and/or non-Contracting Parties, and that **YFT-Table 1** and **YFT-Figure 1** incorporate provisional scientific estimates of Ghanaian catches for 2006-2014.

In the eastern Atlantic, purse seine catches declined by over 60% between 1990 and 2007 (127,700 t to 48,000 t), but subsequently increased to 94,000 t in 2016 (**YFT-Table 1; YFT-Figure 2**). Baitboat catches declined by 70% between 1990 and 2015 (from 19,600 t to 5,900 t), but increased to 9,750 t in 2016. Longline catches, which were 10,300 t in 1990, declined to 4,860 t in 2016. In the western Atlantic, purse seine catches (predominantly from Venezuela) were as high as 25,700 t during the mid-1980s, but have since declined nearly 80% to 5,330 t in 2016. Baitboat catches also declined 80% since a peak in 1994 (7,100 t), and for 2016 were estimated to be about 1,150 t. Since 1990, longline catches have generally fluctuated between 10,000 t and 20,000 t.

The decline in purse seine catches during 1992-2007 was in large part due to a decline in the number of European and associated fleet purse seine vessels operating in the eastern Atlantic (e.g. from 67 vessels in 1992 to 27 vessels in 2007; **SKJ-Figure 9**). However, since that time, the number of purse seiners and overall fleet efficiency has increased as newer vessels with greater fishing power and carrying capacity have moved from the Indian Ocean to the Atlantic. The Committee notes that since 2013, six new purse seine vessels began operations in the Atlantic Ocean. By 2010, overall carrying capacity of the purse seine fleet had increased significantly, to about the same level as in the 1990s, and has increased by nearly 50% since. FAD based fishing has accelerated even more rapidly than free school fishing.

The Committee noted that surface fisheries for tropical tunas in the eastern Atlantic have expanded in recent years. Since 2011, significant catches of yellowfin tuna have been obtained by EU purse seiners south of 15°S off the coast of West Africa (in association with skipjack and bigeye on FADs). Another recent change is the implementation in 2012 of the strategy of fishing on floating objects off of Mauritania (north of 15°N). Catches on floating objects in this area tended to consist almost entirely of skipjack. Effort directed in this manner may therefore have a reduced impact on yellowfin tuna.

Catch-at-size was fully rebuilt for the assessment (1960-2014) to incorporate all new and revised size, and catch at size information available to ICCAT; note that samples from 1960-1965 were very limited. New and revised information were received from major purse seine and longline fleets, and from fisheries such as "*faux poisson*". The species composition and catch at size of tropical tunas landed by Ghanaian baitboats and purse seiners were also updated for the period 2006-2014. These changes are reflected in **YFT-Table 1**. As in previous assessments, catch at age was estimated by slicing from deterministic growth functions.

Eight longline indices were selected for use in the stock assessment based on meeting specific criteria for inclusion. Indices with similar characteristic were grouped together using a cluster analysis. The two "clusters" represent unique hypotheses regarding trends in abundance of yellowfin tuna. Cluster 1 indices showed an initial decline, with nearly constant relative abundance since 1990, while Cluster 2 indices suggest increased abundance during the 1990s, followed by a general decline through 2014 (**YFT-Figure 3**). The two trends represent a major source of scientific uncertainty regarding the abundance of yellowfin tuna. Several nominal baitboat and purse seine indices which had been used in previous assessments were eliminated from the 2016 assessment because they had not been standardized, lacked documentation, or their diagnostic characteristics could not be examined. Abundance indices from surface fleets, particularly those that capture newly recruited fish could be useful if properly adjusted for changes in fishing power. Future work to develop, document and maintain indices from these fleets is desirable.

New information was recently made available (Parker *et al*., 2017a) regarding the standardized catch rates of yellowfin tuna from the South African pole-and-line fishery during 2003-2016. The analyses indicate that the CPUE of the South African baitboat fishery for yellowfin tuna exhibits high inter-annual variability but, overall, has maintained similar levels to those from the previous decade. A decrease in CPUE from 2006-2009 was noted and could not be explained by targeting, weather or effort shifts. With additional evaluation, indices from this region could be considered for use in future stock assessments, especially if the spatial structure of the stock can be better accommodated.

The average weight trends by fleet (1970-2014) are shown in **YFT-Figure 4**. The recent average weight in European purse seine catches, which represent the majority of the landings, had declined to about half of the average weight of 1990. This decline is at least in part due to changes in selectivity associated with fishing on floating objects beginning in the 1990s, which was observed in the increased catches of small yellowfin. A declining trend in average weight and a corresponding increase in the catch of small yellowfin is also evident in eastern tropical baitboat catches. Longline mean weights and catch at size have been more variable.

YFT-3. State of the stock

A full stock assessment was conducted for yellowfin tuna in 2016, applying three age-structured models and a non-equilibrium production model to the available catch data through 2014. As has been done in previous stock assessments, stock status was evaluated using both surplus production and age-structured models. Models used to develop management advice considered two primary sources of scientific uncertainty, the use of index clusters that reflect two disparate hypotheses regarding trends in abundance of yellowfin tuna, and alternative model structures as implemented using four model platforms. Surplus production models that used Cluster 2 indices did not converge and were not considered. Management advice was developed using a joint distribution of the results of seven models (ASPIC Cluster 1; ASPM-Clusters 1 and 2, VPA Clusters 1 and 2, SS Clusters 1 and 2) which were weighted equally. Additional uncertainties in growth, age-slicing, mortality, index selection and data weighting were explored in sensitivity runs. Trends in biomass (**YFT-Figure 5**) and fishing mortality (**YFT-Figure 6**), relative to the levels that produce MSY, were generally similar for all models used to develop management advice, although small differences in current stock status were noted (**YFT-Figures 5** and **6**). Model specific Kobe status plots (**YFT-Figure 7**), with the annual trajectories of stock status, indicate that for most models the 2014 stock status was near B_{MSY} and below F_{MSY}. Annual trajectories should be interpreted with caution because they are not adjusted for known changes in selectivity.

The estimated MSY (median = 126,304 t) may be below what was achieved in past decades because overall selectivity has shifted to smaller fish. The impact of this change in selectivity on estimates of MSY is clearly seen in the results from age structured models (e.g. **YFT-Figure 8**). Bootstrapped estimates of the current status for the seven models, which reflect the variability of the point estimates given assumptions about uncertainty in the inputs, are shown in **YFT-Figure 9**. When the uncertainty around the point estimates from all models is taken into account, there was an estimated 45.5% chance that the stock was healthy (not overfished and overfishing not occurring) in 2014, a 41.2% probability that the stock was overfished, but not experiencing overfishing, and a 13.3% chance that the stock was both overfished and undergoing overfishing (**YFT-Figure 10**).

In summary, 2014 stock biomass was estimated to be about 5% below B_{MSY} (overfished) and fishing mortality rates were about 23% below F_{MSY} (no overfishing).

YFT-4. Outlook

Projections conducted in 2016 considered a number of constant catch scenarios (**YFT-Figures 11-12**). In most cases, catches less than 120,000 t led to, or maintained a healthy stock status through 2024. The results from the seven models were summarized to produce estimated probabilities of achieving the Convention objectives ($B>B_{MSY}$, $F<F_{MSY}$), for a given level of constant catch, for each year up to 2024 (**YFT-Table 2**). Maintaining catch levels at the current TAC of 110,000 t was expected to maintain healthy stock status ($B>B_{MSY}$, $F<F_{MSY}$) through 2024 with at least 68% probability, increasing to 97% by 2024. As the actual 2016 catches exceeded the values assumed for projections and the TAC, the percentages above (and in **YFT-Table 2**), are likely to be optimistic.

YFT-5. Effect of current regulations

Closures in various time-areas in the eastern tropical Atlantic have been in place during some prior years, imposing restrictions on either FAD-associated sets or all surface gears. Rec. 11-01 (later Rec. 14-01) implemented a closure of surface fishing on FADs in the area from the African coast to 10ºS, 5ºW-5ºE during January-February in the Gulf of Guinea. This closure came into effect in 2013. The efficacy of the area-time closure (moratorium) agreed in Rec. 14-01 was evaluated by examining fine-scale (1ºx1º) skipjack, yellowfin, and bigeye catch by month distributions from the European and associated purse seine fleet FAD fishery and the Ghanaian purse seine and baitboat fishery. After reviewing this information, the Committee concluded that the moratorium had not been effective at reducing the mortality of juvenile bigeye tuna, and any reduction in yellowfin tuna mortality was minimal, largely due to the redistribution of effort into areas adjacent to the moratorium area. The anticipated effect of the moratorium described in Rec. 16-01 will be evaluated when data becomes available.

Rec. 14-01 (reiterated in Rec. 16-01) also implemented a TAC of 110,000 t for 2012 and subsequent years. The overall catches in 2012 (104,500 t), 2013 (97,300 t), 2014 (97,000 t) and 2015 (108,900 t) were lower than this TAC, but the 2016 estimates exceeded the TAC (127,800 t).

YFT-6. Management recommendations

Based on the 2016 stock assessment, the Atlantic yellowfin tuna stock was estimated to be overfished, but at 95% B_{MSY} in 2014. Maintaining catch levels at the current TAC of 110,000 t was expected to maintain healthy stock status through 2024. However, 2016 catches exceeded the catch recommendation by 16%.

The Commission should also be aware that increased harvests on FADs could have negative consequences for yellowfin and bigeye tuna, as well as other by-catch species (Anon., 2017b). Should the Commission wish to increase long term sustainable yield, the Committee continues to recommend that effective measures be found to reduce FAD-related and other fishing mortality of small yellowfin tuna.

ATLANTIC YELLOWFIN TUNA SUMMARY	
Maximum Sustainable Yield (MSY)	126,304 t (119,100 - 151,255 t)[1]
2016 Yield	127,800 t
Relative Biomass B_{2014}/B_{MSY}	0.95 (0.71-1.36)[1]
Relative Fishing Mortality: $F_{current\ (2014)}/F_{MSY}$	0.77 (0.53-1.05)[1]
2014 Total Biomass	464,712 t (308,287 – 731,485 t)[1]
Stock Status (2014)	Overfished: Yes Overfishing: No

Management measures in effect:
[Rec. 14-01]:
- Time-area closure for FAD associated surface fishing
- TAC of 110,000 t
- Specific authorization to fish for tropical tunas for vessels 20 meters or greater
- Specific limits of number of longline and/or purse seine boats for a number of fleets

[Rec. 16-01]
- Revised time-area closure for FAD associated surface fishing
- TAC of 110,000 t
- Specific authorization to fish for tropical tunas for vessels 20 meters or greater
- Specific limits of number of longline and/or purse seine boats for a number of fleets
- Specific limits on FADs, non-entangling FADs required

NOTE: $F_{current(2014)}$ refers to F_{2014} in the case of ASPIC, ASPM and SS, and the geometric mean of F across 2011-2013 in the case of VPA. Relative biomass is calculated in terms of spawning stock biomass in the case of ASPM, SS and VPA and in total biomass in the case of ASPIC.

[1] Median (10th-90th percentiles) from joint distribution of age-structured and production model bootstrap outcomes considered.