09th Session of the Working Party on Tropical Tunas – July 2007
Victoria, Seychelles

16-20 July 2007

The Maldivian Tuna Fishery – An Update

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SUMMARY

The Maldivian pole-and-line tuna fishery has been in existence for hundreds of years. The sailing fleet underwent mechanization in the 1970s. By mid 1980s the purpose-built second generation vessels that replaced the converted sailing vessels increased the catch by threefold. However, further rapid increase in catch was slow until late 1990s with third generation fibreglass (FRP) vessels joining the fleet. Catches then doubled from 1996 to 2006. Private sector investments in post-harvest sector are driving the most recent phase of fishery expansion. These include the additional collection and storage facilities, tuna canneries and the rapidly growing fresh tuna export business.

Total reported tuna catches at present are 170,000 mt of which 80% is skipjack tuna *(Katsuwonus pelamis*) followed by yellowfin tuna (*Thunnus albacares*). Other coastal varieties, frigate tuna (*Auxis thazard*) and kawakawa (*Euthynnus affinis*) are caught in small quantities, <5% at present. Roughly a third of this catch is consumed locally the rest are exported in canned, fresh/chilled, frozen, dried, and other forms. The total export earnings in the recent years were in excess of US$ 100 million.

The increasing fishing power and efficiency CPUE of both skipjack and yellowfin tuna are increasing. Skipjack CPUE has increased almost consistently in the recent years; from about 270 kg day in 1997 to over 600 kg /day during 2006. Yellowfin CPUE has been also being increasing from 50 kg /day in 2000 to over 100 kg/day in 2006. The latter may be explained due to increased targeting of yellowfin.

The export business of fresh large yellowfin tuna is growing with increasing investments and availability of ice in the outer atolls. Catches are made exclusively from handline method and targets dolphin-associated schools. During 2006 the total volume exported was over 8,000 mt fetching and export value of over US$ 29 million.

Data collection, processing and reporting needs to be strengthened. Given the changing outlook of the Maldivian tuna fishery this is of high importance. Lack of trained people at the Statistics Unit at the Ministry is the limiting factor in improving the data collection, compilation and dissemination. Despite these short comings, efforts are being made at introducing log book systems.

Tuna size sampling is conducted by fishermen-field officers in 11 islands. Re-establishing of the regional sampling programme was helped by the OFCF/IOTC assistance during 2003-2005. The data are being compiled by MRC. Estimates of average weights from these size samples shows the size of the skipjack may be declining in the Maldives fishery. This decline is more apparent for fish sampled during northeast monsoon season.

Maldives has been actively taking part in the Regional Tuna Tagging Program (RTTP). During 2004/2005 a Small Scale Tagging Program released 5,000 skipjack and yellowfin tuna. Over 6% has been recovered so far. Preparations have been complete to release further 12,000 skipjack and yellowfin tuna. Initially the plan was to release these tags whilst the RTTP vessels were operating close to the Maldives.

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1. INTRODUCTION

The Maldivian pole-and-line tuna fishery is, once again, in a major developmental phase. Following the mechanization in 1970s the tuna fishery expanded rapidly. From the 30,000 mt in 1973 the catch almost tripled by early 1990s. By this time the second generation vessels had replaced sailing vessels converted to mechanized ones. They were larger, more efficient with powerful engines and more spacious for holding bait and the catch. By the beginning of 2000s limitation in post-harvest sector was the bottleneck for the further increases in catch.

A new fishery policy announced at about end of the 1990s allowed private investment and export of fresh tuna. The two most important developments that allowed for increasing the harvesting capacity were the size and character of fishing and vessels and introduction of the light-bait-fishing. Taken together these two developments effectively increased fishing power and efficiency. Conducting night bait fishing meant the entire day can be spared for searching and fishing of vessels. Increased size of the vessel with sleeping quarters meant more comfortable conditions for crew allowing for night operations, i.e., for bait fishing. This was also helped by use of GPS and the vessel's ability to operate in all weather conditions.

The total reported national fish landings of the Maldives were over 100,000 mt from 1995 of which more than 80% were skipjack (*Katsuwonus pelamis*) followed by yellowfin tuna (*Thunnus albacares*). A small proportion of juvenile bigeye tuna (*T. obesus*) are caught with yellowfin but are not recorded separately (Anderson 1006). Other coastal varieties, frigate tuna (*Auxis thazard*) and kawakawa (*Euthynnus affinis*) are caught in small quantities, <5% at present. During 2006 a record catch of 138,458 mt of skipjack and 20,060 mt of yellowfin were made. It is estimated that a third of the catch is consumed locally; the rest is exported in frozen, fresh chilled and other forms. In the 2006 the export value of the tuna products was nearly US$ 130 million which was over 96% of the total value of marine exports. The two most important products were frozen tuna (mainly skipjack and juvenile yellowfin tuna) and fresh chilled large yellowfin.

The sector continues to be a considerable drive of the economy. In the recent years the sector contributed about 10% to the GDP. The sector is a major provider of employment in the Maldivian economy, particularly in outlying atolls. With 14,000 fishermen, the sector employs 11% of labour force and about 20% of the total population is dependent on fisheries as the major income earning activity.

Recent reviews of the Maldivian tuna fishery are MRS (1996), Adam et al. (2003), and Anderson et al. (2003). This paper provides a brief update of the tuna pole-and-line fishery.

2. DEVELOPMENTS IN THE FISHERY

Following the fishery sector privatization policy, a number of important developments are taking place. Some of them have been reported in the paper submitted at WPTT 2003. The most important feature is the change in size of fishing vessels. The vessels are getting larger and nearly all new vessels area being constructed from fibreglass (FRP). Others include the development of a surface handline fishery specifically targeting large yellowfin tuna and the developments in the EEZ longline fishery. Some of these have been reviewed by Anderson et al. (2003). The details of these are given in the following sections.

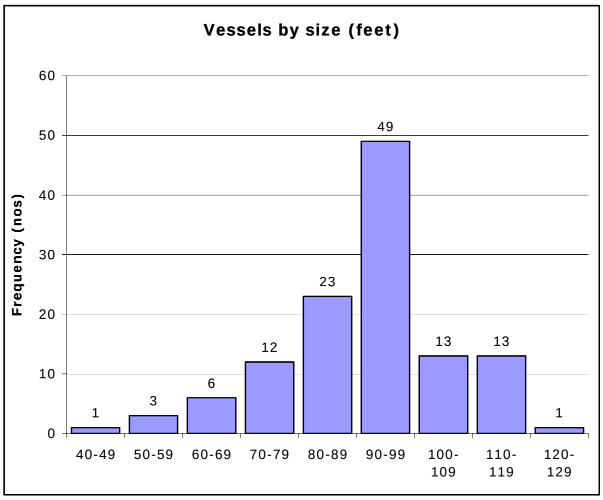
2.1. Fishing fleet

Increase in size of vessels is a feature of the Maldivian pole-and-line fishery since mechanization. About 15 years ago most were in the range between 35 – 45 feet (11 – 14 m) LOA with 28 – 42 HP engines. Ten years ago most of the vessels are within range of the 40 – 80 ft (13 – 27 m) LOA) with the 42 – 150 HP engines. Today of a particular trend is the development of a brand new class of large vessels. They are larger than 80 ft (25 m) LOA and build from fibreglass (FRP). These are built locally and there are reports that that some of these vessels are in excess of the 110 ft (33 m) LOA with over 700 HP engines. Some are said to have twin engines.

The December 2004 tsunami did considerable damage to the fishing industry. The most affected were from damages or lost fishing vessels and destruction of small-scale fish processing units. Over 100 vessels of the medium size range (40 – 60 feet, 12 – 18 LOA) and 20 small vessels were damaged. Additional 20 were out of commission due to damage to engine and fishing gear (World Bank 2005). While most of the rehabilitation work is complete some are still being undertaken that involves replacing damaged vessels and providing cash and in-kind assistance to affected victims.

In September 2006 the Statistics Unit of the MoFAMR carried out a phone survey to know the status of the fishing vessels being constructed on the islands. The survey was undertaken from 5-7 September which involved talking to more than one person from the island and atoll offices. Contacts were made on all 202 inhabited islands. However, information was not available from 3 islands in Seenu Atoll and one island in Thaa Atoll.

There were 136 fishing vessels being constructed during the month of September 2006 and were at varying stages completion. Except for 6 atolls all had more than 2 vessels under construction. As expected most were in the southern atolls of Gaafu Atlfu (24 vessels) and Gaafu Dhaalu (19 vessels) and in the northern most Haa Alifu Atoll (11 vessels) (MoFAMR, unpublished data). Sixty five percent of these vessels are FRP vessels with an average size of the 95 feet (29 m). Twenty five percent of the vessels are being constructed from timber averaging 74 feet (22.5 m). These investments are financed through bank loans and from savings. These results are summarized in Figure 1.



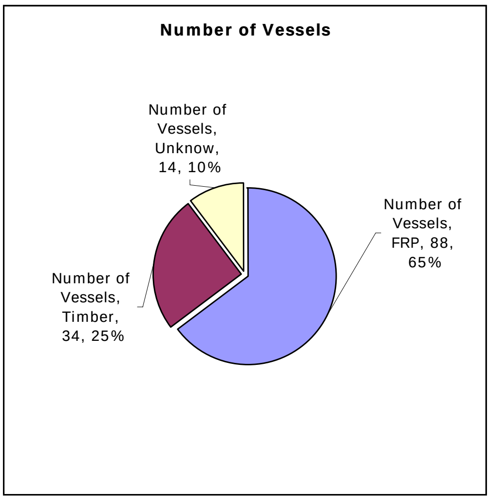


Figure 1: Summary results of phone survey on fishing vessels being constructed during September 2006. Source MoFAMR (unpublished).

2.2. Large yellowfin handline fishery

A direct result of fishery sector privatization was the start of fresh tuna export business by private exporters. The export demand for large yellowfin tuna allowed start up of a handline fishery specifically targeting large yellowfin tuna. The fishery targets dolphin associated schools normally outside the range of the skipjack pole-and-line fishermen. Initially exported as fresh whole (gill and gutted and head and gutted or tuna bullets) they now also exported as fillets and loins. Currently there are 7 packing facilities which are of EU-standard. Exports are to Europe, Japan and now to USA as well. More recently a reasonable proportion of the catch is also being exported to Sri Lanka, in the whole form, which is re-exported to Europe.

The packing facilities area located around Malé area for easy access to airport, although the buyers are now establishing the collection centres in the outlying atolls. Some of these developments are reviewed in Anderson et al., (2003).

The fishing vessels are large mostly the new generation FRP vessels of the size range over 80 feet (24.3 m). Switching to handline yellowfin fishing does not require much investment except for the large FRP ice-boxes placed on deck where the fish would land during pole-and-line operations. The vessels have GPS and communication systems that allow them to undertake multi-day trips lasting 3-7 days. The ice boxes range from 0.75 – 3.0 mt capacity and each vessel carries on board 2 – 4 boxes with flake ice for preserving the catch. It is generally common that vessel owner or the captain to have mutual agreement or less common a formal arrangement for supplying fish in return for the icebox and ice that is provided free of charge. The preservation on board is undertaken with strict instructions from buyers to maintain highest quality.

The handline operation is done using regular livebait. Two types of the livebait are normally used for these operations; the regular small sized (sprats and fusiliers) and large scads (*Selar crumenophthalmus and Decapterus macarellus*). The smaller sized bait is used to attract the school by chumming and scads are used as hooked bait. The fishing is so profitable that it is now spreading to all the atolls of the Maldives. The buyers are taking the full advantage by arranging to collect fish from outer atolls in their own specialized transport vessels. It is also know that many of the grouper fishermen have also switched to large yellowfin fishing.

When the fishery started the price paid for fishermen was MRf 12-15 (US$ 1 = 12.75 MRf) per kg of fresh weight. The current prices are now four times ranging from MRf 30-50 per kg. These high prices are driven in part by the demand from Sri Lankan buyers where unit cost of value-addition is cheaper there with exporters having access to a large market base.

Large yellowfin may be exported dressed-whole, head and gutted, or vacuum packed as loins, fillets and steaks. The packing facilities are strictly regulated by the Maldives Food and Drug Authority (MFDA) and the fishing vessels carry a health certificates and must be registered for undertaking handline fishing operations. The exporters pay a royalty on and export and the catch has to be reported to MoFAMR.

The fishery is little studied and so information about the catch rates and location of catch is not known Rejects from the fishery are landed to Malé Market and so some measurements are available indicating that size range of fish caught (see section on yellowfin). MRC is currently assigning a fishermen-field-officer to undertake sampling of large yellowfin fishery. The lack of human resource capacity at the Ministry is slowing down the timely processing of the catch statistics from this fishery. Only aggregate catch totals are recorded which have been presented in this report.

2.3. Livebait fishery

Developments in the livebait fishery are keeping pace with the development of tuna fishery. After some reluctance by the fishermen, particularly in the north, light-bait-fishing is now common throughout the country. The light-bait-fishing technique is fundamentally different from the regular method of catching bait in the morning. The method does not require so much manual labour and is done during the night time allowing fishermen to use of the entire day for fishing.

Earlier there were reports that light-bait-fishing technique catches large amounts of by-catch and juveniles baitfish that has to be thrown away or cannot be used. Fishermen say they die due to effects of light. However, as the fishermen gained more experience in the technique they were getting comfortable with the method. At present light bait fishing is widely used through out the country although fishermen still opt for the day time catches during periods of poor night time catch.

Estimates of bait catch are not reported by fishermen. The only available estimates of bait catch have been surveys by MRC staff. These involved MRC staff taking part in regular fishing trips for recording the total bait catch. In order to get an estimated of the total catch average weight of bait catch per trip is raised to the number of trips that are reported by the fishermen themselves.

Estimates of bait catch have been made during such surveys. They are summarized in Table 1. The bait catch has been increasing steadily; from just over 3,000 mt during 1978-81 to 15,000 mt per year in the recent times. While fishermen regularly complain shortages of bait and therefore of poor tuna fishing there are two observations that suggest that bait stocks are still robust in the Maldives. First the despite the five fold increase in total bait production over 20 year period the amount of tunas (in wt) caught per unit of bait (kg) has remained more or less the same. Secondly daily logs kept by field officers (in this case south) shows that ‘no bait’ is an insignificant reasons for not going fishing (Table 2).

Table 1: Estimates of total bait catch in the Maldivian pole-and-line fishery for 4 different periods. Source: MRC various reports & unpublished data.

Period	Pole & line effort (days/year)	Average catch (mt tuna / y)	Est. bait catch (mt / year)	Bait utilization (kg bait /day)	(kg tuna / kg bait)
1978-81	101,400	24,097	3,250 ±800	32 kg	7.4
1985-87	161,042	50,997	5,100 ±1,300	32 kg	10.0
1993-94	222,822	82,014	11,000 ±2,700	49 kg	7.5
2003	208,471	143,327	15,000	72 kg	9.6

Table 2: Summary of field officer data on days not fished along with day not gone fishing due to no bait. MRC unpublished data.

Period	1987	1996-2000	2001-2003
Days not fished	389	346	425
No bait	1	0	27
% no bait	0.3%	0%	6.4%
Sampling area	8 islands (Manku et al, 1990)	GDh. Thinadhooo Zaha Waheed	GDh. Thinadhoo MRC Unpublished Zaha Waheed

These observations that bait resource is seemingly healthy and robust does not agree with estimates of bait yield obtained from productivity relationships[1]. Anderson (2006) using such relationships estimate total annual yield of livebait from Maldivian atoll to be around 10,000 – 14,000 mt per year. Taking the productivity relationships further and assuming that bait yield (mt/km²/y) is proportional to area (km²) he showed there was a reasonable correlation between the fishing effort[2] and the atoll area (Figure 2). This relationship indicated that average bait fishing intensity would be around 8-9 days /km^2/year ($y = 8.887x$; $R^2 = 0.635$). While there may be considerable uncertainties in the assumptions and estimates of bait effort, these estimates suggest certain atolls show substantial departures from the expected value. Fishermen of most of these atolls indeed report shortages of the livebait. These results, although very coarse, shows that bait resources may be reaching to biological limits that require active management. More research is required for more meaningful assessment of this important fishery – a pre-requisite for the pole-and-line tuna fishery of the Maldives.

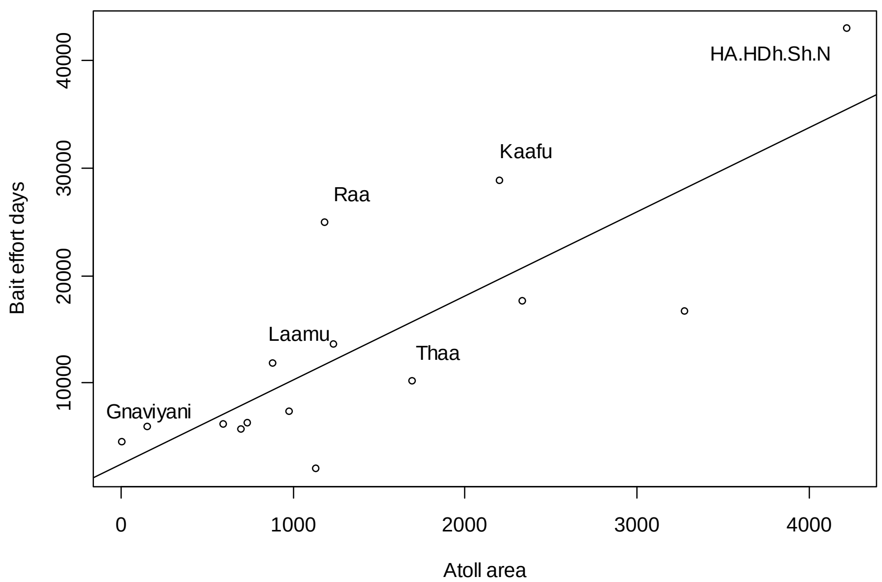


Figure 2: Relationship between atoll area and livebait fishing effort (mean no. of mechanized days – 2003-2005), Reproduced from Anderson (2006) without permission!

2.4. Catch reporting

Maldives has a total enumeration system where each fish is counted individually and the total number caught is reported. Information supplied by the master-fishermen or the owner of the vessel is recorded

[1] These assumes that bait production would be a function of primary productivity and assumed primary productivity in tropical areas like the Maldives would be in the range of 14-46 gmC/m^2/year (Lewis, 1990; Dalzell, 1993) and 36-44 gmC/m²/y (FAO, 1971).

[2] Bait catch by atoll was not available instead fishing effort was used as a proxy for bait catch by atoll.

by the island office and the monthly summary catch is reported to the MoFAMR. This form of reporting was feasible as the fishing communities were small and fisherman conducted regular and daily trips leaving from their islands in the early morning returning home island in the late afternoon and early evening.

The mechanisation of the fleet and the rapid socio-economic developments that took place in the country, however, has disrupted this traditional form of reporting and is causing deterioration of the quality of the data being produced. It is believed there is systematic under-reporting, but also, at times there have been over-reporting as well (Anderson et al., 2003).

The total enumeration system requires having reliable 'average weights' or conversion factors for each species to convert the enumerated numbers into weights. The Basic Fishery Statistics published by the Statistics Unit of the MoFAMR publishes these conversation factors. The actual average weights used and the application of single conversion factor year after year without considering regional and seasonal differences in catch composition has been subject of several studies (for e.g., Parry and Rasheed 1995; and Anderson et al., 2003). However, the high turnover and lack of qualified staff at the Statistics Unit of MoFAMR have consistently stalled the application of the new conversion factors that have been available since 1997 (Anderson et al., 1996).

The Marine Research Centre has been undertaking regular size sampling since 1980s. The regional tuna tagging programme is now expanded to 11 islands. Thanks to OFCF/IOTC financial support in re-activating the programme during 2003-2005. MRC has now built a relatively large network of permanent fishermen-field officers who are regularly monitored. They work on 'contract basis' allowing hiring and firing by MRC easy without having to follow the regular official channels. Average weights are being estimated from these size measurements and its full application estimating a more realistic time series of catch data will be important.

The Statistics Section of the MoFAMR is responsible for coordinating the data collection, data entry, providing summaries and dissemination of the data. The staff of the Unit are doing their best in its present capacity for improving and harmonizing the data collection and entry. The Ministry is fully aware that given increased efficiency and mobility of fishing vessels and multiple landing points, simply recording number of fishing days and total numbers of fish caught is not sensible. The form data collection and compilations requires urgent improvements.

During 2002 attempts were made to introduce logbooks as a small scale pilot activity. Due to inadequate follow-up it was not proved successful. A fresh attempt has been launched last year during December. Logbooks have been introduced to four atolls; Haa Alifu, Haa Dhaalu in the north, and Lhaviyani and Kaafu in the centre. The results so far are proving to be satisfactory. Many have returned the completed logbooks and more are being received. The data has not been computerised yet but many fishermen now believe that they can also take advantage of the logbook data for their record purposes as well.

The new logs books are designed to record weights (fish sales to collector and shore-based collection centres) and numbers (fish that are brought to island for consumption and sale to the small scale processors). It is also records the geographic positions of main area of catch in addition to information on bait fishing. Once they are in place the limitation may still be trained personnel for data entry, analysis and also to undertake field activities. The strategy is to continue the data collection from both the methods (enumerated numbers from island offices and of log books) until the logbook system is fully in place.

2.5. Tuna tagging

Maldives has been active in the Indian Ocean Tuna Tagging Program (IOTTP). As part of the EU funded Regional Tuna Tagging Programme (RTTP) a small scale tuna tagging programme was conducted releasing over 5,000 tuna. These included 3,579 skipjack and 1,227 yellowfin tuna. The recoveries so far amounted to 250 skipjack and 50 yellowfin representing about 6% recovery rate. The details of this program were reported in Project Final Report submitted during February 2005.

Proposal for a new tagging program was submitted to IOTC during 2005 and requested that Maldivian releases be coordinated with the releases in the Western Indian Ocean by the RTTP tagging vessels.

The program was approved during April 2006 while the RTTP cruises were coming to an end. Efforts were made to organize releases during early May at the time when RTTP vessels were also heading towards Seychelles from North Arabian Sea. The RTTP vessels visited the Maldives for livebait and for supplies. Unfortunately the weather turned bad and the vessels had to leave early, releasing only 22 fish on their way to Seychelles. Preparation for releases from Maldivian fishery by the MRC staff was also not ready at the time. Releases from Maldives will now occur during August or as soon as fishing and weather conditions are favourable. The plan is to deploy three tagging teams at the same time. The tagging teams will be taking part on regular fishing trips. Fishermen will be paid premium prices for each release. Money has been allocated to release 12,000 yellowfin and skipjack.

2.6. Size frequency sampling

Tuna sampling has been a regular activity undertaken by the MRC since mid 1980s. The sampling was initially concentrated in Malé Fish Market. The level of sampling effort varied over the years depending on the availability of field officers or samplers at the MRC. The sampling effort expanded to atolls during late 1980s and early 1990s by recruiting field officers who are attached to island and atoll offices. Unfortunately for various reason the “island-field-officer” program did not prove effective in delivering the data. Several of them moved other Government positions and rest was transferred to the Ministry in Malé to work at the Statistics Unit. Tuna sampling in the outer atolls was virtually non existent by the mid 1990s.

Under the World Banks’ Technical Assistance the program was revived, but this time working fishermen-field-officers were hired instead of field officers who reported to island or atoll offices. The program was a huge success and produced good results (Scholz et al., 1997). At the end of the World Bank funding the program was rationalized, and only two remained, one in the south and the other in the north.

The OFCF funding through IOTC during 2003-2004 re-activated the fishermen-field officer tuna sampling programme by recruiting 8 samplers. When the OFCF/IOTC assistance terminated in 2005 permanent Government funding was sought to create 11 new filed officer posts in the islands. Under the new arrangement filed officers are hired on contract-basis giving more authority for MRC in hiring and firing them. MRC regularly updates their work through phone and in-person contacts on opportunistic basis. The annual summaries for skipjack and yellowfin tuna are presented here (Figure 3 and **Error! Reference source not found.**).

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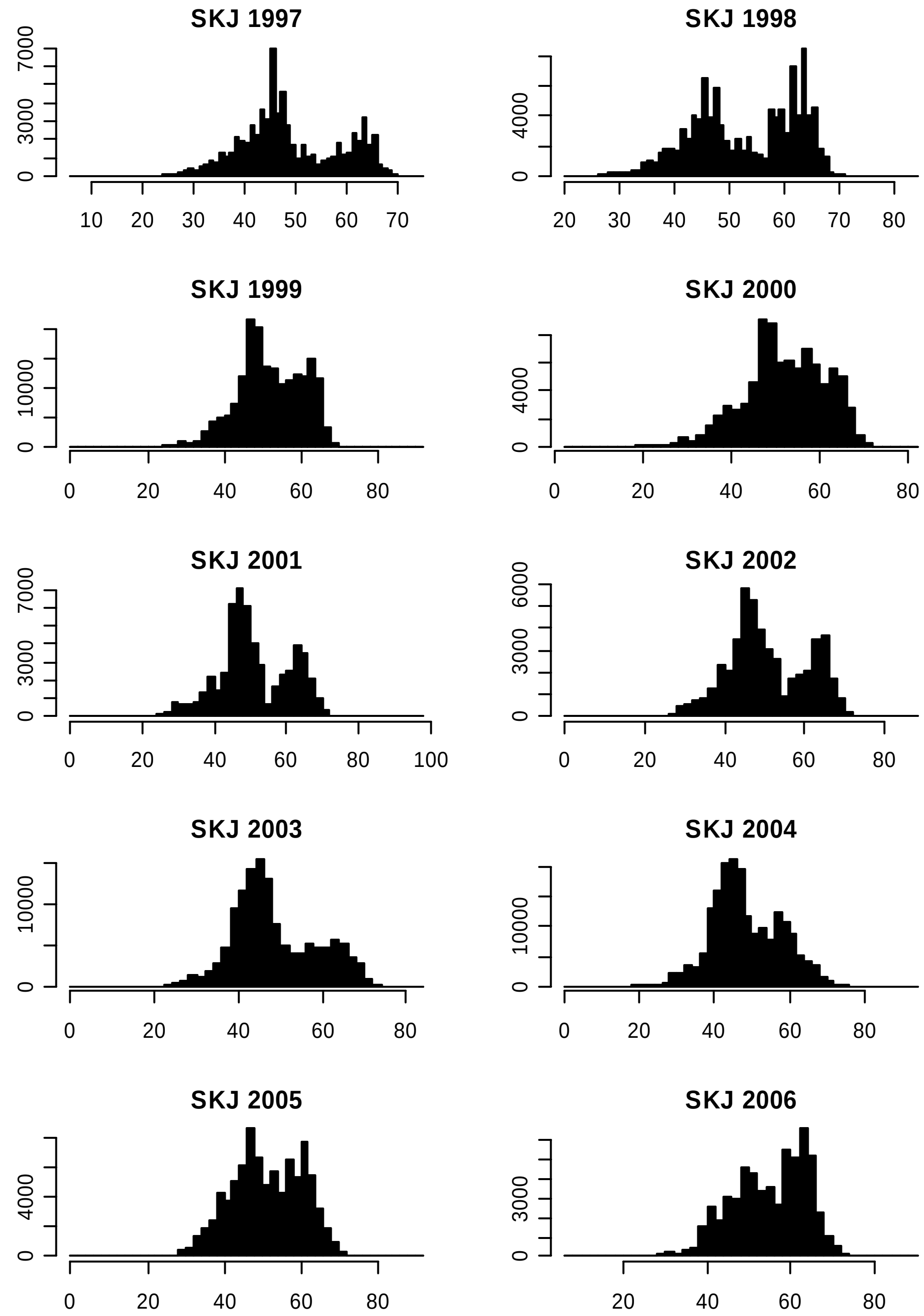

Figure 3: Summary of skipjack size frequency data, 1999-2006. The annual sample sizes ranged between 48,000 of 131,000 obtained from more than one locations.

2.7. EEZ fishery

In the Maldives the EEZ fishery is synonymous with longline fishery. While not explicitly stated in the current Fishery Law net fishing is banned and so only longline fishing is done in the EEZ. The fishery is licensed with VMS in place. Virtually all operations are of foreign owned fleets operated through agreements with Maldivian parties.

EEZ fishing is allowed only outside 75 nautical mile limit. Under the license agreement, reporting is mandatory. However, the reporting is poor and recording of these data are making them accessible is still a problem. In this regard the data presented here should be considered preliminary. Table 3 summarize the catch, effort and number of vessels operated in Maldivian EEZ. Highest number of vessels were active in the early 2000s with record 49 vessels during 2000. Only 24 vessels operated in 2006. These vessels are of Indonesian and Taiwan origin of size range between 50-60 GT; 18-22 m LOA.

Although the number of vessels declined the number of fishing days increased to more than 12,000 during 2005. These increased longline activity may be due to favourable fish landing opportunities in the Maldives (see below). Catch rates (per longline operation days) is declining from a high of 1.24 mt per day to about 0.3 mt per day. The average monthly catch is around 200 mt with no obvious seasonal pattern (Figure 4).

In the past it is common to land the catch in the Maldives. They are believed to tranship or land to Sri Lanka. However, the possibility of packing and air-freight opportunities is making Maldives an attractive port for longline landings. Roughly 80% of the landings is believed to be packed as whole (gill and gutted) or as tuna bullets (head and gutted). The rest is packed as fillets and loins and occasionally frozen. Considering the longline developments taking place, it is important that logbook data be studied more carefully.

Table 3: Summary of Maldivian EEZ longline fishery data. Source: Statistics Unit, MoFAMR.

Year	Tuna catch (mt)	No. of longliners	No of fishing days	Catch per day (mt)
1996	882	18	932	0.95
1997	5,990	48	4,523	1.24
1998	2,994	46	3,990	0.75
1999	811	32	1,453	0.56
2000	3,521	49	4,445	0.79
2001	2213	20	3,372	0.66
2002	3138	43	7,494	0.42
2003	3165	31	6,400	0.49
2004	2545	36	11,043	0.23
2005	3011	37	12,648	0.24
2006	3177	24	8,060	0.39

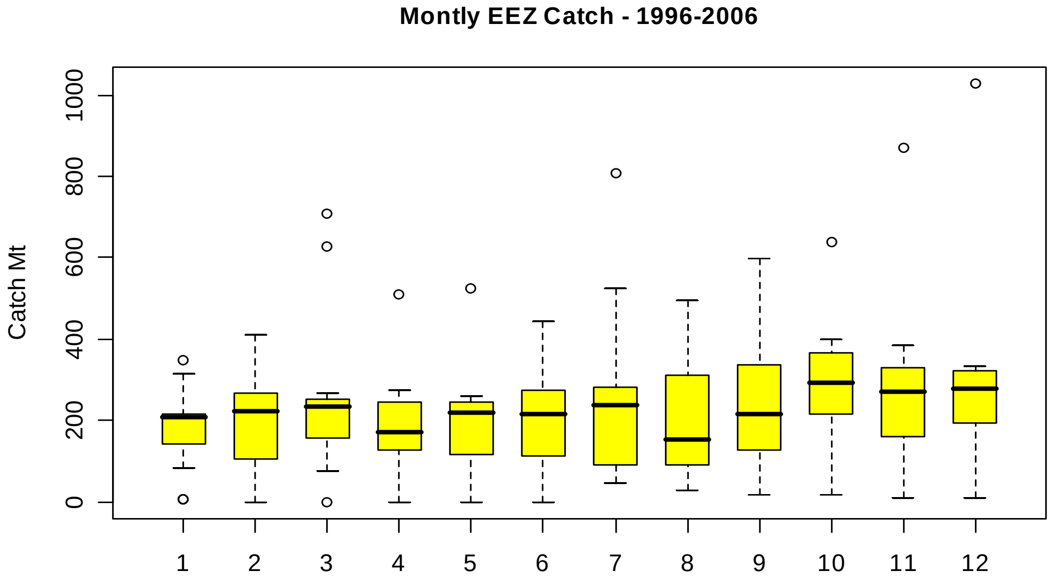

Figure 4: Monthly catch of EEZ (longline) fishery. The catch is mainly bigeye tuna, followed by yellowfin and others (data for 1996-2006).

3. SKIPJACK TUNA

Skipjack tuna continues to be the most important species in the Maldives, contributing about 80% of the total tuna catch. During 2006 a record catch of 138,458 mt of were landed. The catch is entirely from livebait pole-and-line method.

3.1. Skipjack catch and effort trends

Recorded catches of skipjack tuna and fishing effort for the years 1970-2006 are given in, Table 4, Table 5 Figure 5 and Figure 6. From 1988 to 1993 skipjack catches were remarkably stable at around 58-60,000 mt per year. Since then recorded catches have increased spectacularly with current catches reaching close to 140,000 mt.

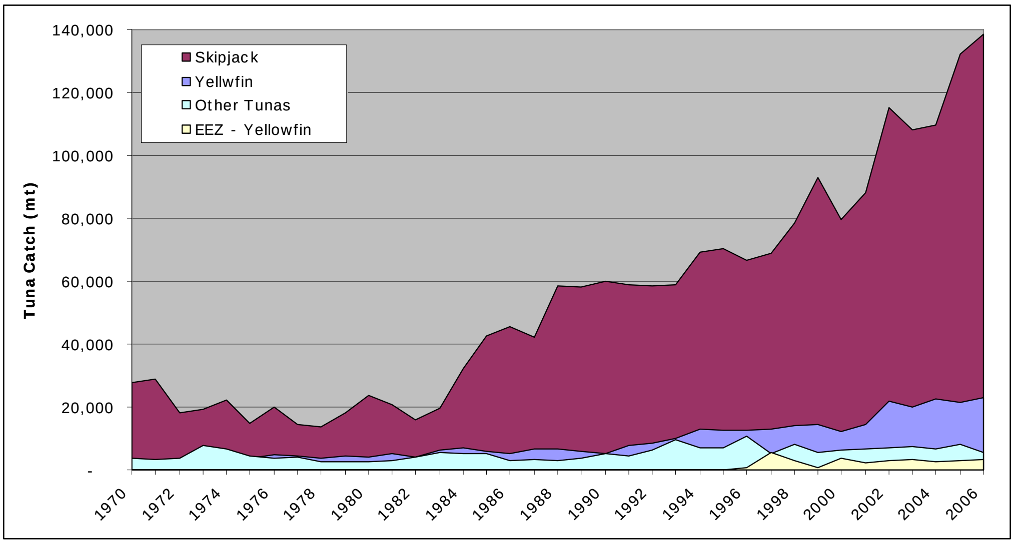

Figure 5: Evolution of tuna catches in the Maldives: 1970-2006. Source: Statistics Unit / MoFAMR.

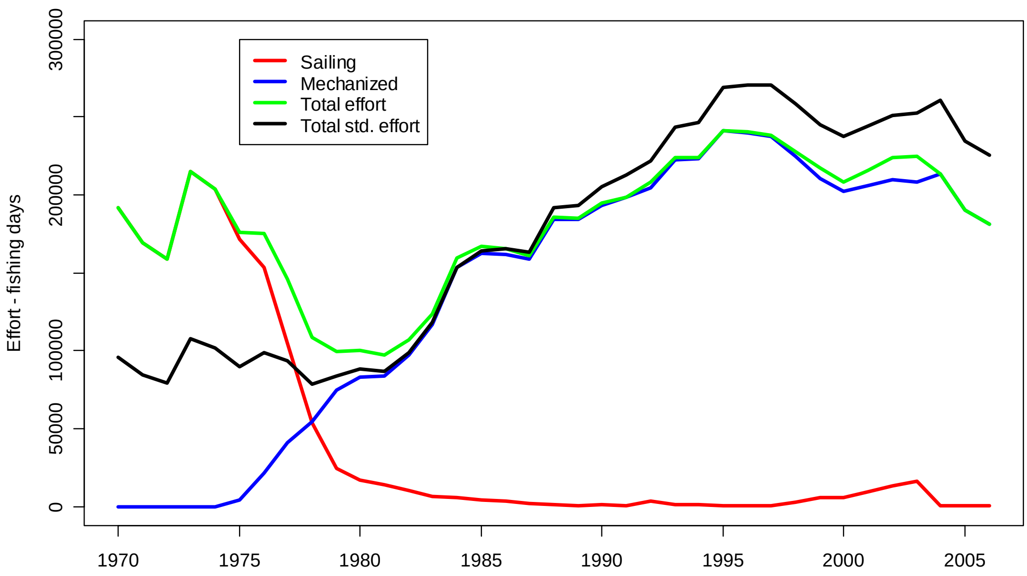

Figure 6: Evolution of tuna fishing effort in the Maldives: 1970-2006. Source: Statistics Unit / MoFAMR

Virtually all skipjack tuna in the Maldives are caught from mechanized pole and line vessels. Nominal pole and line fishing effort increased substantially up to 1995, but has decreased since then. This is in complete contrast to skipjack catch indicating a significant recent increase in catch per unit effort. This is believed to be due to increase in the number of large pole-and-line vessel, particularly the super large fibreglass vessels.

Skipjcak catches are highest in the southern atolls, particularly Gaafu Alifu and Gaafu Dhaalu Atolls. In the north catches are higher only Haaf Alifu Atoll (Figure 7). Recent survey by the Ministry shows that Gaafu Atlifu, Gaafu Dhaalu and Haa Alifu atolls had the largest number of FRP vessels under construction.

From 1996, the total number fishing days has been decreasing; a reflection of severe competition between the smaller inefficient and the larger more efficient vessels. Assuming accurate reporting of catch and number of fishing days (fishing effort), the observed higher catches in recent years despite the declining number of fishing days indicate fishing power is increasing steadily. In fact it is reported that during good fishing days the super-fishing vessels land in excess of 30 mt. The declining number of active fishing vessel further supports this increase this increase in fishing power. In fact the number of active mechanized vessels has been consistently declining from 1993.

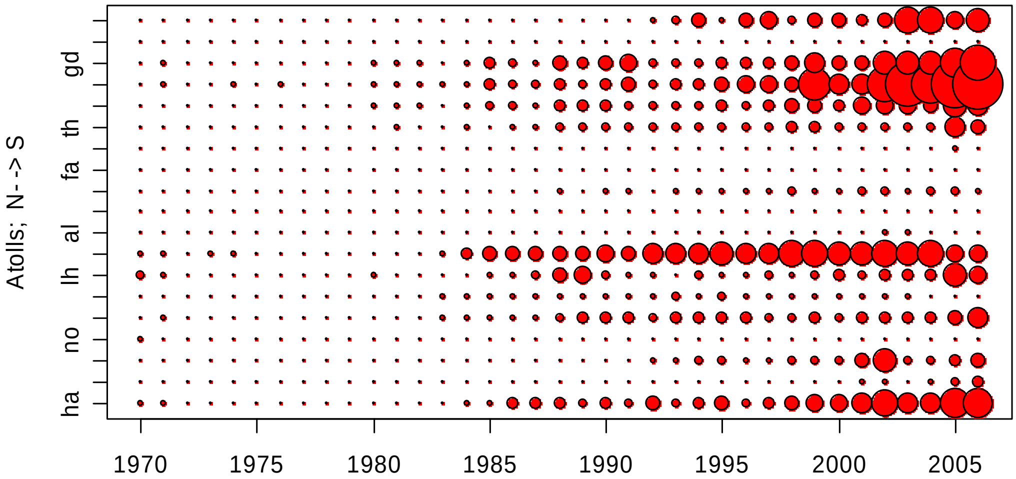

Figure 7: Skipjack catch by atoll: 1970-2006. The biggest circles are in the range of the 20,000 t. Source: Statistics Unit, MoFAMR.

3.2. Skipjack CPUE trends

In the analyses done earlier the fishing effort has been adjusted somewhat arbitrarily to account for increase in fishing efficiency (for example Adam, 1999; Adam et al., 2003). The same assumptions and procedures were followed here for the standardization. They are:

1. The sailing vessels were 0.5 times as effective as mechanized vessel in catching tuna during the period 1980-1977 (inclusive). This is essentially due to the direct results of the mechanization. Therefore, sailing vessel effort was halved during this period.
2. The effective fishing effort of sailing vessels decreased linearly from 0.5 in 1977 to 0 (nil) in 1985. This is the period when the sailing vessel were being displaced from tuna fishing and relegated to reef fishing. Therefore ailing vessels' effort was eliminated from this point onwards.
3. Mechanized vessel fishing power increased by 1% of 1984 level per year from 1985.

With these adjustments CPUE (kg/fishing trip) was calculated to give a crude measure of relative abundance. The CPUE appeared to shows declining trend from 1988—1989 to around mid 1990s. From mid 1990s CPUE shows a sharp increase except for 2000 and 2003 -2004 (Figure 8).

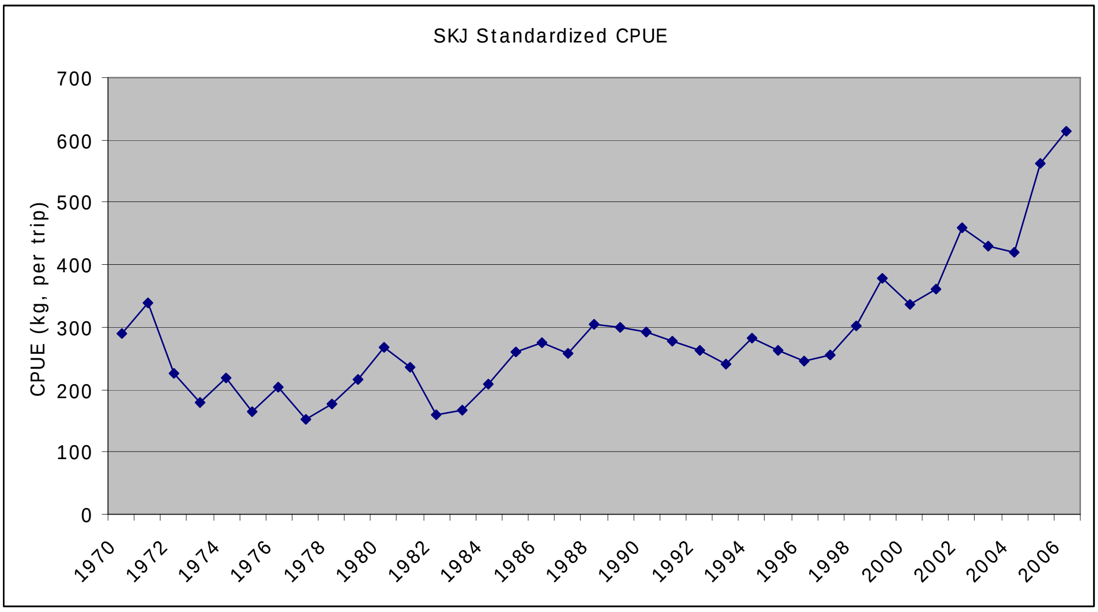

Figure 8: Skipjack standardized CPUE (kg per trip). Data source: Statistics Unit, MoFAMR

Maldives skipjack CPUE trends have shown to be related at least three broad factors; they are changes in oceanographic conditions (El Nino and La Nina years), increasing area of exploitation and finally a consistent increase in fishing power. An attempt to adjust only for the latter is done in the standardization procedure.

Maldivian skipjack abundance has shown to be related to ENSO events (Southern Oscillation Index, SOI). Using a simple GAM that fitted CPUE against year classified as "La Nina", "El Nino" and "Normal" shows strong correlation of catch rates with the CPUE. Catch rates were significantly depressed during El Nino years while in during La Nina year it was increased above normal (Adam, 1999).

Secondly, the increase in CPUE could be due to increase in area of exploitation. Skipjack are cosmopolitan species and show high diffusivity in their movement (Adam and Sibert, 2002). It is possible that increase size, speed and capacity of vessels allowed rapidly to exploiting unfished areas in the EEZ thereby increasing the catch rate. Fishermen indeed report sightings of large and more frenzy schools further offshore than inshore waters.

Thirdly it is highly likely that 1% annual increase in efficiency is not enough to account for real increases in fishing effort, particularly in more recent years. As explained earlier, the vessels have grown in size enormously; they have increased speed allowing to search larger areas than otherwise. Bait catching and holding techniques have improved and there is no reason believe that livebait availability is limiting factor in expanding the fishery. Increased use of GPS navigational system gave more confidence to fishermen to travel further offshore during night time and bad weather. All these would have made real increases in fishing effort that could not be accounted for 1% annual increase as has been done here.

3.3. Movement and fishery interaction

Tagging studies done from the Maldivian fishery shows skipjack tuna are highly mobile showing potential for fishery interaction (Adam, 1999; Adam and Sibert, 2002). In the Pacific Sibert and Hampton (2003) showed that the median lifetime displacement of skipjack is in the range of 420-270 nautical miles. This median half life, a measure of residence time and its displacement decreases as the fishing pressure increases. These observations show the potential for fishery interaction, particularly in situations where multiple fisheries operate within close geographic areas, like in the Indian Ocean surrounding the Maldives' will be higher. The analyses of data from the Indian Ocean Tuna Tagging Program (IOTP) will be useful in estimating the level of the fishery interaction between various fishery components.

3.4. Trends in size of fish caught

In the earlier papers fro the Maldives it has been pointed the average size of the skipjack in the Maldives are declining (Adam & Anderson, 1996). It was believed to be in part attributed to the increased industrial fishing in the Indian Ocean. Similar observations are seen in average weights estimated from the size frequency data. **Error! Reference source not found.** shows the estimated average weights of skipjack in the size samples taken from Maldivian fishery from 1998 to 2006. The average weight trend shows that the sizes of skipjack in Maldivian fishery are declining and this more visible for the fish caught during northeast monsoon season. While this may be a sign of overfishing in general, it may be due local overfishing by the Maldivian fleet as well. Alternative explanation includes sampling bias, oceanographic variation affecting size-related availability (large skipjack tend to stay deeper waters) and affects of fish aggregating devices. It is known from elsewhere that small skipjack tend to aggregate on FADs more than larger skipjack. In Maldives it is believed about 45% of skipjack are caught when associated with FADs (Anderson et al., 1996).

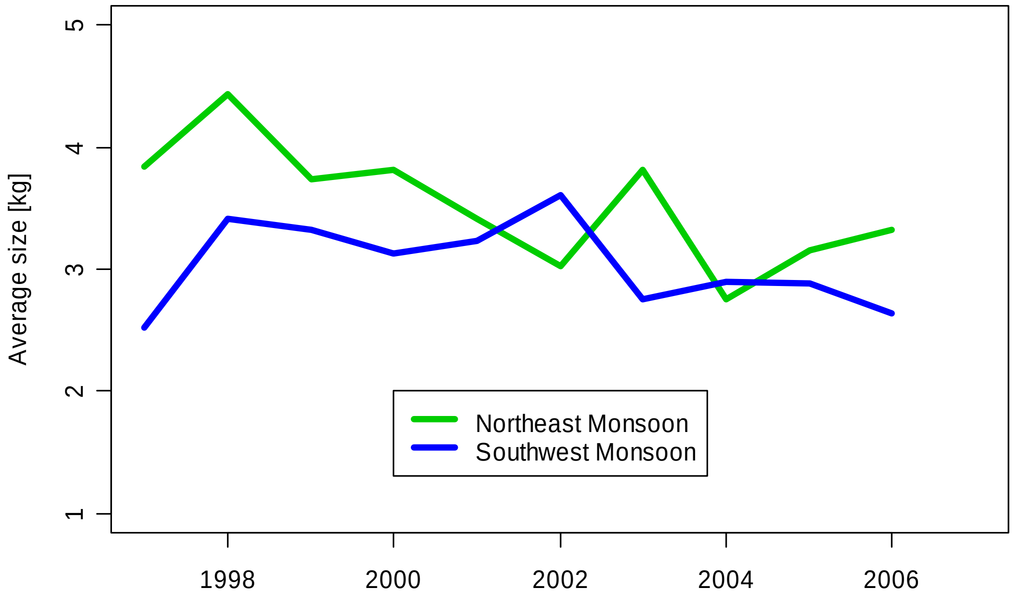

Figure 9: Average size of skipjack from the size frequency sample in the Maldives.

4. YELLOWFIN TUNA

Yellowfin tuna (*Thunnus albacares*) is the second most important species caught in the Maldives, currently contributing 13 – 15% to the total tuna catch. Catches increased threefold between 1991 and 2002, when a record catch of nearly 22,000 mt was landed (Table 4, Figure 5 & Figure 10). In the last 3-4 years catches are around 25,000 mt annually.

Traditionally, the yellowfin fishery in the Maldives was a pole-and-line fishery. Almost all the catch was of small juvenile yellowfin, 30-60 cm FL. However, over the past decade there have been increasing catches of large yellowfin, 60-160 cm TL. This is a direct result of the development of new markets (both domestic and export) for large yellowfin. The favoured gear for catching large yellowfin is livebait handline. Pole-and-line is used, particularly in the northern atolls, where many vessels install pulley systems during the main large yellowfin season there (December to March). The EEZ catches are all from longline (Figure 10).

The collection and compilation of data for yellowfin tuna is more complicated than skipjack because of the variety of gears being used. This has resulted compatibility problems with the existing data base which has a more traditional form collection and reporting. Overcoming these would require additional human resource training at the Statistics Unit. For instance it appears that yellowfin tuna caught by the handline fishery is reported together with the pole-and-line caught fish. The effort data is not recorded separately for pole-and-line and handline fishery.

The evolution of yellowfin catches by atoll is depicted in Figure 11. Most of the recent catch has been reported from Malé. This does not mean that the catches were made around the Malé area. Although most of the handline operations are undertaken from Malé the ability to conduct multi-day (more than 7 days) means that catch can be made either in the south or in the north Maldives.

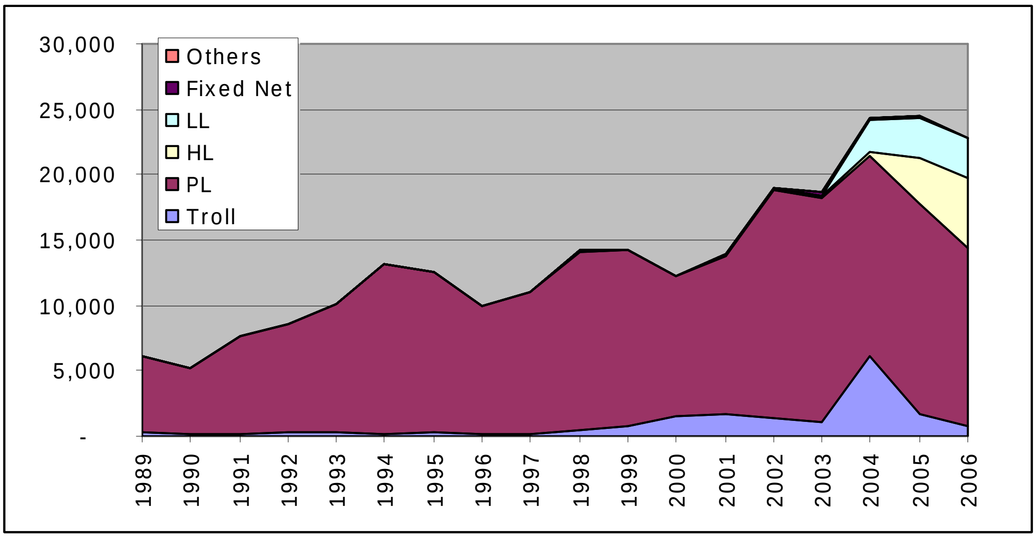

Figure 10: Yellowfin tuna catch broken down by gear as reported to the Statistics Unit: 1989-2006. Note the values in the last few years are different from what reported in aggregated form. Source: Statistics Unit, MoFAMR

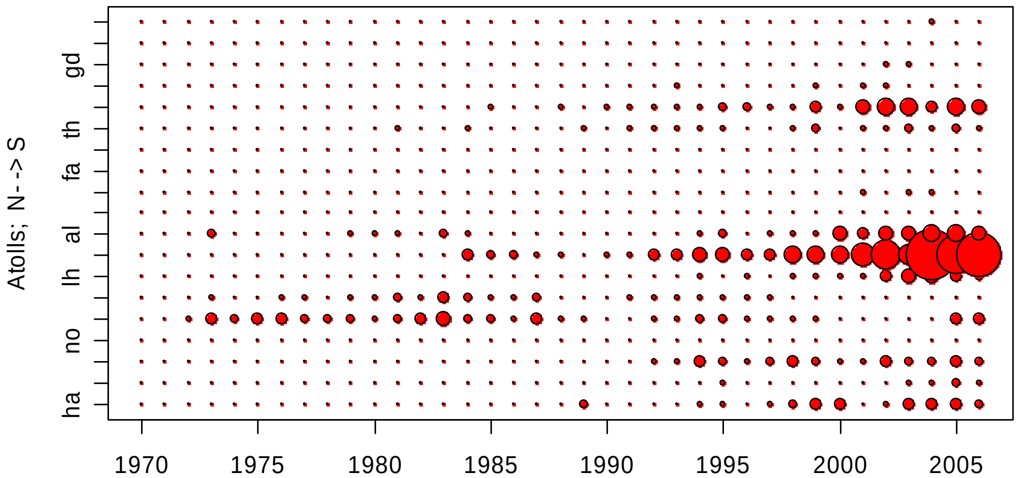

Figure 11: Yellowfin tuna catch from all gear by atoll: 1970-2006. Source: Statistics Unit, MoFAMR.

4.1 Yellowfin CPUE trends

Catch per unit effort of yellowfin tuna in the pole-and-line fishery has been increasing steadily from 1990 onwards. During this period, the adjusted, or the standardized CPUE increased from just over 20 kg per day to over 100 kg /day in 2006. From 2000 onwards the annual increase CPUE was much higher, presumably because of targeted fishing taking due to increased saleability yellowfin tuna.

In addition to catches of yellowfin by Maldivian pole-and-line vessels, catches are made by commercial longliners in the outer waters of the Maldivian EEZ. Catch and effort statistics are summarized in Table 4 and Table 5. They are believed to be grossly underreported.

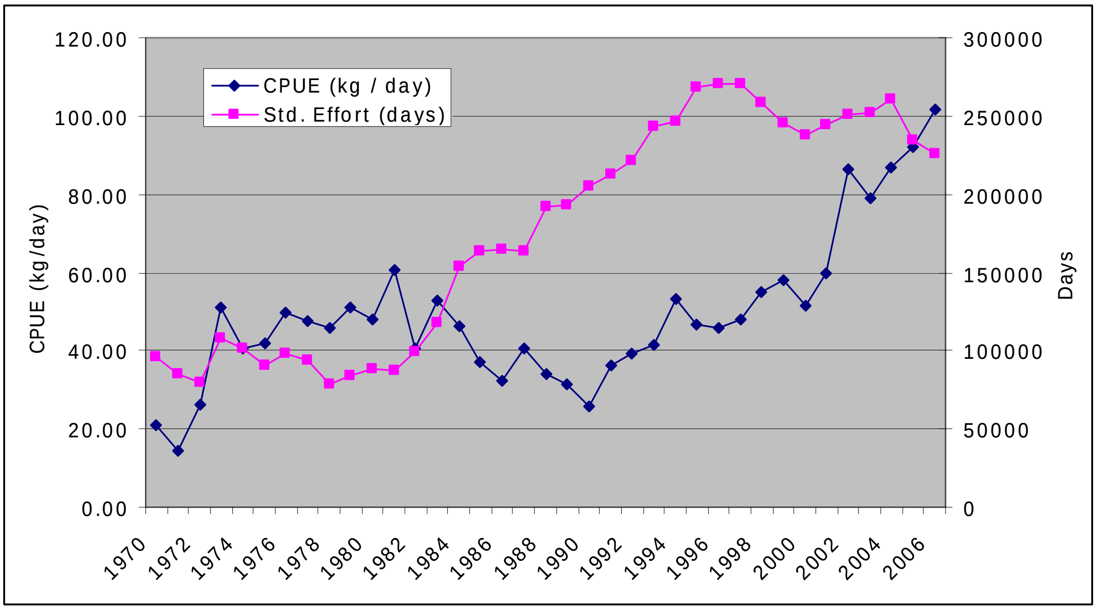

Figure 12: Pole-and-line caught **y**ellowfin tuna CPUE and standardized pole-and-line fishing effort (same as Figure 6): 1970-2006. Source: Statistics Unit, MoFAMR.

4.2 Trends in size of catch

The sizes of pole-and-line caught yellowfin tuna area shown **Error! Reference source not found.**. The most common size class is 40-60 cm FL. The larger size classes are taken in the handline and yellowfin fishery (Figure 14). Almost all of the large yellowfin were sampled in Malé Market where the rejects from fresh fish exporters are landed. Assuming the sample is a reasonable representation the sizes range from 80 – 150 cm FL.

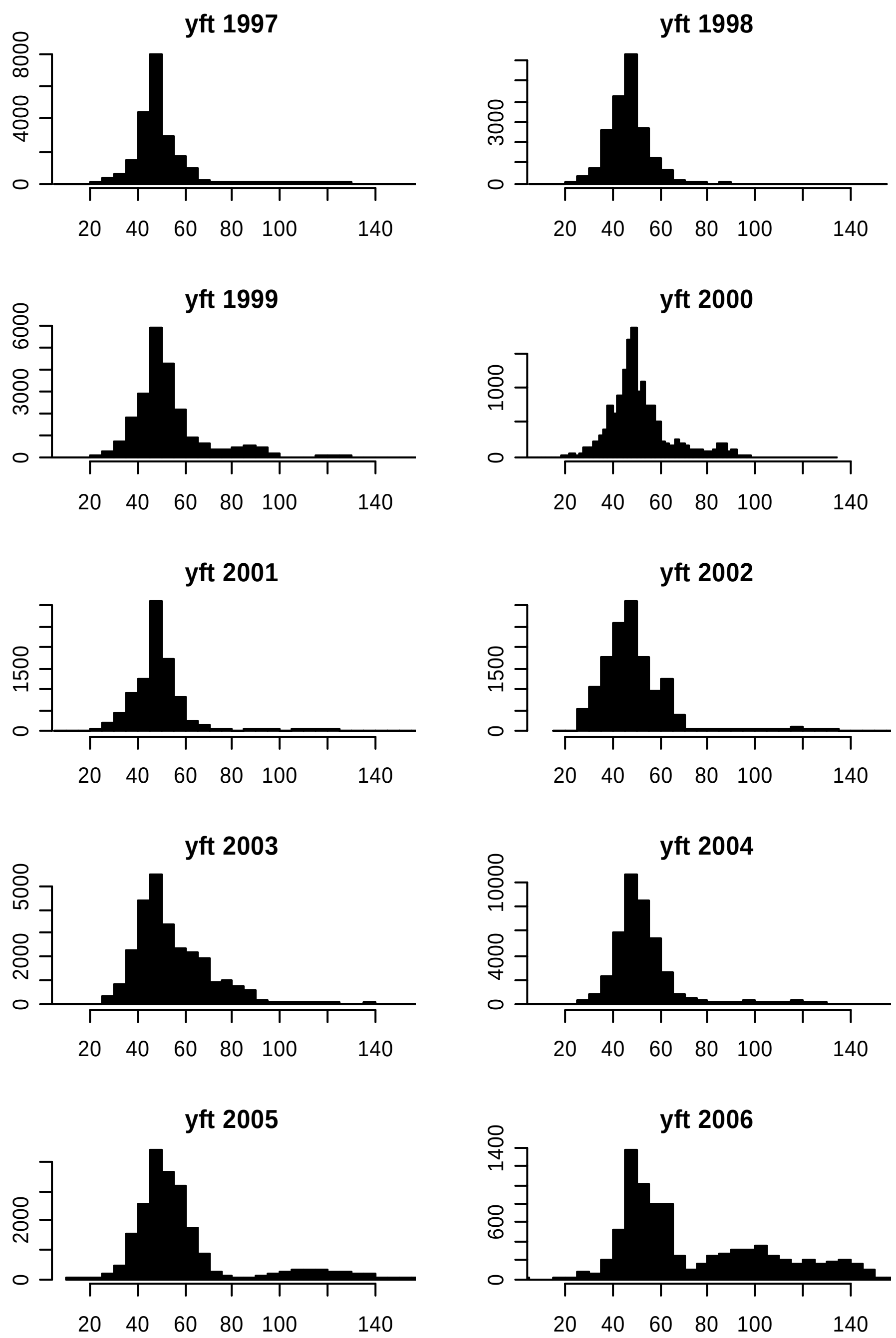

Figure 13: Summary of the size distributions of the yellowfin tuna caught in the Maldives.

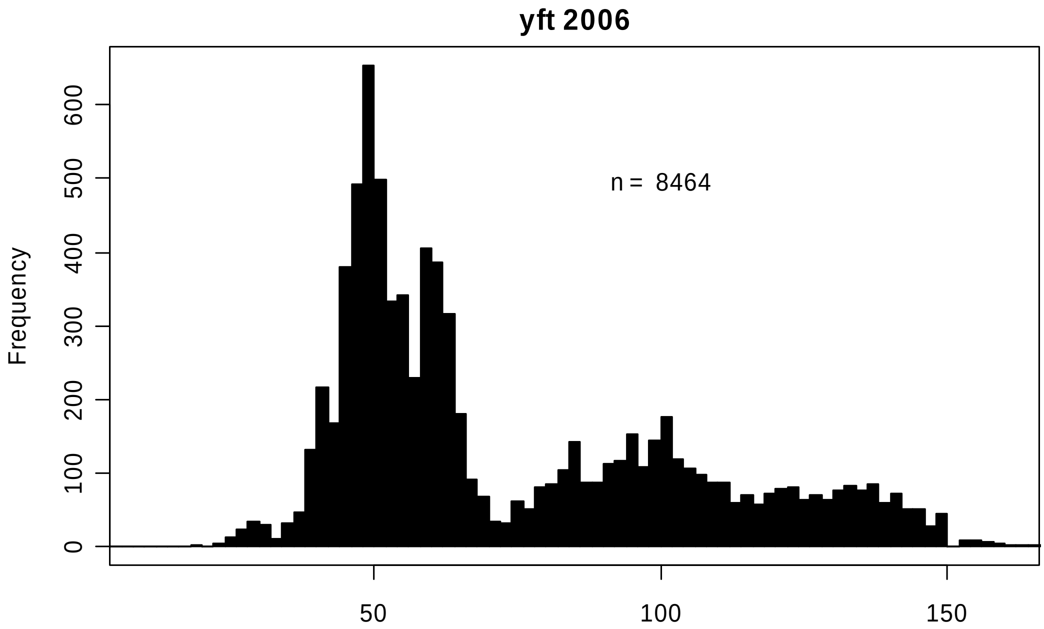

Figure 14: Size frequency distribution of yellowfin tuna measurements taken during 2006. The larger modes on the right are the large yellowfin tuna from handline fishery.

6. ACKNOWLEDGEMENTS

I am most grateful for the staff of the Statistics Unit of Ministry of Fisheries, Agriculture and Marine Resources for assisting in data compilations. Ahmed Sinan and Aminath Raufiyya attended my data and provided in the format I wanted. The field officers the Marine Research Centre, Ali Yshau and Ahmed Hamid deserve special thanks for so meticulously compiling the size frequency data. Finally thanks are due to Mohamed Ahusan for summarizing the size frequency data.

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Table 4: Summary of Maldives tuna catches: 1970-2006. Source: Statistics Unit / MoFAMR.

Year	Skipjack	Yellowfin	YFT_EEZ	Frigate	Kawakawa	Dogtooth	Other MF	Total
1970	27,684	1,989	--	3,023	644	n/a	2,602	35,942
1971	28,709	1,227	--	3,015	473	n/a	1,349	34,773
1972	17,971	2,076	--	3,186	596	n/a	1,633	25,462
1973	19,195	5,475	--	6,626	1,088	n/a	1,934	34,318
1974	22,160	4,128	--	6,006	830	n/a	2,026	35,150
1975	14,858	3,774	--	4,057	415	n/a	1,843	24,947
1976	20,092	4,891	--	2,707	953	n/a	3,017	31,660
1977	14,342	4,473	--	3,080	927	n/a	3,661	26,483
1978	13,824	3,584	--	1,661	768	n/a	6,403	26,240
1979	18,136	4,289	--	1,701	721	n/a	3,417	28,264
1980	23,561	4,229	--	1,595	1,063	n/a	4,349	34,797
1981	20,617	5,284	--	1,606	1,274	n/a	6,386	35,167
1982	15,881	4,005	--	2,061	1,887	n/a	7,279	31,113
1983	19,701	6,241	--	3,540	2,087	n/a	4,906	36,475
1984	32,048	7,124	--	3,105	1,714	376	5,333	49,700
1985	42,602	6,066	--	2,824	2,177	182	6,723	60,574
1986	45,445	5,321	--	1,778	1,071	136	4,520	58,271
1987	42,111	6,668	--	1,921	1,232	105	3,402	55,439
1988	58,546	6,535	--	1,629	1,257	84	3,423	71,474
1989	58,145	6,082	--	2,146	1,322	108	3,444	71,247
1990	59,899	5,279	--	3,013	1,891	281	6,011	76,374
1991	58,898	7,711	--	2,582	1,677	234	9,612	80,714
1992	58,577	8,697	--	3,389	2,451	337	8,584	82,035
1993	58,740	10,110	--	5,456	3,569	628	11,438	89,941
1994	69,411	13,126	--	4,019	2,656	387	14,446	104,045
1995	70,372	12,504	--	3,938	2,694	439	14,619	104,566
1996	66,502	12,440	882	6,485	3,789	624	15,574	106,296
1997	69,015	13,029	5,590	2,488	2,088	490	14,657	107,357
1998	78,409	14,169	2,994	4,217	3,624	470	14,230	118,113
1999	92,887	14,268	811	3,401	1,692	426	10,622	124,107
2000	79,682	12,184	3,521	3,990	1,897	451	17,236	118,961
2001	88,044	14,579	2,213	3,981	2,148	647	15,520	127,131
2002	115,322	21,729	3,139	4,187	2,242	789	15,239	162,647
2003	108,329	19,936	3,165	4,356	2,406	746	15,137	154,075
2004	109,749	22,584	2,546	3,639	2,290	615	17,473	158,895
2005	132,060	21,560	3,011	5,057	2,703	542	21,047	185,980
2006	138,458	22,883	3,177	3,532	1,674	512	17,099	187,335

Table 5: Annual fishing effort (nos. of boat) by vessel type and number of fishermen. 1970-2006. EEZ vessels are longline vessels. Source: Statistics Unit, MOFAR

Year	Sailing	Mechanized	Total	Troling	EEZ_Vessels	No. of Fishes
1970	191,421	-	191,421	104,482		17,094
1971	169,237	-	169,237	67,378		18,075
1972	158,544	-	158,544	76,136		18,535
1973	215,278	-	215,278	90,461		18,807
1974	203,362	-	203,362	93,504		19,362
1975	171,808	4,200	176,008	90,100		19,666
1976	153,539	21,800	175,339	135,031		21,381
1977	104,943	41,300	146,243	157,948		21,594
1978	53,739	54,800	108,539	176,878		22,683
1979	24,615	74,904	99,519	132,903		23,924
1980	16,877	83,134	100,011	136,934		24,330
1981	13,852	83,731	97,583	130,362		22,301
1982	10,036	97,085	107,121	132,342		21,727
1983	6,339	117,172	123,511	118,342		22,262
1984	6,220	153,460	159,680	110,314		21,028
1985	4,681	162,430	167,111	110,061		19,671
1986	3,354	161,910	165,264	79,139		22,245
1987	2,355	158,785	161,140	69,380		22,387
1988	1,242	184,353	185,595	51,460		21,880
1989	911	183,944	184,855	39,725		22,025
1990	1,317	193,045	194,362	37,933		21,725
1991	424	198,320	198,744	35,814		21,432
1992	3,602	204,808	208,410	28,137		21,195
1993	1,057	222,548	223,605	34,507		19,995
1994	1,138	223,095	224,233	31,687		22,268
1995	623	240,858	241,481	30,826		21,932
1996	731	239,787	240,518	30,431		22,109
1997	580	237,661	238,241	32,106	4,523	22,463
1998	3,020	224,751	227,771	24,436	3,990	21,998
1999	6,050	210,816	216,866	18,323	1,453	22,098
2000	6,048	202,195	208,243	17,513	4,445	19,108
2001	9,508	205,897	215,405	14,273	3,372	16,816
2002	13,776	209,839	223,615	10,463	7,497	14,355
2003	16,495	208,471	224,966	8,504	6,400	14,891
2004	430	213,384	213,814	11,164	11,043	14,826
2005	644	189,941	190,585	9,569	12,648	14,395
2006	553	180,983	181,536	7,958	8,060	14,184

Table 6: Numbers of active fishing vessels operating in the Maldives. 1985-2006. P/L = pole and line vessels. Source: Statistics Unit, MoFAMR

Year	Sail P/L	Mech P/L	Total P/L	EEZ- Vessels
1985	43	988	1031	--
1986	32	1009	1041	--
1987	21	1044	1065	--
1988	16	1096	1112	--
1989	14	1114	1128	--
1990	11	1151	1162	--
1991	6	1252	1258	--
1992	38	1347	1385	--
1993	15	1434	1449	--
1994	42	1410	1452	--
1995	8	1407	1415	--
1996	13	1397	1410	--
1997	9	1328	1337	48
1998	30	1271	1301	46
1999	52	1206	1258	32
2000	41	1137	1178	49
2001	66	1128	1194	20
2002	90	1102	1192	43
2003	115	1104	1219	31
2004	8	1085	1093	36
2005	5	1002	1007	37
2006	3	923	926	24