Recent studies on the population delineation of yellowfin tuna in the Indian Ocean – considerations for stock assessment

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Abstract

The Indian Ocean yellowfin tuna (YFT) stock assessment by Indian Ocean Tuna Commission (IOTC) is undertaken based on the assumption of a single stock for the entire Indian Ocean. However, molecular studies by Kunal *et al.* (2013), based on the Mitochondrial DNA D-loop analysis identified three discrete populations of yellowfin tuna in the Indian waters (Northern Arabian Sea, Lakshadweep Islands and rest of Indian Seas). A larger study with samples from all the oceans using whole-genome sequencing in concert with a draft genome assembly also indicated possibility of a distinct yellowfin tuna population in the Arabian Sea in addition to Atlantic and Indo-Pacific populations (Barth *et al*., 2017). The probable existence of distinct yellowfin populations in the Indian Ocean raises important management considerations for this species, which need to be addressed at the earliest for ensuring sustainability of the species.

Introduction

Yellowfin tuna (*Thunnus albacares* (Bonnaterre, 1788), being a highly valued food fish, is one of the most sought after fish species in the world oceans. Yellowfin tuna (YFT) fishing and fisheries have become a focal point while addressing issues of development, utilization and management of fisheries in the Indian Ocean in the light of EEZ regulations and other international conventions (Somvanshi *et al*., 2008). The economic stability, food security and livelihood of many Indian Ocean coastal nations, especially Small Island Developing States (SIDS) heavily depends on this fishery. Further, the indirect benefits in the form of licenses, servicing to the Distant Water Fishing Nations (DWFN) industrial fleets and fees received for the use of port facility are contributing additional earnings for the Indian Ocean coastal states from tuna fishery.

In the stock assessment of 2018, the Indian Ocean Tuna Commission (IOTC) determined that the Indian Ocean (IO) YFT stock is overfished and subject to overfishing, since the catch reported/estimated in 2017 (409,567 t) was much higher than the Maximum Sustainable Yield (MSY) estimated (403,000 t). This warrants concerted, immediate and effective action by all stakeholders to avoid any further decline in the biomass which may compromise the economic stability, food security and livelihood in the region.

Fish stock assessment is fundamental in identifying management measures for sustaining the fishery perpetually. However, the success of any fish stock assessment exercise critically depends on the robust understanding about biological population units of the exploited species. Knowledge of stock structure is of prime importance to the management of any fishery, since each stock within the exploited species can possess novel genetic, physiological, behavioural, and other characters that promote distinct differences in life-history traits (Reiss *et al*., 2009). Although, there are several methods for studying the stock structure, the genetic approach is widely accepted, due to its sensitivity and reliability (Kunal *et al*., 2013). The Indian Ocean YFT stock assessment by the IOTC is undertaken based on the assumption of a single stock for the entire Indian Ocean (IOTC, 2015).

YFT stock delineation studies in the Indian Ocean

There were several attempts to delineate the stock structure of YFT of the Indian Ocean. The first attempt to study the YFT stock structure of the Indian Ocean with representative samples from eastern and western Indian Ocean by genetic methods was that by Chow *et al*. (2000). In this study, samples taken from two selected locations, at the westernmost and easternmost parts of the Indian Ocean were subjected for PCR-RFLP analysis on mitochondrial DNA (mtDNA) D –loop using *Nla* III and *Taq* I restriction enzymes, to investigate the probable genetic variation among these samples. However, the study failed to draw definitive conclusions on the stock structure of the Indian Ocean YFT. As a continuation of this study, Nishida *et al*., (2001) carried out the RFLP analysis in the nuclear gene loci, *viz.* 2nd intron of S7 ribosomal protein gene (S7PR2) and 4th intron of calmodulin gene (CAM) Results of this study

proved no significant difference between the western and the eastern samples.

Dammannagoda *et al*. (2008) studied genetic variation in 285 YFT specimens collected from seven locations in Sri Lankan and Maldivian waters. Variation in the mitochondrial ATPase 6 and 8 region (498bp) and three microsatellite loci were screened, resulting in detection of significant genetic differentiation among the sites for mitochondrial DNA and at two microsatellite loci. Spatial analysis of molecular variance of mtDNA data in this study could identify three genetically heterogenous groups suggesting the possibility of existence of genetically discrete YFT populations in the north western Indian Ocean.

Similarly, Kunal *et al*. (2013) examined the population structure of YFT of the Indian Ocean using mtDNA sequence analysis of 321 YFT samples collected from seven geographically distinct locations (from Veraval in the north-western India to Port Blair in Andaman and Nicobar Islands) along the entire Indian coast. The 500 bp segment of D-loop region was sequenced and analysed in this study. Hierarchical analysis of molecular variance showed significant genetic differentiation among three groups of samples, ie., Veraval (north west Indian coast); Agatti (south west Indian coast) and rest of the samples analyzed. Further, spatial analysis of molecular variance identified three genetically heterogeneous groups of yellowfin tuna in Indian waters, rejecting the null hypothesis of single panmictic population of yellowfin tuna in Indian waters.

In a recent study, Barth *et al*. (2017) carried out a whole genome sequencing of the samples and corresponding Single Nucleotide Polymorphisms (SNPs) analysis of mitochondrial reads, mapped and indexed against a fully assembled YFT mitochondrial genome to delineate major population stocks. In their study, samples were collected from 8 localities including the U.S.A, Republic of Cabo Verde, Ivory Coast, South Africa, Oman, Indonesia, Japan and El Salvador; covering most of the global distribution of the yellowfin tuna. This study could detect significant differentiation of Atlantic and Indo-Pacific yellowfin tuna populations as well as the possibility of a third diverged YFT group in the Arabian Sea.

Pecoraro *et al*. (2018) also used SNPs to study the genetic differentiation among YFT of the Atlantic, Indian and Pacific oceans. The samples collections in this study were from Venezuela, Gulf of Mexico, Angola, Sierra Leone, Madagascar, Somalia, western central Pacific Ocean and western Mexico. By studying a panel of 939 neutral SNPs, and comprehensive data set of YFT samples, the authors established genetic differentiation among the Atlantic, Indian and Pacific oceans. The genetic stock structure analysis carried out with 33 outlier SNPs, putatively under selection, identified discrete populations within the Pacific Ocean and, for the first time, also within the Atlantic Ocean. However, this study has not examined the possible existence of a discrete Arabian Sea population of YFT (Barth *et al*., 2017) since sample collection was not attempted from this area.

Although the tag recoveries of the IOTC Regional Tuna Tagging Project of the Indian Ocean (RTTP-IO) provide evidence of large movements of yellowfin tuna, thus supporting the assumption of a single stock for the Indian Ocean (IOTC, 2015), most of the studies listed above indicate strong reasons for the possibility of existence of discrete populations of yellowfin tuna in the Indian Ocean.

Recent developments in the field of electronic tags have dramatically increased the potential to collect more high quality data, especially on fish migrations (Sippel *et al*., 2015). Tagging studies with Pop-up Satellite Archival Tags (PSATs) can provide valuable information on distribution, movement, and individual behaviour of fishes (Block *et al*., 1998). Nimit Kumar *et al*. (in press) studied the migration of YFT in the Arabian Sea and Bay Bengal in the Indian EEZ by deploying PSATs on 42 yellowfin tunas. The results of this novel study show that the yellowfin tunas tagged using PSATs from different locations of Indian seas did not undertake large movements indicating multiple resident stocks of yellowfin tunas in the Indian Ocean.

Conclusion

The earlier studies to delineate stock structure of yellowfin tuna of the Indian Ocean indicated single panmictic population for the whole Indian Ocean. However, the recent genetic studies, coupled with tagging studies with PSATs indicate probable presence of distinct yellowfin populations in the Indian Ocean. This raises important management considerations for this species, which need to be addressed at the earliest for ensuring sustainability of this ecologically and economically important species.

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