IOTC TUNA TAGGING CONSULTANCY IN THE SULTANATE OF OMAN

(11-01-2003 to 25-01-2003)

by

Jean-Pierre HALLIER

****

February 24th 2003

****

iotc ctoi Indian Ocean Tuna Commission
Commission des Thons de l'Océan Indien

IOTC TUNA TAGGING CONSULTANCY IN THE SULTANATE OF OMAN **(11/01/2003 – 25/01/2003)**

by

Jean-Pierre Hallier[1]

1. PURPOSE AND BACKGROUND

The Indian Ocean Tuna Commission (IOTC) proposes to conduct broad scale mark and recapture experiments to provide the basic biological information that is necessary to do stock assessment and to manage tuna stocks in the Indian Ocean. Information on all three tropical tuna species is urgently required. However, current management concerns dictate a priority to tagging bigeye (*Thunnus obesus*) and yellowfin tuna (*T. albacares*) over skipjack (*Katsuwonus pelamis*). The main issue with skipjack concerns interaction issues between industrial-scale international purse seine fleets and coastal/artisanal fisheries. A variety of tag types (i.e. conventional, sonic, archival, pop-up satellite archival tags-PSAT) and methodologies have been proposed from several different types of tagging platforms, both dedicated and opportunistic.
The main programme plans to tag an average of 200 tunas per day from a dedicated pole-and-line bait tagging platform. This boat will probably target surface tunas in their best fishing season during two years in the purse seine fishing area. These operations are the backbone of the Indian Ocean Tuna Tagging programme (IOTTP).
Opportunistic tagging is planned in local fisheries using different fishing gears and possibly in sport fisheries. Opportunistic tagging is mainly intended to tag fish sizes, periods or areas that cannot be covered by the IOTTP chartered bait boat (for instance: Maldives, Mayotte, Oman, La Reunion). PSAT tagging, that does not required a large number of fish, can also be implemented from small tagging platforms.
In Oman, fishermen catch yellowfin tunas of intermediate sizes at between 60 to 105 cm FL (sub-adult yellowfin) as well as adult fish (105 to 135 cm (Figure 1).

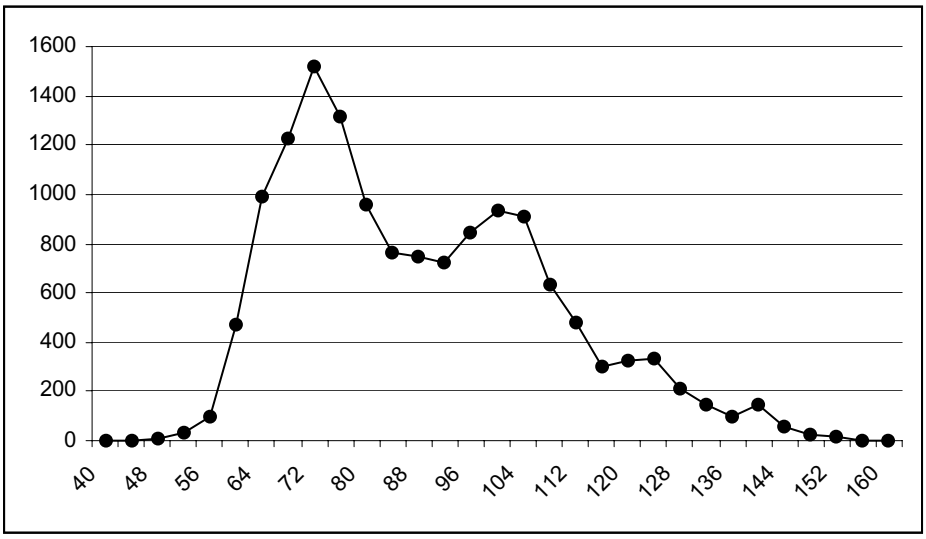

Figure 1: Oman yellowfin size distribution from samples taken from 1987 to

[1] IRD scientist, UR 109, CRHMT, B.P. 171, 34 203 – Sète, France. Tel : (33) 4 99 57 32 38, Fax : (33) 4 99 57 32 95, E-mail : Jean.Pierre.Hallier@ifremer.fr

1994 mainly from the gillnet fishery (Mamry, 1996).
These 60-105 cm yellowfin are quite rare in the purse seine catch that is composed mainly of small fish on schools associated to drifting logs or FADs (mode around 55-60 cm) and large adult yellowfin, mostly on free schools (mode around 130 cm) as shown in Figure 2.

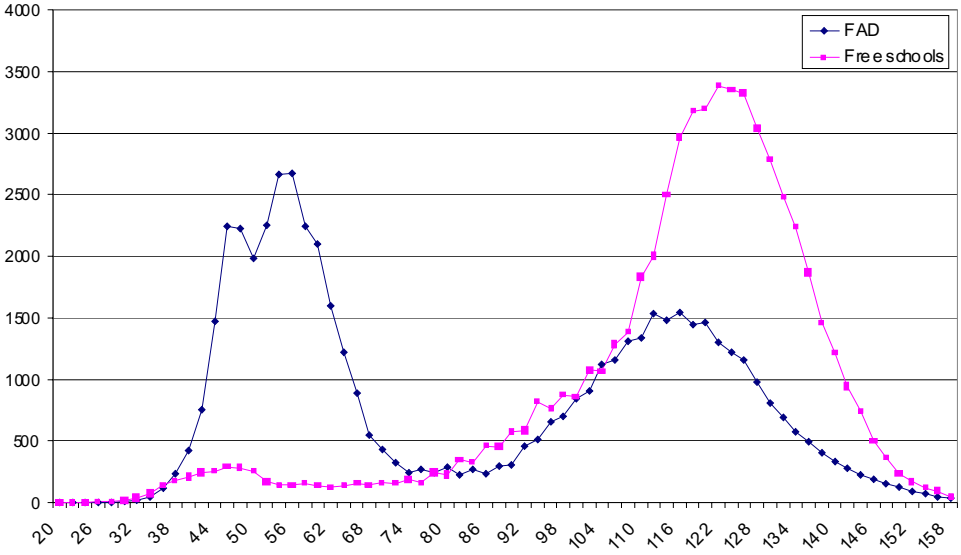

Figure 2: Indian Ocean purse catch by size classes for FAD and free schools catch from 1982 to 2001 (From Fonteneau, IRD)

Longliners catch almost only adult fish and rarely catch sub-adult yellowfin (65- 105 cm FL) (Figure 3).

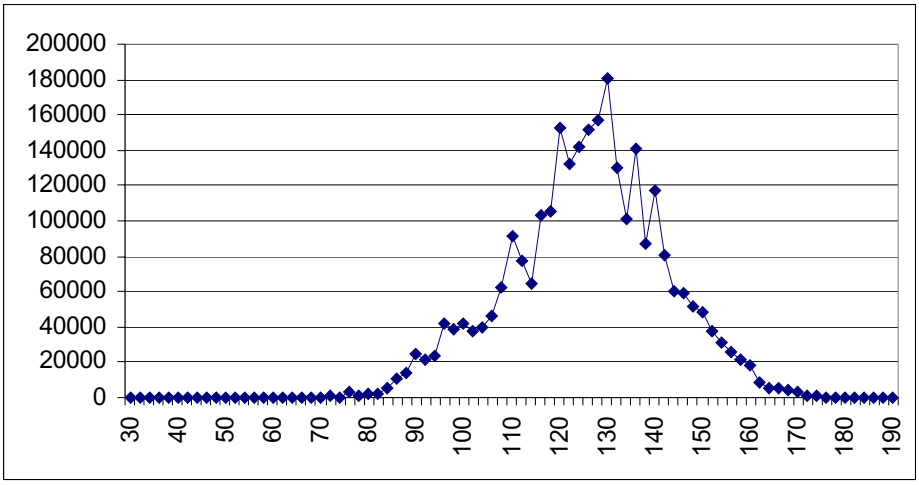

Figure 3: Indian Ocean longline catch by size classes from 1990 to 2000 (from Fonteneau, IRD).

One hypothesis is that yellowfin of intermediate sizes, well represented in the Oman fishery, belong to the same population as the yellowfin fished by the purse seine and the longline fisheries of the Indian Ocean. At least part these intermediate sizes, missing in the purse seine fishery, are present in the Oman waters. It is necessary to tag both in the purse seine fishery and in the Oman fishery to answer the basic questions: do these yellowfin belong to the same population and is there any interaction between the two fisheries and of which magnitude? These are important issues for the Oman artisanal fishery on yellowfin tuna.
The purpose of this consultancy is to examine the possibilities of tagging yellowfin tunas in the waters of Oman.

2. OBJECTIVES

The specific objectives of the study mission were to:

- Conduct experimental tagging cruises on local fishing vessels to determine their suitability as tagging platforms and to train some local staff in tagging practice;
- Assess the local fishing gears for catching tunas in good condition;
- Assess the number of tuna that could be tagged in Oman;
- Discuss the reward scheme for recaptured tuna for this experimental tagging and for future operations;
- Draft a proposal for an Oman Tuna Tagging Programme (OTTP).

3. ACTIVITIES RELATED TO STUDY MISSION

11th January – Saturday
Traveling from Sète (France) to Muscat (Oman) via Paris and Frankfurt.

12th January – Sunday
I arrived in Muscat, capital of the Sultanate of Oman, without my luggage, therefore without any tagging equipment. As staff from IOTC are expected in Oman tomorrow, I made an arrangement with IOTC in Seychelles for bringing to Oman the minimum of equipment for this mission. Staff of the Ministry of Agriculture & Fisheries (MAF) met me at the airport. Later during the day, I met Dr. Ahmed Mohd. Al Mazrooei, Director of the Marine Science & Fisheries Centre (MSFC) for a first informal discussion on my mission. The MSFC is more or less the research section of MAF and as such is taking care of my mission in Oman. The different persons met during the consultancy are listed in Appendix I. The daily activities of the consultant appear in Appendix II.

13th January – Monday
I was driven to MSFC that lay about 40 km to the south of my hotel, where I met Dr. Mazrooei and other staff of the Centre. Two members were going to assist me during my mission: Mr. Abdulaziz Al-Marzouqi (Aziz), a biologist working on demersal stock assessment with Dr. Sadok Ben Meriem from Tunisia and Mr. Al-Musharafi (Nasser), a field technician from Sharqiah region (Sur). I started to collect documentation from the library on Oman Tuna fishery. I met at the Ministry of Agriculture & Fisheries, Mr. Habib Al-Hasni, in charge of the International Relations of the Ministry who has dealt with my entry visa to Oman.

14th January – Tuesday
Mr. Abdulaziz Al-Marzouqi picked me up at 6.30 am for a visit to Mutrah fish market near Muscat where I could watch local fiberglass boats unloading their early morning catch. There was a great variety of species mainly demersal and small pelagics such as Hemiremphidae, small scads, Indian mackerel (*Rastrelliger kanagurta* - Photo 1), sardines (*Sardinella longiceps* - Photo 2). But most species were demersal fish. Large pelagic unloaded were very few: *Elegatis bipinnulata*, Carangidae, Sphyraenidae (barracudas). Other large pelagic fish were also unloaded from freezer trucks coming from other districts especially from Sur: yellowfin (*Thunnus albacares*), longtail tunas (*T. tonggol*), kawakawa (*Euthynnus affinis*), kingfish (*Scomberomorus commerson*). All demersal and large pelagic fish were caught with handline, small pelagic with gillnet. Interviewed, the fishermen regret that tunas are not around. They mentioned that in the Sharqiah region they are presently fishing yellowfin and apparently yellowfin fishing is very good in Yemen.
With the Director of MSFC we collected Dr. Alejandro Anganuzzi, IOTC Deputy Secretary and Mr. Koichi Sakonju, OFCF Co-ordinator, at their hotel on our way to an appointment with Dr. Younis Khalfan Al-Akhzami, the Director General of Fisheries at MAF. The organisational chart for the Directorate General of Fisheries is given in Appendix III. The objectives of this meeting was to cover various topics including the tagging pilot mission in Oman and a future prospect for an Oman Tuna

Tagging Programme (OTTP). I had prepared a small draft paper on the purpose and background of this mission as well as its main objectives.
From fishermen's account, actually yellowfin are caught only in Sur (Sharqiah region). Therefore, back to MSFC, it was decided to organize tagging trips from a boat from Sharqiah region. Several points for the mission to Sur were discussed with MSFC Director and staff: transport to Sur, accommodation in Sur, contracting a fisherman verbally for chartering his boat.

15th January – Wednesday
Morning at the MSFC to fix up last minutes details for the trip to Sur. MSFC Director will come to Sur with Dr. Anganuzzi and Mr. Sakonju and will return to Muscat tomorrow afternoon. Therefore two 4x4 cars from the Centre will go to Sur. One will remain in Sur with Mr. Marzouqi, Mr. Musharafi and myself. We leave at 3.00 pm and arrived in Sur at 6.30 pm.

16th January – Thursday (first trip)
Early morning, we meet with the fishermen (Mr. Jemal Al-Shuaibi, the owner of the boat and Mr. Abdullah Al-Musharafi) at Sur-Al-Bar, a small harbour near Sur where a dozen fibreglass boats are located. With the two fishermen, Aziz and Nasser we depart for our first trip at 7.30 am. The boat is a typical Yamaha 25 feet fibreglass boat, 4 feet width with no deck (Photo 3). A 55 Hp Mariner outboard engine and a 75 Hp Yamaha engine motorize it. But, only one engine will be used at a time. We are carrying 5 kg of sardines (*Sardinella longiceps* – Photo 4), lines (threaded black lines of 2 mm with at the end a 6 to 7 m nylon leader of 1 mm and a straight hook partially bent) and stones of roughly half a kilo each (Photo 5). These stones are about the size of a hand and more or less flat.
The fishing ground is reached in 15 to 20 minutes and is located to the north of Sur and at less than a mile from the shore just passed the gas factory and harbour facilities that export natural gas from Oman (Photo 6). The sea is very calm and the sky completely clear. Around us 21 other fibreglass boats are already there. They are of the similar size (between 16 and 25 feet) each carrying between one to four fishermen. They are anchored in depth between 70 to 200 meters. In the next one and an half hour 40 more boats will join us all concentrated in an area of roughly one-mile radius. The distance between some boats is less than 50 meters (Photo 7). We are on the edge of this area the closest to shore. A lot of jellyfish are floating around in mid-water. This invasion of jellyfish was unknown to fishermen and is taking place in many areas of Oman waters since the middle of 2002. This causes difficulties for gillnet fishery. They are near the surface at night and they swim deeper during the day. We set four lines. A sardine is set onto the hook and it is wrapped with the line together with another sardine onto a stone (Photo 8). The stone is dropped overboard down to the bottom. When it reaches bottom one or two meters of the line is pulled up and with a strong pull the stone is released together with the free sardine. Then the line stays there for 15 to 20 minutes. After, it is pulled up and another sardine is set onto the hook while the previous one that was on the hook is used as a free sardine. This is the typical "drop stone" technique originated from Polynesian countries and now widely used for tuna fishing around the world as in Mayotte in the Comoros islands. We stopped fishing at 11.45 to meet with the rest of the team before they leave for their return trip to Muscat. We have caught a 55 cm Sphyraenidae (barracuda). All catches are summarized in appendix IV. There is little activity among the fleet but obviously few boats managed to catch some big yellowfin. On our way back we checked three boats, only one has caught 3 YFT of the same size. I measured one of the fish on the mattress; it is a 93 cm FL fish (roughly 15 kg).
I was surprised that so many boats were keeping fishing with so little success. But in fact we learned later that on Wednesday, the previous day, yellowfin tuna fishing has been very good as every boat return from fishing with at least a few fish. Therefore, on Thursday, fishermen expected good catch and they were all on the spot but apparently most yellowfin have passed their way to offshore areas or elsewhere.
At 5.20 pm we stopped at Sur at the main landing place for yellowfin, right onto the beach where buyers with freezing trucks are waiting (Photo 9). Anganuzzi has already observed this situation in 2002. Fish auction takes place directly on the beach and sold fish, not gutted, are loaded in ice in trucks heading for Muscat, United Arab Emirates (U.A.E. - Dubai) or Saudi Arabia. Prices fluctuate with the landing abundance but overall they remain high. Yellowfin tunas are much praised and their prices are among the highest on the fish market. At periods with very high abundance, a 90 cm YFT (15 kg fish) will fetch only OR 2 (Oman Rials, 1 OR = 2.5 €). During this period of low abundance the same fish is sold at OR 10. On the beach that evening I watch the unloading of three large yellowfin

(two were about 110 cm FL – around 25 kg- but the third was a 135 cm YFT of roughly 45 kg) they were sold for OR 72 (€ 190). That will fetch a lot of money on the market as this trader and maybe other intermediates will take their share.

17th January – Friday (second trip)
Picked up at 6.15 by Aziz, we (Aziz, Nasser, the two fishermen and myself) leave the beach at 6.30 and were second on the fishing ground. We anchored more offshore in deeper waters but fishermen found it too deep and soon we moved more inshore to find ourselves again one of the closest to shore. There were less jellyfish than yesterday. We caught a carangid, a 90 cm barracuda and three catfish (*Arius thalassimus*). I tried to use chopped sardines mixed with sand instead of the free sardine released with the stone as in the *palu-ati* Hawaiian technique. But that does not make our fishing more successful. We set six lines this time. There was little activity among the rest of the fleet but at least we observed a YFT catch on a nearby boat. We stop fishing at 11.00 am as it is Friday and most of the boats were also leaving. At the most there have been only 13 other boats with us today. There were some clouds today and in the end of the afternoon some very small rain in Sur. I went to the landing site in Sur and two trucks were waiting but I did not watch any landing.

18th January – Saturday (Third trip)
We leave at the same time as yesterday. There was only one fisherman with Nasser and myself. The other fisherman has been there on vacation and he has returned to Muscat where he is working for the army. Aziz was sick and cannot join the team. We were the second boat on the fishing ground and we anchored at the same location as yesterday. As the wind and the current were very weak we first drifted to check the depth then we anchored. Jellyfish were present and also plankton drifting at the surface and into the sea: The waters seem rich in nutrients. We fished until 4.00 pm; only one boat remained on the fishing ground when we left. Today we have never been more than 14 boats on the fishing ground. We caught 5 barracudas and a small shark. Jemal had a YFT on his line but the line broke when he pulled the fish alongside to haul it up. It was the same size YFT we have seen so far (between 85 to 95 cm). The boat next to us caught two YFT and missed a third one. Another boat has also caught two YFT but six other boats, which were checked, did not catch any YFT. As during the two previous days, there was very little activity among the fishing fleet as YFT abundance was low. Generally, either the bait was eaten up by small demersal fish or by barracuda that got caught sometimes. Or, bait remained untouched. I measured 10 sardines; all of them were 16 cm FL fish except one 15 cm fish.
We have tried hard all day long without success and it was the same for most boats; we have set 3 lines. Clouds were building up since morning and in the afternoon there were dense dark clouds with thunderstorm but no lightning. Obviously it was raining in Sur and on nearby mountains; we only got a bit of rain at sea; wind was blowing from the north. In Sur and around, it has rained a lot at least sufficiently to have water flooding some wadis (local name for dry riverbeds). This is not uncommon during this season but overall for the last years drought has been severe in this area. It was low tide when we reach the little harbor. Therefore, we cannot enter the harbor and we cannot remain outside, as wind blowing from the north was becoming stronger lifting waves. But, fishermen have the solution: a 4x4 truck is driven onto the dry sand of the harbor next to the boat and this one is pulled up into the safe of the harbor (Photo 10).

19th January – Sunday (Fourth trip)
We leave the same three persons at 6.55; the sea was choppy but nothing serious and the wind was still blowing from the north but it calmed down during the morning and therefore we can stay fishing. As this fishing technique required to anchor the boat and to have the line very close to the bottom, where YFT are present at this time of the year, strong winds and/or currents prevent any fishing. We started fishing at 7.30 and we fished until 1.40 pm. We quickly had to change our anchor place as strong current prevent our lines from touching bottom. We caught two Lethrinidae, two Carangidae and one catfish. This fish was used for tagging training for Nasser. We have set four lines (Nasser was taking care of two lines by himself). We were only four boats altogether in two groups of two. One boat was closer to us; the two others were ½ mile to the south of us. In mid-morning our companion boat left us to join the other group. We should have down the same as when we leave and we checked their catch they all have caught YFT: one had 6 YFT and the two others two YFT.

20th January – Monday (Fifth trip)

We leave at 6.50 and were the first on fishing ground. Aziz feeling better has joined us. We have to shift anchorage for the same reason as previous days. Finally, we were again quite close to shore; only 5 other boats were closer to shore than us. By 9.00, we were 40 boats around: is it the catch account of the three boats of yesterday or the fact that most boats had not fished for the last days that explains this abundance of fishing boats? Nasser thought it was for the second reason. We used four lines and Aziz used also a bottom line for demersal fish. He caught a 130 cm barracuda, 2 *Lethrinus* and an *Epinephelus chlorostigma*. On handline, we caught a 55 cm barracuda. We stopped fishing at 11.40; a few boats have already left. On leaving, we contacted 15 boats to check if they use live bait and if they have caught YFT. Some boats have a bait tank in which they keep live sardines (Photo 11). In these tanks the water circulation is very limited: four bolts (two on the side and two at the bottom) are removed to permit some water circulation. Nine boats used only dead baits, 6 used live and dead baits. Ten did not catch any YFT and 5 had caught one YFT (three were using dead bait and two live bait).
Aziz and myself we leave Sur for Muscat at 2.45 pm and were in Muscat at 6.00.

21st January – Tuesday

Some misunderstanding on my picking-up at my hotel resulted in me not going to MSFC today. I spent the day working on the report.

22nd January – Wednesday

Picked up at 9.00 am, I had a debriefing with Dr. Ahmed and Aziz regarding the trip to Sur and we discussed the other actions of today. With Aziz we go to Harsnal (Sidab) and to Mutrah landing places to interview fishermen on their tuna fishing activities (boats and gears, season, species, sizes, interests in tagging). In general we were welcomed and the fishermen express their interest. I have taken with me the Tagging Instruction Manuel, I had prepared, where tags used, tagging cradle and mattress, tagged tunas are illustrated.
We had a visit to Mutrah fish market that was very busy at noon with a very large variety of demersal and pelagic fish in very fresh and good conditions. Small pelagics available were: sardine, anchovy (look like *Stolephorus heterolobus* – Photo 12), and several species of scads, small mullet and Indian mackerel. Large pelagics were also abundant: longtail tuna, striped bonito, frigate tuna, yellowfin, kingfish, kawakawa, rainbow runner, queenfish, *Seriola*, barracudas. All yellowfin –they were only few fish - were coming from other regions especially Sur. There were also cuttlefish, shrimp, shark, ray, job fish, needlefish, jack, merou, grouper, croaker, catfish, etc…But there was no time left to go to Qurayyat an important fishing port in the north of Muscat. But there is no reason why fishermen from Harsnal and Mutrah would fish differently as they frequent the same yellowfin fishing grounds.
I made contact next to MSFC with some staff of a sport-fishing club (The Blue Marlin). But the president and other members of the board were not present; I left my card and my hotel telephone number for future contacts.
I bought at the market three longtail tunas of 3 kg each that were used later at MSFC laboratory for tagging training.

23rd January – Thursday

Work at hotel on the report. I borrowed the Fisheries Statistical Year Book 2000 to pick up data on Oman fisheries.

24th January – Friday

Work at hotel on the report.
Leaving the hotel at 11.00 pm for the airport.

25th January – Saturday

Plane taking off at 1.00 for Frankfurt. Arrival at 15:30 in Montpellier

4. YELLOWFIN FISHERIES OF OMAN[2]

4.1. Catch of the artisanal fishery

The artisanal fishery of Oman is important as it has landed on average from 1989 to 2000, 97 530 t of fish and crustaceans annually. This catch includes 20 818 t of tunas (yellowfin (*Thunnus albacares*), longtail tuna (*T. tonggol*), kawakawa (*Euthynnus affinis*), frigate tuna (*Auxis thazard*), striped bonito (*Sarda orientalis*), skipjack (*Katsuwonus pelamis*), mixed tunas). Yellowfin makes up 58.3 % of these tuna catches. Yellowfin represent also 36.9 % of the total catch of large pelagic fish of Oman (apart from the species listed above, large pelagics include kingfish (*Scomberomorus commerson*), queenfish (*Scomberoides sp.*), barracuda (Sphyraenidae), cobia (*Rachycentron canadum*), sailfish (*Istiophorus platypterus*), large jacks and miscellaneous species. When taking into account the total catch of the artisanal fishery, yellowfin represent 12.5 % of this total catch for the period 1989-2000 (Figure 4). Documents used during the consultancy and for the purpose of this report are listed in appendix V.

The artisanal fishery produces most of the yellowfin catch from Oman waters. From 1989 to 2000, the artisanal fishery catch accounted for 74.1 % of total yellowfin catch against 25.9 % by foreign longliners (Mamry, 1996; cf. § 4.4). From 1989 to 2000, 16 770 t of yellowfin were caught each year in Oman on average, with 12 146 t from the artisanal fishery.

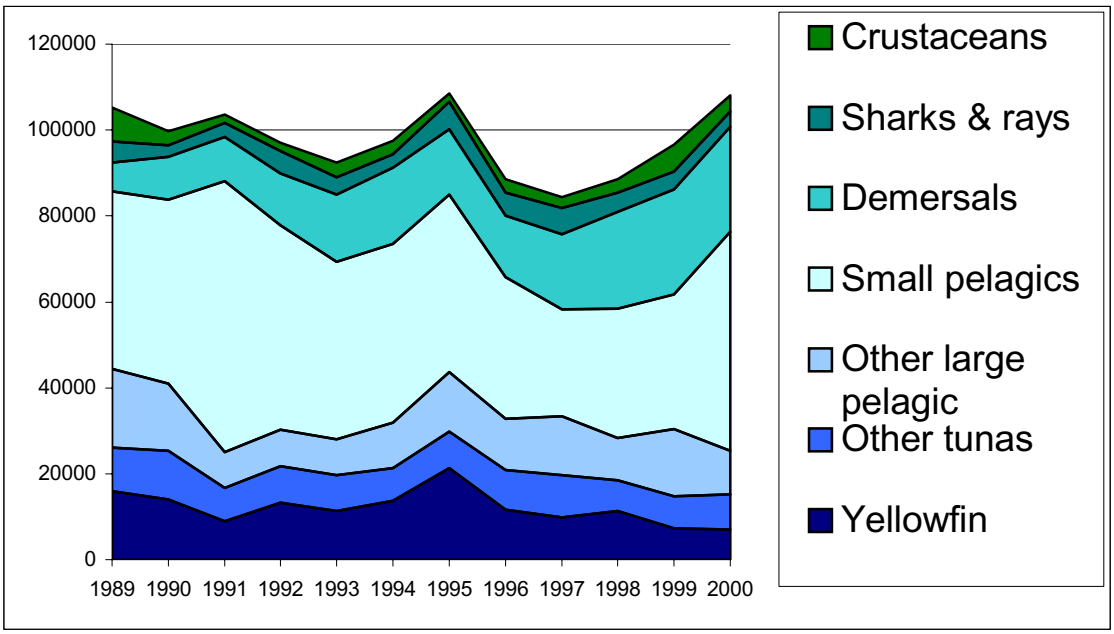

Figure 4: Oman artisanal fishery catch (in t) by groups of species from 1989 to 2000.

Yellowfin is identified as such in the statistics only since 1988 and skipjack since 1994. In conclusion, yellowfin represent the largest part of the tuna catch of the country and this is almost the only high sea tuna tropical species caught in Oman. The skipjack catch is generally low, on average 446 t from 1994 to 2000 and bigeye is not reported. The other tuna species are generally listed as coastal or minor tunas but their catch is important for Oman. Figure 5 show the proportions of the different tuna species caught by the artisanal fishery since 1989. Mamry (1996) noted that the development of Oman fisheries is related to the introduction of new nylon materials and of fibreglass boats in the 1970's. In 1985, yellowfin catch was estimated at 5 017 t harvested by traditional fishermen using handlines and gillnet (IPTP, 1992). In 1986 and 1987, yellowfin catches were respectively 6 007 and 6 829 t (Abdisalaam, 1991).

[2] Most data presented in this report are coming from a thesis for a Master of Sciences by Mamry (1996) on yellowfin tuna in Omani waters and from the Fisheries Statistical Year Book 2000 of the Ministry of Agriculture & Fisheries (2001); cf. appendix V.

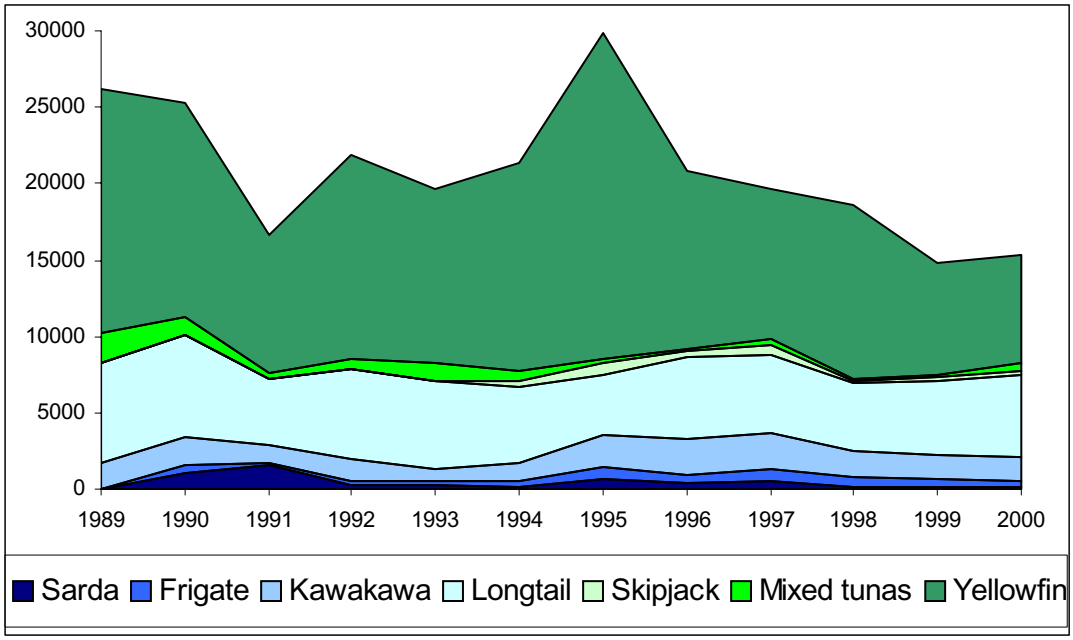

Figure 5: Catch (in t) of tunas by species for the artisanal fishery of Oman (1989-2000)

The coast of Oman (1 700 km) is divided into 6 regions which are, from north to south: Musandam, Batinah, Muscat, Sharqiah, Wusta and Dhofar (Figure 6).

The yellowfin catch by region is given in Figure 7 from 1988 to 2000.

Several main points are illustrated by Figure 7:

- The overall catch, which fluctuated around 12 500 t (average 1988-2000), has dropped seriously in recent years to reach the lowest level ever recorded of 7 000 t in 2000.
- Three regions (Sharqiah, Muscat and Batinah) account for 96.3 % of the catch and Sharqiah itself for 57.7 %;
- The downward trend of the catch is pronounced in Muscat since 1996, it is also important in Sharqiah but mostly since 1999. Conversely, the catch is increasing but remained low in Batinah, Dhofar and Musandam. The overall average yellowfin catch for 1988-1996 and 1997-2000 decreased by 36.5 %; in Sharqiah it decreased by 41 %, in Muscat by 49 %, in Wusta by 68 %, but the catch increased in Batinah by 8 %, in Musandam by 62 % and in Dhofar it was multiplied by 4.7.
- The best catches were recorded in 1989 in Musandam, Batinah and Wusta, in 1990 in Muscat, in 1995 in Sharqiah and in 1998 in Dhofar.

The time series of yellowfin catch is quite short (13 years) and the decreasing trend still recent (since 1996 or 1999 depending on the region), therefore it is premature to draw any conclusions regarding this trend. Nonetheless, it is necessary to look closely to the data for 2001 and 2002. Fishermen consider the yellowfin fishing season, which goes from July to May, as very bad in 2002-2003; in the Muscat region they are still waiting for the start of the yellowfin fishing season.

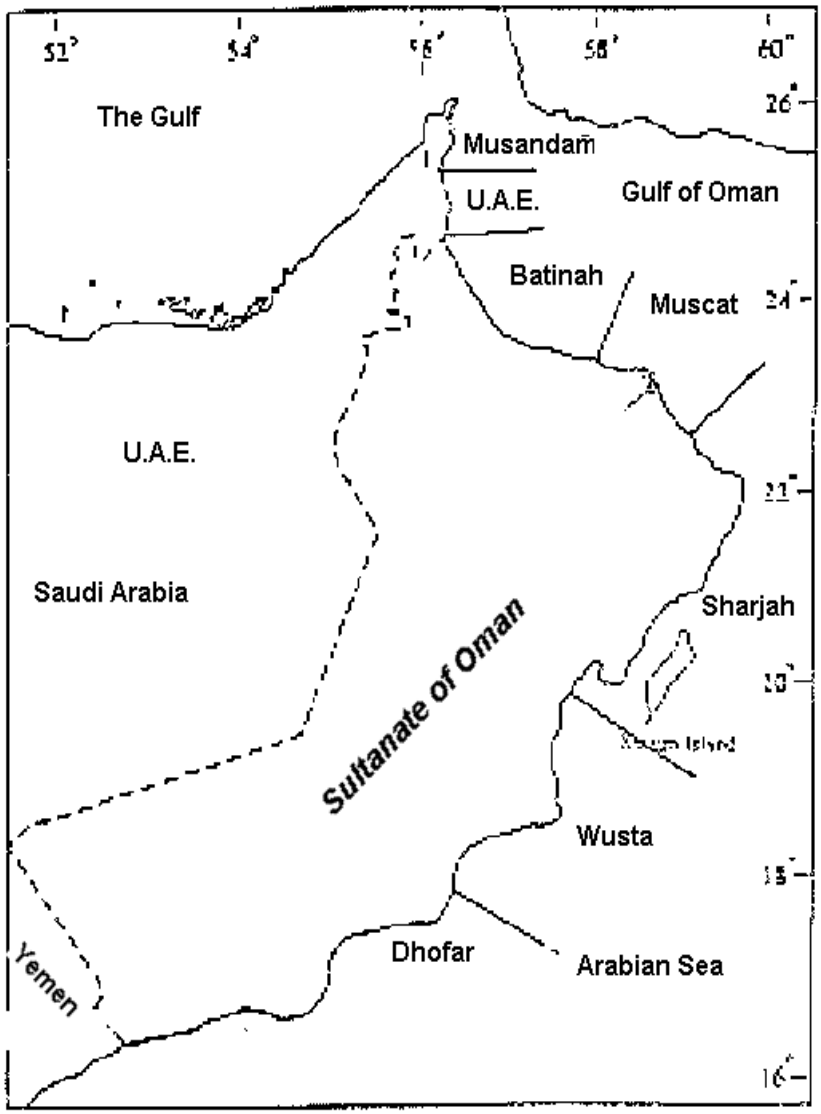

Figure 6: The Sultanate of Oman and the different regions of the country.

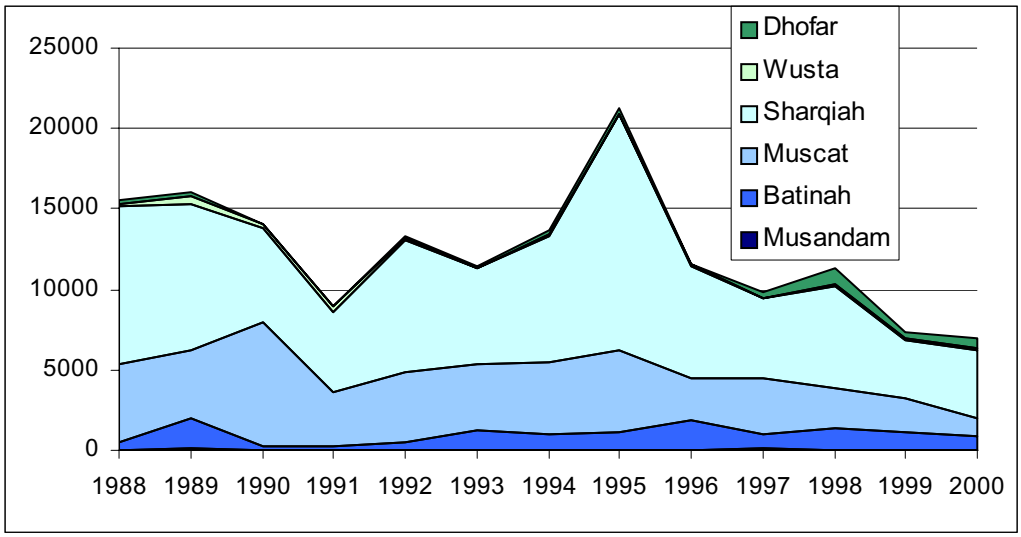

Figure 7: Yellowfin catch (in t) by the artisanal fishery of Oman by region (1988-2000)

Several hypotheses can be put forward to explain this decreasing trend such as:

- Natural fluctuation of yellowfin migration abundance in the region not related to fisheries;

- Environmental change that modified the migration routes of yellowfin in this area or that might decrease the abundance of yellowfin preys in Oman waters; (but in the latter case, shouldn't the abundance of the other tunas be also affected?).
- A change of the migration route of yellowfin in relation with the seeding of thousands of FADs (Fish Aggregating Devices) by the purse seine fleet fishing further south and especially in the Somali Basin. These FADs might trap yellowfin, especially juveniles, and prevent them from following their traditional migrations into Oman waters;
- An overall decrease of the yellowfin stock in relation with the large catch of purse seiners in the Western Indian Ocean; this decrease being more pronounced in the peripheral areas of the stock.

The IOTTP (Indian Ocean Tuna Tagging Programme) is particularly well suited to address these questions through an important tagging effort in the purse seine fishery and in peripheral areas such as Oman. Some additional projects, such as TAGFAD[3] and FADIO[4], will be conducted outside IOTTP but at the same time will address issues regarding the behaviour of tuna in relation with FADs.

When one compares the two periods 1990-1995 and 1996-2000, the catch of the different species of tunas or species related to tunas evolve as follows: yellowfin decreased by 32 %, longtail by 6 %, Sarda by 63 %, sailfish by 11 % and kingfish by 12 %, but frigate tuna catch increased by 56 % and kawakawa by 38 %. Therefore, there is no general decrease trend among tunas and related species in Oman waters, but some concerns are raised regarding some well-fished species (yellowfin, kingfish and longtail). Skipjack are caught mainly in Sharqiah region (87.4 % of the catch for 1994-2000) and in very small amounts in the Muscat and Batinah regions.

The seasonality of the yellowfin fishery is given in Figure 8 from 1989 to 1994 (Mamry, 1996). Despite fluctuations from year to year, the seasonal pattern is quite clear:

- May and June and sometimes July are among the months with minimal yellowfin catch for all years.
- In July or August the catch increases more or less rapidly.
- From September to December the catch increases rapidly and the highest monthly catch is recorded in October or November.
- Then, the catch decreases, generally rapidly, but another catch increase of smaller magnitude is recorded in March or April. This is not the case for all years, as in 1993 and 1994 the catch remain low from February or March to April.
- In 1990, however, catches in March and April were almost as large as the catch in October and November
- 1991 was also peculiar as the highest monthly catch was recorded in March.

This seasonality of the yellowfin fishery is more or less the same whatever the region (Figure 9). In 2000, the month with the highest catch was August in most regions, which is quite unusual.

Sea surface temperature (SST) in this area is favourable to yellowfin presence all-year round, as it fluctuates from 24.3 °C in February to 29.1 °C in July (average from 4806 oceanographic stations in the area 16N-25N/53E-62E from 1980 to 1999) or from 23.9 °C in February to 29.3 °C in June (average from a subset of 545 stations in the area Muscat-Sharqiah – 21°N-23°N/58°E-60°E; data extracted with GAO software, IRD).
The thermocline is not well marked and the decrease of temperature with depth is gradual. The depth of the 20°C isotherm fluctuates from 88 m in August to 152 m in April. One knows that the habitat

[3] TAGFAD is a joint programme between IRD (Institut de Recherche pour le Développement, France) and IEO (Instituto Espanol de Oceanografia, Spain) that should take place in the second half of 2003, is supported by EC funds; its target is to tag medium size yellowfin and bigeye tunas on FADs in the Somali Basin with archival tags in order to better understand the behaviour of these species when they are associated to FADs.
[4] FADIO is a research programme funded by EC from 2003 to 2005 and designed to develop sonic tags suited to FAD-associated tunas and indices of tuna abundance around FADs independently of the fisheries.

limits for tunas in this area are not driven by SST or temperature with depth by the oxycline (the amount of oxygen into seawater).

4.2. Effort and Catch by boat in the artisanal fishery

Effort records available for the Oman artisanal fishery are very difficult to use, as the only data available (Mamry, 1996, covering the period 1985-1994 and Fisheries Statistical year book for 2000) is the total number of boats and fishermen according to the number of licences delivered by MAF. After 1992, MAF blocked the issue of new licences to fishermen or to new boats for some years. The evolution of the number of boats and fishermen for the entire artisanal fishery is given in Figure 10 from 1985 to 1994 and for 2000.

From 1985 to 1992, the number of fishermen increased regularly, while the number of boats, still showing a global increase, decreased in some years (1987 and 1990). Since 1994, if the increase in boats is small (+14 %), the increase of the number of fishermen is much more important (+45 %).

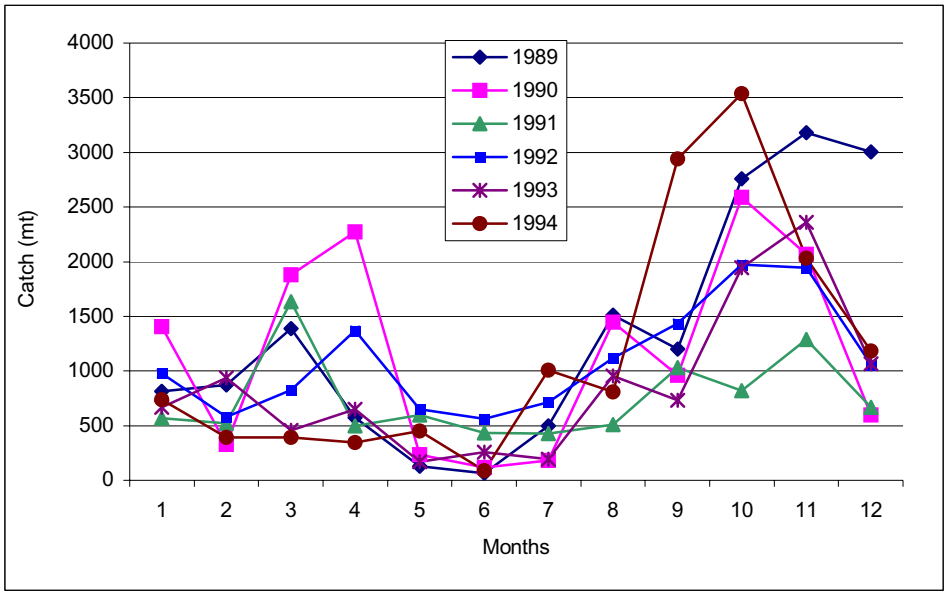

Figure 8: Yellowfin catch (in t) on a monthly basis from 1989 to 1994 (all regions)

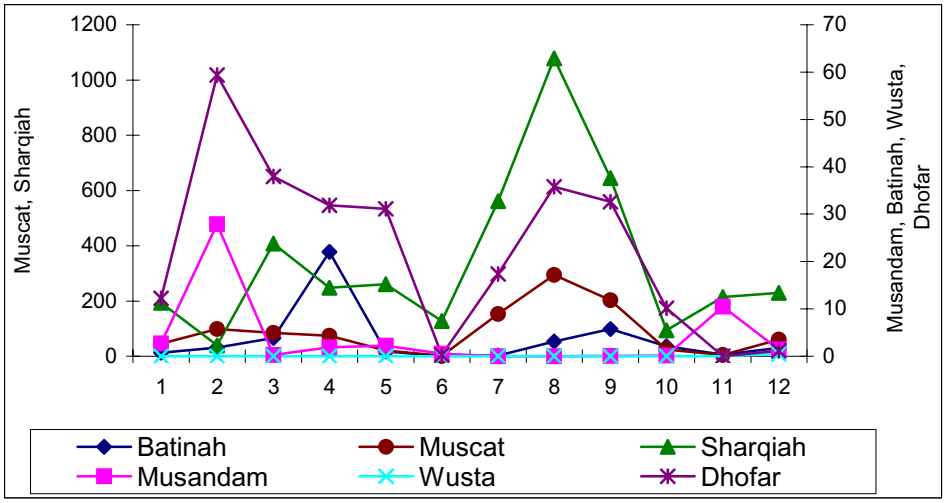

Figure 9: Seasonality by region in 2000 (catch of yellowfin in t/month/region)

However, this increase varies by region, from +182 % in Musandam to –7 % in Dhofar. The overall data suggest that all fishermen are not full time fishermen and some might have other occupations and revenues. Therefore, they do not regularly apply for licences for themselves and for their boats. Most fishermen own their boats, but some can possess several boats. Generally fishermen from one region are not allowed to fish in other regions. For instance, people from Wusta are not well attracted to sea

activities despite the great richness of their waters. Therefore, catches remain low in this area and do not reflect at all the fish abundance of these waters.

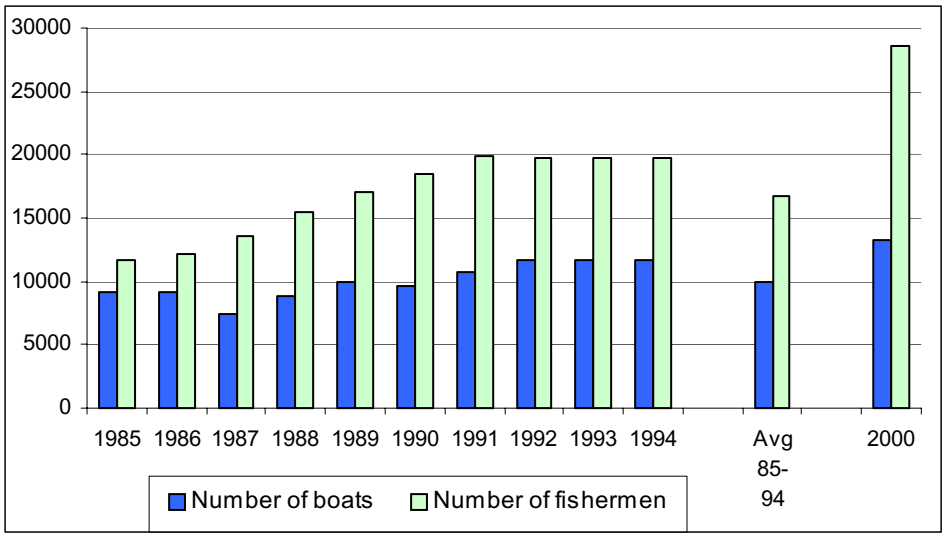

Figure 10: Total number of boats and fishermen licensed in the artisanal fishery of Oman (1985-1994)

Another difficulty comes from the fact that the artisanal fishery uses mainly two different kinds of boats: fibreglass open boats and wooden dhaws, also called launch.

The most common boats are the fibreglass open boats of the Japanese style found in many artisanal fisheries around the world. In Oman, their length range from 16 to 33 feet (in Sur, most of them are 23 or 25 feet). Their width is generally 4 feet. They are all fitted with outboard engine(s) with powers ranging from 15 to 75 HP. In Sur, engines are generally between 55 and 75 HP and the bigger boats have often two engines. One to four fishermen operate on each boat.

The wooden dhaws, mostly manufactured in Sur, are wonderful boats built in the traditional Oman style developed centuries ago. But, as they are in wood, their number tend to decrease because of their high manufactured and maintenance costs. Only few are still built in Sur and many are left to decay in ports. They have a length of 36 feet and above.

There are also three other kinds of vessel (Shasha, aluminium and Hori) of dimensions similar to fibreglass boats. Mamry (1996) distinguish only two types: fibreglass and dhaw. Therefore he probably grouped together fibreglass boats with aluminium, shasha (a type of boat found only in Batinah region) and hori. According to Mamry (1996), these boats together with fibreglass boats account for 80 % of Oman artisanal fishery. In 2000, fibreglass boats account for 80.3 % of the artisanal fleet, other small boats for 16.2 % (together with fibreglass they make 96.5 % of the fleet compared to 80 % in 1995) and dhaws are no more than 3.5 % of the fleet. It is in Sharqiah region where the percentage of dhaws among the fleet is the highest (11.2 % in 2000).

In order to calculate a Catch Per Unit of Effort (CPUE) for yellowfin, it would have been necessary to collect the targeted species for each boat-trip. But, as these data are not available, a yellowfin CPUE calculated as catch per boat per year is not usable as many boats in different regions are almost never or only sometimes targeting yellowfin. Even in the main yellowfin regions, when yellowfin are not abundant, boats target other species (other tunas or large pelagic fish or small pelagic or demersal fish). However, in the region of Sharqiah, where demersal and small pelagic catches are not very important, most of the fishing effort is devoted to tunas. Therefore, the catch per boat and per fisherman has been calculated for all large pelagics, for tunas in general and for yellowfin in particular for this region (Figures 11 & 12).

The catch per boat in 2000 is lower for tunas in general and yellowfin in particular in the Sharqiah region, compared to the period 1990-1994. For large pelagic fish the catch per boat is the second lowest record of this series after 1991.

The catch per fisherman shows the same tendency as the catch per boat; year 2000, ranks last in terms of the catch per fisherman for tunas and yellowfin. Despite the limitations of these catch rates, a

dramatic decreasing trend of large pelagics catch and catch rates is noticed in Oman fishery in general and of tunas and yellowfin in particular.

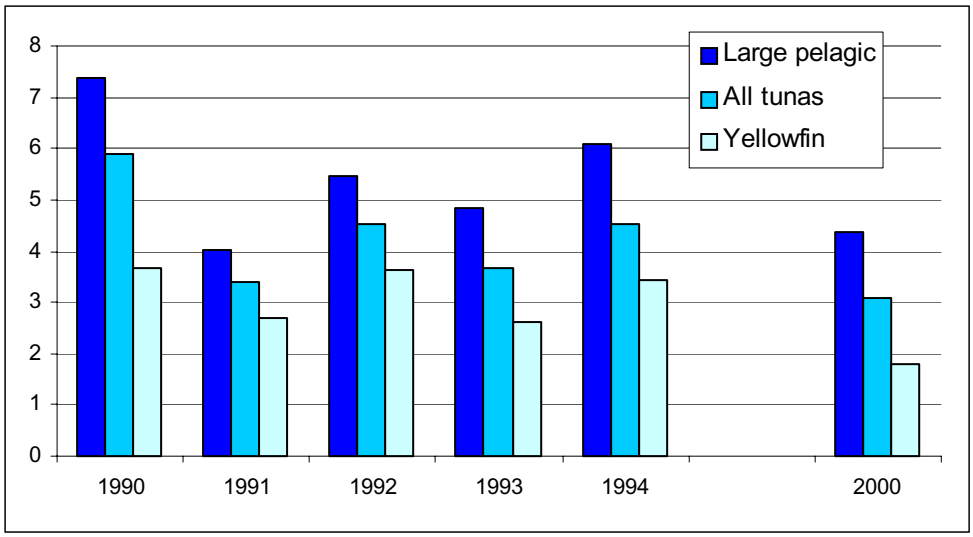

Figure 11: Catch per boat (in t/boat/year) in Sharqiah for several groups of species

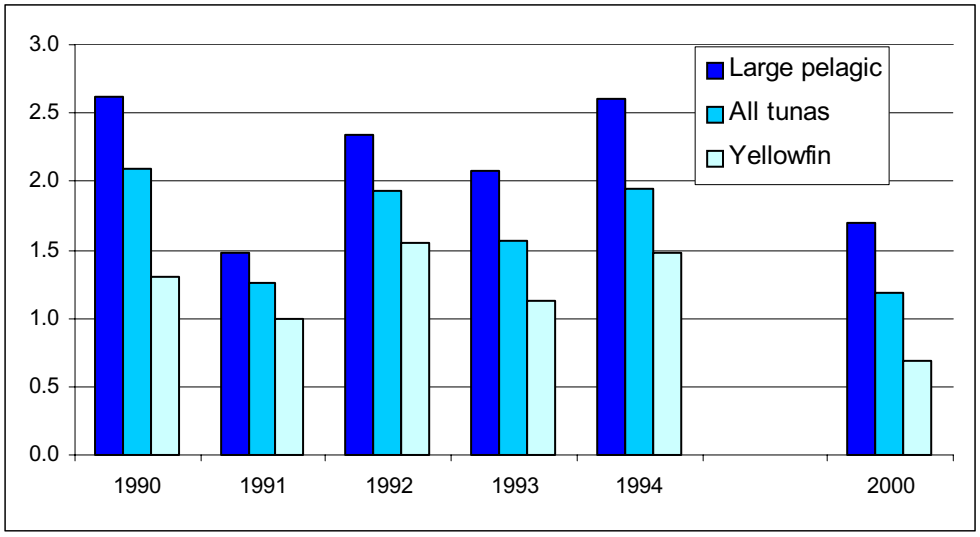

Figure 12: Catch per fisherman (in t/year) in Sharqiah for several groups of species.

4.3. Yellowfin sizes

So far, no size sampling is done routinely on tunas landed in Oman. Mamry (1996), for the purpose of his master of sciences, has collected yellowfin sizes in Oman fish markets by 4 cm interval, but without gear type (Figure 1). He estimated that around 80 % of the fish measured were coming from the gillnet fishery (Mamry, pers. comm.). The overall histograms from Figure 1 present two main modes for yellowfin at 72 cm and at 100cm FL. Sizes range from 40 cm to 160 cm, which means that, yellowfin juveniles and adult fish are found in Oman (yellowfin age at first maturity is around 105 cm). No gonad study has been conducted in Oman, but it would be very interesting to do this for large yellowfin in order to know if they reproduce in this region. The main spawning ground for yellowfin tunas in the Western Indian Ocean has been found to be between Seychelles and Chagos during the first quarter of the year, but some local spawning areas can exist elsewhere. In Oman, it should be quite easy to collect gonads from yellowfin as fish are sold ungutted. When yellowfin are bought, it is quite common that the buyer has the fish filleted in the fish market (as observed in Mutrah fish market) and it would be easy to get the size of the fish and to collect the gonad or to weight it and estimate the maturity stage.

The seasonality of yellowfin sizes is illustrated in Figures 13 & 14 where sizes have been grouped by quarter. From Figure 13, the size of the smallest yellowfin is increasing with the fishing season (the

third term is considered as the start of the fishing season). There are more yellowfin between 88 and 96 cm during the first quarter of the season (July-September) than during the other quarters (this is found for most years). There are many 72-76 cm yellowfin during the second quarter of the year (April-June) but this is related only to years 1991 to 1993 and for the month of April.

These features are better illustrated in Figure 14, where sizes have been gathered in four groups. The proportion of the small group (40 to 68 cm) decreases from 27 % at the beginning of the fishing season (July-September) to 9 % at the end (April-June). This decrease may show that the smallest fish are just passing through the area and are regularly replaced by newcomers slightly bigger. But it could also be the result of the growth of the fish with time. Yellowfin entering into the fishery at 56 cm in July will have grown to 68 cm by June the following year. This increase of 12 cm in a year will represent a growth rate of 1 cm/month. Yellowfin of these sizes can well attend this growth rate. The large number of 88 to 96 cm fish during the first quarter of the fishing season (29 %) is not found in the following quarters (percentage between 11 and 15 %). Either this is an artefact of the sampling or part of this size group corresponds to yellowfin that are just passing through Oman waters.

However, these speculations have to be handled cautiously as we don't know what sampling procedure has been followed and, therefore, if these sizes are a representative sample of the catch. Only a routinely size sampling procedure can give a good knowledge of the yellowfin catch by size.

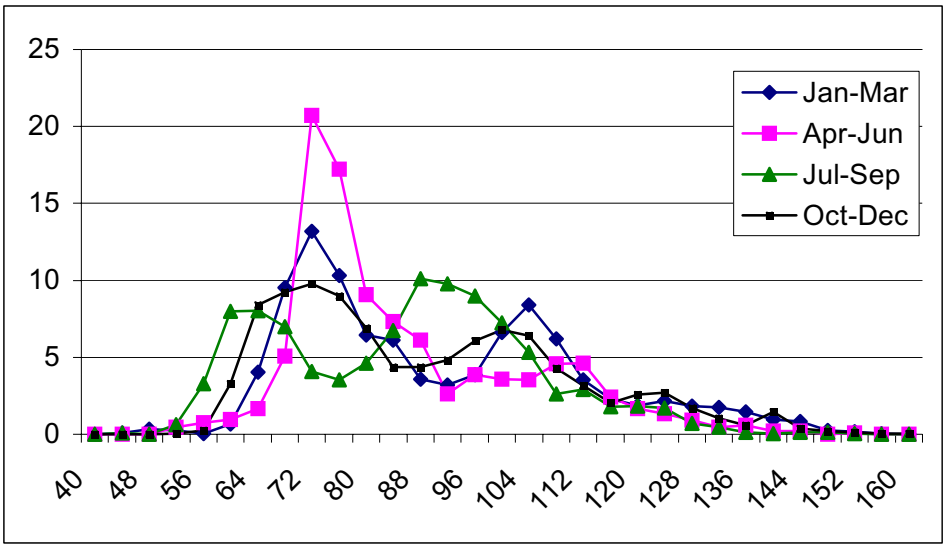

Figure 13: Yellowfin size distribution by quarter in percentage of each size class for the period 1987-1994.

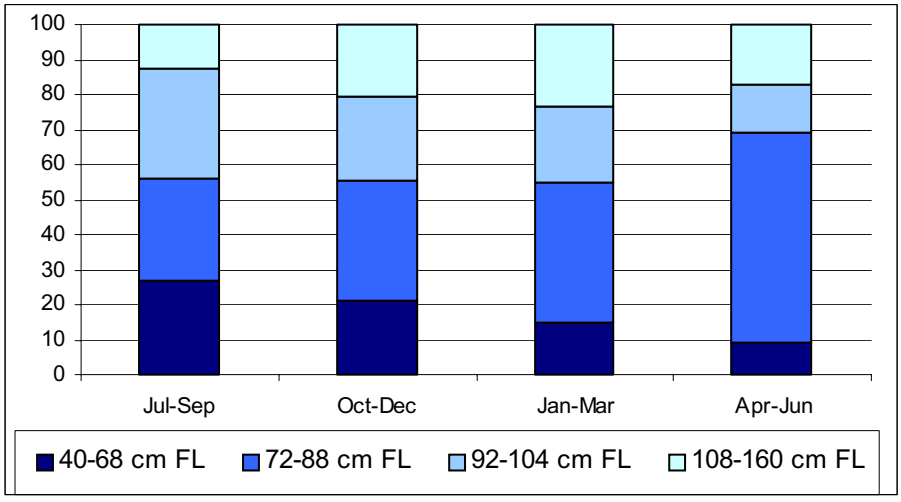

Figure 14: Yellowfin size distribution by quarter in four different size groups for the period 1987-1994.

4.4. Catch of the longline fishery in the Oman EEZ

The Government of Oman started to deliver licences to longliners in 1989 (except in 1999), with some restrictions in order to protect the artisanal fishery (no fishing less than 20 miles from shore). These vessels were from Taiwan, Seychelles and other flags. They do not unload their catch in Oman. The average total catch of this foreign fleet in Oman waters for this period is 5 123 t (from 1 030 t in 1989 to 9 975 t in 1993). This catch is composed of 90 % yellowfin, 6 % sharks, and other species for the rest. The proportions of yellowfin caught by each gear (artisanal and longline) are given in Figure 15 from 1989 to 2000. The catch of foreign longliners was high from 1993 to 1997; since then it has decreased dramatically, as has the duration of the fishing season, down from 12 months per year (1993 to 1995) to 4 months in 2000 (from March to June). The proportion of yellowfin caught by longliners decreased from 44 % in 1993 and 1996 to 16 % in 2000. The yellowfin catch per vessel-day does not show any particular trend, but 2000 with 0.67 t of yellowfin per vessel-day is the lowest CPUE recorded by this fishery since its beginning in 1989 (highest CPUEs are 1.6 t in 1990, 1992 and 1998). One should recall that artisanal yellowfin catch by fisherman is also very low in 2000 (Figure 12).

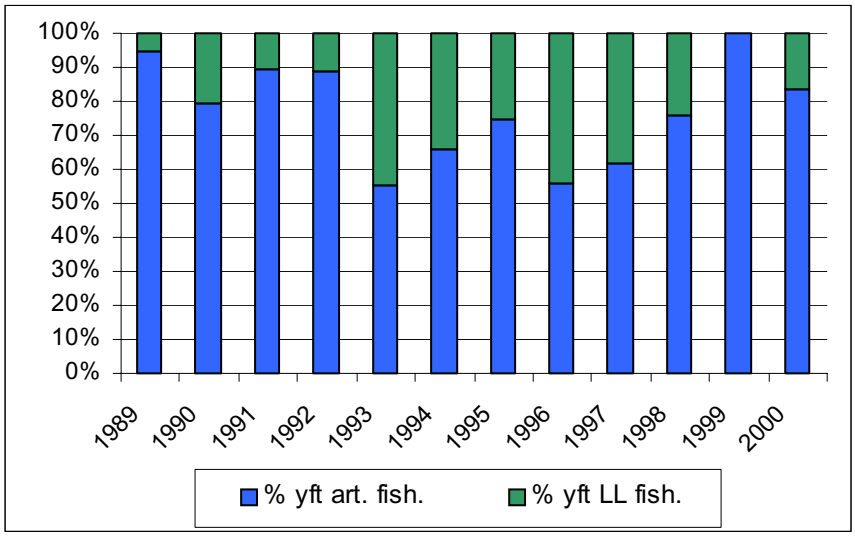

Figure 15: Proportions of yellowfin catch by artisanal and industrial (longline) fisheries in Oman EEZ (1989-2000)

4.5. Catch (by weight and by size) of the purse seine fishery near Oman

Purse seiners are not allowed to fish in Oman waters, but are very active in the vicinity of Oman; for instance to the southwest in the Somali basin since 1984 and in Iran waters east of Oman (purse seiners from Spain, Iran and France since 1996).

There is no purse seine fishing between 16°N and 22°N. To the south of 16°N, the purse seine catch is composed of skipjack (66 %), yellowfin (24 %) and bigeye (10 %). This is due to the fact that purse seiners fished essentially on drifting FADs in this area. However, north of 22°N, the purse seine catch is made between 57° and 62° East and includes 82 % yellowfin, 14 % skipjack and 4 %bigeye.

The area along the costs of Oman and Iran is rich in yellowfin but poor in the two other species of tropical tunas. If one considers this yellowfin catch in the area 8°N-25°N and 50°E- 69°E by three weight grades (or groups): small yellowfin of less than 10 kg (FL <80 cm), medium weight yellowfin between 10 and 30 kg (from 80 cm to less than 115 cm) and large yellowfin from 30 kg and above (FL >= 115 cm), their distribution is given in Figure 16. South of Oman (south of 16°N), the yellowfin catch is dominated by small sized yellowfin, but at the latitude of Oman and to the East, medium sized yellowfin are the most abundant followed by large sizes.

These data confirm what Mamry (1996) has illustrated for Oman waters: medium and large size yellowfin are very abundant in the Northwest part of the Indian Ocean.

4.6. Tuna schools, tuna associations and tuna abundance in Oman

In order to have a better understanding of how different fishing gears at different times are used in Oman, a description of the tuna schools in Oman is necessary.

This area is characterized by catches of six different species of tunas (yellowfin, longtail, kawakawa, frigate, striped bonito and skipjack), by two main gears (gillnets and lines). Schools can be pure or mixed, at the surface or not, close to shore or not, associated or not to birds, dolphins or whales. This

information has been collected with fishermen of Sur, Harsnal and Mutrah (these two last locations are in Muscat close to the MSFC).

4.6.1. In Sharqiah region

In Sur region in December and January, yellowfin (fishes mainly between 80 and 140 cm) can stay close to shore (even at less than ½ mile), next to the bottom (even at less than 150 m) but never at the surface. During the other winter months, yellowfin are not at the surface but not close to the bottom and can therefore be caught by gillnets. In general, in summer, yellowfin are near or at the surface while in winter they will stay deeper.

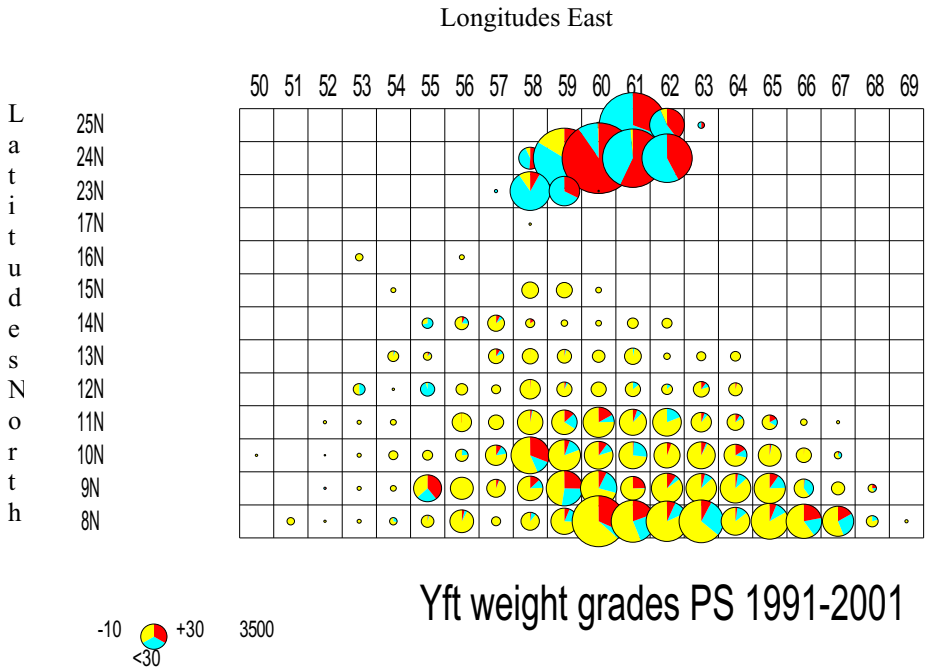

Figure 16: Yellowfin catch distribution in three grades (Wt < 10 kg, 10 <= Wt < 30 kg, Wt >= 30 kg) from purse seiners (1991-2001) by latitude from 8°N to 25°N and by longitude from 50°E to 69°E.

Sometimes, yellowfin are not at the surface but associated to other tunas such as kawakawa or frigate tunas that swim at the surface. Longtail are almost never mixed with yellowfin. Bird are generally associated with longtail schools, but this species can be mixed with all the other neritic tunas (kawakawa, frigate, striped bonito) and with skipjack. Sometimes, skipjack are in pure schools, generally with birds. Skipjack, associated or not, are caught by gillnets in summer. Longtail and kawakawa are more abundant from March to September and frigate from January to July (Figure 17).
Drifting objects or logs are rare and, in some cases, sharks and big yellowfin may be associated together under logs.
Yellowfin are sometimes associated to whales or dolphins. Yellowfin can be associated to dolphins when they are chasing sardines together. The yellowfin, large specimens, will swim deeper in front of the dolphins that swim at the surface. When yellowfin chase the sardines, they will bring them up to the surface and dolphins take advantage of this situation to feed on them. There is no particular season for this behaviour.

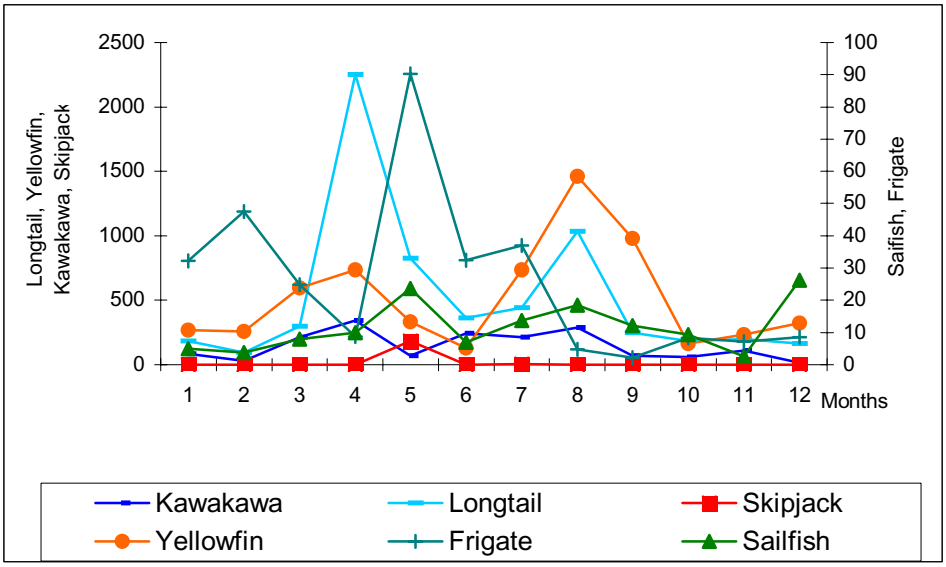

Figure 17: Tunas and sailfish catch (in t) by month in 2000 in Sharqiah region.

In winter, yellowfin catches are irregular, while in summer schools are more regularly abundant.
Fishermen do not think that it is necessary, for better fishing success, to be on the fishing ground at dawn before sunrise and they can keep fishing all day long.
Fishermen complained that yellowfin and longtail abundance are decreasing in recent years.

4.6.2. In Muscat region

In Muscat, bird schools with yellowfin at the surface (generally smaller sizes: 50 to 65 cm) can be found more or less all year round, but are more abundant from September to March or April, generally with a catch decrease in December and January and an increase in February. In the two ports visited in Muscat, fishermen mentioned the frequent attacks of yellowfin by sperm whales (species identified according to their description: square head, dark skin, big teeth). In this case, they cannot fish for yellowfin because they will swim fast in any direction. In Harsnal, they also mentioned that another whale species could chase the sperm whale. However, yellowfin are not associated to this or to any other whale. They recognized yellowfin are often associated to other tunas but they did not mention log schools.
Fishermen recognized that yellowfin and longtail abundance are decreasing since last year. They also mentioned that about 15 years ago they were used to catch skipjack in bigger quantities than now, even if always in lesser quantities than yellowfin.
In Mutrah, they said that smaller yellowfin are more abundant at the beginning of the season than later.

4.7. Gears used to catch yellowfin tuna in Oman

Mamry (1996) is describing four different gears used by the artisanal fishery: gillnet, lines (handlines and troll lines), seine net or coastal nets and trap fishing. Seine nets, which are apparently beach seines, and traps are not catching yellowfin tunas. But Lewis (1995), in a short survey on Oman tagging opportunities, mentioned that costal setnets produce small yellowfin from time to time. Cast nets are also used from shore to catch small pelagics (sardines, Indian mackerels, mullets).
In Sur, as most shores are rocky, coastal nets are not used. Gillnets, handlines (drop-stone technique) and troll lines (when tunas are at the surface) are widely used.
In Harsnal, gillnets, handlines (drop-stone technique) and troll lines are used (this latter technique being largely employed). In Mutrah, the fisherman interviewed used gillnets, troll lines and handlines. For this latter technique, they do not use stones, they just set on the hook a live or a dead bait that they throw into surface tuna schools. To bring tunas in frenzy to the surface, they throw free live baits at sea and then use their handlines. In both locations, they also used small handlines with 2 or 3 hooks with lures to catch sardines to be used as live bait for yellowfin fishing.

4.7.1. Gillnets

Gillnets are widely used for small pelagic fish, for tunas and for sharks in all regions of Oman. Mesh sizes vary according to the species targeted: a bar mesh of 4 cm for small pelagics, 6.5 cm for tunas (Photo 13) and 16 cm for sharks.
For tunas, a piece of gillnet is 80 m long and 9 m high. Fibreglass boats use 6 or 7 pieces and dhaws 10-12 pieces. Gillnets are always set at night: the boats leave in the afternoon or late afternoon to set the net. A net set at 6.00 pm will be hauled up at 11.00 pm, a second set can be made for the rest of the night. This technique in Sur is used all year round when tunas are present, except in December and January when yellowfin are close to the bottom inshore and never at the surface. Therefore, gillnets cannot be set and only handlines are useable in shallow waters (less than 200 m). Dhaws are not equipped with sounders and have no way to find deep-swimming tunas. In general, the artisanal fishery in Oman do not use sounders or GPS; boats, especially for the small fibreglass boats, generally remain in sight of the land. Often, when yellowfin are not at the surface, handline and gillnet sets are made blind by taking into account the fishermen's experience on where fish are found in each season.
While handlining for yellowfin is located in a very limited spot around Sur near the shore adjacent to the gas factory (maybe because this is the only spot where the shelf is not too deep), gillnets are set all along the coast. Gillnets are set at different depths according to the season. When set on logs, large mesh size are used to target sharks, sometimes associated to big yellowfin.
Gillnet and handline techniques are badly affected by rough seas and strong currents. Fishing grounds in the gulf of Oman (Figure 6) are more or less protected from the winds from the southeast monsoon blowing from June to September, but this is not the case for the fishing grounds of the Arabian Sea (southern part of Sharqiah region and all shores of Wusta and Dhofar regions). This is one of the reasons why catches in these two regions are much lower than in the rest of Oman. When the winds stop, dhaws find yellowfin far offshore and fish them with gillnets. Some fibreglass boats might follow them and fish with gillnets also. After a few weeks, yellowfin come closer to shore and become available to all the fibreglass boats. It seems that most yellowfin and other tuna fishing take place close to shore; therefore, this fishery experiences bad catches if the yellowfin are too far offshore.
A good gillnet catch of yellowfin or longtail is around 4 to 5 t (about 800 longtail of 5-6 kg each or 400 yellowfin between 10-15 kg).

4.7.2. Hand and troll lines

We have already mentioned and described the drop stone fishing technique used in Oman (§ 3 – 16th January and photo 7) as well as in many different places around the world to catch yellowfin. I found the lines a bit 'light' for the size of the targeted fish this might result in some fish loss. Baits used are generally sardines, alive or dead. If live baits are used, a dead sardine is still placed on the hook and a free one set as usual with the stone, together with a live bait on a branch line about one meter above the hook. The hook is passed between the eyes of the live bait, while dead bait are hooked by the middle of the body in the front part to have the bait floating more or less in an horizontal and quite natural position. The bait tank is covered with wooden planks. Live bait can also be thrown at sea to bring yellowfin at the surface or to create a feeding frenzy, when trolling will be used (as on bird schools) or just surface baited handlines without any stone.
Handline fishing grounds are found by trial and experience. The fishing grounds are just a 15 to 25 minute ride from Sur harbour and 2 or 3 hours away in Harsnal. Often, only a few boats go fishing while the other fishermen watch their return to port. According to their catch, the next day they will or not go out. That is why I observed these important variations from day to day in the number of boats at sea in Sur.
If yellowfin are found feeding on sardines at the surface, the boat will slowly approach the sardines which sometimes come for shelter under the boat making it easier to catch yellowfin with surface handlines with dead or live baits. Generally, if the yellowfin are abundant, only dead baits are used; in cases of low abundance, live baits are used also. However, all boats are not fitted with tanks. Dead bait are fresh but are not kept on ice on board, maybe because fishing generally lasts between half a day and less than 10 hours. Also, this fishing technique takes place in winter, when temperatures are not too high. Similarly, the yellowfin catch is kept without ice under the wooden deck of the boat where they are protected from the sun. Yellowfin are not gutted prior to marketing (Photo 14).
In Harsnal, troll lines are used when yellowfin are at the surface. When fishermen are fishing for live sardines as bait, they throw and pull small handlines among the sardine school. Sardines hooked in the belly or by the mouth are used dead, those hooked by the fins or the body are used alive.

4.7.3. Comments on the Oman yellowfin fishery

Apparently, anchored FAD are not commonly used in the yellowfin fishery of Oman. Recent use of anchored FADs may have occurred only in Batinah, but more information could not be obtained on this. However, conditions seem to be favourable to the use of FADs for the benefit of the fishermen. Yellowfin of the sizes found in Oman are known to aggregate to FADs (in Comoros or La Reunion for instance in the Indian Ocean, but also in many places in the other oceans). FADs might gather yellowfin otherwise more widespread, making them more vulnerable to fishermen. With the use of FADs, the fishing area and maybe the fishing season could be extended. So far, handlining takes place near shore in depths of less than 200 m. With FADs anchored in deeper places, fishermen might have access to more offshore yellowfin.

Bottom longlines could be used to catch yellowfin but, as this technique requires a winch, it cannot be used onboard fibreglass boats. Dhaws can probably make use of this technique but they will need echo-sounders to detect the presence of yellowfin near the bottom.

During the handline season in Sur gillnet, are not used as yellowfin are near the bottom. I wonder why gillnets are not set near the bottom: bottom too bumpy, gillnets not equipped for this setting?

5. TAGGING OPPORTUNITIES IN OMAN

The interest to tag yellowfin in Oman is explained in § 1 and the presence of medium sized yellowfin is stressed. With an annual catch around 10 000 t and fishing taking place almost all year round (but mostly from August to April) yellowfin are easily available. Artisanal boats and more specifically fibreglass boats make most of the catch. Yellowfin catch statistics are not reported by gear (gillnet and handline mainly, and to a lesser extend troll lines) but gillnets apparently account for most the catch. Yellowfin are caught predominantly in Sharqiah region and secondly in Muscat and Batinah regions.

5.1. Tagging yellowfin from fibreglass boats fishing with handlines

During this mission to Oman, there was unfortunately no yellowfin catch in the Muscat region and some limited catch in Sur. The only possibility was to attempt tagging trials in Sur.

The choice of a fibreglass boat from Sur-Al-Bar was directed by the short notice, the short duration of the mission and the fact that the MSFC technician, Nasser Al-Musharafi, originated from a nearby village that belong to the same community.

Chartering of the boat instead of paying for tagged fish at a higher price than the market price was directed by the necessity to be sure that the boat would go out every day and would embark several persons. When fishing is good, it is certainly not difficult to find a boat to go out and to embark a tagger. But when fish are not abundant, most boats remain in port and it might then be very difficult to find a boat for embarkation. For instance, on Thursday after a good Wednesday's fishing, 60 boats were out, but three days later as fishing remained very poor, only 3 boats went out fishing.

Fishermen from Sur-Al-Bar use gillnets almost exclusively and do not usually fish yellowfin with handlines. Therefore, they rarely fish in December or January when yellowfin are caught only with handlines. Even if yellowfin handlining does not require very special skills, it is nonetheless certain that in case of low yellowfin abundance a skilled fisherman will have more chance to catch fish than a unskilled one.

For the purpose of this study, catch per boat day were not available, but the Statistical Office of the MAF has just made these data available to IOTC and they would be of interest to plan future handline tagging trips. Meanwhile, from fishermen's accounts, each fibreglass boat catches at least 2 or 3 yellowfin in periods of good yellowfin abundance, with the best catching a dozen fish. But during the handline yellowfin season in Sur, abundance varies from day to day and this season last two months at most. These conditions are not very favourable for planning tagging trips, especially if we consider the distance between MSFC office in Muscat and Sur.

Furthermore, yellowfin caught are quite large (fish from 85 to 145 cm FL). Yellowfin are never landed alive on fibreglass boats; they are killed alongside the boat with a few nocks to the head. It is certainly not easy to land large live yellowfin on small boat, but it is feasible for fish less than 80-90 cm FL. For larger yellowfin, it might be necessary either to tag them alongside directly into the back muscles by using BETYP tags (Photo 15) or to use a stretcher. However the use of these tags in these conditions presents two main difficulties: firstly no length measurement could be taken such that these fish will

not be useful for growth studies; secondly, in the absence of length, the price estimation might be difficult and bring contestation from fishermen. Therefore, it is recommended to use the stretcher solution. Its design should be well studied, as it should be manoeuvrable by one person and sufficiently small not to interfere with fishing activities.
When comparing the Mayotte and Oman tagging trials, it appears preferable to use separate boats for fishing and tagging activities. Catch rates from this gear are very low and any possibility to improve the number of fish tagged is welcomed. In Mayotte, as in Oman, anchored boats in a limited area performed the handline drop stone technique. A tagging boat moving between fishing boats can have access to many boats, greatly increasing the number of fish tagged. The tagging boat can be either a chartered boat or a boat of the Fisheries Department, as in Mayotte. However, the use of two boats raises the problem of the transfer of the line between boats. When a tuna is hooked, a cooperating fisherman will start to pull it up and call for the tagging boat. Then, he will transfer the line to the tagging boat that will pull the fish on board. It is very rare that the sea is calm enough to permit the two boats to stay alongside. The two boats will need to part from each other, then the situation becomes difficult as the line will be divided in two: the part with the fish at its end with the tagging boat and the rest with the fishing boat. Either the tagging boat is tied up with a rope to the fishing boat until the fish is released from the fishing line. Or there should be an easy way to separate the line for instance a snap swivel as used on longline.

5.2. From fibreglass boats fishing with troll lines
Troll lines can be used to locate yellowfin schools that are not at the surface then chumming them with live and dead bait to bring them at the surface where surface baited handline will catch them. Local fishermen already practise this technique for instance in Muscat and Sharqiah regions. In some regions or seasons when yellowfin are at the surface, troll lines are also used to catch yellowfin that are generally small (45 to 65 cm FL) – a catch of 50 yellowfin/boat/trip is common (from fishermen accounts at Harsnal). This gear with some modifications such as filed barb on the hook, use of shock absorbers and short lines to keep fish in the best condition can produce catch for tagging. As this fishing technique is not static, the tagger has to be on board the fishing boat.

5.3. From fibreglass boats fishing with gillnets
During this mission, I did not have an opportunity to watch gillnet fishing for yellowfin (a boat of Sur-Al-Bar made a gillnet trial without success). Therefore, it is difficult to say if some yellowfin could be tagged with this gear. With passive gears such as longline and gillnet, the survival of the fish is in question. Abbes *et al.* (1999) have proved that yellowfin and bigeye caught on longline can well survive during several hours but, with gillnets, fish caught probably die rapidly of anoxia. Gillnets have an advantage over handline they catch yellowfin in larger quantity. However to bring on board 500 m of net takes time. Therefore, probably very few fish are still alive when they arrive on board.
Another constraint is the lack of room: the net itself takes all the middle part of the boat; the rest of free space is necessary to manage the net and the fish caught. Therefore, there is certainly not much place left on board for a tagger and a tagging mattress. In principle, the use of this gear for opportunistic tagging is not recommended. But, before this gear is definitively put aside, several points are to be checked:

- What is the proportion of live yellowfin brought on board?
- Is there room available on board for tagging?

5.4. Tagging yellowfin from dhaws
These vessels are catching yellowfin only with gillnet therefore their use as tagging platform is mainly related to the possibility to tag with this gear. But there are other constraints such as the duration of their trips (several days), their small number and their high deck above the sea. In these conditions they do not seem to be a reasonable choice as tagging platform.

5.5. Baits and baitboats
Conditions to perform tuna fishing with a pole-and-line boat seem to exist in Oman: tuna schools at or near the surface (at least in some places and seasons) and availability of live baits. A large number of yellowfin might therefore be tagged in Oman using the IOTTP chartered pole-and-line boat in Oman waters.

Several species of tuna live baits are abundant in Oman waters (Figure 18): Indian oil sardine (*Sardinella longiceps* – Photos 2 & 4), *S. albetta*, Indian mackerel (*Rastrelliger kanagurta* – Photo 1), anchovy (*Stolephorus heterolobus* – photo 12 and *S. buccaneri*). In statistics for Oman, sardines are not always recorded by species but more than 95 % of the sardines landed are *S. longiceps*. Biologists from MSFC question whether *S. buccaneri* is present. This species is generally an more open sea species and would be caught more in offshore waters. Anchovy seen by the consultant on fish markets were *S. heterolobus*.

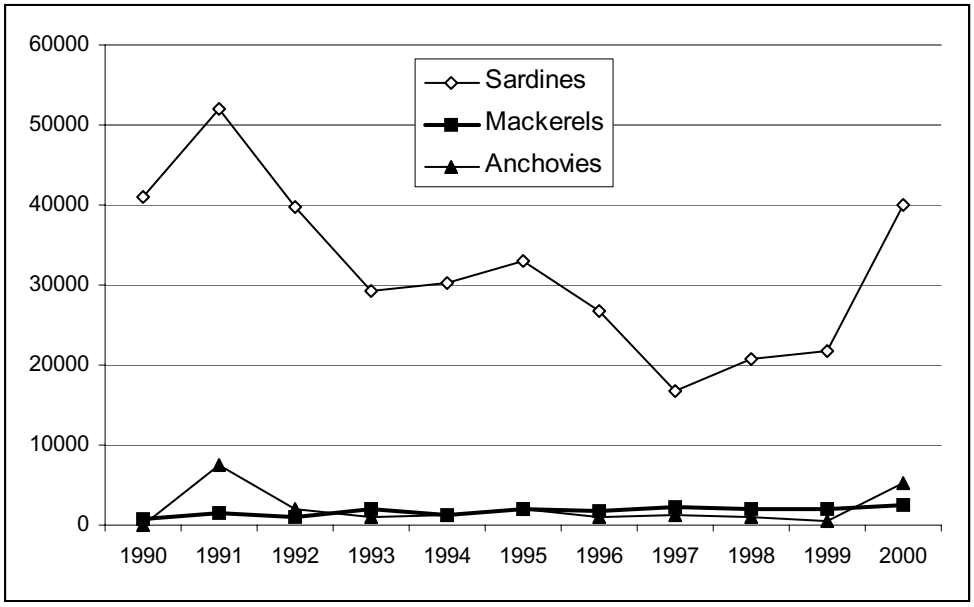

Figure 18: Catch (in t) of the three groups of live bait present in Oman waters (1990-2000)

Sardines are much more abundant than the other groups. Sardines are present in each region (Figure 19) but are more abundant in Batinah, Dhofar and Muscat regions. However the low catch in the other regions such as Sharqiah might not be related to a lower abundance of sardines but to the fact that other species with better prices are available (for instance tunas). Sardine catches in Batinah and Dhofar decreased in the first half of the 90s, then remained more or less stable, while catches increased in the second half of the 90s in Muscat and in Sharqiah (since 1999). However, abundance of sardines is known to present large fluctuations.

A study of the seasonality of sardine landings in Muscat from MSFC data from 1994 to 1998 shows the lowest landings from April to July. The seasonality is available for 2000on Figure 20. In Batinah and Muscat, sardines are available all-year round, with higher catch from February to April. In Dhofar sardines are also more abundant from February to April, but are not fished from July to September. The absence of catch during this period is probably related to the strong winds that blow from southeast. In Sharqiah, there is no seasonality and the sardine catch is more or less the same for every month.

Sardine size frequency data are not available to assess the size fluctuations over the year, but if landings occur all year round in some regions, this probably means that sardines of average size are available all year round. This is a very interesting point for pole-and-line fishing. In general, regarding availability of sardines and other bait in Oman and considering the small quantities necessary for the pole-and-line boat, live bait is certainly not a constraint.

Live baits need not only to be abundant but also strong and with appropriate behaviour.

Actually this sardine is commonly used as live bait by the handline yellowfin fishery of Oman. Therefore, it is strong enough to be kept in rudimentary tanks on board fibreglass boats during several hours. The catch with a boke ami and survival in bait tanks on board a pole-and-line boat have to be tested, but prospects for a success are high. If they prove to be hardy enough, it is even conceivable to use them for pole-and-line operations in the north of Somalia which is only a 350-450 miles journey or one and a half to two days' trip.

The behaviour sought for live bait is to come to hide under the boat for shelter when they are thrown at sea, attracting tunas in the vicinity of the boat where lures on hooks are available.
Local fishermen have noticed that *Sardinella longiceps* schools, when chased by tunas, seek refuge under boats. This reveals that this species probably possesses this very essential behaviour.

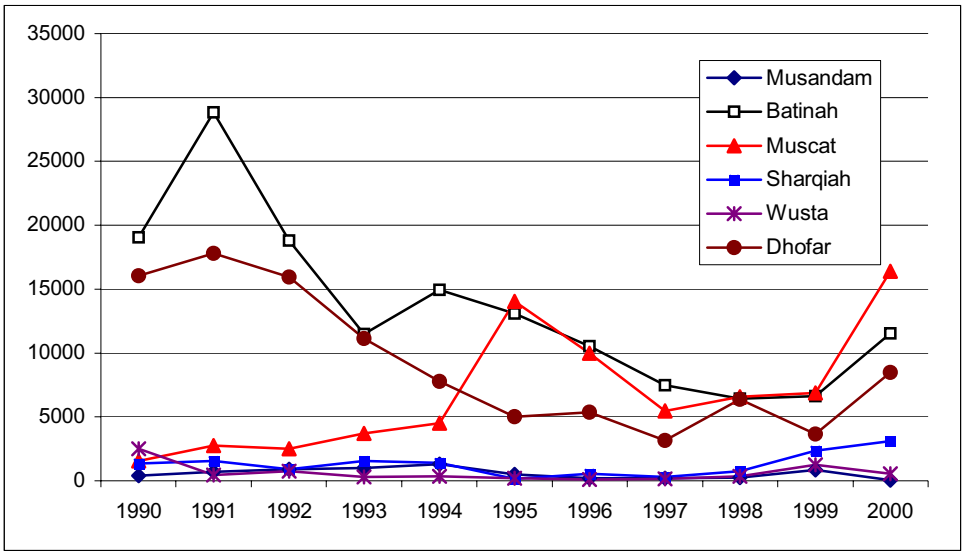

Figure 19: Sardine catch (in t) in the different regions of Oman (1990-2000)

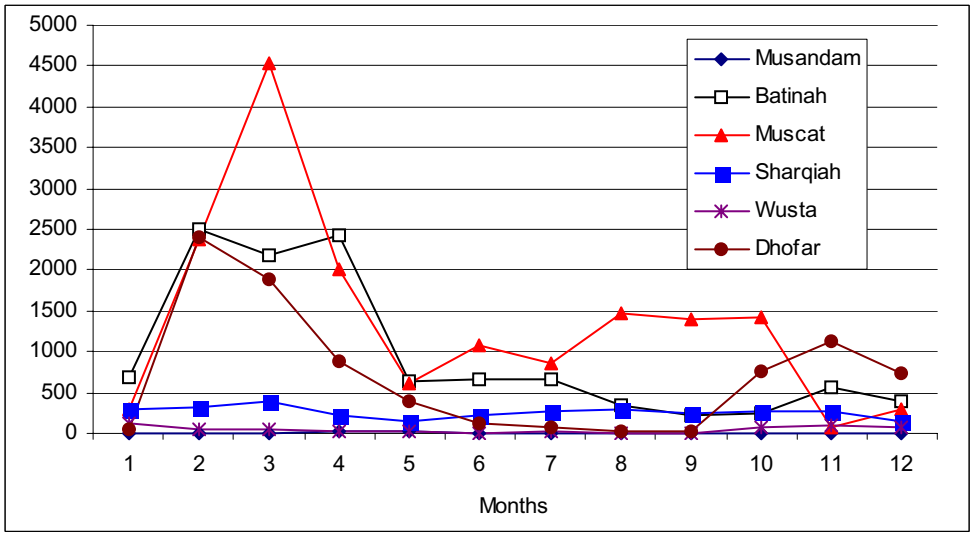

Figure 20: Sardine catch (in t) seasonality in the different regions of Oman (2000)

From these data, *S. longiceps* seems the most promising species:

- This the most abundant bait,
- They have the shelter-seeking behaviour necessary for live bait,
- They are available almost all-year round,
- They are already used as live bait for handline yellowfin fishing,
- They are apparently sufficiently hardy to support confinement in tanks, maybe for several days,
- They have the good size, probably most of the time.

It would be desirable to check whether this species is attracted at night around underwater lights for catching with a boke ami net. If not, their capture during daytime by purse seine is certainly feasible but might result in higher mortality rates.
However, other species such as *Stolephorus hererolobus* and *Rastrelliger kanagurta*, when smaller than 15 cm, can also be used as live bait. When bait is fished at night using boke ami and underwater lights, sardines might be caught together with anchovies and mackerels. However, the abundance of sardines is such that they will most certainly dominate the catch. *Rastrelliger kanagurta* as well as some *Decapturus* and *Selar* species can also be used as live bait, but their size must be lower than 15-17 cm. Above this limit, when thrown to the sea, they tend to flee in any direction, dispersing tunas and keeping them away from the boat.
Barracuda seems to be quite abundant in Oman waters. This species, when abundant, can disrupt bait fishing at night with a boke ami.
Based on practices with Dakar vessels, a pole-and-line boat of the size that could be chartered by the IOTTP will need around 5 t of sardines for a 15 day trip. These quantities are very small when compared to the sardine catch in Oman. Therefore these catches cannot harm the local fisheries.

5.6. Manpower and costs involved

For opportunistic tagging on board fibreglass boats, only one person is sufficient if the tagger is on board the fishing boat, but two are needed if he is on board a separate tagging boat (a tagger and a crew member to steer the boat). As the catch rate is very low for handlines (an average of 2-3 fish per trip) and quite low for trolling (20-30 fish per trip), one tagger is can both tag and record tagging data. In order to cope with possible higher catch rates, the tagger could be provided with a tape recorder.
If tagging is implemented in Oman, it will be done under MSFC responsibility, but MSFC has limited staff resources and for instance no scientists are working on pelagic fish (either small or large pelagics). The Centre possesses a Research Vessel 16 m, *Al-Salt*, mainly geared as a trawler, but several other fishing techniques can be implemented such as longline, squid jigging and trapping. Fibreglass boats similar to those used by fishermen are also available.

During the consultancy, the boat used to go at sea was chartered for reasons explained in § 5.1. The cost was OR 50 per day (US$ 128) for the boat and yellowfin tagged had to be paid at market price. During a period of low abundance when only some boats are catching yellowfin, these conditions are very favourable to the fisherman. Furthermore they are not very incentive as, with only the charter money, the fisherman more than saved his fishing day.
For an operational tagging programme, these conditions would be totally prohibitive and are not recommended. On one hand, the objectives of a tagging programme is to tag as many fish as possible at the lowest possible price. On the other hand, the price paid to fishermen needs to be high enough to secure their participation. In Mayotte, during the tagging consultancy, fish were paid at a price 20 % higher than the market price, a deal well accepted by fishermen.
There should be a payment difference when fish are tagged on the fishing boat or on a Fisheries Department tagging boat. One should consider that taking an extra person on board and having enough room available for tagging could mean reducing the number of crew, probably by no more than one person. If this is the case, it is necessary to take into account this lower fishing power in the price to pay for tagging. However, as the activity level is very limited (2-3 fish/trip) the tagger will generally prefer to handle a fishing line instead of doing nothing.
In Oman, if tagging is taking place on board a separate boat, a bonus of 30 % above the market price should be a good incentive. If tagging is taking place on board the fishing boat, this bonus could reach 50 %. The payment as a bonus above market price presents another advantage: tagging trips should be

planned when yellowfin abundance is high, which also corresponds to lower tuna price on the market. An OR 10 yellowfin during low abundance can be sold for only OR 2 during high abundance periods. The tagging planning should take yellowfin abundance into account very precisely as this will greatly lower the cost per tagged fish and increase the number of fish tagged.
The average yellowfin price per kilogramme in 2000 was OR 0.9 (US$ 2.3) in Musandam, 0.8 (US$ 2) in Batinah, 0.9 in Muscat, 0.5 (US$ 1.3) in Sharqiah (1999), 0.5 in Wusta and 0.4 (US$ 1) in Dhofar (Fisheries Statistical Year Book 2000). It appears that the closer the region is to the UAE, the higher the prices. The UAE market would greatly influence prices on local market. Average yellowfin price in Muscat is very similar to yellowfin price in Mayotte (€2.3/kg). They are other similarities between the two fisheries such as the boats used (fibreglass boat of same size), the same drop stone technique that catch medium size yellowfin (12.3 kg on average for *T. albacares* and *T. obesus* from 1997 to 2000).

6. PUBLICITY AND REWARDS

During the consultancy, with the help of MSFC translator and of Dr. Sadock Ben Meriem, the IOTTP poster was translated into Arabic (Appendix VI). In accordance with the Director of MSFC, it was decided that the tags and the recapture data should be forwarded either to regional offices of the MAF or to the traditional Chief of the different districts.
Rewards suggested by MSFC are about OR 10 to 15, that is more or less the price of a large yellowfin during periods of low abundance. This is a fairly high price, considering the fact that the fish is not required and remains in fisherman's hands to be sold for his own profit. As no yellowfin were tagged during the consultancy, the level of the reward did not have to be set at that time. Discussions on the level of rewards are still going on among scientists involved in the tagging project. Several parameters to set the level of reward can be taken into consideration: the average price of the fish, the average fisherman salary, the country minimum wage. In Oman, as yellowfin caught have a large weight range (mainly from 5 to 50 kg) and price fluctuations on markets are important (a multiplying factor of 5 between prices in low abundance and high abundance), it is difficult to base the reward on tuna prices. I have not been able to collect information on fisherman's salary or on minimum wages. In these conditions, the rewards to be paid for a tag returned in Oman is still to be determined.

7. SPORT FISHING CLUB

I took this opportunity of being at the MSFC to pay a visit to the nearby sport-fishing club, the Blue Marlin, where I met Mr. Mohammed Al-Wahaibi, Marketing & Sales Executive of Marina Bander Al-Rowdha. I did not have a chance to meet somebody from the board, but I left my card and explained the purpose of my visit, which was to inform the club of the beginning of a large tuna-tagging programme in the Western Indian Ocean in which sport fishing clubs may be involved. The well-furnished store of the club and the number of boats in the harbour let think that the club is quite active. There are few other sport-fishing clubs around Muscat and species targeted are sailfish and yellowfin.

8. OMAN TUNA TAGGING PROGRAMME

There is no doubt that yellowfin tuna tagging in Oman should be one component of the IOTTP, considering the importance of the catch (about 10 000 t/year) and the fish size range (60 to 140 cm FL). The importance of yellowfin tunas for Oman fishermen as well as for Oman fisheries has been discussed in previous pages. Even with the help of IOTC funds, the realization of tagging operations in Oman will need the commitment of MAF through its working arm the MSFC.
Two different tagging operations are recommended: opportunistic tagging from the artisanal fishery and tagging trips by the IOTTP bait boat.

8.1. Opportunistic tagging

At this stage with the data available, it would be unrealistic to set a detailed Oman Tuna Tagging Programme with a calendar and detailed budget, but to help in establishing the order of magnitude of such a tagging programme, some expense estimates are given in Appendix VII. These estimates are given more for discussion among the different parties concerned than as realistic figures.
Several requirements are listed for better planning of tagging operations in Oman:

- To analyse the yellowfin catch per boat trip and by gear for the most recent years,
- To analyse recent yellowfin seasonality in Muscat and Sharqiah regions in general and Muscat ports in particular;
- To sample yellowfin sizes in Oman.

The decreasing trend of yellowfin catch in Oman in general and in the Muscat region in particular is worrying and can affect the success of planned tagging operations. The analysis of the most recent data should confirm this trend and give some idea on the number of yellowfin that can be expected by boat trip. Size samples would give the seasonality by gear.
At the beginning, to make it simpler and cheaper, it is recommended that tagging trips should be organised with fishermen from ports located near the MSFC such as Harsnal, Qurayyat and Mutrah. The proximity with MSFC has several advantages:

- Easier and cheaper to organize tagging trips;
- Easy to have real time information on yellowfin fishing conditions, greatly improving the probability of successful tagging trips;
- The manpower required from MSFC will be lower than for tagging operations in Sur, as very little time will be lost in transport from MSFC to ports;
- Strengthening relations between the MSFC and its staff on one side and the local fishermen on the other side.

Considering the seasonality of the yellowfin fishery and the fact that most tagging funds are not yet available to IOTC, first tagging trials could not be planned for the on-going fishing season but at the best during the next season starting in August 2003.

The cost involved will be similar to cost estimates listed for Mayotte because of the similarities in:

- Fishing techniques: drop stone fishing technique or trolling,
- Fishing boats,
- Tagging boat,
- Yellowfin size,
- Yields per boat per trip (this need to be confirmed),
- Yellowfin price paid to fishermen

Costs have been estimated on two hypothesis of tagging effort: a low effort of 1.5 trip/week and a high one of 2.5 trips/week. Two periods of tagging in accordance with yellowfin seasonality are proposed:

- August to October or September to November (3 months)
- February-March or March-April (2 months).

However it is not certain that fishermen will use handlines to catch tunas for these two periods in ports around MSFC. As was noted, handlines are used in Sur only from December to January. The two periods listed above will need to remain flexible in order to take into account the natural fluctuation of yellowfin seasons. With these assumptions, cost estimates are listed in Appendix VII.
The use of one of MSFC fibreglass boat and the participation of the boat driver and one technician for tagging would be the MSFC contributions to the OTTP.

8.1.1. Tagging from handline fishing

Tagging should be conducted with fibreglass boats when they fish with handlines (either drop stone or surface baited techniques) or troll lines. If fishing is done by handline, it is recommended to test the possibility to use one of the MSFC fibreglass boats for tagging fish caught by the commercial fleet. To implement this procedure, it is necessary to approach fishermen to know how many would be willing to participate. The MSFC boat will accompany fishing boats on fishing grounds and collect from participating boats any line with hooked yellowfin. In Mayotte, an official receipt was delivered on the spot and payment was made later through fishermen's cooperatives, but in Oman, it might be necessary to pay for the fish directly at sea. This will probably prompt more fishermen to participate.
It might be necessary to supply co-operative fishermen with snap swivels for easy partition of the line.
Results from these tagging trials in Muscat region will determine if it is necessary to organize some tagging in Sur. In Sur, if no MSFC fibreglass boat is available, it will be necessary to charter a local boat, at least at the beginning, but with a charter cost of OR 50/day or OR 900 for the purchase of a 23

fibreglass boat plus OR 850 for a 55 Hp outboard engine, it might be cheaper on the long term to buy one. Another possibility is to drive one from MSFC in Muscat to Sur. But in Sur, tuna tagging will certainly be limited to December and January as, for the rest of the year, tunas are only caught with gillnets.

8.1.2. Tagging from troll fishing

If fishing is done by trolling or surface baited handline, it is recommended that the MSFC member should board a fishing boat to conduct tagging on board. The dynamic of these fishing techniques and the rapidity of fishing operations are incompatible with the use of two boats. Tagged fish would be paid at 50 % above market price.

8.1.3. Tagging from gillnet fishing

As gillnets are the main fishing gear used to catch yellowfin, information on the availability of live yellowfin from this gear should be studied. Eventually some tagging trials should be performed.

8.2. Bait boat tagging

It is expected that the IOTTP will start in 2004 when EU funds become available. This programme is scheduled to last 5 years, including two years of pole-and-line vessel charter (mid 2004 – mid 2006). This vessel is expected to concentrate its activities in the western basin of the Indian Ocean. The pole-and-line fishing technique requires live bait that are not available everywhere. Quantities required (5t/15 days) can be easily found in Oman.

Therefore, authorizations will have to be obtained from the government of Oman:

- For live bait fishing,
- For tuna fishing for tagging.

Staff from MSFC should be invited to participate to the IOTTP bait boat activities in Oman. If baits from Oman are sufficiently strong, one can envisage that bait from Oman may be used in nearby waters.

For future IOTTP bait boat trips to Oman, it will be interesting to collect more information on the sardine availability by size by month, as well as the occurrence of yellowfin surface schools.

9. CONCLUSIONS

No yellowfin could be tagged during this mission to Oman due to the absence of yellowfin in Muscat region and its very low abundance in Sur. However, data collected and fishing techniques observed locally have confirmed the possibility of tagging yellowfin in Oman and the tagging potential in this region. The handline drop stone technique used in Oman to catch yellowfin has many similarities with the technique used in Mayotte and trolling around FADs in Mayotte is certainly comparable to trolling on surface schools in Oman. Therefore, tagging operations in Mayotte will bring valuable information on the tagging potential in the Oman artisanal fishery and the costs involved.

The potential for tagging from a bait boat appears to be very high and should be attempted in due course. One can wonder if it will be necessary to conduct tagging from artisanal fishery if tagging from a bait boat can be successful. However, the bait boat would probably not have access to adult yellowfin and its cruises will be quite limited in time, while opportunistic tagging from the artisanal fishery can have access to large yellowfin and can take place at different times during the yellowfin season.

AKNOWLEDGEMENTS

This mission and report was carried out by the consultant with the help of the staff of the Marine Sciences and Fisheries Centre in Oman under the leadership of its Director Dr. Ahmed Al Mazrooei. The assistance of MSFC staff such as Mr Marzouki and Musharafi and Dr. Ben Meriem, was very helpful.

The views expressed herein are those of the author and do not necessarily coincide with those of the Omani Government or of IOTC.

APPENDIX I : PERSONS MET DURING THE MISSION

Dr. Younis Khalfan Al-Akhzami, Director General of Fisheries, Ministry of Agriculture & Fisheries, P.O. Box 467, Postal code 113, Muscat, Sultanate of Oman. Tel : (968) 69 63 69, Fax : (968) 60 56 34, E-mail : younisa@hotmail.com

Dr. Ahmed Mohd. Al Mazrooei : Director Marine Science & Fisheries Centre, Ministry of Agriculture & Fisheries, P.O. Box 374, Postal code 324, Muscat. Tel : (968) 73 64 49 / 74 00 61/2, 933 34 83, Fax : (968) 74 01 59, E-mail : ahmed483@omantel.net.om

Mr. Habib Abdullah Habib Al-Hasni, Director of International Relations, Ministry of Agriculture & Fisheries, P.O. Box 467, Postal code 113, Muscat. Tel : (968) 69 41 82, Fax : (968) 69 59 09, E-mail : agricop@omantel.net.om

Mr. Abdulaziz Al-Marzouqi, biologist on stock assessment of demersal species at MSFC, P.O. Box 467, Postal code 113, Muscat. Tel : (968) 74 00 61; 920 22 55 E-mail : zizo2@yahoo.com

Dr. Sadok Ben Meriem, biologist on stock assessment of demersal species at MSFC, P.O. Box 467, Postal code 113, Muscat. Tel : (968) 921 32 40, E-mail : bmsadok@Francite.com

Mr. Nasser Al-Musharafi, technician of MSFC and ex-fisherman from Sur.

Mr. Jemal Al-Shuaibi, fisherman and owner of the fibreglass boat chartered for this mission during trips at sea from Sur-Al-Bar.

Mr. Abdullah Al-Musharafi, fisherman on the fibreglass boat of Sur-Al-Bar.

Mr. Mohammed Al-Wahaibi, Marketing & Sales Executive of Marina Bander Al-Rowdha at the Blue Marlin Sport Fishing Club near MSFC. P.O. Box 940, Muscat Postal Code 113, Sultanate of Oman. Tel : (968) 73 72 88 extn. 143, GMS : (968) 9 36 88 08, Fax : (968) 73 72 85, E-mail : mohd@marinaoman.com, Internet : www.marinaoman.com

Dr. Alejandro Anganuzzi, IOTC Deputy Secretary, IOTC, PO Box 1011, Victoria, Seychelles. E-mail: aa@iotc.org

Mr. Koichi Sakonju, Projet Co-ordinator, Overseas Fishery Cooperation Foundation (OFCF), IOTC, P.O. Box 1011, Victoria, Seychelles. E-mail: ks@ioyv.org

APPENDIX II : CONSULTANT DAILY ACTIVITIES

Date January	Location	Activity
11	In transit	Depart Montpellier 11.00, transit via Frankfurt and Dubai
12	Muscat	Arrival at 9;00, transfer to hotel, meeting with the Director of MSFC
13	Muscat	Meeting at MSFC with scientists and technicians
14	Muscat	Official meeting with the Director General of Fisheries, cruise planning
15	Muscat / Sur	Cruise planning and trip to Sur
16	Sur	First trip at sea
17	Sur	Second trip at sea
18	Sur	Third trip at sea
19	Sur	Fourth trip at sea
20	Sur / Muscat	Fifth trip at sea
21	Muscat	Working on report
22	Muscat	At MSFC, Harsnal and Mutrah and visit to a sport fishing club
23	Muscat	Working on report
24	Muscat	Working on report
25	In transit	Depart Muscat 1.00, transit via Frankfurt, arrival at Montpellier 15.30

APPENDIX III. ORGANISATION CHART OF THE DIRECTORATE GENERAL OF FISHERIES

This directorate includes 5 sections:

- Development of fisheries resources
- Inspection and fishing permits
- Popularisation
- Quality control centre
- Marine Sciences & Fisheries Centre (MSFC)
    - Laboratory for living resources
    - Laboratory for Salalah resources
    - Laboratory for aquaculture
    - Laboratory for environment
    - Laboratory for fishing technology
    - Computer section

APPENDIX IV : TAGGING CRUISE CATCH SUMMARIES

Date	Species	Qty	Gear	Tagged	Comments
16/01/03	*Sphyraena jello*	1	HL		55 cm FL
17/01/03	*Alectis ciliaris*	1	HL		Carangidae
17/01/03	*Sphyraena jello*	1	HL		90 cm FL
17/01/03	*Arius thalassimus*	3	HL		Catfish (55, 76, 60 cm FL)
18/01/03	*Sphyraena jello*	5	HL		All the same size (50-55 cm)
18/01/03	Shark	1	HL		80 cm FL
19/01/03	*Lethrinus nebulosus*	2	HL		
19/01/03	*Arius thalassimus*	1	HL		62 cm FL used for tagging training
19/01/03	*Alectis ciliaris*	2	HL		
20/01/03	*Sphyraena jello*	1	HL		57 cm FL with bottom line
20/01/03	*Epinephelus chlorostigma*	1	BL		with bottom line
20/01/03	*Lethrinus nebulosus*	2	BL		with bottom line
20/01/03	*Sphyraena jello*	1	BL		130 cm FL with bottom line

HL: Handline, BL: Bottom line

APPENDIX V : BIBLIOGRAPHY CONSULTED

Abbes, R., F-X. Bard (Eds.), 1999. ECOTAP: Etude du comportement des thonidés par l'acoustique et la pêche en Polynésie Française. Rapport Final Convention Territoire/EVAAM/IFREMER/ORSTOM n°951070, 523 p.

Abdisalaam, T. Z., 1991. Yellowfin tuna in Oman : A status report. IPTP Coll. Vol. Work. Doc.- 6, TWS/91/28, pp. 189-190.

Anganuzzi, A., 2002. Back-to-office report: Mission to the Sultanate of Oman (April 29th, 2002 – May 3rd, 2002). IOTC, 4 p.

Anonymous, 2001. Fisheries Statistical Year Book 2000. Sultanate of Oman, Ministry of Agriculture & Fisheries, July 2001, 238 p.

R. D. Dudley, 1989. Large Pelagic Final Report. Ministry of Agriculture and Fisheries, Directorate General of Fisheries, Marine Sciences & Fisheries Center.

Dudley, R. D., 1989. Oman's large pelagic species: Management and research considerations. Ministry of Agriculture and Fisheries, Directorate General of Fisheries, Marine Sciences & Fisheries Center; MSFC Research Brief Number 89 – 2; 7 p.

Hallier, J.P., B. Wendling, M. Ducrocq, 2002 Pilote mission for opportunistic tuna tagging in Mayotte Island (France) and supply opportunities for live baits (21/05 – 29/05/2002). IOTC, 52 p.

Hallier, J.P., 2003. Tagging Manuel: some comments and instructions for tuna tagging in small-scale fisheries; 9 p.

IPTP, 1992. Report of the workshop on stock assessment of yellowfin tuna in the Indian ocean, Colombo, Sri Lanka. IPTP/91/GEN/20, 1992; 90 p.

Itano, D.G., J.P. Hallier, 2002. IOTC tuna tagging consultancy in Seychelles (01/10 – 02/11/2002). IOTC, 49 p.

Lewis, A.D., 1995. A proposal for tagging in the Sultanate of Oman; IPTP, 2 p.

Mamry, J. M., 1996. Fisheries study on Yellowfin tuna (*Thunnus albacares*) family Scombridae in Omani waters. Thesis at the University of Science, Suez Canal University; 180 p.

APPENDIX VI : INSTRUCTIONS FOR TUNA RECAPTURES (TAGGING POSTER)

APPENDIX VII : COST ESTIMATES FOR OPPORTUNISTIC TAGGING FROM FIBREGLASS BOATS WITH THE ASSISTANCE OF A MSFC FIBREGLASS BOAT

Hypothesis	Low number of trips/week	High number of trips/week
Number of trips/week	1.5	2.5
Number of tagging weeks[1]	12 + 8 = 20	12 + 8 = 20
Number of tagging trips	20 * 1.5 = 30	20 * 2.5 = 50
Yellowfin average weight[2]	12.3	12.3
Average yield/boat/day (kg)[3]	56	56
Average yield/boat/day (nb)	56 / 12.3 = 4.5	56 / 12.3 = 4.5
Number of participating boats[4]	3	3
Number of Yellowfin tagged	30 * 4.5 * 3 = 405	50 * 4.5 * 3 = 675
Weight of tagged Yellowfin	405 * 12.3 = 4981.5	675 * 12.3 = 8302.5
Cost of tagged Yellowfin (€ 3/kg)	4981.5 * 3 = 14944.5	8302.5 * 3 = 24907.5
Number of gasoline liters/trip[5]	130	130
Gasoline cost (€ 0.32/L)	130 * 30 * 0.32 = 1248	130 * 50 * 0.32 = 2080
Small materials (€ 500/tagging year + € 1/tag)	500 + (405 * 1) = 905	500 + (675 * 1) = 1175
Total cost (€)	14944.5 +1248+ 905 = 17097.5	24907.5 +2080+ 1175 = 28162.5

1: 12 weeks (3 months) from August to October or September to November and 4 weeks (2 months) from February to March or from March to April.
2: Taken from Mayotte artisanal fishery as Oman yellowfin average weight caught by handline and troll line is unknown.
3: Taken from Mayotte artisanal fishery until data from Oman become available.
4: Taken from Mayotte artisanal fishery.
5: Taken from Mayotte tagging trials. For Oman, in Sur this consumption will be much lower as fishing grounds are very close to port but additional costs will come from the distance between MSFC and Sur; in Muscat, it will depend on the distance between MSFC and fishing grounds.

Photo 1 : Indian mackerel (*Rastrelliger kanagurta*) at Mutrah fish market (Oman)

Photo 2: Sardines (*Sardinella longiceps*) at Mutrah fish market (Oman)

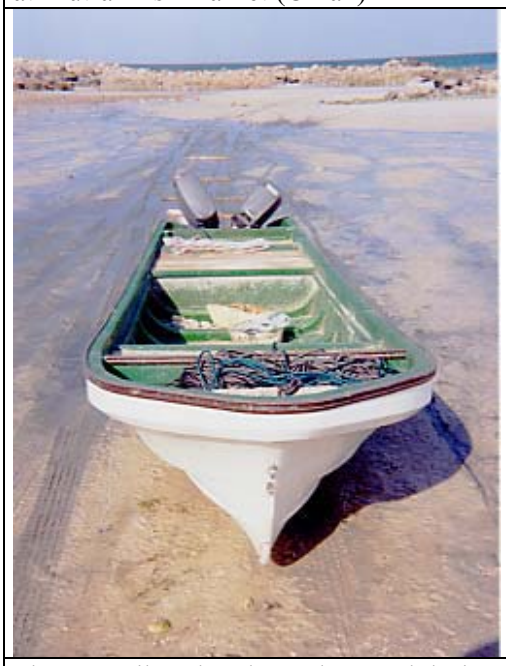

Photo 3: Fibreglass boat chartered during the consultancy (25 x 4 feet) in Oman

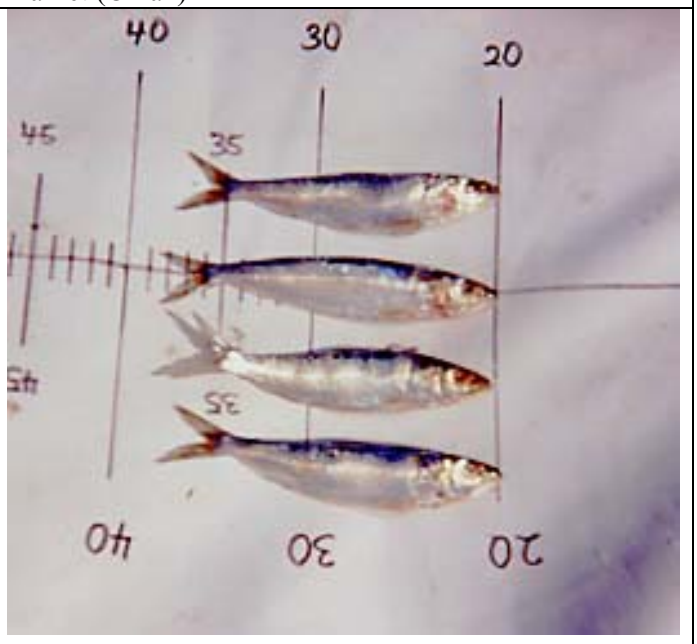

Photo 4: *Sardinella longiceps* used as bait for the drop stone fishing technique for yellowfin in Oman

Photo 5: Handline and bait used for the drop stone fishing technique for yellowfin in Oman

Photo 6: Chartered fibreglass boat on yellowfin fishing ground north of Sur (Oman)

Photo 7: Anchored boat handline fishing for yellowfin near Sur (Oman)

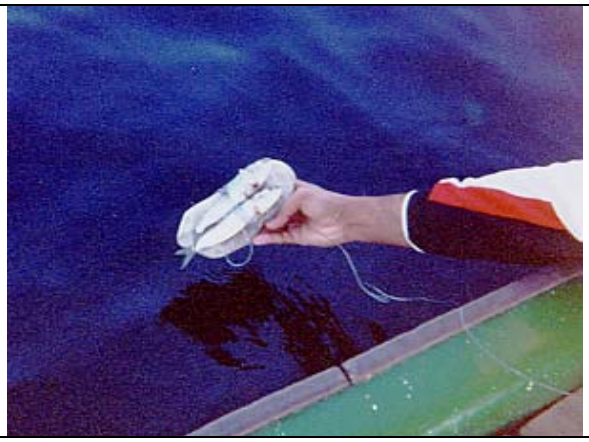

Photo 8: Drop stone fishing technique: one sardine on hook wrapped together with a free sardine on a stone, ready to be thrown overboard.

Photo 9: Beached boats and trucks on the beach in Sur (Oman)

Photo 10: Beaching boat with a 4x4 trucks in Sur-Al-Bar harbor (Oman) at low tide

Photo 11: Small bait tank with live sardines on board a fibreglass boat near Sur (Oman)

Photo 12: Anchovies (*Stolephorus heterolobus*) at Mutrah fish market (Oman)

Photo 13: View of the gillnet mesh used for tuna fishing in Oman

Photo 14: Ungutted yellowfin at Mutrah fish market (Oman)

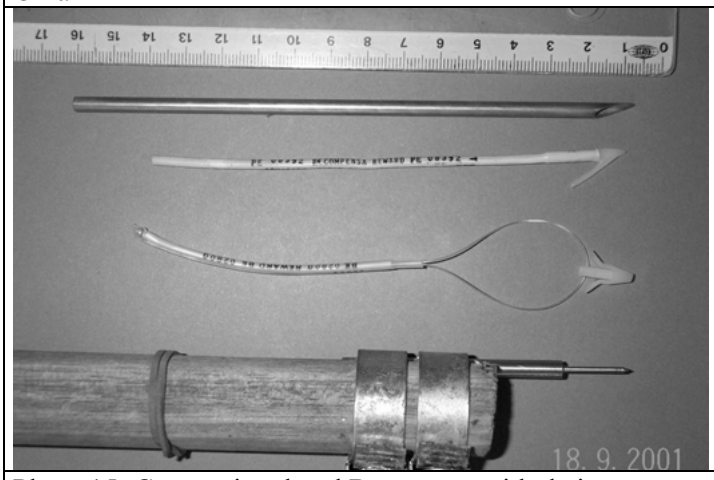

Photo 15: Conventional and Betyp tags with their applicators

Scale in cm

Tag applicator for conventional tag

Conventional tag

Betyp tag

Tag applicator for Betyp tag tied up on a hand pole on which a rubber band is set to avoid the dropping of the tag