STATUS OF THE INDIAN OCEAN TUNA TAGGING PROGRAMME - RTTP-IO

Jean-Pierre Hallier[1]

1. GENERAL CONTEXT

The objective of this document is to give a general idea of the Regional Tuna Tagging Project of the Indian Ocean (RTTP-IO) and the data collected at the end of May 2008.

The main objective of the RTTP-IO is to provide the IOTC with the necessary parameters for tuna stock assessment.

The different data and information presented in this document are based on the different RTTP-IO databases as at June 9th 2008. For recoveries, as they continue to flow in at a reasonable rate considering the end of the tagging operations last August 2007, the original recovery database is increasing regularly containing today more than 24,500 recoveries instead of the 24,147 presented here.

2. THE RTTP-IO PROJECT

The RTTP-IO is an answer of the European Union to the request of the Indian Ocean Tuna Commission (IOTC) scientists who asked for a large-scale tuna tagging programme to address the issue of the state of the tuna stocks of the Indian Ocean for the three main species: yellowfin tuna (*Thunnus albacores*), bigeye (*T. obesus*) and skipjack (*Katsuwonus pelamis*).

Large-scale tagging is necessary for an efficient assessment of tropical tuna stocks. As Europe was alone to finance this large-scale tagging it was decided that the tagging operations of this project will be limited to the Western Indian Ocean where the EU purse seine fishery is active. To cover the Eastern Indian Ocean, the IOTC received limited funds from Japan which permitted to undertake some small-scale tagging off Maldives, Lakshadweep and Andaman (Indian Islands) and Indonesia. Few other small-scale tagging operations were and are still developed in the Western part in Mayotte, Seychelles and South Africa with Japan funds and funds from the EU DG-Fish. The small-scale tagging together with the RTTP-IO are known as the Indian Ocean Tuna Tagging Project (IOTTP). This document is dealing with the activities of the RTTP-IO.

The RTTP-IO received 14 Million Euros from the 9th European Development Fund (EDF) to face the expenses of this large-scale tagging project. The financial agreement was signed in December 2003 and the project started in February 2005 for a total duration of 5 years.
Vessels and staff were provided via 4 contracts: one for each vessel, one for the coordinator and one for the technical assistance. Both contracts for the vessels were won by AZTI from Spain (Arrantzuarekiko Zientzia Eta Teknika Iraskundea - Instituto Tecnologico Pesquero y Alimentario), the contract for the coordinator by J-P Hallier from France and the contract for the technical assistance by MEP from Great Britain (McAllister Elliott & Partners).

The Authorizing Officer of the Project is the Indian Ocean Commission (IOC – COI) based in Mauritius which is an inter-governmental organization made of Comoros, Madagascar, Mauritius, Seychelles and France (for La Reunion). The Technical Supervisor of the Project is the Indian Ocean Tuna Commission

[1] Chief Coordinator of the RTTP-IO, c/o IOTC, P.O. Box 1011, Victoria, Seychelles E-mail : jph@iotc.org

(IOTC); this is why the Project is based within IOTC in Seychelles. Furthermore Seychelles is the biggest tuna port in the Indian Ocean as being the main base of the EU purse seine fleet.

The European Commission Delegation (DEC) in Mauritius is the funding body of the Project.

The EDF rules are not well-suited to the RTTP which activities are not limited to the 5 countries of the IOC (ACP countries) and this created difficulties in implementing the Project. One of the solutions was the signature of a Contribution Agreement between the FAO-IOTC and the DEC at the end of 2005. This contribution agreement is covering all recovery and publicity expenses of the Project as well as some other minor expenses.

3. STAFF

At the beginning, the project was staffed as follows:

- A Chief Coordinator (CC): Jean-Pierre Hallier;
- A Publicity and Tag Recovery Officer (PTRO): Charles Anderson assisted by Teresa Athayde;
- A Financial and Administrative Officer : Michael Stockwell;
- A secretary : Betty Honore;
- A driver : Pascal Mathiot;
- Three Cruise leaders;
- Three Tagging Technicians.

C. Anderson is acting mostly via missions to Seychelles while the running of the Publicity and Recovery aspects of the project is implemented by T. Athayde.

Under the budget of the project, the IOC also recruited in September 2005 an Accounting Officer, Soudha Nunkoo, based in Mauritius at the beginning and then in Seychelles from January 2006.

Under the MEP contract, short-term expertises are also provided whenever necessary.

The RTTP also benefit from the support of the countries boarding the Indian Ocean. These countries facilitate the at-sea operations of the two vessels used for the tagging operations by providing EEZ access for tuna tagging as well as access to their coastal waters for bait fishing and to their ports for bunkering. They also provided scientific and technician staff as Regional Tagging Technicians (RTT) who boarded the vessels and participate into the activities conducted at sea.

At the beginning of the project the duty definition of the secretary and driver posts were redefined as Secretary-Data Entry and Driver-Tag Recovery Officer.

The project also benefit, especially during the first 2 ½ first year of the strong participation of the IOTC Tagging Officer, Julien Million, and of the IOTC Executive Secretary, Alejandro Anganuzzi as well as other IOTC staff.

An IT part-time administrator was also recruited in January 2006, Nishan Sugathadasa, in order to maintain the IT system of the project and to develop the ACCESS databases required.

Very quickly when recoveries started to flow in it became obvious that most recoveries showed up in Victoria, Seychelles. Starting from April 2006, the number of recoveries recorded per month out passed 500 and 1000 in December 2006. The ground staffs available in Seychelles were not sufficient to cope with such an influx of recoveries. Different solutions were envisioned and finally a 2nd Tag Recovery Officer (TRO) was recruited in February 2007 on the budget of the project and in March 2007, 4 Tag Recovery Assistants (TRA) were recruited under the Contribution Agreement. This staff increase also offered the possibility to modify the way recoveries were collected increasing greatly the quality of the data.

Overall, the project suffered from staff shortage especially during the first two years putting a lot of pressure on the RTTP and IOTC staff and affecting partially the quality of the data.

4. VESSELS

4.1. Specifications and charter conditions

For different reasons, including security reasons, two pole-and-line vessels were chartered to implement the tagging phase of the project. The vessels chartered via AZTI were two sister ships from Spain based in Senegal: The FV Aita Fraxku and Kermantxo. They were 38 m long, 158 m^3 of well capacity and 960 HP engine. They started navigation in May 2000 and before the project fished off Spain, Venezuela and Senegal-Mauritania. They have about 15-16 crew members from Spain, Venezuela, Senegal, Madagascar and Tanzania.

The vessels contracts lasted from March 23rd 2005 until 22nd September 2007 but it was extended for one month until 22nd October 2007, i.e. 31 months. This chartering period encompassed the transit from Spain to Seychelles and back which took overall 80 days. The available operational time of the two vessels goes from April 29th 2005 until September 11th 2007.

4.2. Distribution of the different activities

The activities of the vessels have been distributed in 8 different components which are described and assessed below in table 1 and illustrated by figure 1.

Only 3.2 % of the operational time was lost due to mechanical problem which is very low. The fact that the vessels were only in their sixth year of navigation when they started their RTTP charter period certainly played an important role in this low number of days lost to mechanical problems as well as the day-to-day care performed by the engineers.
The Indian Ocean is not well-known for its calm waters as the Tropical Atlantic Ocean. The monsoon system is responsible for about 5-6 months of bad weather. The low number of days lost to bad weather (0.5 %) is due to the fact that the vessels found along the coasts of Tanzania and Kenya some reasonable calm seas to work in during the South-East monsoon.

The dedication of the captains and their crew, their willingness and their experience as pole-and-line fishermen is strongly to be praised for the success of the tagging operations. Their excellent fisherman capacity was particularly well illustrated during the Oman survey of February-March 2007 when they were able to fish more than 3000 medium to large-size yellowfin in waters were no pole-and-line vessels have never been successful in the past.

The operational time is divided into cruises which more or less correspond to the duration between staff rotation on any one boat. There were 26 cruises altogether which lasted on average 33 days; during cruise n°18 no fish were tagged as most of the cruise was spent in shipyard for an overall maintenance.

4.3. Area surveyed

The tagging operations by the two chartered pole-and-line vessels Aita Fraxku and Kermantxo started at the beginning of May 2005 in Seychelles and the different waters surveyed during the project are listed in Table 2.
Most of the time, for security reasons, the two vessels worked together. As much as possible when prospecting they kept steaming more than 5 to 10 nm apart.

4.4. Baiting

Baiting, as feared at the beginning, proved to be a strong limitation to the surveyed activities. Only three main places yielded more or less adequate bait in quantity and quality: the North-East coast of Madagascar, the coasts of Tanzania/Kenya but mostly the island of Mafia and the coasts of Oman. But the quality was most of the time just acceptable therefore it was often not possible to plan trips very far away from these

three baiting grounds. An attempt to purchase bait with Maldivian fishermen failed which jeopardized together with low tuna abundance the unique survey done by the RTTP in the waters of Maldives.

Fortunately Mafia Island off Tanzania provided sufficient bait near a very productive tagging area. Furthermore, the vessels managed to tag a large number of tuna without using any bait.

4.5. The Associated School Fishing Technique

Off Tanzania, the vessels were able to implement the associated school fishing technique (ASFT). This technique developed by the Dakar-based bait boats in the 80's consists of a permanent association between a tuna school and the bait boat. As in the Atlantic some very special conditions are necessary for the success of this fishing technique. The presence at the surface of schools made of skipjack and juvenile yellowfin and bigeye is of prime importance. There should be also in the vicinity the presence of a food chain offering preys to the tuna. Whatever the necessary conditions, they were perfectly met off the coasts of Tanzania. After having fished normally the area in 2005, the vessels managed to develop this technique in April 2006 and again in May 2007. In 2006 they kept the school until the beginning of December 2006 when they have to let it go for calling into Mombasa for an overall maintenance period. In 2007, they kept the school until the beginning of September when it was the time to join Seychelles before the completion of their RTTP operations. Two vessels are necessary for the ASFT as there should always be a bait boat with the school. At the beginning the vessels took their turn above the school. When one was tagging the other was bunkering in port or at the baiting ground. But in July 2006, the vessels managed to tag without bait just using bare hooks or hooks with lures. These fishermen knew and have practiced this technique off Mauritania which they call Tikitaka. But in the Atlantic, it sometimes works but for a very short period. Off Tanzania, they could carry on with Tikitaka for days, weeks and months. In 2006, they fished almost 4 months without any bait and in 2007 during 1 ½ month.

4.6. The concentration of tagging off Tanzania

Table 2 and figure 2 show the overwhelming importance of the Tanzania/Kenya area. The concentration of the activities of the vessels in this area is justified by:

- The relative good sea conditions during the SE monsoon;
- The presence of a regular supply of reasonable amount of bait off Mafia Island;
- The presence of mixed schools of yellowfin-bigeye-skipjack;
- The possibility to implement with great success the ASFT, even without bait;
- The constant renewability of tuna in the ASFT (= reasonably low recapture rates by the RTTP vessels);
- The overall low tuna abundance in this region which keeps away purse seiners most of the time (= few short time-at-liberty recaptures by purse seiners);
- The fact that recoveries demonstrate the large diffusion of the fish tagged off Tanzania offering a good dispersion of the tagged tuna.

4.7. The performances of the two vessels

As the vessels were working almost always together there are not many differences in their performances. The Kermantxo overall has obtained slightly less success for baiting but a little more success in tagging than the Aita Fraxku. The Kermantxo tagged 84,997 tuna with 27% YFT, 20% BET and 53% SKJ; the Aita Fraxku tagged 83,166 tuna with 38% YFT, 21% BET and 40% SKJ. If both tagged the same proportion of bigeye, there are important differences in the % of YFT and SKJ for which we don't have any explanation.

5. TAGGING

5.1. The number of fish tagged and released

Overall 168,163 tuna with tag were released including 34,570 bigeye, 54,663 yellowfin, 78,324 skipjack and 606 tuna with unknown species. The species composition of the tagged tuna is given in figure 3.

The RTTP-IO target in term of tagged fish was 80,000 with 168,000 the RTTP-IO has doubled its target. Bigeye and yellowfin were assigned as the primary species as the IOTC scientific community has more concern on the state of these two stocks than on the skipjack stock. With more than 50 % of bigeye + yellowfin the RTTP is doing very well especially because the fishing technique used, pole-and-line, is generally more prone to catch skipjack than the two other species. This is mainly due to the fact that pole-and-line is fishing right at the surface and skipjack is the most surface tuna species before yellowfin and bigeye, this last one tends to be deeper. This achievement was possible with the ASFT where juvenile bigeye and yellowfin are abundant and at the surface.

The monthly distribution of the tagged tuna is given in figure 4. The tagging off Tanzania is easy to spot with the presence of the three species as in August-October 2005, April-November 2006 and June-August 2007.
In May-July 2005 the vessels were tagging in the Mozambique Channel essentially rich in skipjack associated to some yellowfin. The Seychelles EEZ was mainly fished in November-March 2006 and was characterized by large amounts of skipjack and significant amounts of yellowfin. From February to beginning of April 2007, the vessels fished exclusively on yellowfin in the Arabian Sea. In April 2007, on the way from Oman to Maldives the vessels tagged nearly 2000 skipjack in the North-West of the Lakshadweep Islands (India).

Only off Tanzania and off Seychelles, the monthly tagging rates by the two vessels were above 10,000; the maximum being reached in August 2007 with more than 22,000 fish tagged.

Overall the RTTP-IO has used 197,021 tags distributed as follows:

- 196,003 were implanted on tuna released at sea;
- 857 were lost at sea;
- 161 were rejected.

5.2. The release by type of tagging

Most tuna were tagged with one single yellow dart tag; some received two yellow tags in order to address the tag shedding rate issue but white and red dart tags were also used in smaller amounts. The white tags identified fish injected with Oxy-TetraCycline (OTC) for growth study and red to identify fish implanted with electronic (archival) tags.

The distribution of the numbers of tag by types is given in table 3 and figure 5 illustrates the species composition for all those different types. Species composition for single dart tags (fig. 5a) is somewhat different of the species composition for double-tagged (fig. 5b) and OTC types of tag (fig. 5c). This is due to the fact that double tagging does not start before January 2006 and OTC before June 2006. Archival tags because of their size and the fact they have to be inserted into the abdominal cavity of the tuna was restricted to yellowfin and bigeye generally greater than 60 cm (fig. 5d). Very few sonic tags (40) were implanted, they were identified with a white tags as they fish received an OTC injection. White tags were more or less evenly distributed between the three species: yellowfin, bigeye and skipjack.

Single tagging
This is the most used tagging mode of the RTTP-IO with 133,848 fish tagged or 79.6%.
The project used three different sizes of dart tags. At the beginning in order to cope with tuna of very different sizes, the project possessed tags of 9.5 cm, 11.5 cm and 14.5 cm long. It is thought that the use of small tag might be preferable in order to decrease the tagging mortality for very small tuna: for instance, a

14.5 cm long tag might induce a higher mortality rate when implanted on less than 40 cm tuna. The problem with tropical tuna is the large mixture of species and sizes. If you add the difficulty of handling tags of different lengths at the same time it becomes unpractical to use tags of different length during large-scale tagging operations at least during the same tagging operation. During pole-and-line operations, biting is generally intense but for short period of time therefore speed is essential as we want to tag large numbers. Consequently on a practical point of view it is not easy to handle different size tags at the same time. The 9.5 cm were discarded quite quickly and only 392 releases beard these tags (0.24% of all tag released).

When tagging juvenile YFT and BET, one must keep in mind that these two species can grow a lot with time and consequently the tag part sticking out of the fish will decrease up to a point when no tag remained outside the flesh. It is occurring more for small tags set on small tuna (YFT & BET). As the project tagged large numbers of juvenile YFT and BET, it was decided to stick to the larger 14.5 cm tags. Only 38,205 tags of 11.5 cm (23.6% of all tags) were released including 8,928 DT; 123,342 tags of 14.5 cm (76.3%) were released including 18,917 DT.
The species composition by number and in percentage of ST releases is given in table 3 and illustrated by figure 5a. SKJ are accounting for 50% of all ST tagged tuna.

Double-tagging
The RTTP double tagging target was 20% and the level of double tagging achieved is 16.6% for a total of 27,845. Double-tagging started only in January 2006 but the 20% target was already reached in September 2006 and more or less maintained until the beginning of July 2007. But later on we slowed down the DT rate because 1) we already have more than 25,000 DT which is more than any other tropical tuna large-scale programme; 2) Almost all main taggers have each released more or less 1,500 DT, a fair sample and 3) as a DT recovery with the two tags received a double rewards we fear experiencing before the end of the project a lack of fund for paying rewards. The number and percentage of DT tagged tuna for each species is given in figure 5b and it is as follows:

- YFT : 10,677 or 19.5% of all YFT;
- BET : 7,518 or 21.7% of all BET;
- SKJ : 9,620 or 12.3% of all SJK.

As mentioned in the previous §, 11.5 and 14.5 cm tags were used for double tagging. The species composition of the DT tagging is given in table 3 and figure 5b.

OTC tagging
For growth and age study, some tunas received an injection of Oxy-TetraCycline (OTC) an antibiotic commonly used for this type of study. To differentiate them from the normal tagged tunas that bear one or two yellow dart tags, a white tag was used on these fish. Altogether, 5,944 tuna have received a white tag or 3.5 % of the total. The species composition of the OTC tagged tuna is given in table 3 and figure 5c. We put more emphasis on YFT and BET because 1) they are our priority species and 2) otolith reading of SKJ has not proven yet their efficiency for estimating the age.
We used two different tag sizes: 11.5 and 14.5 cm. Only 496 tuna were OTC tagged with 11.5 cm tags and 5488 with 14.5 cm tags. The smaller tags also have a smaller diameter: about 1 mm instead of 2 mm for the longer ones which might make them less easy to spot at recovery.

Archival tagging
The TAGFAD project (DG-Fish funded project, 2003) has donated 139 archival tags to the RTTP-IO. Furthermore 150 tags were purchased on the budget of the project. These 289 archival tags (Table 3 and figure 5d) have been released exclusively on YFT (222) and BET (67). All ET tagged tuna received also an OTC injection and a red spaghetti tag.
We tagged preferably YFT with archival tags because 1) we have noticed a lower recovery rate for BET especially for OTC tagged fish; 2) we set a lower 60 cm size limit for archival tagging and BET of larger sizes were less abundant than YFT and 3) for recovery, large YFT are still caught in large number by purse seiners while most large BET will end up in the longline fishery which does not seem to return well the recovered tagged tuna.

Sonic tagging

A very limited survey took place in October-November 2006 with the financial and technical help of FADIO and IOTC with funds provided by Japan. The objective of this survey was to assess the time of residency of tuna in the associated school (cf. 2006 Scientific Committee). 40 tunas received a sonic tag (Table 3), an injection of OTC and a white tag. As it is not essential to recover the sonic tags these fish deserved a normal OTC reward. Altogether 60 sonic tags were purchased by the IOTC, 40 were implanted in 2006 and the objective was to use the 20 remaining tags in 2007. However sea conditions and currents conditions were too bad in 2007 to put at risk the Argos detecting station. During the ASFT, most of the time, the vessels are not drifting but steaming slowly. In the area where the ASFT took place it was not rare to experience currents as high as 3 knots. When these strong currents are associated with rough sea, the risk of loosing the Argos Device in tow is too high and furthermore manoeuvres became dangerous for the crew.

5.3. The size distribution

The distributions of the sizes of the tagged tunas are given in figure 6a for YFT, 6b for BET and 6c for SKJ. The sizes for the three species are covering a wide range and I would say almost the maximum range that can be expected from pole-and-line fishing especially for YFT (YFT bigger than 100 cm are difficult and dangerous to handle). For the three species, the smaller size tagged was around 32 cm.

The range of the FL x axis on figures 6 is the range of the tagged fish; however for very small and very large fish their number being very small they are not visible on the figures.

Most of the yellowfin between 80 and 120 cm were tagged in the Arabian Sea but some were from the Amirantes in Seychelles. Apart from some yellowfin tagged in the Arabian Sea, all yellowfin tagged by the RTTP-IO are juveniles. For bigeye (Figure 6b) they are all juveniles and they almost all come from Tanzania area. The size distributions for the main country/area are given in annex 1.
For example, in Oman the size distribution of the yellowfin clearly show two modes: one at 75-80 cm spreading from 61 to 93 cm and a second mode at 108-112 spreading from 94 to 120 cm. There are also some bigger yellowfin up to 145 cm.
In Seychelles, medium size yellowfin were also tagged; they spread between 80 and 105 cm with a maximum at 90-92 cm. These medium size yellowfin of Seychelles as well as those of Oman were very difficult to catch with pole-and-line because (1) they are heavy and very lively, generally the two poles-one line system was used, (2) they are very mobile at the surface and (3) they often come at the surface for very short time periods. One of the consequences is the large amount of bait necessary for catching these fish in sufficient numbers.

Figures 7a, b & c show the distribution of the tagged sizes for different types of tagging (ST, DT & OT) for yellowfin, bigeye and skipjack respectively. Overall the size distribution of the tagged tuna according to the different tagging is quite similar; only for large sizes some type of tagging are more represented than others.

5.4. The number of tag by tagger

The quality of the tagging is playing an important role on the tagging mortality as well as on the tag shedding. If tag shedding can be easily estimated with double tagging, tagging mortality is more difficult to assess. Tagging a tuna is not a complex action but it requires experience in order to maintain a good quality as it is performed under the stress of fast fishing rates and often difficult sea conditions. In order to minimize tag shedding and tag mortality several actions were taken:

- Applicators used to implant tags into fish must be sharp and maintained in good conditions including hygienic conditions;
- The preliminary preparation of tags in their applicators ready for use in blocks of 100 is essential for large-scale tagging;
- The same usual pool of technicians.

To fulfil this third necessity, the RTTP-IO right at the start faced a problem because of its structural shortage of manpower. Each of the two vessels chartered for the Project can easily harbour three tagging stations

according to the place available on board where tagging cradles can be set and the number of fishermen who can provide fish to the tagging platforms (at least two fishermen per tagging cradle). Each tagger must be assisted by one person in charge of receiving the fish brought by the fishermen, taking off the hook if necessary, keeping the untagged fish at the high end of the cradle and passing them one by one to the tagger. In these conditions, with three tagging stations you need between 6 and 9 fishermen, 3 assistants and 3 taggers. The assistant to the tagger can be a dedicated person or a fisherman. However, it should be kept in mind for pole-and-line fishing that the number of fish caught is directly proportional to the number of fishermen. Furthermore, some fishermen are necessary for providing live bait to their colleagues and to the chummer. The technical assistance provided to the RTTP-IO included 3 Cruise Leaders (CL) and 3 Chief Tagging Technicians (CTT) on a rotation basis. Therefore at any one time only 2 CLs and 2 CTTs were available for the two vessels. Consequently, the RTTP-IO did not have enough staff to service 3 cradles which was a pity considering the high cost of chartering the 2 pole-and-line vessels (nearly 2/3 of the M€14 budget of the project).
We benefit from the staff placed on board the vessels by the vessels' contractor, AZTI, to ease the language communication difficulties. The four who boarded the vessels between May 2005 and September 2006 were all biologists and they participated to the tagging.
It was also envisaged that the different countries of the IOC and of the region will provide technicians and scientists who will complete the staff on board. The advantages of this system are to get the countries better involved in the Project and to train their staff. These local staffs were called Regional Tagging Technicians (RTT). And this is how the Project started functioning at the beginning. However the limits of this system were easily obvious: a quick rotation of always new staff which required constant training from an already limited number of CLs and CTTs. Furthermore in term of tagging quality this was very damaging. Consequently we tried to favour the boarding of the same people. Especially we were able to set up with the help of the Seychelles Fishing Authority a poll of 4 technicians who rotates on board. Other technicians from Madagascar, Tanzania and Kenya also boarded the vessels for several cruises. Of the 27 different RTTs who boarded the vessels only 9 of them tagged tuna.
Including the CLs and CTTs, altogether 30 different persons tagged tuna during the RTTP tagging. But 5 of them are accounting for 49% of all tags and 8 for 82%. The RTTs accounted for 32% of all tags but the Seychelles RTTs alone are accounting for 28% of all tags.
In conclusion, the taggers who are accounting for a very large proportion of the tagged tuna were well-experienced in tagging. Therefore we can be quite confident in the tagging quality of the RTTP-IO tagging.

5.5. The geographical distribution of the tags

Figure 8a give the geographical distribution of the tag released. This figure illustrates the overwhelming importance of Tanzania (figure 8b) and the presence of the three species in this area. Oman is characterized by the exclusive tagging of yellowfin, Madagascar is almost totally skipjack while Seychelles is predominantly skipjack with some yellowfin. We can also notice far away off the Indian coasts the tagging of skipjack.
The Tanzania-Kenya area is accounting for 84% of all yellowfin tagged, 95% of the bigeye and 63% of the skipjack (76% of the three species). A zoom of the tag released in this area (figure 8b) shows their remarkable distribution along the coast. The vessels were not able to navigate the AS away from this limited area.

5.6. Tagging by fishing gear

The RTTP-IO used almost exclusively the pole-and-line fishing technique. Some variance in the practical use of this technique took place:

- As mentioned in § 5.3, pole-and-line without bait was widely practised with the ASFT;
- When large yellowfin were accessible, the fishermen used two poles on one line like in Seychelles and very often in Oman;
- Catching tuna on troll lines was also used but on a very minor scale. When fish were quickly pulled on board and were not too damaged by the hook they were tagged and released. Only 601 tuna (463 YFT, 50 BET and 88 SKJ) trolled were released. This practice slowed down quickly with time as

518 trolled fish were tagged in 2005 but only 76 in 2006 and 7 in 2007. Of the 518 tagged in 2005 so far 48 have been recovered which gives a recovery rate of 9.3%. The recovery for pole-and-line tuna caught in 2005 is 13.1%. This lower recovery rate of the trolled tuna might be due to a higher mortality resulting from the gear used to catch these fishes. Hopefully they only represent 0.36% of all tagged tuna.

5.7. Tagging by cradle

On the RTTP tagging vessels cradles were generally set on starboard side but in some particular sea conditions or during the ASFT without bait cradles could be placed at the stern or on port side. According to their positions the cradles were coded as follows:

- FSC: Front Starboard Cradle;
- MSC: Mid-Starboard Cradle;
- BSC: Back starboard Cradle;
- SSC: Stern Starboard Cradle;
- SPC: Stern Port Cradle;
- BPC: Back Port Cradle;
- MPC: Mid-Port Cradle;
- FPC: Front Port Cradle.

For the implantation of the archival tags, a special cradle called ARC (Archival Cradle) was used or a mattress (MAT).

The distribution of the tag released at the different cradles by species is given in table 4. This table shows the importance of starboard side with 80% of the tagged tunas. The differences in species composition between starboard and port sides are biased by the fact that starboard was used everywhere while port side occurred almost exclusively when fishing on the AS without bait. There is a tendency of a bigger proportion of YFT and BET at the back and the stern especially on starboard side.

6. RECOVERIES

6.1. The number of recoveries

The last tagging day of the RTTP-IO was August 29th 2007 but recoveries are still coming at a reasonable rate: in April we already have more than 800 recoveries in our database and this amount is still preliminary. On June 9th 2008, we had 24,147 recoveries in our database. The species distribution of these recoveries is given in figure 9.
If we compare this data to the tagging data (figure 3) we can notice that the species composition between tagging and recovery is not much different consequently recovery rates are quite similar between species (Figure 10): 14.7% for YFT, 13.2% for BET, 14.4% for SKJ and 14.4% overall.

6.2. Recoveries per month

The collection of recoveries per month is in figure 11. The date taken into consideration is the date of return: the date the tag and the information are handled to the RTTP recovery team. It is remarkable that recoveries started to pick up only in February 2006 even if at the end of January 2006 the RTTP-IO has already released 30,000 tagged tuna. This means that most tagged tuna were not recaptured quickly. This feature remains a constant aspect of the RTTP tagging: we were not tagging close to the purse seine fleet and consequently it took some times before the fish were caught by the purse seine fleet.

The recovery per month picked up in March, April and July 2007 with more than 1,600 tags. Then it slowed down to reach a lowest point in February 2008. Numbers are still preliminary but there is an increase in the recoveries in March and April 2008.

6.3. Recoveries by type of tag

The numbers of recoveries by tagging mode are given in table 5 and the recovery rates per species and per tagging mode in table 6 and figure 12.

The recovery rates are very different according to the tagging month except for the ST and DT tagging which have a quite similar recovery rate but to the advantage of the DT. This higher recovery rate for DT might be due to (1) a better reporting rate for DT than ST tagged fish and (2) to the double reward. It seems easier to spot a tagged tuna with two tags than with only one tag. The recovery rate of the OTC tagged tuna is surprising with only 9.1% instead of 14.5% for the ST. Two main reasons can be put forward: (1) the lower reporting rate due to the white colour of the tag less visible than the yellow one of the ST and DT tags; (2) a higher mortality rate induced by the OTC injection. Regarding the lower reporting rate, we noticed that the recovery rate of the smaller white tags (smaller size and smaller diameter of the tag) is only 7.5% while the one of the larger tag by length and diameter is 9.1%. A lower detection will mean that a higher proportion of tagged fish will pass the first detections points (at sea or during unloading) to be discovered on reefers, or in cold stores or in canneries. The percentages of recoveries done in these last platforms are:

- 4.6% for DT;
- 11.1% for ST
- and 19.3% for OT

The reporting rate of the archival tagged tuna is even lower: 2.4%. We have a real problem at this level because among the 7 recoveries of archival tagged fish several have lost the archival tag and retained only the red spaghetti tag.
Several hypotheses can be brought forward:

- A lower reporting rate due to the red colour of the tag;
- A higher mortality rate due to the surgical operation and associated lengthy time out of sea together with the OTC injection;
- A lower recovery rate for these YFT and BET greater than 60 cm;
- A strong rejection process but this will not apply to the red spaghetti tag.

The recovery rate is decreasing with the size at tagging however for BET between 60 and 80 cm at tagging (most ET tagged tuna are within this range) the recovery rate of ST/DT tagged fish decrease from 10.2 to 6.1% and for YFT from 13.3 to 9%; nothing close to the 2-3% of the ET tagged tuna.

6.4. Recoveries per gear

The recoveries according to the gear used for the recapture are given in table 7. Recoveries by purse seiners are tremendously high. Pole-and-line recoveries (483 or 2%) are almost all from the two RTTP chartered vessels (457 including 250 YFT, 88 BET and 119 SKJ). This high recaptures by our vessels is the consequence of the ASFT (432 out of the 457). These recaptures by the chartered vessels were considerably reduced by the policy put into place when fishing on the Associated School. It was decided that every recaptured fish will be re-released except if the fish or the implantation of the tag was bad (432 were in this case). All re-released tagged tuna had their tag number(s), species, length, date, position and state registered anytime they were recaptured (ref. §6.12). The few other pole-and-line recoveries are coming from Maldives.
Considering the importance of the recoveries by purse seiners, it was essential to estimate the reporting rate from this fishery. This is done via a tag seeding operations conducted by the IOTC since 2004, with the collaboration of the RTTP since 2005 and the support of the purse seiners as well as their representatives and EU observers. This operation will be carried on until the end of the RTTP-IO. The preliminary findings are released during the actual meetings.

The extreme importance of the recoveries by purse seiners is for the three species; only the YFT with 93.7% is slightly better caught by other gears.

On the opposite, the low numbers of recoveries by the other gears is not only related to their lower tuna catches than the purse seiners as non-reporting of recoveries is often playing an important part in all artisanal fisheries but also in longline fisheries.

Gillnet recoveries are coming from "artisanal" fleets from Tanzania, Sri Lanka, Iran, Kenya, Oman and Maldives.

Handline recoveries are reported by Comoros, Tanzania, Kenya, Oman, Thailand, Mayotte, Seychelles, Sri Lanka and Yemen.

Longline recoveries are reported by Japan, Taiwan, Korea, South Africa, Indonesia, Mayotte, La Reunion and Spain. The number of recoveries still remains very low as numerous YFT and BET tagged as juveniles by the RTTP have now grown up and entered into the longline fishery. But between January and April 2008, this number has almost doubled and we have still 15 more recoveries already reported but not yet in the database. We are devoting more efforts in publicity, Tag Recovery Scheme and missions to raise the awareness and the tag reporting from the different longline fleets active in the Indian Ocean.

6.5. Recoveries by size at tagging and at recapture

As much as possible sizes at recovery are collected. These data are illustrated in figures 13a, b & c for yellowfin, bigeye and skipjack respectively.

The important shift of the recovered size curve from the tagging size curve is the consequence of the fish growth as well as the large time-at-liberty (ref. § 6.7). The RTTP-IO is also collecting now some large yellowfin and some large bigeye in fewer numbers which have been at sea for long periods. These recoveries are bringing interesting information on the growth and movements of these large individuals of these two species. Skipjack is also affected at a lesser degree by the same situation.

6.6. Recovery rates by size at tagging

Figure 14 gives the recovery rate by 5 cm class at tagging for the three species. Generally the recovery rate for the smaller class (<40 cm) is much lower than for the following classes except for BET. Does it reveal a lower natural and fishing mortality for these very small BET? Then, for BET and SKJ there is a very sharp decrease starting from a maximum reached at 45-49 cm for SKJ and 50-54 cm for BET. The slope for YFT is less sharp because large YFT have been tagged by the RTTP and caught by purse seiners. The slope is driven by the natural and the fishing mortality of the different species. It can also be influenced by the migration of some of the fish outside the purse seine fishing grounds.

6.7. Recovery rates by tagger

Figure 15 illustrates the recovery rates by tagger. We have only kept tagger with more than 1,000 tags released; they are accounting for more than 98% of all tagged and recovered tuna. One can notice the low dispersion of the data, another parameter related to the good quality of the tagging of the RTTP-IO. The tagger with the lowest RR (<10) has released all his tagged fish during the last three tagging months. Therefore we can expect that his RR will increase with time.

6.8. Where recoveries were found

The recovery can take place either at sea (often associated to a precise date and position) or at unloading, transhipping or on reefers, cold stores or canneries. Further down the line of the tuna process the recovery takes place lower will be the quality of the data collected. In the quality section we will come back on this point. Table 8 give the distribution of the different locations where the recoveries took place. For the other fishing gear, recoveries are found at sea, or in fish market or at the cannery.

For purse seiners when the recovery is found on the vessel itself while unloading or transhipping we should have one or several possible wells from where the tagged tuna is coming from. With the logbook of the purse seiners we will be able to associate to this recovery the different sets loaded at sea into this well. This will give us one or several possible date(s) and position(s). This sets attribution to a recovery is called the data editing. This is processed from time to time when purse seine logbooks are made available.

6.9. During what process recoveries were found

The process undergo by the fish when the recovery is found gives also an indication on how good the recovery data will be. The distribution of the recoveries by process is given in table 9.
From tables 8 and 9, it is good to note that 27% of the recoveries are found at sea during fishing therefore most of those will be associated to precise date and position of recovery and another 64% are found on the fishing boat (purse seiners) and can therefore be associated to one or several well number(s). Even if reefers and canneries are improving their traceability, recoveries found on reefers, in cold stores, or in canneries somewhere along the tuna processing line will generally have no or very imprecise data in term of date(s) and position(s) of recovery. Only 10% of the recoveries are in this situation.

6.10. What state of the recovered fish

Table 10 is giving the proportion of fish state. The state of the fish, fresh or frozen, will play a role on the species identification (especially between juvenile YFT and BET) and on the length: (1) frozen fish might be smaller than fresh one; (2) frozen fish can be bent, flattened or crushed.

It is thought that fresh fish when frozen will shrink; we are searching for some relation between fresh and frozen tuna to check if corrections are necessary. But the shrinkage could be mostly post-mortem than to the freezing action.
However, all fish found at sea on board purse seiners are not measured or weighted fresh. Many vessels agree on keeping the recovered tuna into their food freezer; calling on our Tag Recovery Team while in port to collect the date and position of recovery, to identify the species, to measure and weight the frozen fish.

6.11. Recoveries from fish tagged in the Associated School

The ASFT has been detailed in §4.5 and some aspects related to the recoveries discussed in §6.4. This technique was implemented in 2006 (April 15th to December 1st) and in 2007 (from June 1st to August 29th). In 2006, 79,255 tuna were released in the AS and in 2007, 43,343. They accounted for 81% of all fish tagged in 2006 and 89% in 2007. Altogether 73% of all RTTP-IO tagged tuna were tagged in an Associated School.

In this peculiar fishing technique tuna are always present under and around the vessel. The school size was estimated by the captains between few tenths to several hundred tons. If the turn-over in the school is not sufficient as many tuna that belong to the school are tagged every day, the proportion of tagged tuna in the school will increase and result in increasing recaptures. Considering the fishing success on the AS at the beginning, we feared this scenario and in fact recoveries were registered in the very first days of fishing the school. As these recoveries were not serving the objectives of the RTTP-IO - the tagging vessels are not part of the fishing effort on the three stocks - it was decided to re-released all recoveries except when the fish was in bad shape or the tag ready to fall. Furthermore, when the recovery rate during a tagging session became too high (25% or more), fishing was stopped until the next session. There were usually 3 sessions per day: one around 5h45-6h30, the second around midday and a third before sunset.

The species compositions between tagged and recaptured fish are illustrated by figures 16 and 17. The 2007 AS is much richer in BET and richer in SKJ to the detriment of YFT (figure 17). But in both years, YFY + BET accounted for the largest proportion: 70% in 2006 and 67% in 2007.
Species compositions between tagging and recovery can be different within a year and between years underlying differences in abundance, behaviour and/or turn-over in the school.

The proportions of tagged tuna among the tuna caught daily for the 2006 and 2007 AS are given in figure 18a & b respectively. Tuna that ended up on deck (not re-released) are accounted for in these figures. It can be noted from these two figures that the evolution of the proportion of tagged tuna in the daily catch is quite different between both years: in 2006 (figure 18a), it tended to be high at the beginning and then to decrease sharply becoming often close to nil with a bit of increase at the end; in 2007 (figure 18b), it goes up and down but tend to remain higher. In fact the overall proportion for 2006 AS is 7.1% but 10.9% in 2007 AS. The captains recognized that on average the AS of 2007 was not as big as the one of 2006. The number of recaptured fish that cannot be re-released accounted for 215 fish in 2006 (4.7% of all fish recaptured) and 217 in 2007 (5% of all recaptured). All recaptures while fishing the AS were registered.
The overall number of recaptures and the number of fish on deck remained very reasonable when one considers the very large number of tagged tuna during both years. This demonstrates the high turnover of tuna in the AS which brought us to call this AS and the region the "tuna hub" of the Western Indian Ocean.

One unexpected result for the AS is the multiple returns of the same fish. Some tagged tuna were so unaffected by their tagging experience that they continue to bite on our lines and some at a totally unreasonable rate. In 2006, 5 YFT were fished 8 times; the 1st they were tagged and the 7 other times they were registered and re-released. These multiple recaptures occurred between 36 and 96 days. In 2007, a SKJ was caught 10 times during a 59 day period. The number of recovery occurrences and the recoveries by each individual are given in table 11a & b (a for 2006 and b for 2007).

The Associated School has permitted the release of a very large number of fish of the three species with a majority of yellowfin and bigeye. As soon as 2006, the recoveries from the AS proved to be very valuable as they were not caught rapidly and most of the fish moved out quickly away from Tanzania waters and mixed pretty well with the rest of the populations. Tanzania and the AS proved to be an incredible asset for the RTTP-IO.

6.12. Time-at-liberty

The durations between the date of release and the date of recovery called time-at-liberty (TL) are given in figures 19 a, b, c for YFT, BET and SKJ respectively. We have not taken into consideration the 457 recoveries done by the RTTP chartered vessels while fishing on the AS.
For YFT, the mode of the distribution is at 3 months and from that maximum it decreases regularly; more than 50% of all releases are recovered more than 6 months after their release. There are still 21% of the releases more than 1 year after release.
For BET, the mode of the distribution is at 9 months but after that there is a sharp decrease; more than 50% of all releases are recovered more than 7 months after their release. There are still 11% of the releases more than 1 year after release.
For SKJ, the mode of the distribution is at 3 months and from that maximum there is a regular decrease as for YFT; more than 50% of all SKJ releases are recovered more than 5 months after their release. There are still 12% of the releases more than 1 year after release.
The average time-at-liberty are 145, 204, 212, 216 and 345 for Oman, Seychelles, International waters, Tanzania and Mozambique areas respectively. For Oman, this low value underline a possible non-vulnerability to fisheries for most fish tagged; we are expecting that these fish will be recovered later as spawning adult in the purse seine fishery. The high value for the Mozambique Channel tagged tuna is due to the fact that tagging took place at the end of the season therefore most tagged tuna have to move a long way before they can get caught by PS or were caught only the year after when the Mozambique Channel season starts again. It is remarkable that TL for the other three areas is almost the same denoting the similar mixing of the tagged fish within the PS catch.
The general aspect for the three species is a low recovery rate during the first month after release then a sharp increase during the 2nd month for YFT and SKJ but a more moderate increase for BET followed by a regular decrease leading to few fish recovered after 2 years. For YFT and BET there is a slight increase for recoveries between 18 and 21 months.
Figure 20 shows the wide spread distribution with time of the fish tagged each month between May 2005 until August 2007.

6.13. Growth between tagging and recovery

With lengths taken at tagging and at recovery growth of the three species will be assessed and these data are very robust. They will be completed with the reading of the OTC otoliths in order to obtain a length-age relationship. A first look at the data has shown that the growth curves presently used by the IOTC for the assessment of yellowfin and bigeye are not supported by the tagging-recovery data. On the contrary, the RTTP-IO data would support the Skipjack growth curve used by IOTC (Adam, 1999).

When we just look at the average increment per month at sea for the three species we have an average growth of 2.3 cm/month, 1.7 and 0.6 for yellowfin, bigeye and skipjack respectively. These average increments are quite variable with the size of the fish. For yellowfin and bigeye, there would be a slower growth between 45 and 60 cm followed by a remarkable increase after 60 cm until the fish approach maturity when growth will slow down. A two stanza growth curve for yellowfin has already been described in most of the other oceans but a similar growth curve for bigeye is very new. But studies will have to confirm these first assumptions.

6.14. Recoveries by geographical area

Figure 21 shows the geographical distribution of the recoveries of the three species. Considering the overwhelming importance of the recoveries from the purse seine fleet, this distribution gives a good idea of the purse seine fishing area (figures 22 a, b).
Figures 23 a, b, c illustrate the theoretical movements between the tagging and the recovery positions for the three species. The general aspects are (1) a large dispersion of the RTTP tagged tuna including some ocean crossing recoveries towards Indonesia; (2) the dispersion similarities between the three species; (3) the importance of the average distances travelled (cf. next §). Presently, the IOTC stock assessments are based on the hypothesis of a unique stock for the all Indian Ocean for each species. The RTTP-IO tagging results prove that it is the case:

(1) YFT, BET and SKJ moving from the Western part of the Ocean into the Eastern part;
(2) YFT from Tanzania and Seychelles moving to the Arabian Sea and from the Arabian Sea to the South of the Equator;
(3) BET moving from Tanzania to the South of Madagascar and off South Africa;
(4) SKJ from the Mozambique Channel moving among the entire PS fishing area and up to the Arabian Sea and to Maldives;
(5) The central role of Seychelles in the Western Indian Ocean as fish tagged in this region are radiating in all directions.

Another paper is dealing specifically on the movements issued from the tagging and recovery positions.

6.15. Distances travelled

Distances travelled measured as a direct line between tagging and recovery positions are given in figures 24 a, b, c for YFT, BET and SKJ respectively. As previously we have not taken into consideration the recoveries done by the RTTP chartered vessels while fishing on the AS.
Modes are at 800 miles for YFT and 600 miles for BET and SKJ. The average distances are 696 miles for YFT, 637 miles for BET and 654 miles for SKJ. Distances travelled are more or less the same for the three species however these data together with the previous ones illustrated in figure 23 give the following picture:

- YFT movements are the most developed among the three species;
- SKJ: the amplitude of the SKJ movements appears as important as for YFT (figure 23c); however they present the lowest average distance travelled. This apparent contradiction is due to the fact that significant numbers of SKJ were released off Seychelles and those experienced a lower average distance travelled driving down their total average distance travelled. For YFT the overwhelming importance of Tanzania is giving them a higher average distance travelled.

- BET movements are more restricted to the West (less BET recoveries are recorded East of 60°E than for YFT) than for YFT even if some fish are recaptured in the Eastern Indian Ocean.

Some individuals from the three species crossed the all ocean from the African coasts to Indonesia.

If we compare the average distances travelled according to the tagging area we notice the following data: 325, 385, 600, 644 and 731 miles for Seychelles, International waters, Oman, Mozambique Channel and Tanzania respectively. As mentioned before in § 6.14, fish tagged in Seychelles are not moving away from this area as much as for Tanzania. Fish tagged in the Mozambique Channel or in Oman either are recaptured locally or they have to move quite far before entering active tuna fishing zones explaining the high distance travelled. The highest average distance travelled is Tanzania which confirmed the "Tuna hub" aspect of this region and the generally low abundance of tuna in this region and beyond which keeps away most PS from the region. This fast moving outside the AS is illustrated by figure 25. The first 4 bars of the figure correspond to the average distance travelled (DisT) for the recoveries made after 7, 14, 21 and 30 days (1 month) after tagging. One month after tagging the Tanzanian releases are registered with an average distance travelled of more than 800 nm. This confirms the Tuna hub vision of this region: tuna present in this region are leaving it very quickly in all directions; consequently they spread rapidly in the all PS fishing grounds. This makes the Tanzania area a perfect tagging spot well-fit to the objectives of the RTTP-IO.
Between 4 months and 25 months of TL, the average DisT is more or less between 600 and 800 nm. There are some decreases for 9-10 months at liberty and for 21-22 months at liberty; it might be due to the return of some fish towards their tagging location or link to the seasonality of the PS fishery. This needs to be investigated.

7. CONCLUSIONS

The RTTP-IO has more than fulfilled its target in term of number and species of tuna tagged but it has also registered a very large number of recoveries characterized by genuine long time-at-liberty and large distances travelled. It demonstrates movements from West to East all across the Indian Ocean confirming the existence of only one stock for each tropical tuna species. It also shed new lights on the growths of yellowfin and bigeye. Other documents presented during these meetings and analysis conducted during the WPTDA as well as later will bring more information on the status of the tuna stocks of the Indian Ocean.

Table 1: Distribution of the activities of the two vessels (in days and in %)

Codes	***Description of the activity codes***	***Duration***
PO	In Port for rotation of crew, for provisions or for preparation	328.6
BA+BF	Anchored or searching for bait and Bait fishing	323.7
SD+SN	Steaming during the day or the night	308.3
SE+SS	Searching for tuna schools	361.3
CH+FI	Chasing and Fishing a tuna school	66.1
DR+DG+DL+DS	Drifting for several reasons	277.3
DW	Drifting or at anchor or in port because of bad weather	8.7
DT	Drifting or at anchor or in port because of mechanical problems	55.5
	Total duration (in days)	*1729.5*

Table 2: Periods and durations spent by the RTTP-IO vessels in the waters of the different countries of the Western Indian Ocean

	Start[1]	End	Duration
Seychelles	29/04/2005	18/05/2005	19
Mozambique Channel[2]	19/05/2005	18/07/2005	60
Tanzania/Kenya[3]	19/07/2005	06/11/2005	110
Seychelles	11/11/2005	16/11/2005	5
Oman	20/11/2005	10/12/2005	20
Seychelles	15/12/2005	07/01/2006	23
Madagascar/Seychelles[4]	08/01/2006	23/02/2006	46
Tanzania	24/02/2006	09/03/2006	13
Madagascar/Seychelles[4]	10/03/2006	02/04/2006	23
Tanzania/Kenya[3]	06/04/2006	13/12/2006	251
Seychelles	16/12/2006	10/01/2007	25
Tanzania	13/01/2007	18/01/2007	5
Seychelles	22/01/2007	27/01/2007	5
Oman	02/02/2007	24/04/2007	81
Maldives	02/05/2007	11/05/2007	9
Seychelles	16/05/2007	21/05/2007	5
Tanzania/Kenya[3]	23/05/2007	05/09/2007	105
Seychelles	08/09/2007	11/09/2007	3

[1] The days between were spent in International waters

[2] Madagascar, Comoros, Mayotte & Mozambique

[3] Baiting off Madagascar, tagging off Seychelles

[4] Mostly in Tanzania, episodically in Kenya

Table 3: Number of tagged tuna by species and by tagging type

	YFT	BET	SKJ	UNK	Total	***% type***
Single yellow dart tag (ST)	41744	24528	67198	378	133848	***79.6***
Double yellow dart tag (DT)	10677	7518	9620	30	27845	***16.6***
OTC white dart tag (OT)	2004	2429	1487	24	5944	***3.5***
OTC + sonic + white dart tag (OTS)	14	12	14		40	***0.0***
OTC + archival + red dart tag (ET)	222	67			289	***0.2***
Unknown type of tag (UN)	2	16	5	174	197	***0.1***
Total	*54663*	*34570*	*78324*	*606*	*168163*	
Percentage (%)	***32.5***	***20.6***	***46.6***	***0.4***		

Unknown type of tag can be either ST or DT

Table 4: Tag releases by cradle and by species

	Numbers					% species				% of Total
	YFT	BET	SKJ	UNK	Total	*YFT*	*BET*	*SKJ*	*UNK*	**tagged**
FSC	11528	6458	17119	134	35239	*32.7*	*18.3*	*48.6*	*0.4*	**21.0**
MSC	15577	9432	26441	180	51630	*30.2*	*18.3*	*51.2*	*0.3*	**30.7**
BSC	18335	9752	18575	103	46765	*39.2*	*20.9*	*39.7*	*0.2*	**27.8**
SSC	2136	2622	2998	73	7829	*27.3*	*33.5*	*38.3*	*0.9*	**4.7**
SPC	611	901	287	5	1804	*33.9*	*49.9*	*15.9*	*0.3*	**1.1**
BPC	3823	1514	2826	19	8182	*46.7*	*18.5*	*34.5*	*0.2*	**4.9**
MPC	2446	3814	10049	92	16401	*14.9*	*23.3*	*61.3*	*0.6*	**9.8**
FPC	34	12	15		61	*55.7*	*19.7*	*24.6*	*0.0*	**0.0**
ARC	169	65	14		248					
MAT	4				4					
Starboard	45440	25642	62135	417	133634	*34.0*	*19.2*	*46.5*	*0.3*	**79.5**
Stern	2747	3523	3285	78	9633	*28.5*	*36.6*	*34.1*	*0.8*	**5.7**
Port	6303	5340	12890	111	24644	*25.6*	*21.7*	*52.3*	*0.5*	**14.7**

Table 5: Recoveries by tagging mode

	YFT	BET	SKJ	UNK	Total	***% type***
Single yellow dart tag (ST)	6104	3396	9933	1	19434	***80.5***
Double yellow dart tag (DT)	1705	999	1451	1	4156	***17.2***
OTC white dart tag (OT)	207	158	174		539	***2.2***
OTC + archival + red dart tag (ET)	5	2			7	***0.0***
Unknown type of tag (UN)	1	4	5	1	11	***0.0***
Total	8022	4559	11563	3	24147	
Percentage (%)	***33.2***	***18.9***	***47.9***	***0.0***		

Table 6: Recovery rates per species and per tagging mode

	DT	ET	OT	ST	Total
YFT	16.0	2.3	10.3	14.6	14.7
BET	13.3	3.0	6.5	13.8	13.2
SKJ	15.1		11.7	14.8	14.8
Total	***14.9***	***2.4***	***9.1***	***14.5***	***14.4***

Table 7: Recovery per recapture gear and per species

	YFT	BET	SKJ	UNK	Total	***% per gear***
Purseseine	7515	4435	11297	3	23250	***96.3***
Pole line	255	88	140		483	***2.0***
Gil net	129	4	52		185	***0.8***
Hand line	57	16	34		107	***0.4***
Troll line	20		32		52	***0.2***
Longline	27	16	3		46	***0.2***
Unknown	19		5		24	***0.1***
	8022	4559	11563	3	24147	

Table 8: Locations where the recoveries took place

	YFT	BET	SKJ	UNK	Total	*% per location*
At sea	2379	1383	2522	1	6285	***26.0***
Fish. boat in port	5031	2866	7432		15329	***63.5***
Cannery	428	206	1269		1903	***7.9***
Reefer	138	94	275	2	509	***2.1***
Cold store	14	5	37		56	***0.2***
Fish market	16	1	3		20	***0.1***
Other	5	1	3		9	***0.0***
unk	11	3	22		36	***0.1***
	8022	4559	11563	3	24147	

Table 9: Process involved when the recovery took place

	YFT	BET	SKJ	UNK	Total	% per process
Fishing	2482	1433	2564	1	6480	26.8
Unload	1977	1381	3908	2	7268	30.1
Transfer	3121	1544	3815		8480	35.1
Sorting	276	139	868		1283	5.3
Ranking	28	16	117		161	0.7
Butcher	71	19	58		148	0.6
Other	39	19	125		183	0.8
unk	28	8	108		144	0.6
	8022	4559	11563	3	24147	

Table 10: Recoveries per fish state

	YFT	BET	SKJ	UNK	Total	*% per fish state*
Frozen	7055	4132	10791	2	21980	***91.0***
Fresh	924	408	671	1	2004	***8.3***
Cooked	16	18	76		110	***0.5***
Unk	27	1	25		53	***0.2***
	8022	4559	11563	3	24147	

Table 11: Recoveries from the Associated school by the RTTP vessels (by occurrence and by individual fish); a (on top) = 2006; b (bottom) = 2007

	2006 ASSOCIATED SCHOOL									
	Occurence					Individual fish				
Return Nb	YFT	BET	SKJ	UNK	Recoveries	YFT	BET	SKJ	UNK	Fish recovered
1	3342	640	579	7	4568	2512	590	463	3	3568
2	830	50	116	4	1000	570	46	74	4	694
3	260	4	42	0	306	154	4	29	0	187
4	106	0	13	0	119	69	0	11	0	80
5	37	0	2	0	39	25	0	1	0	26
6	12	0	1	0	13	7	0	1	0	8
7	5	0	0	0	5	5	0	0	0	5
Total	4592	694	753	11	6050	3342	640	579	7	4568

	2007 ASSOCIATED SCHOOL									
	Occurence					Individual fish				
Return Nb	YFT	BET	SKJ	UNK	Recoveries	YFT	BET	SKJ	UNK	Fish recovered
1	1764	1570	1019	1	4354	1346	1478	818	1	3643
2	418	92	201		711	330	80	134	0	544
3	88	12	67		167	72	11	41	0	124
4	16	1	26		43	14	1	17	0	32
5	2		9		11	0	0	6	0	6
6	2		3		5	1	0	1	0	2
7	1		2		3	1	0	1	0	2
8			1		1	0	0	0	0	0
9			1		1	0	0	1	0	1
Total	2291	1675	1329	1	5296	1764	1570	1019	1	4354

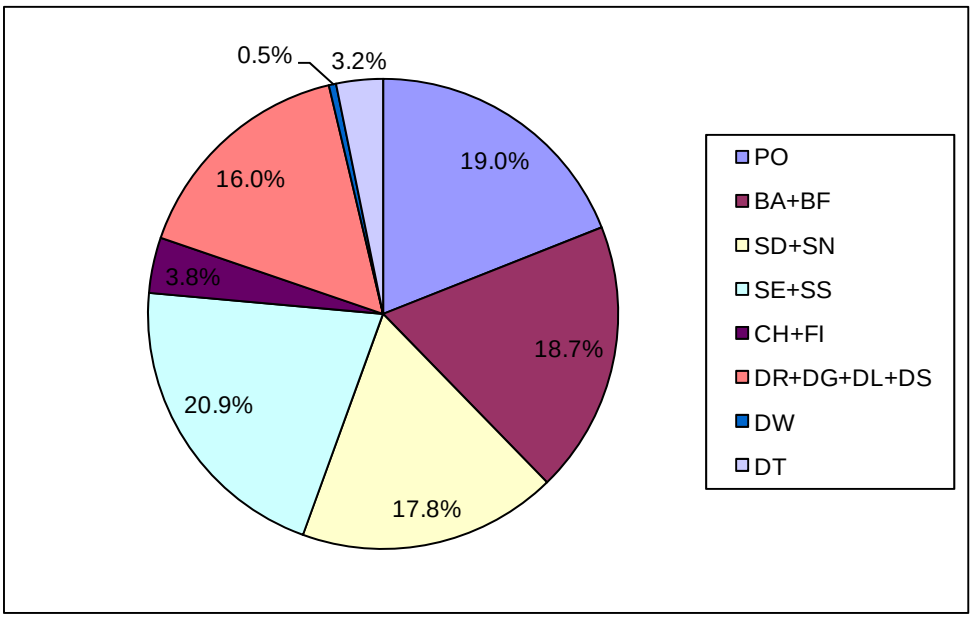


Figure 1: Distribution of the main activities of the two vessels during their operational period (April 29th 2005 to September 11th 2007)

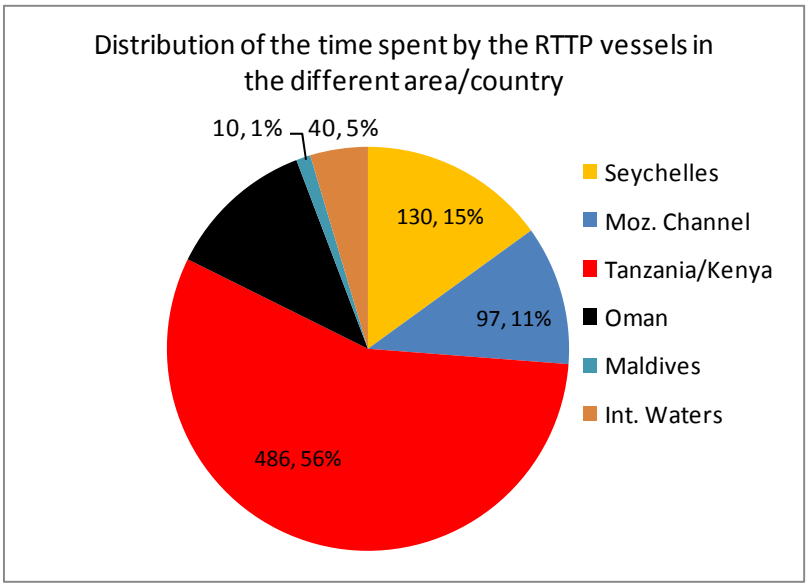


Figure 2: Duration spent in the different area/country of the Western Indian Ocean by the RTTP-IO vessels (in days and in percentage)

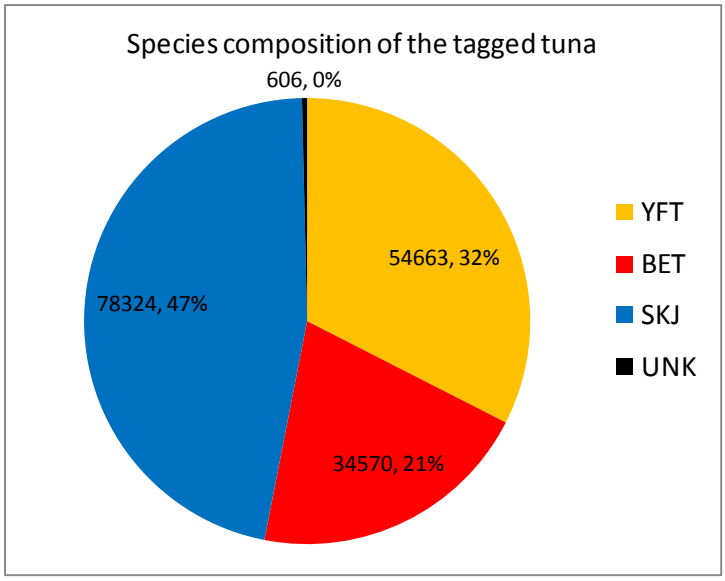


Figure 3: Distribution in number and in percentage by species tagged by the RTTP-IO

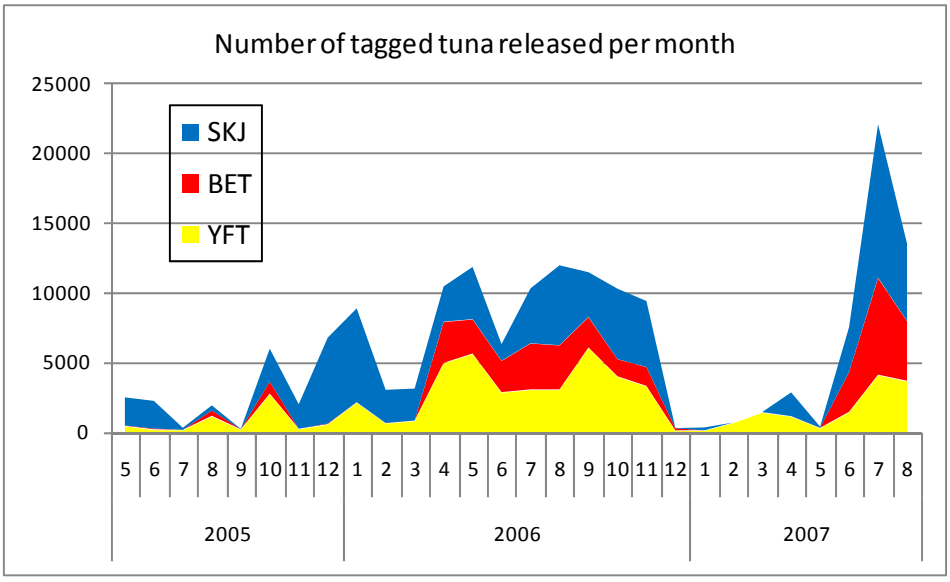
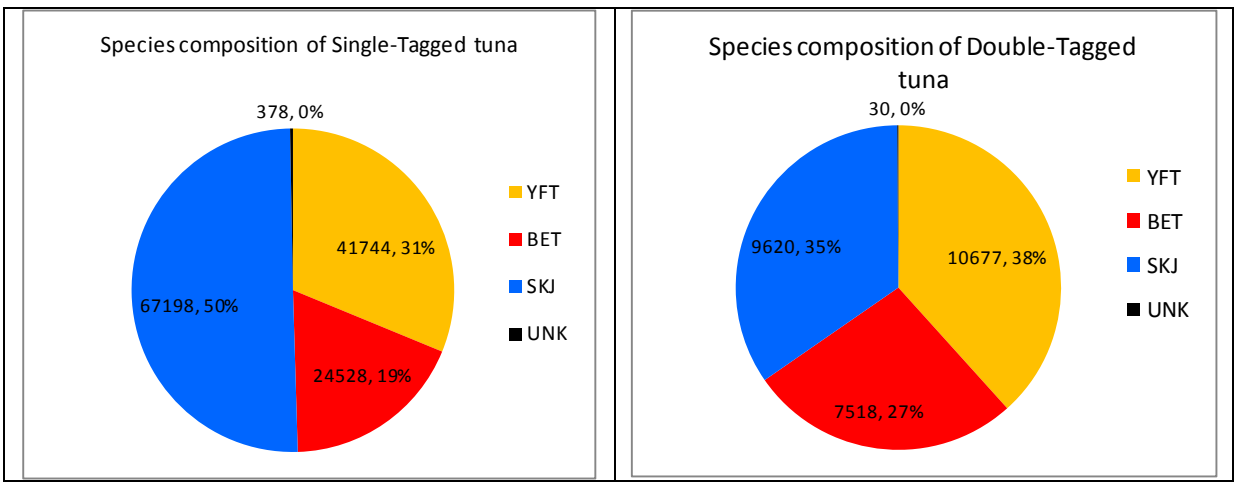


Figure 4: Monthly distribution of the tagged RTTP-IO tuna by species



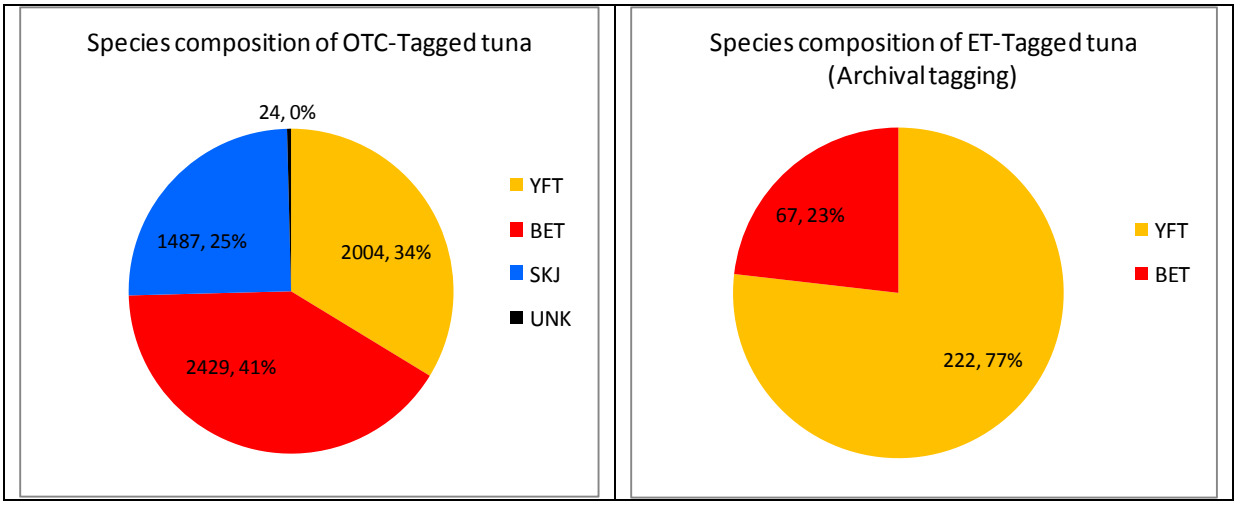


Figure 5: Species composition of the tagged tuna by type of tagging: for single tagging (a: top left), Double tagging (b: top right), OTC tagging (c: bottom left) and Archival (electronic) tagging (d: bottom right)

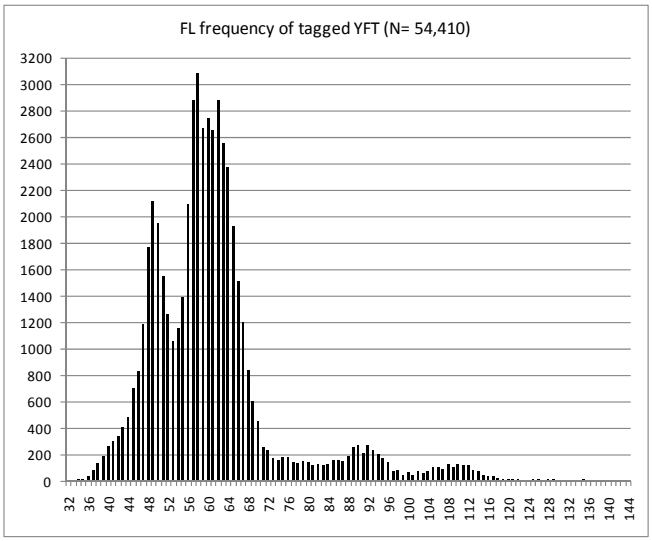


Figure 6a: Size distribution of the yellowfin tagged by the RTTP-IO

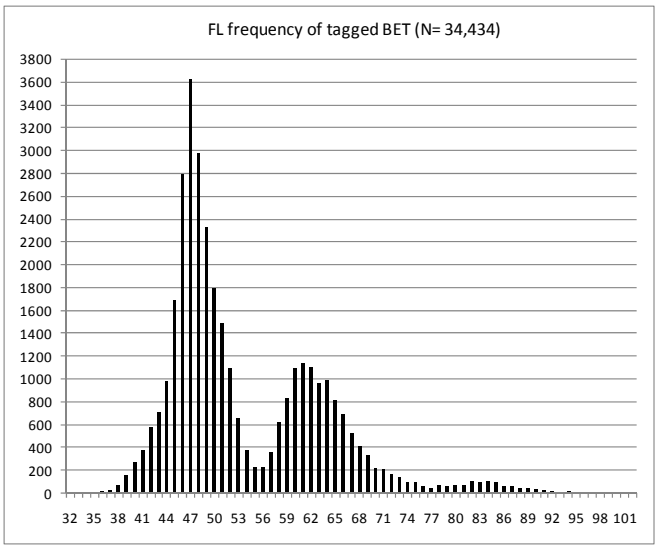


Figure 6b: Size distribution of the bigeye tagged by the RTTP-IO

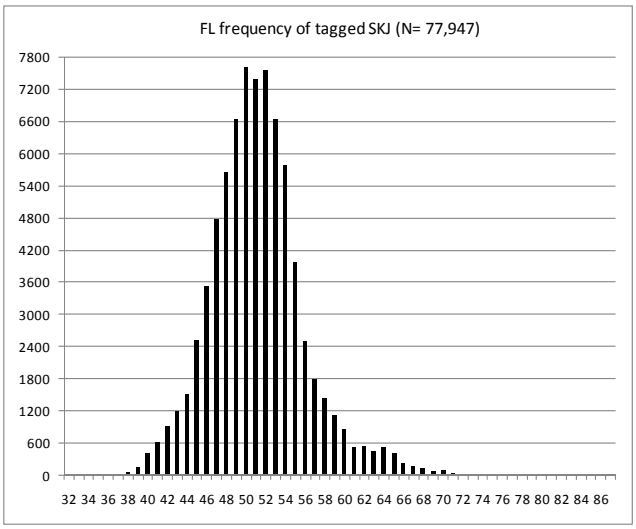


Figure 6c: Size distribution of the skipjack tagged by the RTTP-IO

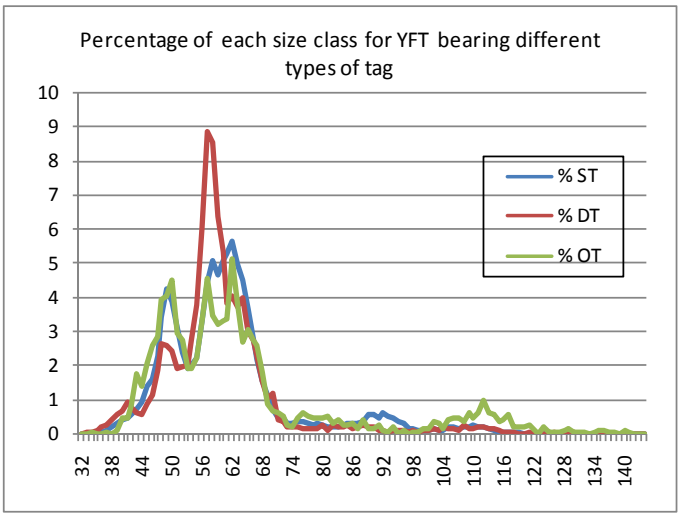


Figure 7a : Distribution of the YFT per size class for different types of tagging
(ST= Single tagging; DT= Double-tagging; OT= OTC tagging)

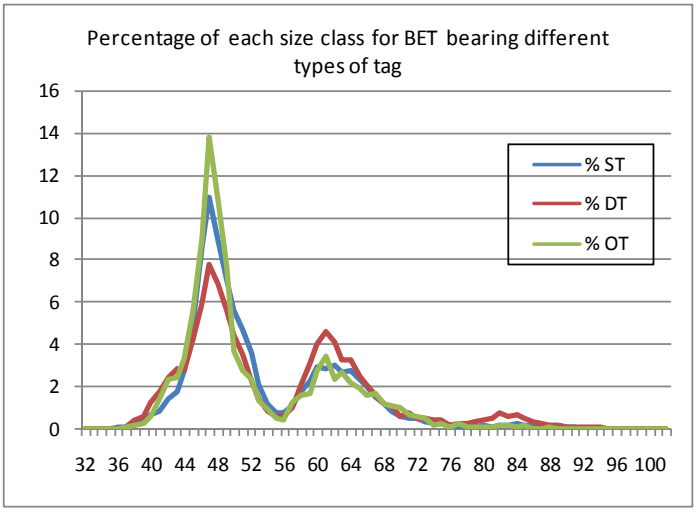


Figure 7b : Distribution of the BET per size class for different types of tagging
(ST= Single tagging; DT= Double-tagging; OT= OTC tagging)

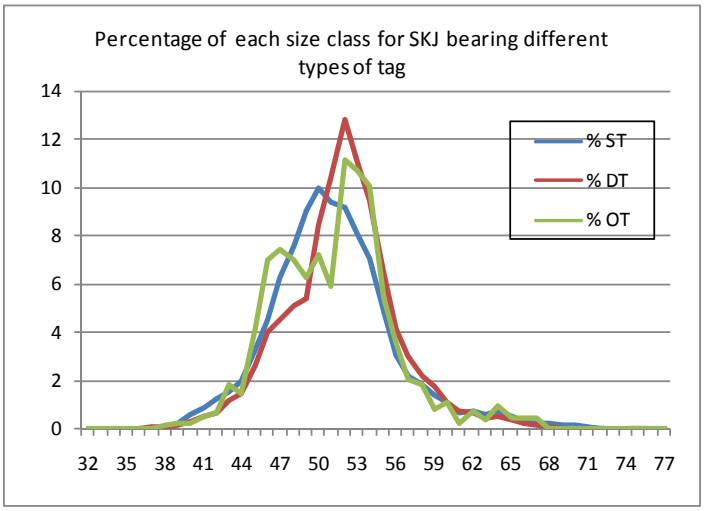


Figure 7c : Distribution of the SKJ per size class for different types of tagging
(ST= Single tagging; DT= Double-tagging; OT= OTC tagging)

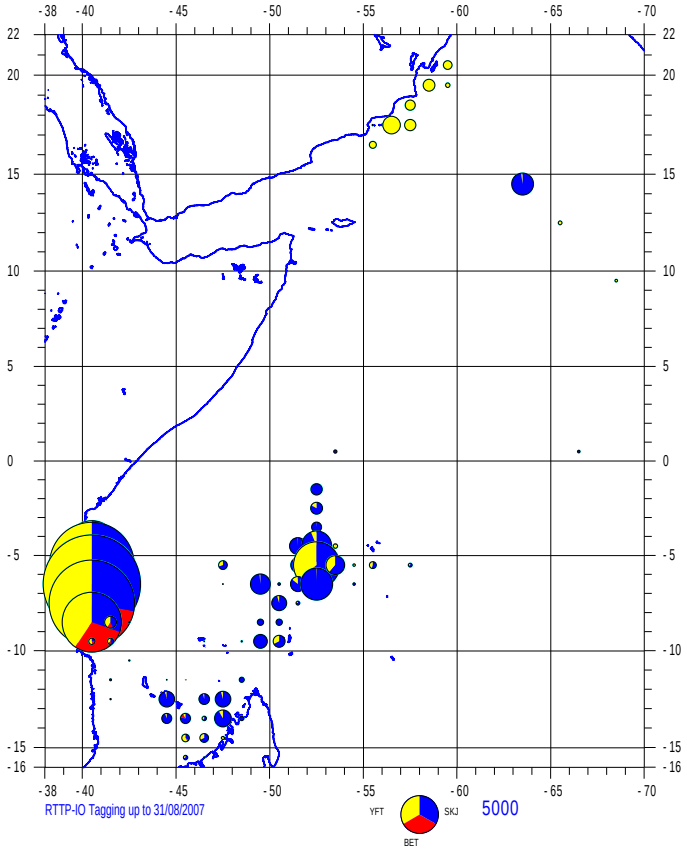


Figure 8a: Distribution of the tags released by the RTTP-IO

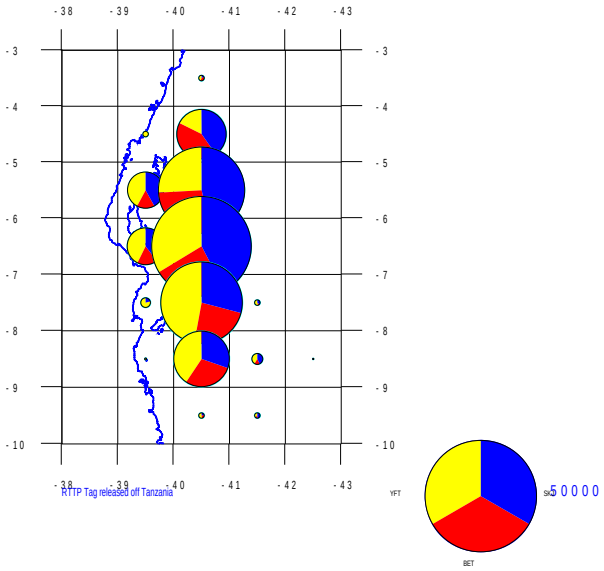


Figure 8b: A zoom on the geographical distribution of the tag released by the RTTP-IO off Tanzanian and Kenyan coasts

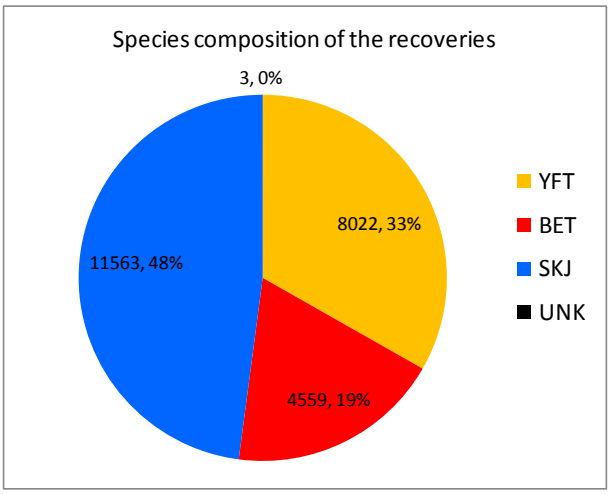


Figure 9: Species composition in number and in percentage of the RTTP-IO recoveries

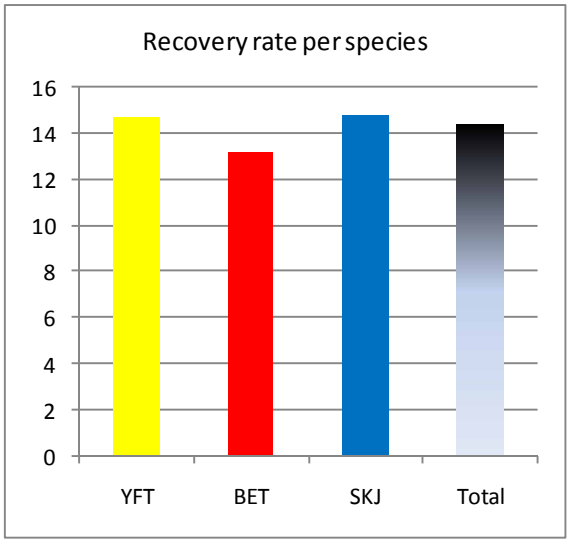


Figure 10: Recovery rate per species

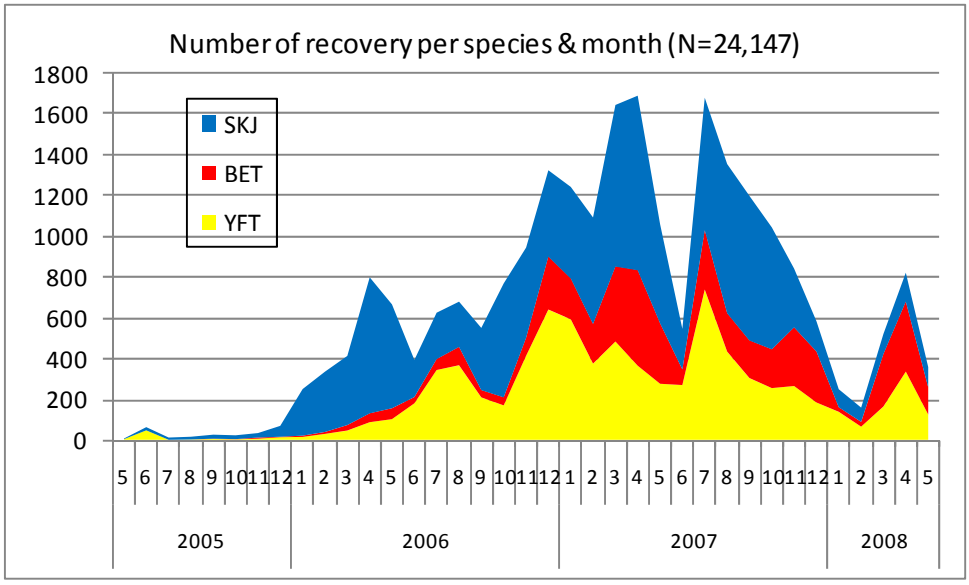


Figure 11: Number of recoveries collected by month (April and May 2008 data are still preliminary)

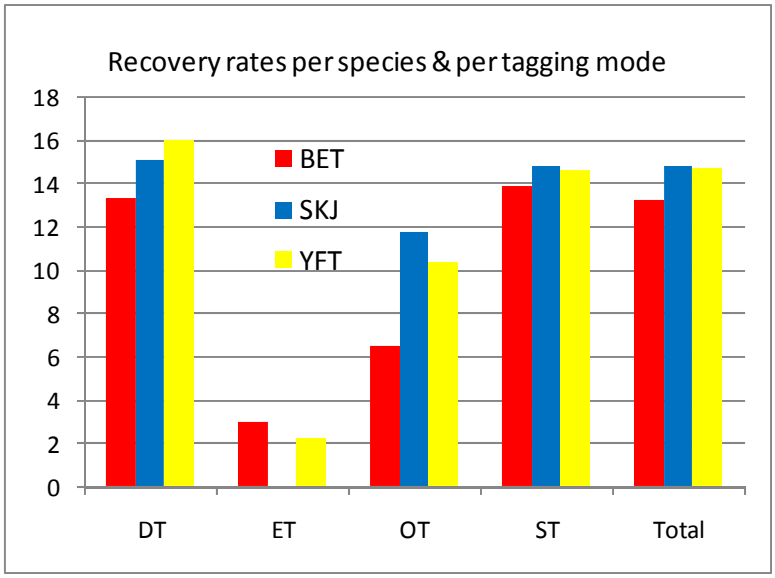


Figure 12: Recovery rate per species and per tagging mode

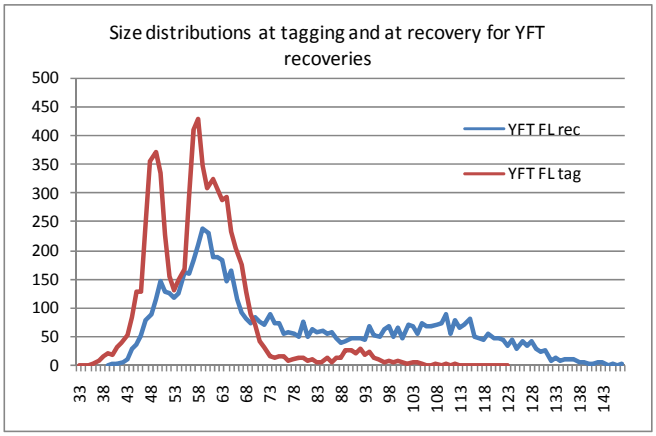


Figure 13a: Size distribution of the YFT recovered and their size distribution at tagging

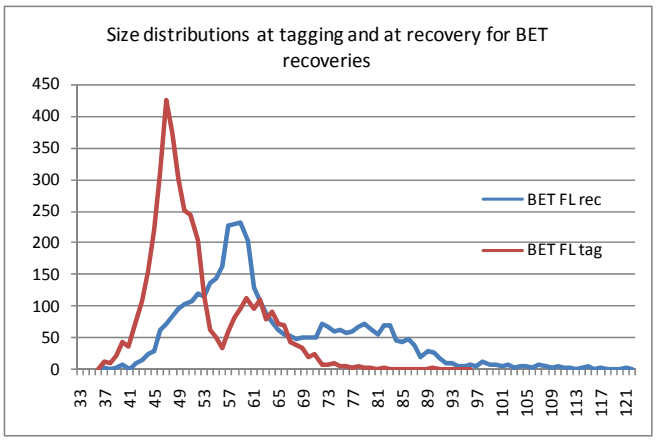


Figure 13b: Size distribution of the BET recovered and their size distribution at tagging

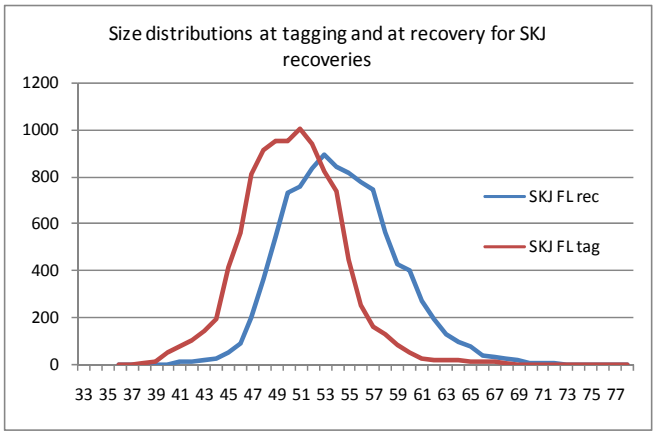


Figure 13c: Size distribution of the SKJ recovered and their size distribution at tagging

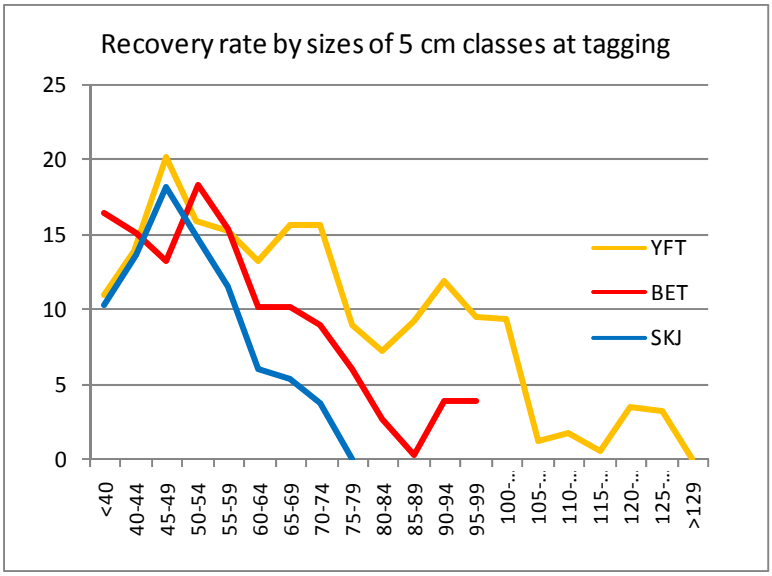


Figure 14: Recovery rate by species for every 5 class interval of fish at tagging

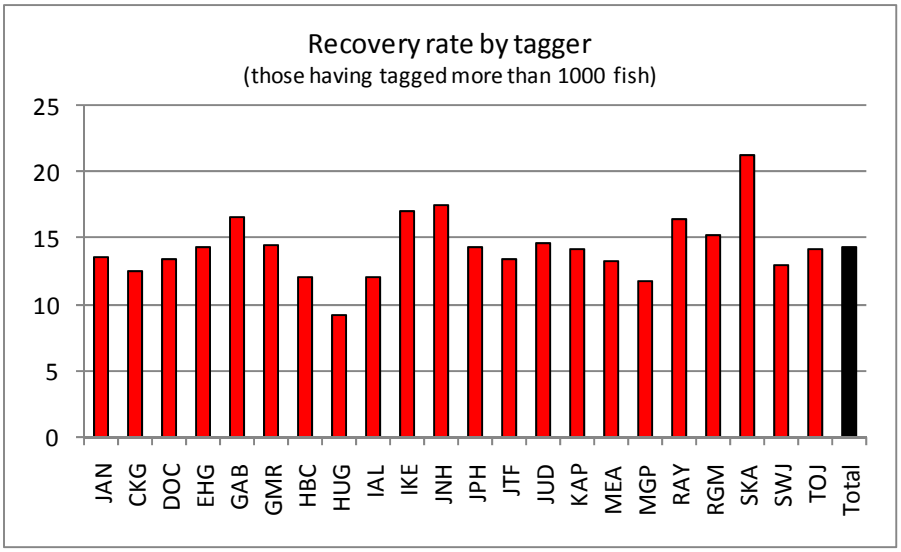


Figure 15: Recovery rates (RR) by tagger with more than 1000 releases

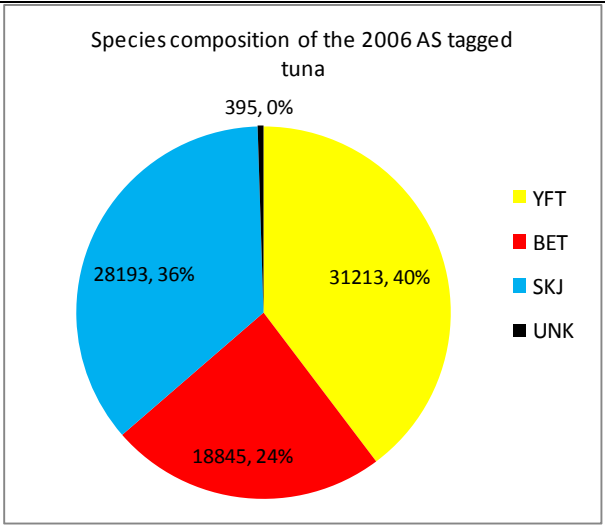


Figure 16a: Species composition of the tuna tagged in the AS in 2006

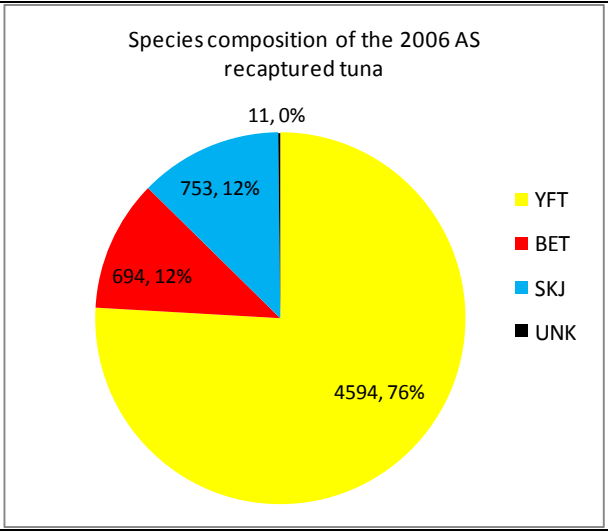


Figure 16b: Species composition of the tuna recaptured in the AS in 2006

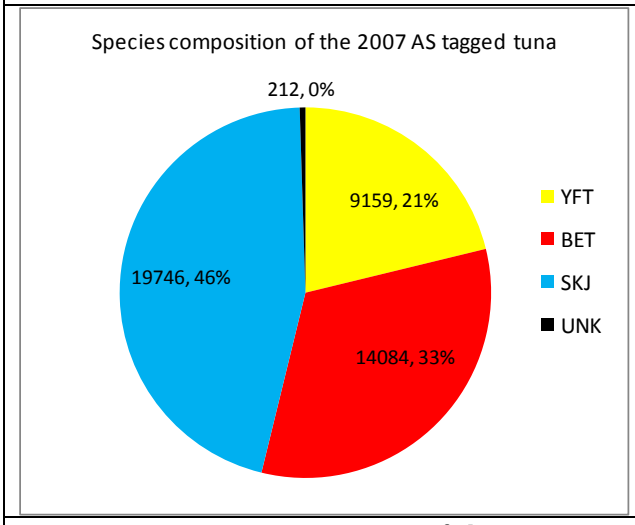


Figure 17a: Species composition of the tuna tagged in the AS in 2007

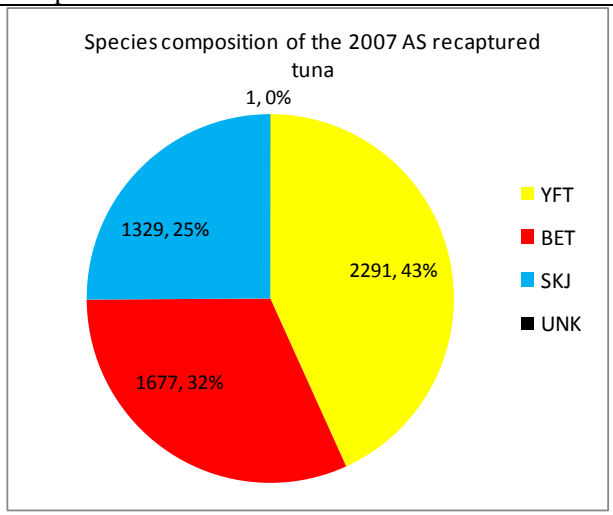


Figure 17b: Species composition of the tuna recaptured in the AS in 2007

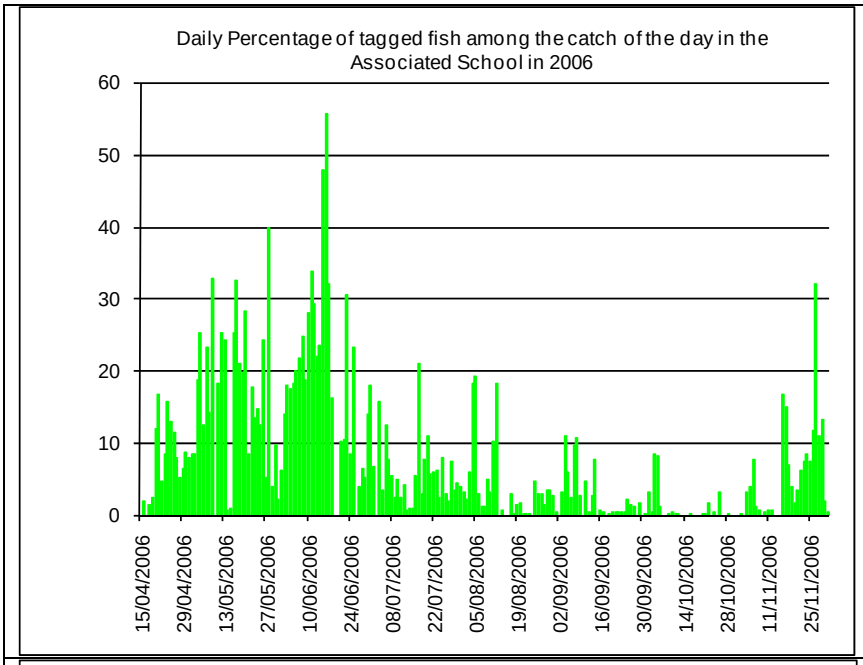


Figure 18a: Daily recovery rate in the 2006 AS (% of recaptures among the total number of fish caught for the day)

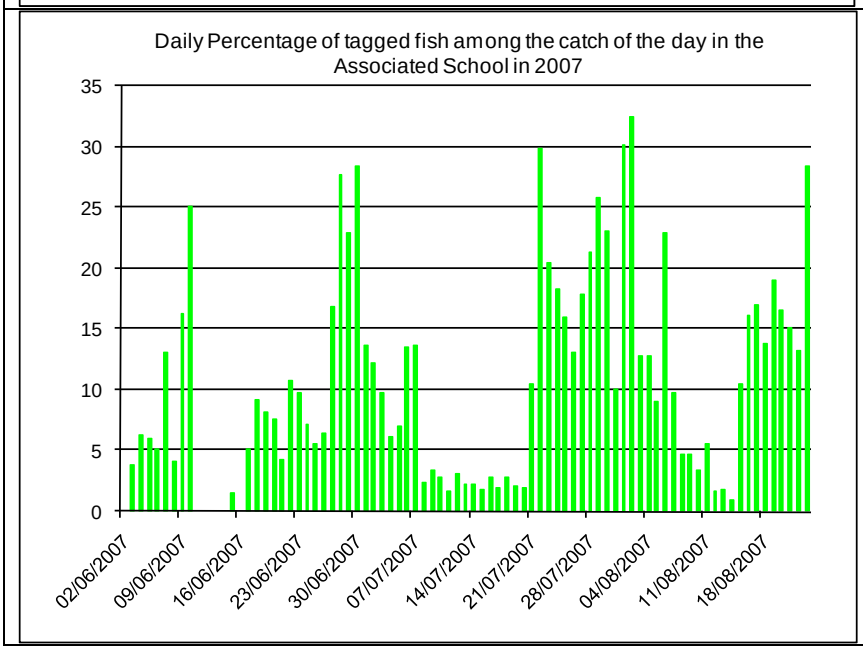


Figure 18b: Daily recovery rate in the 2007 AS (% of recaptures among the total number of fish caught for the day)

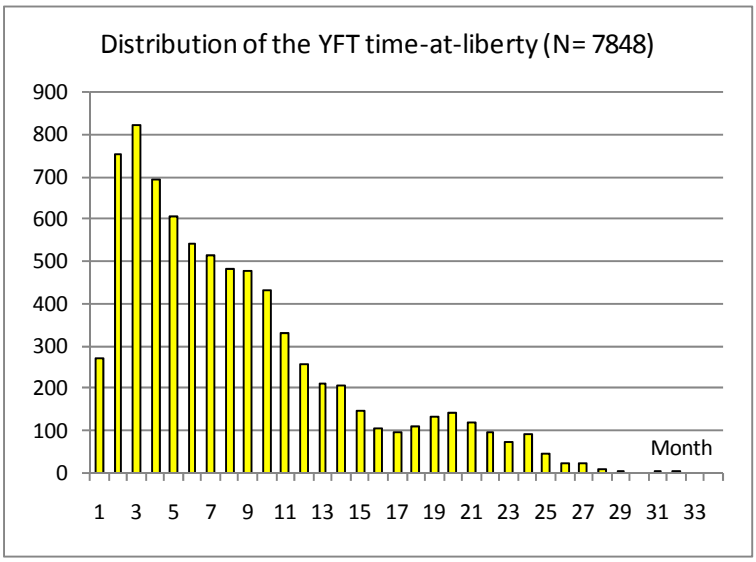


Figure 19 a: Time-at-liberty for yellowfin recoveries

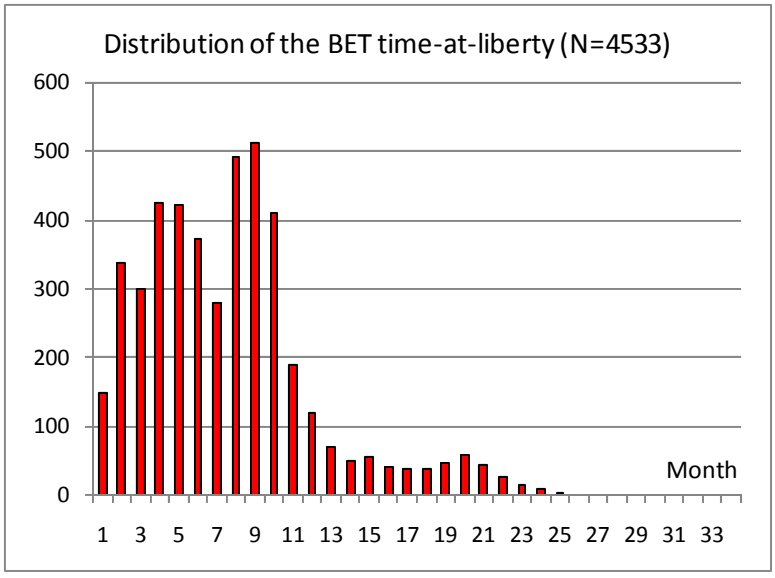


Figure 19 b: Time-at-liberty for bigeye recoveries

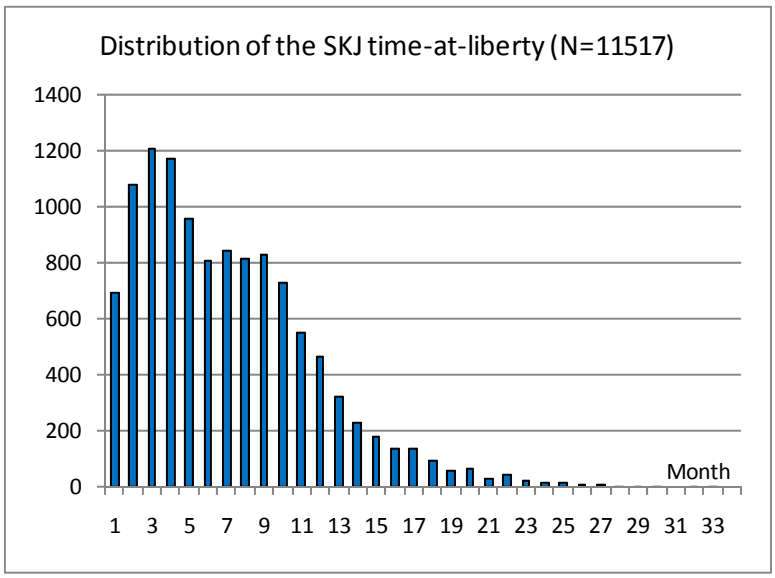


Figure 19 c: Time-at-liberty for skipjack recoveries

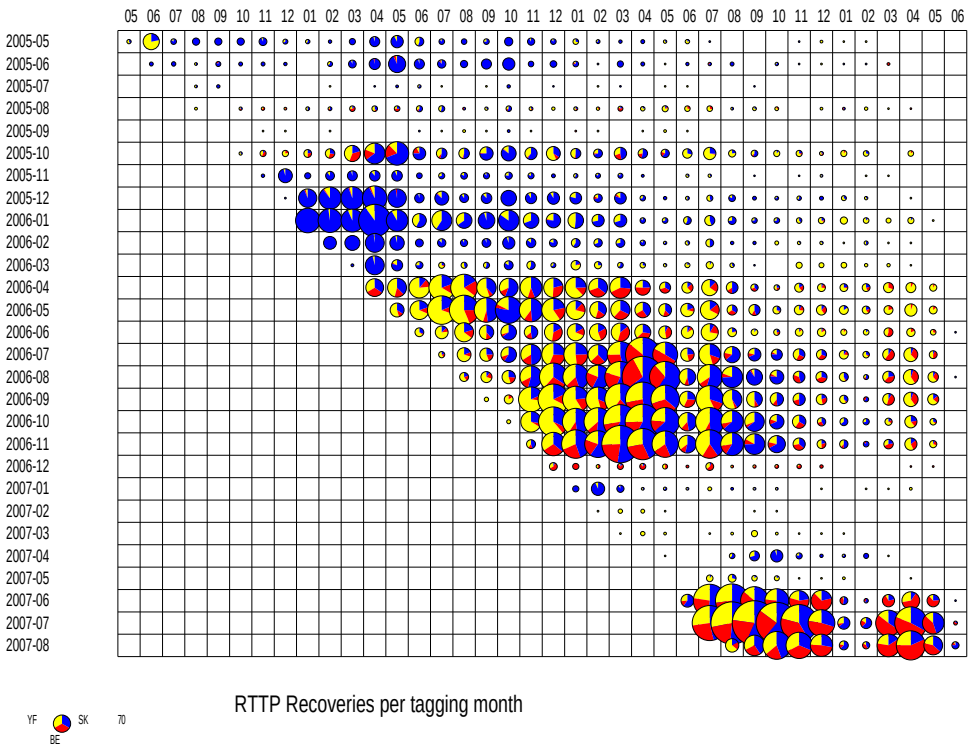


Figure 20: Monthly distribution of the recoveries from each tagging month

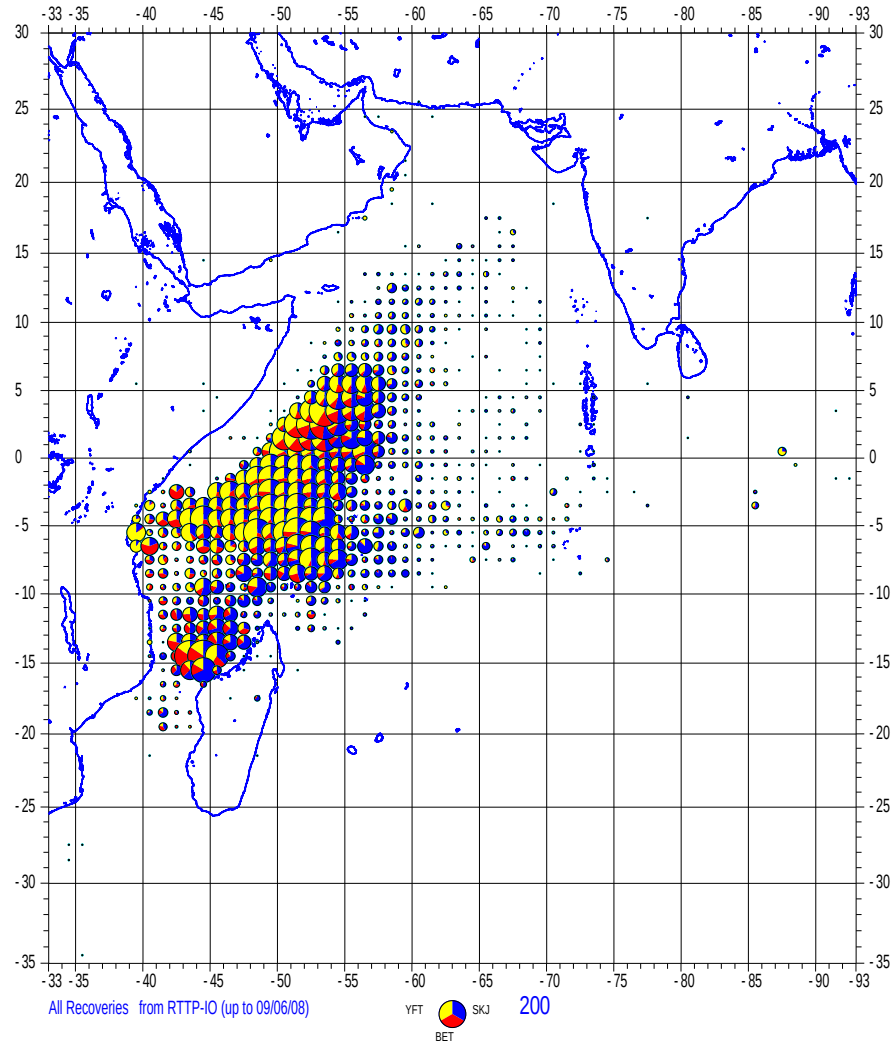


Figure 21: Geographical distribution of the recoveries

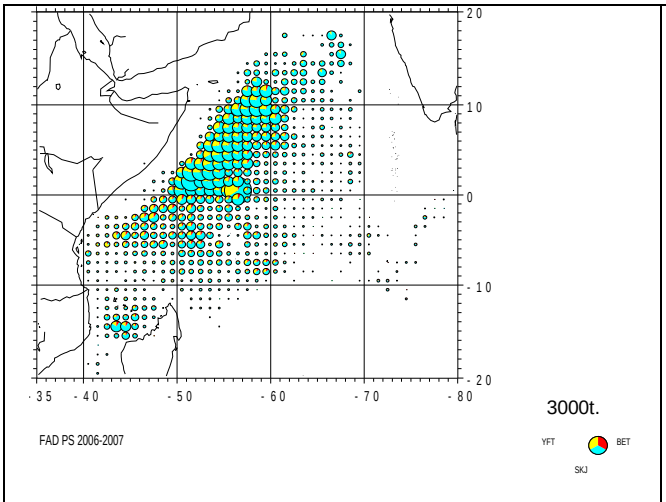


Figure 22a: Distribution of the PS catches on FADs (Average 2006-2007, courtesy of Dr. A. Fonteneau)

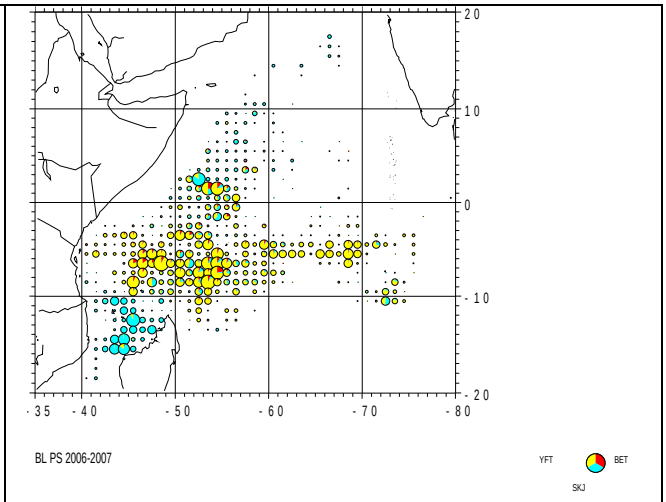


Figure 22b: Distribution of the PS catches on Free Schools (Average 2006-2007, courtesy of Dr. A. Fonteneau)

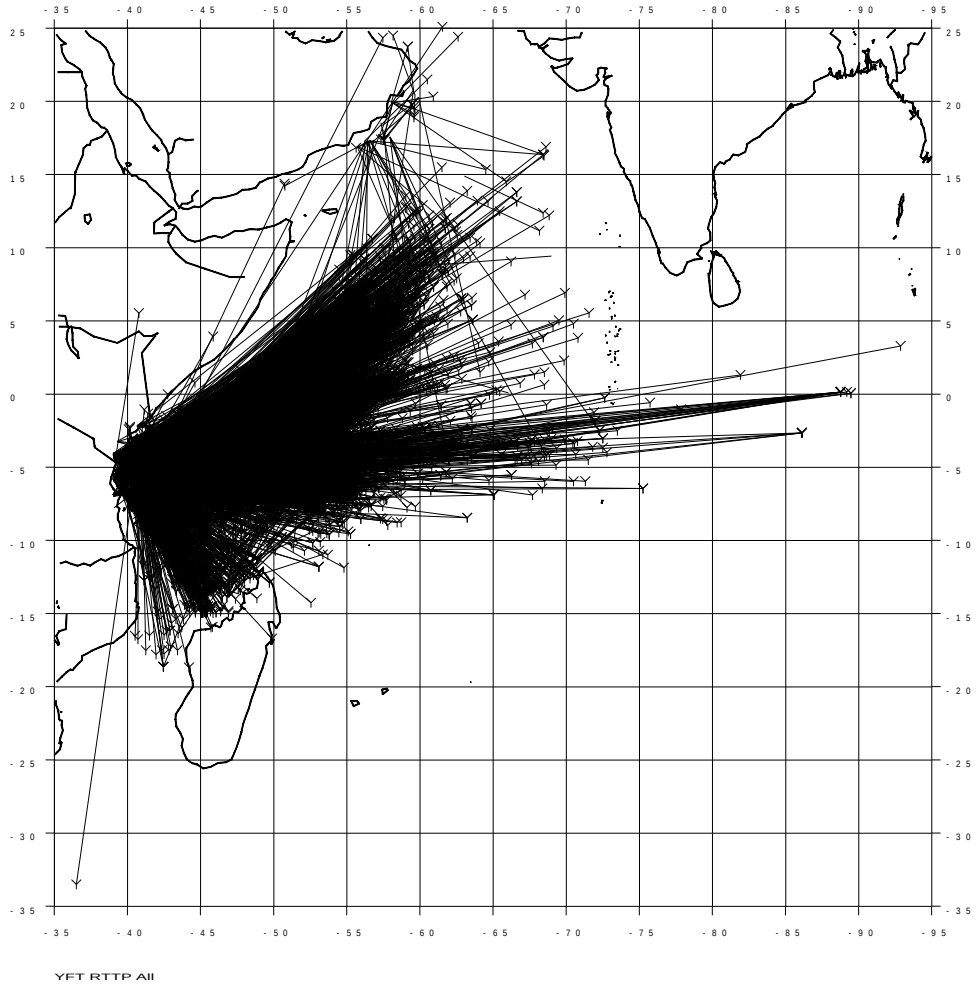


Figure 23a: Theoretical lines between tagging and recovery positions for yellowfin recoveries

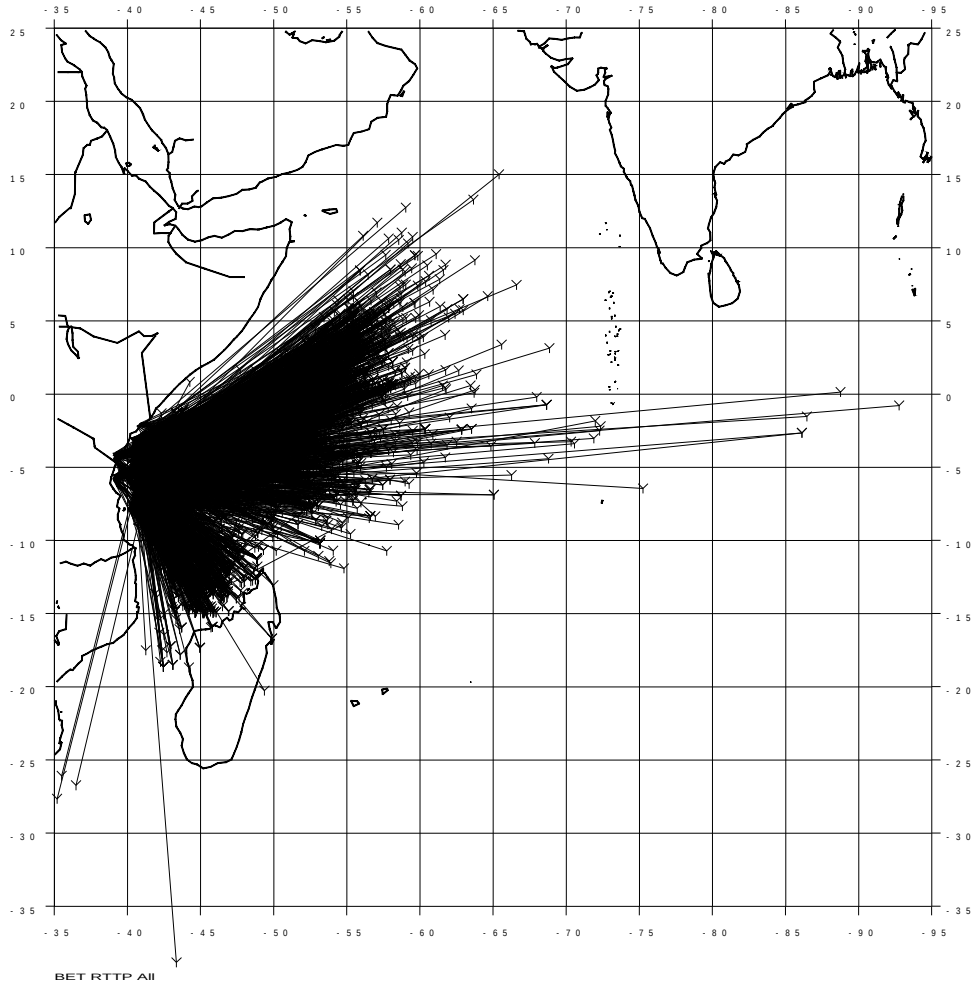


Figure 23b: Theoretical lines between tagging and recovery positions for bigeye recoveries

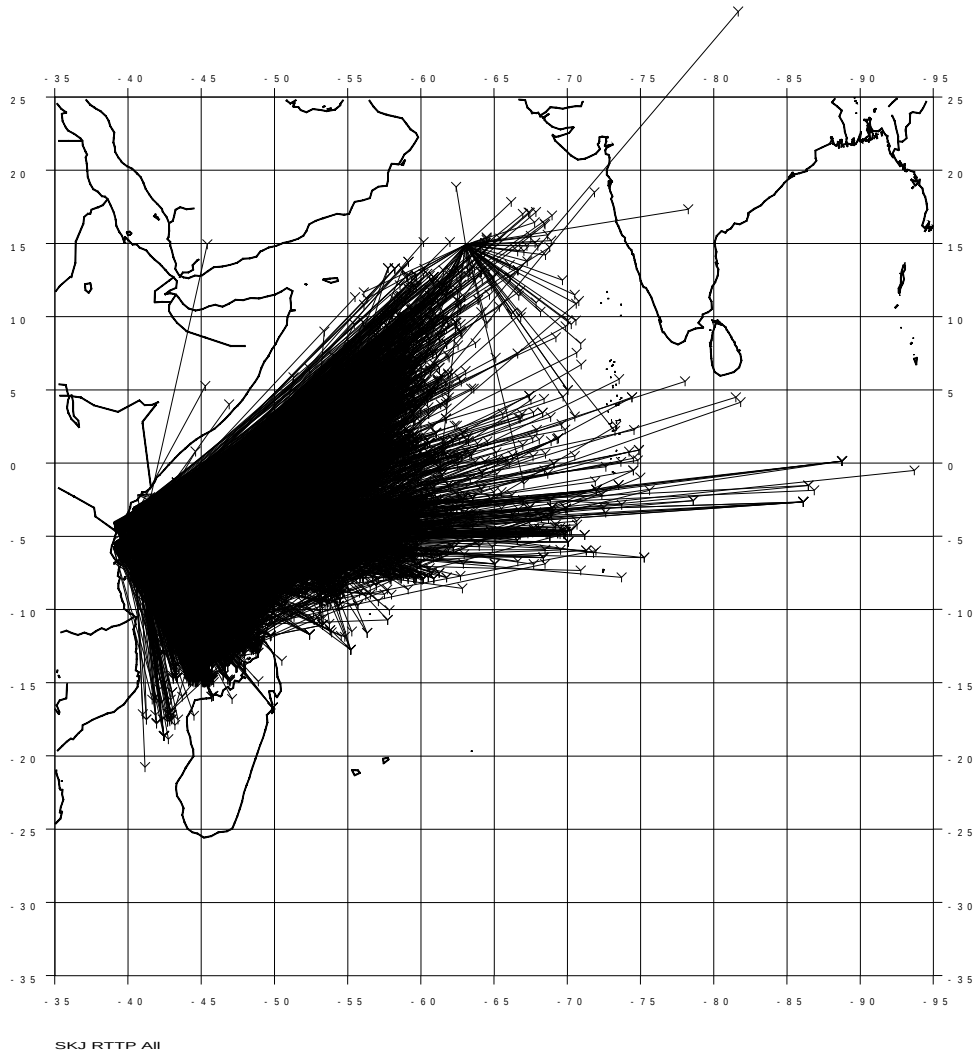


Figure 23c: Theoretical lines between tagging and recovery positions for skipjack recoveries

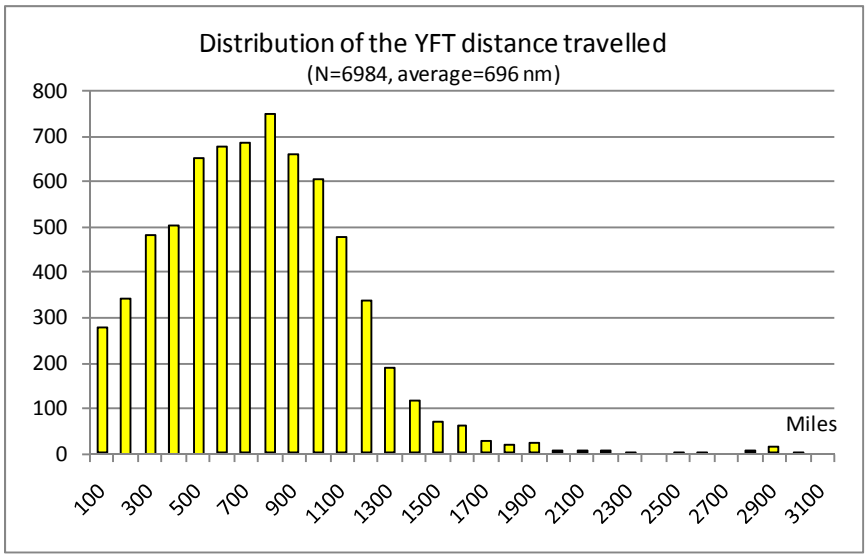


Figure 24a: Distribution of the distances travelled by YFT

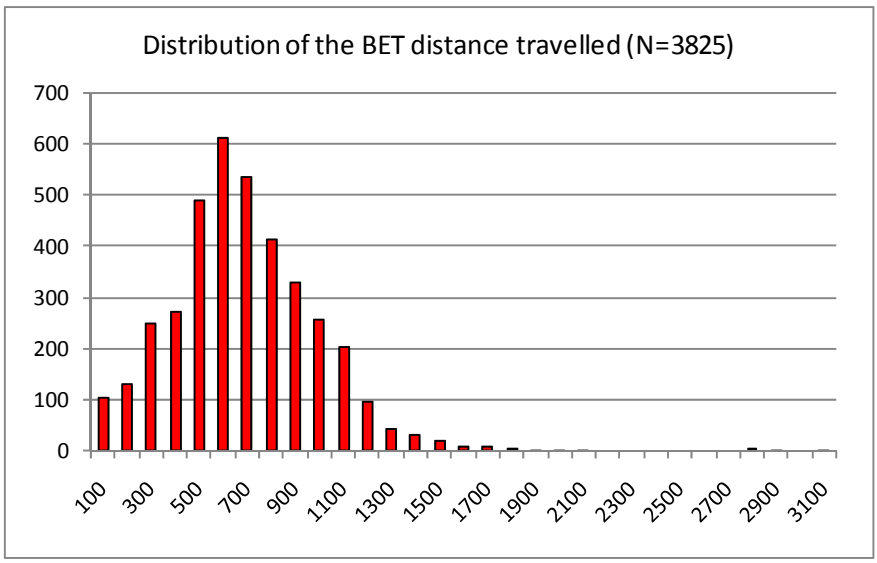


Figure 24b: Distribution of the distances travelled by BET

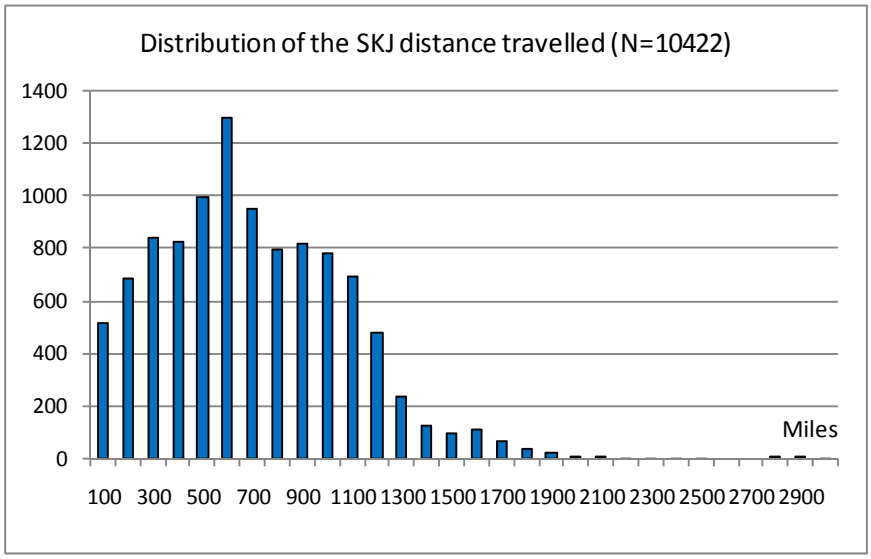


Figure 24c: Distribution of the distances travelled by SKJ

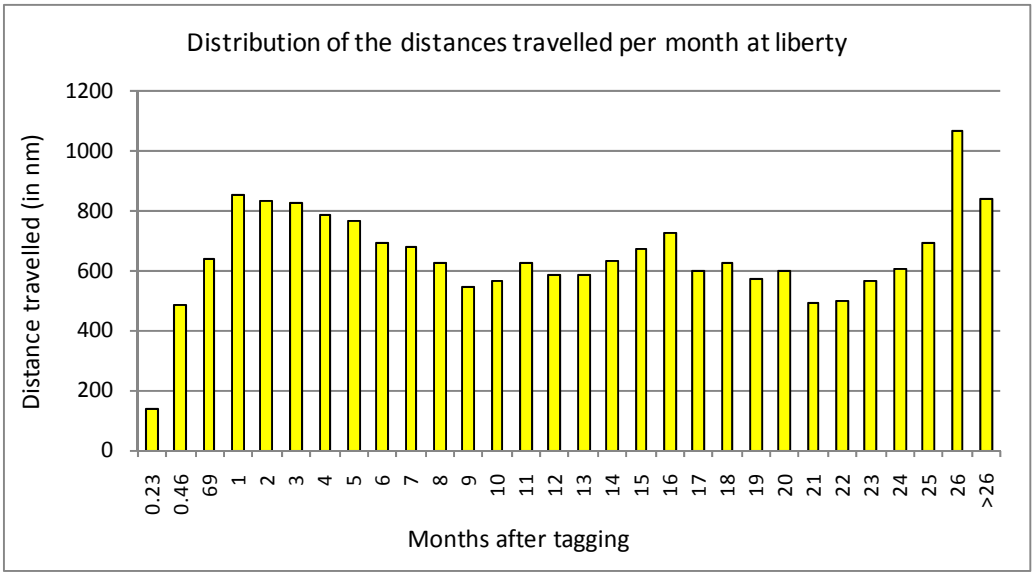
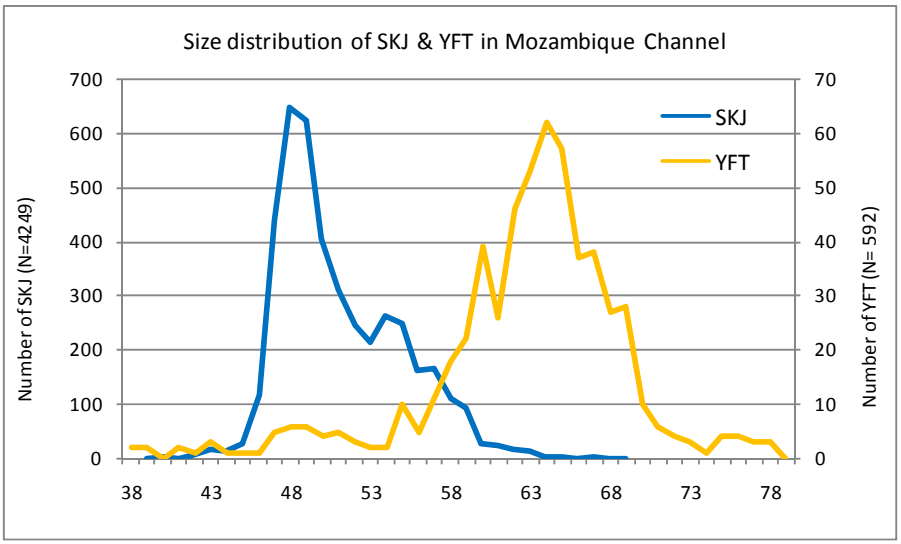


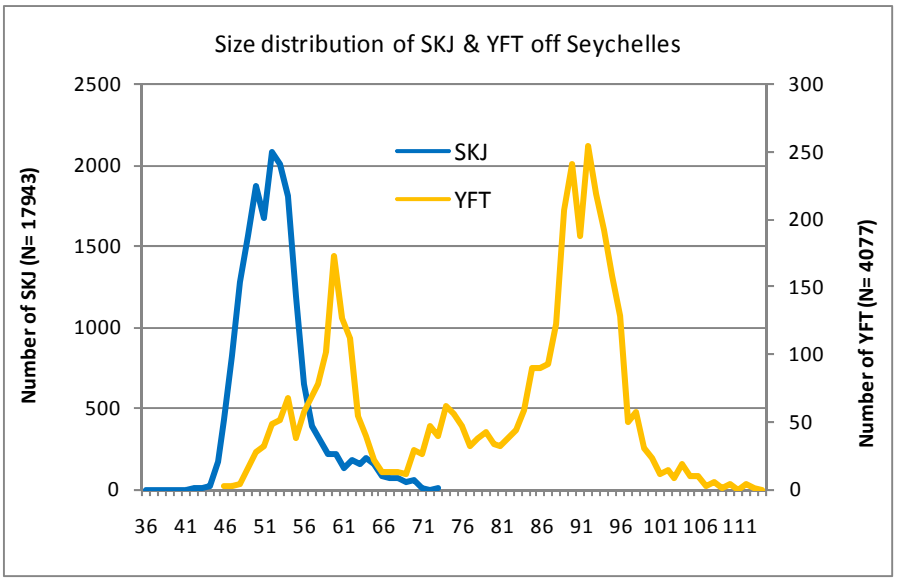
Figure 25: Distribution of the average distances travelled per month at liberty

ANNEX 1

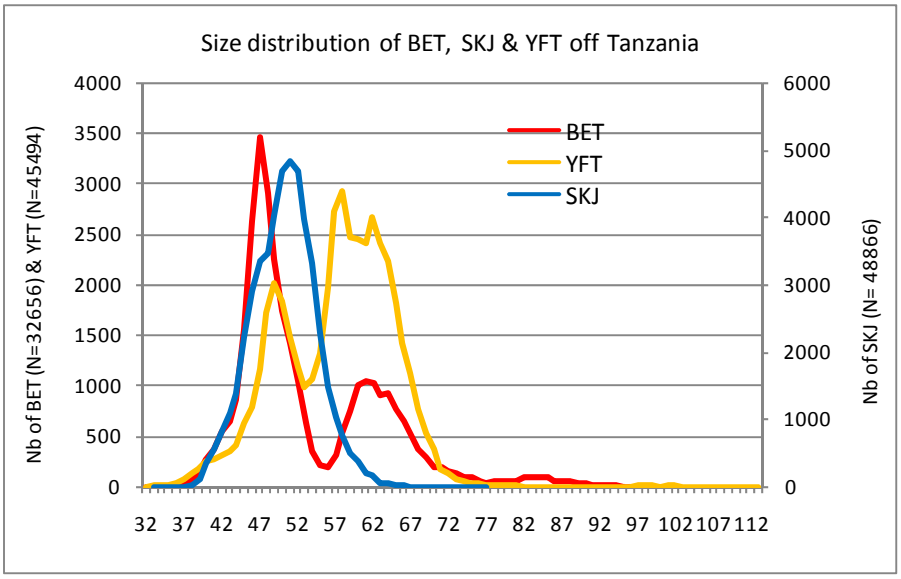
Size distribution of the tuna tagged in the different country/area of the Western Indian Ocean (when a species was not tagged in large numbers, it is not presented)



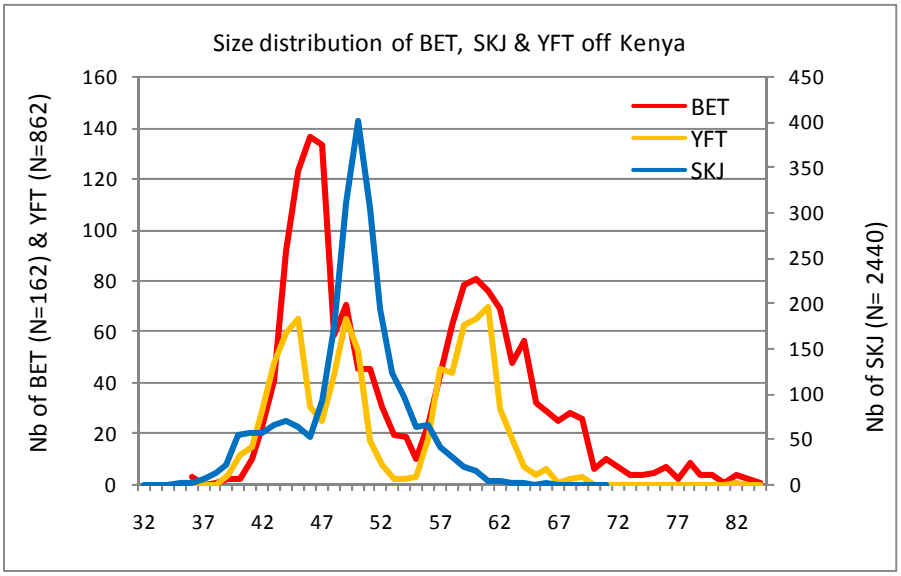
MOZAMBIQUE CHANNEL



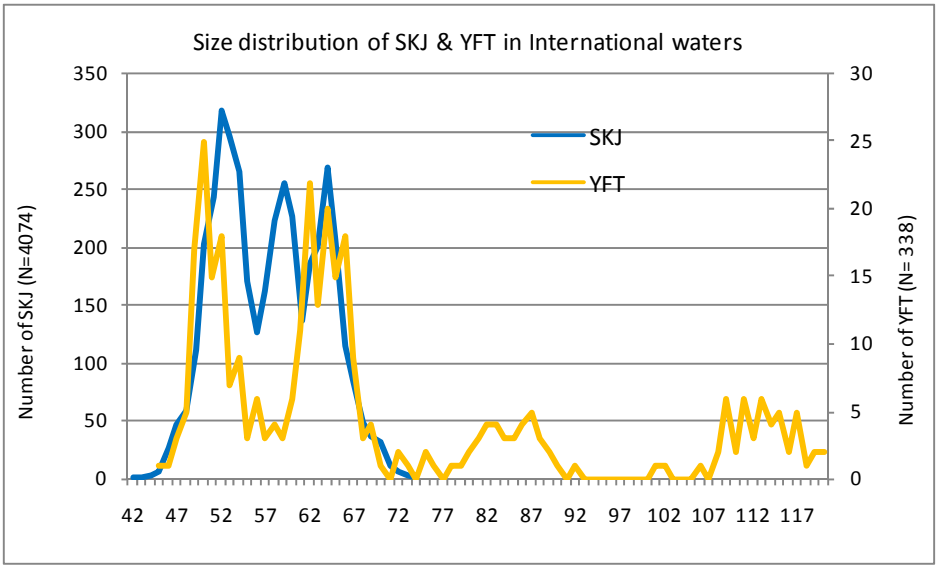
SEYCHELLES



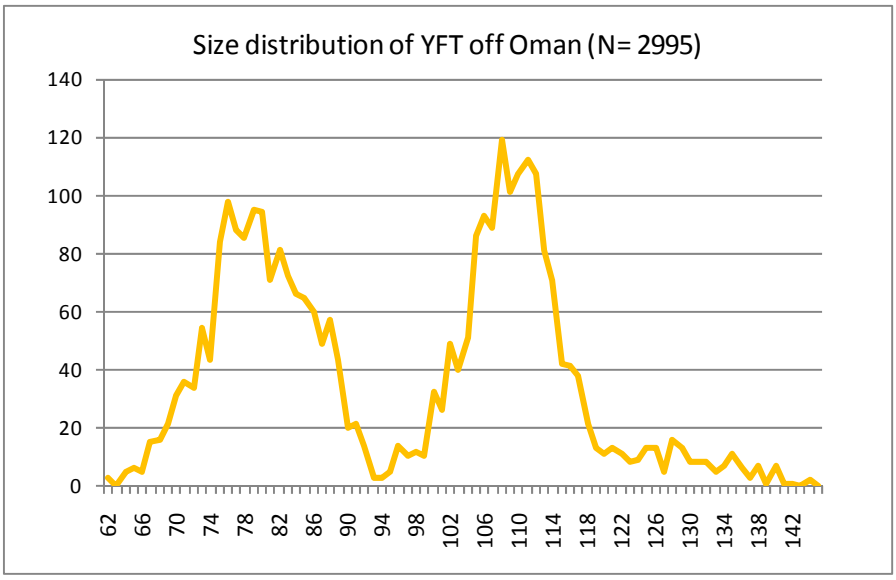
TANZANIA



KENYA



INTERNATIONAL WATERS
(mainly between Seychelles and Tanzania & between Oman and Maldives)


Size distribution of YFT off Oman (N= 2995)
140
120
100
80
60
40
20
0
62
66
70
74
78
82
86
90
94
98
102
106
110
114
118
122
126
130
134
138
142

ARABIAN SEA