Movement patterns shown by the recoveries of tunas tagged with dart tags in various areas of the Atlantic

by Dr Alain Fonteneau



I-Tagging and recoveries by area: historical & AOTTP tagging

Canary CaboVerde Senega GØN N Brazil Sierra Sao _eone Angola midBrazil **StaHelena** ulletSAF S Brazil ICCAT tagging by species 1960-2020

recovery patterns over time,

- Under increasing exploitation rates exerted today by fisheries

- Numbers of tags widely heterogeneous in various fishing zones, in historical and AOTTP tagging

Linear trajectories between tagging & recovery locations (historical & AOTTP tagging).



> 60 years of tagging and recoveries have been showing that our 3 species are following well the article 64 of the UN law of the sea, they don't know EEZs, but to variable degrees between species and tagging areas

However, the average distances travelled (in miles) between tagging & recovery are quite limited for the 4 species: each of the studied species shows a moderate range of its apparent average movements, and then probably a quite high regional viscosity (McCall 1990) in most tagging areas

| Average distances after 1 month | YFT | SKJ | BET | LTA | |
|---------------------------------|-----|-----|-----|-----|--|
| Historical recoveries | 388 | 192 | 199 | | |
| AOTTP recoveries | 181 | 281 | 296 | 161 | |

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Maximal distances travelled: average of the 10 longest distances between tagging & recovery locations (1960–2020) from each of the tagging areas



These "maximal" distances are targeting to evaluate the potential of fishery interactions between distant areas: most fishing zones at distances >1500 miles (25° of latitude) would show very low potential of fisheries interaction
Many areas showing viscosity: losses of local biomass due to harvesting are replaced mainly by *in situ* population growth, immigration proceeding at negligible rates
Keeping in mind that all the fisheries active in cold waters (NE USA, Azores, South Brazil, Angola, South Africa) correspond to feeding areas that are necessarily in interaction with fisheries active in the spawning areas close to equator

II) Severe limitations still faced by the today tagging & recoveries for the study of tuna movements

A) Questionable tagging and recoveries from 2 major tagging areas: => Cote d'Ivoire

- ✓ This tagging allowed to tag large numbers of YFT: **21%** of the YFT tagged by AOTTP
- But this tagging was mostly done in coastal waters of Cote d'Ivoire & producing 35% of short term recoveries (tagging month)
- A great majority of tagging were done on anchored FADs and on oil rig & most recoveries have been reported very close to their tagging locations (ecological trap?) by local fleets that are poorly followed by statistics & rarely caught by PS (only 1.6% of recoveries) the main gear fishing in areas very close to the tagging anchored FADs.
- As a consequence: the ivorian tagging & recoveries cannot be used in the study of tuna movements or in stock assessment studies

=> Sao Tome

- This tagging was potentially done in ideal conditions because this EEZ was closed to purse seiners during the tagging period and allowing to tag good numbers of YFT (6% of the YFT tagged by AOTTP)
- But unfortunately an inadequate tagging method was used: as a consequence its YFT recoveries rates are extremely low, only 2%
- This percentage is widely too low, as this tagging area was during the tagging season very close to the 2 major fishing areas off Ghana/Cote d'Ivoire and off Cap Lopez
- As consequence these results are very difficult to use

B) Insufficient AOTTP tagging in various major fishing zones in the Eastern Atlantic for instance east of 10°W

The locations of the AOTTP tagging cruises was far to be ideal, especially in the Atlantic, an ocean where the tuna movements appears to be quite limited creating a need to tag tunas in all the major fishing zones

 ✓ Fishing areas positioned east of 10°W are clearly of major importance: producing about 44% of tropical tuna catches,



✓ However very few SKJ and BET (2200 and 520), and questionable YFT have been tagged east of 10°W (Cote d'Ivoire & Sao Tome tagging)
✓ Insufficient AOTTP tagging of YFT along the USA coast (only 656 individuals):

not enough to confirm the YFT transatlantic migration that has been well shown, based on the historical 9500 tags and their 45 transatlantic recoveries.

C) Very low reporting rates of tagged tunas by longliners & unknown reporting rates for several major fleets

Longliners are exploiting tropical tunas in wide geographical areas, but the reporting rates of tagged tunas by these fleets tend to be very low:

✓ Historical recoveries: Only 29 recoveries of large size YFT & BET reported by longliners, 12 times more tags reported by surface fleets in this size range of tunas.
✓ AOTTP recoveries: only 4 tunas in the today LL recoveries, vs 1326 recoveries of large tunas reported by surface fisheries, while LL are catching about 78% of large the BET & 28% of the large YFT. Many reporting rates of tags also appear to be unknown or low, for instance Ghana: only 374 recoveries by Ghana PS vs 4065 recov. by EU PS, These unknown very low reporting rates of tags are clearly introducing major uncertainties or errors in the estimated tuna movements and interactions between gears and areas

D) Excessive numbers of short term recoveries

Many tagging cruises have been conducted in very active fishing strata, and as a result, the AOTTP recoveries have been very high during the 1st month at liberty, thus without providing useful information on tuna movements or on tuna growth...

| | YFT | SKJ | BET | LTA | Total |
|-----------------------|--------|--------|--------|-------|---------|
| Number tags | 40 649 | 46 893 | 24 192 | 7 827 | 119 561 |
| Number recoveries | 7 806 | 3 248 | 4 691 | 597 | 16 342 |
| Recoveries 1st month | 2 307 | 1 642 | 1 584 | 348 | 5 881 |
| %recoveries 1st month | 29,6 | 50,6 | 33,8 | 58,3 | 36,0 |

E) Insufficient numbers of SKJ tagged?: because tagged SKJ are vanishing very quickly from the fisheries in the Atlantic



Percentages of SKJ recoveries as a function of month at liberty during 2 years: historical & AOTTP tagging, and Indian Ocean

✓ The today AOTTP profile (oct. 2020) of SKJ monthly recoveries appears to be similar to the profile observed in the ICCAT historical SKJ recoveries: showing very few recoveries after 2 months : SKJ recoveries are quickly vanishing
✓ Why?: high total mortality of SKJ? migration outside fishing zones? Other?
✓ These vanishing recoveries are a serious limiting factor in the study of SKJ movements, as only 47.000 SKJ were tagged during the AOTTP
✓ Taking note that on the opposite, the Indian Ocean SKJ recoveries have been showing high & sustained numbers of SKJ recoveries after more than 2 months of liberty,

III) Hypothetical movements of Atlantic tropical tunas: before & after the AOTTP: Yellowfin





Observed movements of YFT from dart tags in the Atlantic (FAO, 1986); in red: new AOTTP movements

The recovery of AOTTP dart tags are not widely changing the hypothesis on the YFT stock structure that was proposed 30 years ago by Fonteneau & Marcille in 1988:

Confirming the viscosity of the Atlantic YFT population: various sub stocks showing low mixing

Adding new information on the small scale movements of YFT close and outside the Santa Helena island and in South Africa

Adding new information on the exchange of tagged YFT between the areas north of Brazil and off the Sierra Leone ridge

+ Homing migration of large YFT from the US coast remains an unconfirmed but valide hypothesis

Hypothetical movements of skipjack: before & after the AOTTP





ISYP 1981: observed movements of SKJ in the Eastern Atlantic (ICCAT ISYP, 1986), in red: new AOTTP movements

 ✓ North-South movements of SKJ in the North East Atlantic, a migratory axis between Azores-Madeira-Canary islands-Mauritania, is now very clear
✓ Many SKJ tagged by AOTTP West of 30°W: 19164
✓ Very few SKJ recoveries crossing the mid Atlantic frontier at 30°W (or accross the ICCAT stock line): a confirmation of 2 SKJ stocks E & W Atlantic

✓ Drifting FADs from East to West may create a new westward movement of SKJ?

 \checkmark A confirmation that there is an apparent viscosity of the SKJ individuals in the Eastern Atlantic.

✓ Very low rates of SKJ recoveries in the West Atlantic tagging, only 1%, why?: low exploitation rates? low reporting rates? Tagging of many dead SKJ?

Hypothetical movements of bigeye: before & after AOTTP



 \checkmark Movements of juvenile BET inside the BET nurseries of the eastern Atlantic are well shown by historical & by AOTTP recoveries

✓ North-South movements of pre-adult BET in the North East Atlantic, in a migratory axis between Azores-Madeira-Canary islands-Mauritania, is also clear
✓ Feeding and spawning migration of adult BET remain hypothetical: they probably migrate between their feeding and spawning zones: BET being scattered in their feeding zones, and seasonally concentrated and heavily fished in their spawning zones

IV) Implications for statistical stock assessment models

- 1) The recovery of AOTTP dart tags are confirming the results of historical ICCAT tagging: tropical tunas are often showing extensive movements at large distances outside the EEZ frontiers
- 2) Many AOTTP recoveries are showing that fixed aggregating structures such as sea mounts, anchored FADs and oil rigs are widely reducing the distances travelled, especially in the short term
- 3) Most recoveries are confirming that the range of movements tend to be limited, with the exception of historical YFT tagging off the US coast: most recoveries are indicative that these tuna stocks are in fact "viscous": for instance, mixing rates of SKJ fished off Côte d'Ivoire & Angola (1500 miles) or Azores (2000 miles) are probably very low, because of the great distances between these areas
- 4) Consequently: all future stock analysis statistical models of ICCAT tropical tunas should well handle this viscosity: they should be based on a significant number of sub areas & estimating seasonal movements of individuals between areas as a function of their age.