# SKIPJACK TUNA (*KATSUWONUS PELAMIS*) IN THE MALDIVES

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## INTRODUCTION

Skipjack tuna (*Katsuwonus pelamis*) is the most important species of fish caught in the Maldives. In 1994 catches of skipjack tuna reached a record level of nearly 70,000 t, which was 67% of the total national fish landings. The Maldivian fishery is largely a live-bait pole-and-line fishery. Catches of skipjack tuna are made almost exclusively by traditional (but now mechanized) pole-and-line vessels, which accounted in 1994 for 99% of the total skipjack landings.

Previous work on Maldivian skipjack tuna includes those of Hafiz (1985, 1986), Rochepeau and Hafiz (1990), Yesaki and Waheed (1992), Bertignac, Kleiber and Waheed (1994), Bertignac (1994) and Hafiz and Anderson (1994). This paper presents a brief overview and update of information about skipjack in the Maldives.

## CATCH TRENDS

Recorded catches of skipjack tuna for the years 1970-1994 are given in Table 1 and Figure1. The relative contributions to annual catches by the main vessel types are illustrated in Figure 2. Pole and line is clearly the most important fishing method for skipjack tuna the Maldives. The pole-and-line fishery in the Maldives is a traditional one dating back hundreds of years, but the fleet was mechanized starting in 1974. By the beginning of 1980 the active component of the pole-and-line fleet had been almost entirely mechanized.

Mechanization did not bring an immediate increase in total skipjack catches. Although mechanized pole-and-line vessel catches increased rapidly during 1975-80, sailing vessel catches crashed during the same period (Figure 2). This partly reflected the decrease in the number of sailing vessels as some were mechanized, but was also partly due to the fact that it was the oldest and least productive sailing vessels that were not mechanized. These vessels eventually dropped out of the fishery altogether, resulting in a net loss to the fleet. Also, in the early years, the full potential of mechanized vessels was not realised due to problems with fuel distribution and engine maintenance.

As a result of these difficulties the full benefits of mechanization, in terms of increased skipjack catch, were not seen until the mid- and late 1980s, when total recorded skipjack catch soared from a low of 16,000 t in 1982 to 58,500 t in 1988. From 1988-93 skipjack catches stagnated at about 59,000 t, although the 1994 catch did increase to 69,000 t.

The increase in skipjack catch between 1982 and 1988 may in large part be attributed to an increase in fishing effort. The number of mechanized vessels engaged in pole-and-line fishing increased during this period by 34%, from 1166 to 1558. More importantly, the number of days fished, which is a more useful index of fishing effort, increased steadily by 73%, from 107,000 total pole-and-line vessel days in 1982 to 185,500 days in 1988. An increase in the fishing power of pole-and-line vessels (over and above that attributable to mechanization) was also significant (Hafiz and Anderson, 1994). Increased size of vessels and engines, increased use of binoculars for spotting birds, widespread use of inter-vessel radio communication, improved bait catching and holding techniques, increased deployment and use of FADs, and increased capacity of the freezer/collector vessels throughout the country all contributed to this increase in production of skipjack.

However, the increase in skipjack catches during 1982-88 cannot be explained by increases in fishing effort and fishing power alone. During this period crude fishing effort increased by an estimated 73%. Taking rough account of increases in fishing power, effective fishing effort may have increased by something of the order of 100%, but skipjack catch increased by an estimated 260%. This suggests that there was a substantial increase in apparent abundance of skipjack over the same period.

From 1988 to 1993 there was a continued increase in fishing effort (by 21%, from 185,500 pole and line vessel days in 1988 to 223,600 days in 1993) and fishing power. The decrease in catch during this period was a result of a decrease in skipjack CPUE.

Table 1. **Maldivian skipjack tuna catches by vessel type, 1970-94. Source: Ministry of Fisheries and Agriculture / EPCS.**

| *Year* | *Sailing P/L* | *Mech. P/L* | *Total P/L* | *Trolling* | *Total Catch* |
|---|---|---|---|---|---|
| 1970 | 27,068 | - | 27,068 | 616 | 27,684 |
| 1971 | 28,200 | - | 28,200 | 509 | 28,709 |
| 1972 | 17,634 | - | 17,634 | 337 | 17,971 |
| 1973 | 18,761 | - | 18,761 | 434 | 19,195 |
| 1974 | 21,760 | - | 21,760 | 400 | 22,160 |
| 1975 | 13,921 | 680 | 14,601 | 257 | 14,858 |
| 1976 | 14,777 | 4,826 | 19,603 | 489 | 20,092 |
| 1977 | 6,935 | 7,097 | 14,032 | 310 | 14,342 |
| 1978 | 3,338 | 10,211 | 13,549 | 275 | 13,824 |
| 1979 | 1,603 | 16,195 | 17,798 | 338 | 18,136 |
| 1980 | 1,349 | 21,725 | 23,074 | 487 | 23,561 |
| 1981 | 577 | 19,621 | 20,198 | 419 | 20,617 |
| 1982 | 214 | 15,480 | 15,694 | 187 | 15,881 |
| 1983 | 122 | 19,369 | 19,491 | 210 | 19,701 |
| 1984 | 11 | 31,582 | 31,593 | 335 | 31,928 |
| 1985 | 165 | 42,005 | 42,170 | 432 | 42,602 |
| 1986 | 169 | 45,099 | 45,268 | 177 | 45,445 |
| 1987 | 196 | 41,676 | 41,872 | 239 | 42,111 |
| 1988 | 142 | 57,966 | 58,108 | 438 | 58,546 |
| 1989 | 135 | 57,671 | 57,806 | 339 | 58,145 |
| 1990 | 47 | 59,724 | 59,771 | 128 | 59,899 |
| 1991 | 46 | 58,715 | 58,761 | 137 | 58,898 |
| 1992 | 93 | 58,269 | 58,362 | 215 | 58,577 |
| 1993 | 107 | 58,452 | 58,559 | 181 | 58,740 |
| 1994 | 67 | 68,453 | 68,520 | 891 | 69,411 |

## CATCH PER UNIT EFFORT (CPUE) TRENDS

The Maldivian skipjack fishery is dominated by mechanized pole-and-line vessels. The best available measure of fishing effort, and the one used here, is the number of fishing days. Annual average catches per unit effort (CPUE) for 1979-1994 are given in Table 2 and Figure 3. The problems associated with using number of fishing days as a measure of pole-and-line fishing effort are well known (*e.g.* Anderson, 1993; Hafiz and Anderson, 1994). These include the problems of variation in bait availability, sea bird abundance, vessel interaction, *etc.* These difficulties mean that individual annual estimates of Maldivian CPUE may not be too accurate. Nevertheless, these factors may to some extent average out on an annual basis, and the time series is believed to give a useful picture of major trends.

Table 2. **Catches and catch per unit effort (CPUE) of skipjack tuna for mechanized pole and line vessels, 1979-94. Source: Ministry of Fisheries and Agriculture / EPCS**

| *Year* | *Skipjack Catch (t)* | *Effort (Days)* | *CPUE (kg/day)* |
|---|---|---|---|
| 1979 | 16,195 | 79,904 | 203 |
| 1980 | 21,725 | 83,134 | 261 |
| 1981 | 19,621 | 83,731 | 234 |
| 1982 | 15,480 | 97,085 | 159 |
| 1983 | 19,369 | 117,172 | 165 |
| 1984 | 31,582 | 153,460 | 206 |
| 1985 | 42,005 | 162,430 | 259 |
| 1986 | 45,099 | 161,910 | 279 |
| 1987 | 41,676 | 158,785 | 262 |
| 1988 | 57,966 | 184,353 | 314 |
| 1989 | 57,671 | 183,944 | 314 |
| 1990 | 59,724 | 193,045 | 309 |
| 1991 | 58,715 | 198,320 | 296 |
| 1992 | 58,269 | 204,808 | 285 |
| 1993 | 58,452 | 222,548 | 263 |
| 1994 | 68,453 | 223,095 | 307 |

Table 3. **Estimates of Maldivian skipjack growth rates from four separate studies.**

| *Source* | *Growth rate (cm/mo) at length* | | | | *Method* |
|---|---|---|---|---|---|
| | *40cm* | *50cm* | *60cm* | *70cm* | |
| Hafiz (1985) | 2.0 | 1.5 | 0.9 | 0.4 | L. Freq. |
| Hafiz (1986) | 1.6 | 1.2 | 0.8 | 0.5 | L. Freq. |
| Yesaki and Waheed (1992) | 2.4 | 2.1 | 1.8 | 1.4 | Tagging |
| Anderson et al. (1995) | 1.4 | 1.1 | 0.9 | 0.7 | Tagging |

The average annual skipjack CPUE for mechanized pole-and-line vessels decreased from a high of about 260 kg $day^{-1}$ in 1980 to a low of about 160 kg $day^{-1}$ in 1982-83. From 1982-83 to 1988 the annual average CPUE increased steadily, except for a dip in 1987, to over 310 kg $day^{-1}$ in 1988-89. From 1989 CPUE gradually decreased at a rate of about 4% annually to about 260 kg $day^{-1}$ in 1993. In 1994 CPUE increased to about 305 kg $day^{-1}$.

The relatively low estimated skipjack CPUEs during 1982-83 and 1987 could be due to a decrease in apparent skipjack abundance as a result of unfavourable oceanographic conditions in Maldivian waters during these years, which were all El Niño years. This point is discussed further below.

The increase in skipjack CPUE during the 1983-1988 period may be due to a combination of factors, including increased apparent abundance of skipjack and increased fishing power of pole-and-line vessels. The increase is also due in part to an increase in the proportion of large skipjack reported during this period (Hafiz and Anderson, 1988; Rochepeau and Hafiz, 1990). This in turn may have resulted from a real increase in abundance of large skipjack, the greater ability of mechanized vessels to catch large skipjack (Hafiz and Anderson, 1988) and/or a

*Figure 1. Maldives skipjack catch by vessel type, 1970-1994.*

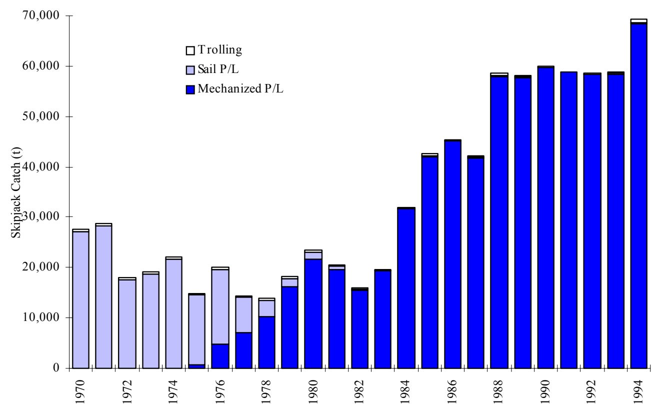
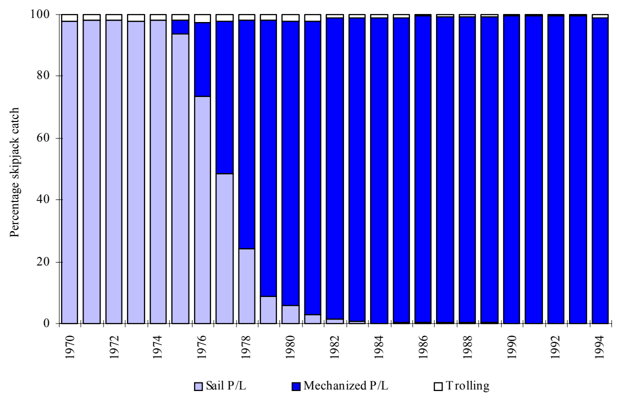



*Figure 2. Percentage of skipjack caught by vessel type, 1970,-1994.*




decrease in the accuracy of Maldivian fishery statistics (Rochepeau and Hafiz, 1990; Anderson and Hafiz, 1995).

The gradual decrease in CPUE in 1988-1993 may be due to a decrease in the apparent abundance of skipjack around Maldives. Possible explanations for this include:

1. A change in oceanographic conditions in the area. Tunas are known to be affected by changes in oceanographic conditions, both within the Maldives (Anderson, 1987, 1993; Hafiz and Anderson, 1994) and within the wider western Indian Ocean (Hallier and Marsac, 1990; Marsac, 1992). In particular, the decline in Maldivian skipjack CPUE during 1988-1993 might be due to medium-term changes in the oceanographic conditions in the region. This is discussed below.
2. Increased catches of skipjack elsewhere in the western Indian Ocean, notably by the purse-seine fishery, adversely affecting abundance in the Maldivian fishery. Figure 4 illustrates an apparent inverse relationship between Maldivian skipjack CPUE and total skipjack catches from the western Indian Ocean (FAO Statistical Area 51). This relationship is not strong (r = -0.343), and there is no proof of cause and effect. Nevertheless, this is a source of concern to the Maldives. Two tagging experiments carried out in the Maldives (Yesaki and Waheed, 1992; Anderson, Adam and Waheed, 1995) have demonstrated that there is movement of skipjack tuna from Maldivian waters to the western Indian Ocean purse-seine grounds. There is a need for skipjack tagging to be carried out in the western Indian Ocean to quantify skipjack movements towards the Maldives.

It is possible that Maldivian CPUE is not a reliable index of skipjack abundance. For example, local competition between pole-and-line vessels at high levels of fishing effort might tend to reduce CPUE. However, the fact that Maldivian pole-and-line CPUE data for all tuna target species (skipjack, yellowfin, frigate tuna, and also kawakawa) show consistent responses to oceanographic variations suggest that this is not the case.

## OCEANOGRAPHIC VARIATIONS AND SKIPJACK CATCHES

Perhaps the most obvious seasonal variations in Maldivian waters are those associated with the seasonal monsoons. The seasonal movements of skipjack within Maldivian waters have not yet been well worked out. However, Hafiz (1986) and Rochepeau and Hafiz (1990) have described some regular seasonal changes in the abundance of skipjack. Anderson (1991) noted that small skipjack tended to be most abundant in Vaavu and Meemu Atolls (east central Maldives) during the southwest monsoon and early northeast monsoon (May-December), while large skipjack were most abundant during the northeast monsoon (November-April). Yesaki and Waheed (1992) noted a general northward movement of tagged skipjack released at the end of the northeast monsoon (May). In contrast, tagged skipjack released at the end of the southwest monsoon (October and November) showed a net southerly movement.

Catches of skipjack tuna in Maldivian waters are affected by ENSO (El Niño-Southern Oscillation) events (Anderson, 1987, 1993; Hafiz and Anderson, 1994; Rochepeau and Hafiz, 1990). 1972-73, 1976, 1982-83, 1987, 1992-94 were all El Niño years. During those years (with the exception of 1994) skipjack catches and catch rates were noticeably depressed (Figures 1 and 3). El Niño years bring increased sea surface temperatures, low wind mixing and strong vertical gradients in the thermocline to the western Indian Ocean (Marsac and Hallier, 1990). It is not known how these conditions affect skipjack in Maldivian waters. One possibility is that increased sea

**Figure 3.** *Mechanised pole-and-line CPUE for skipjack tuna, 1979-1994, for the entire Maldives (kg/day).*

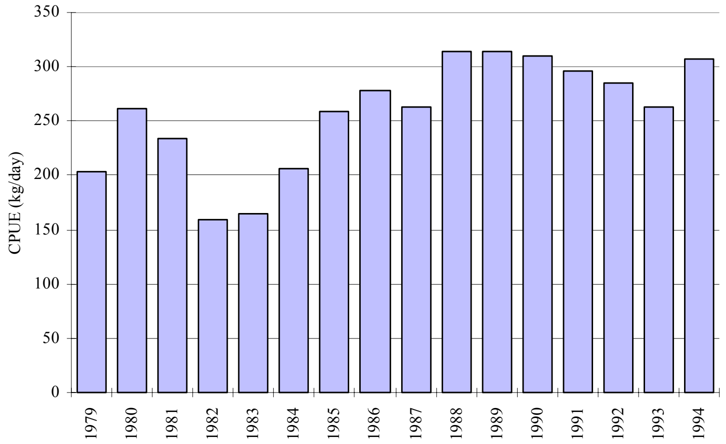
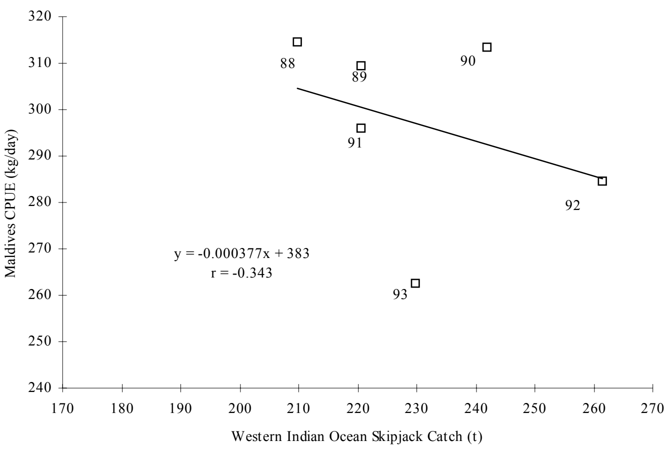



**Figure 4.** *Relationship between Western Indian Ocean skipjack catches and Maldivian CPUE of skipjack, 1983-93. (Sources: MOFA & IPTP).*




surface temperatures may reduce larval survival and hence recruitment to the Maldivian fishery. Forsbergh (1989) noted a decrease in skipjack larval abundance at temperatures above 29ºC in the eastern Pacific Ocean.

Anderson (1993) and Hafiz and Anderson (1994) have suggested that apparent medium-term changes in Maldivian tuna CPUE indices, including that of skipjack tuna, may be related to medium term cyclical changes in oceanographic conditions around Maldives. If such oceanographic variations are real they might explain part of the variation in skipjack CPUE noted above (*i.e.* the increase during 1983-88 and decrease during 1988-93). There is clearly a need for much more research on the effects of oceanographic variations on skipjack in the central Indian Ocean.

## SIZE DISTRIBUTION OF SKIPJACK CATCHES

A regional tuna sampling program involving active pole-and-line fishing skippers was initiated in 1993 (Anderson and Hafiz, 1995). Data are collected from 8 islands, representing regions throughout the country. Skipjack data have been compiled, and some summary length frequency histograms are presented in Figure 5. At Malé market fish are measured with tapes, not boards as elsewhere. These data have been converted to board lengths using a board length-tape length conversion factor (Marine Research Section, unpublished data).

The great majority of the skipjack caught in the Maldives are within the size range of 35-65 cm FL. This confirms previous work (Hafiz, 1985, 1986; Rochepeau and Hafiz, 1990; Anderson, 1991). The size distribution of skipjack caught in the Maldives is often bimodal (note the length-frequency histogram for H.Dh. Kulhudhufushi, Figure 5a; see also Hafiz, 1985, 1986; Hafiz and Anderson, 1988; Rochepeau and Hafiz, 1990). Maldivians classify skipjack into two size classes: small (*mas*) and large (*godhaa*). The frequently bimodal size distribution of skipjack catches in the Maldives is believed to provide a biological basis for this division (Hafiz and Anderson, 1988). Traditionally, a large skipjack is one which when carried by the tail will have its snout touching the ground. Large-scale commercial purchasing of skipjack throughout the Maldives under two different size categories has led to some blurring of this traditional classification (Rochepeau and Hafiz, 1990; Anderson and Hafiz, 1995). It is interesting to speculate on what further changes to this traditional classification might occur as improved nutrition in the Maldives causes the average height of the population to increase.

The cause of the bimodal distribution often seen in Maldivian skipjack catches is the relative under-representation of 50-60 cm skipjack in the catch. This again is apparent from these length samples. Of particular note is the dramatic decrease in numbers of skipjack above about 50 cm caught in the islands of M. Maduvvari and L. Maamendhoo. It is possible that these fish move offshore, away from the Maldives, for example towards Sri Lanka (Anderson and Waheed, 1990). 50+-cm skipjack certainly appear in quantity in the catches of Sri Lankan offshore vessels (*e.g.* Maldeniya and Dayaratne, 1994). Many of these vessels fish right up to, and even inside, the boundary of the Maldivian EEZ. This suggestion is discussed further by Anderson, Adam and Waheed (1995).

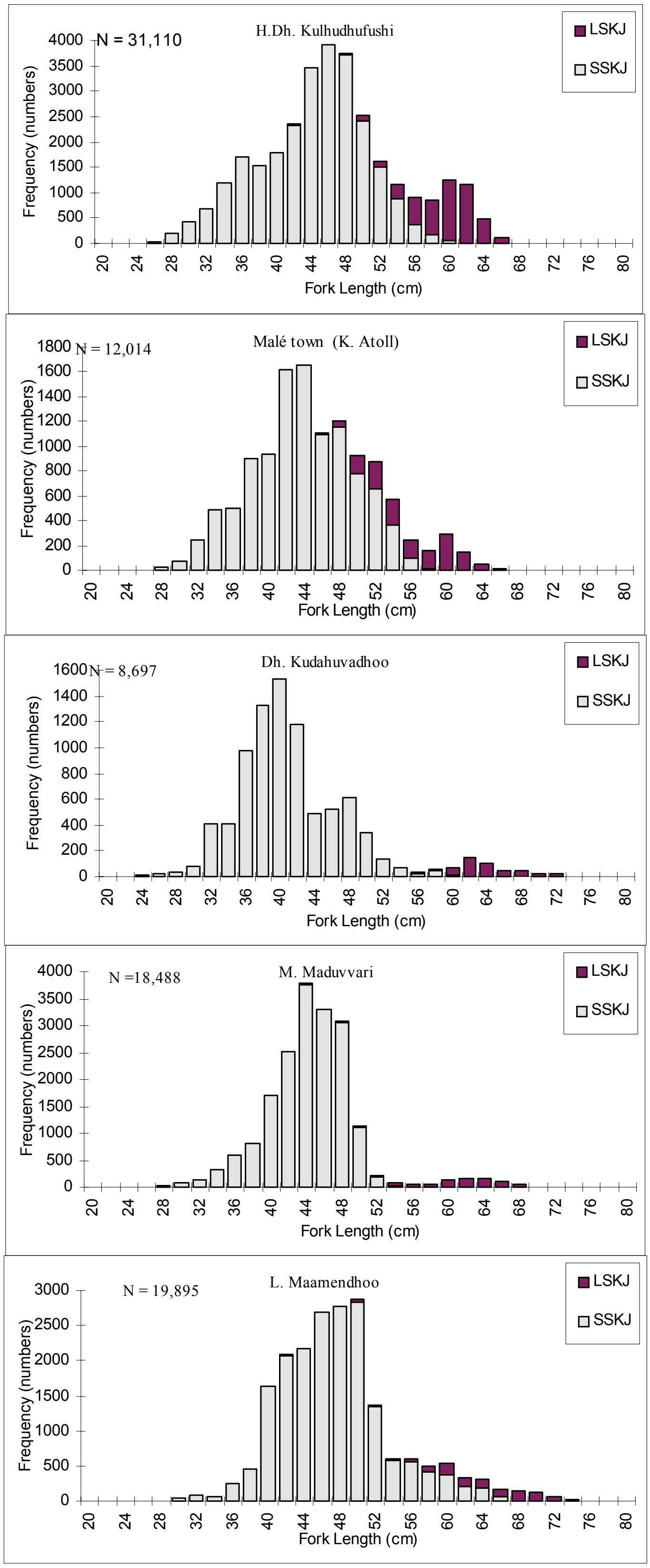
It has been reported previously, on the basis of analysis of catch data (Hafiz, 1985, 1986; Rochepeau and Hafiz, 1990; Anderson, 1992, 1993), that the proportion of large skipjack in the catch is greater in the north of Maldives than in the south. The length data presented here support this contention. Large skipjack are more abundant in catches in the two northernmost islands sampled (Kulhudhufushi and Malé) than in the three islands further south. However, the overall proportion of large skipjack in the samples appears to be somewhat less than that noted in previous years (cf. Hafiz, 1985, 1986; Rochepeau and Hafiz, 1990). Note, however, that because of the possibility of sampling bias the differences between years may not be as great as they seem.

Cook (1995) reported a decrease in average weight of skipjack purchased by the Maldives Industrial and Commercial Fisheries Company (MIFCO) during 1990-94. The weighted mean weight of skipjack purchased in 1990 was about 4 kg, but this dropped to about 2.7 kg in 1993. During this period MIFCO purchased 36% of the total recorded catch of skipjack and yellowfin (data source: MIFCO, compiled by MOFA/EPCS). Note that MIFCO started buying smaller-size fish than before in December 1993, so data from 1994 are not considered here.

## STOCK STATUS

The Indian Ocean skipjack stock is generally believed to be very large. Furthermore, oceanographic variations are likely to cause considerable variations in local abundance. Nevertheless, the possible decrease in the proportion of large skipjack in the catch, the definite decrease in the average weight of a very substantial sample of the skipjack catch during 1990-93/4, and the drop in skipjack catch rates over the period 1988-93, are a cause for major concern in the Maldives.

***Figure 5**. Length frequency distribution of skipjack tuna from the Maldives, 1994.*



## SKIPJACK GROWTH

Hafiz (1985, 1996) estimated von Bertalanffy growth parameters for skipjack tuna from analysis of length frequency samples from two locations in Maldives. His results were:

| | | | | |
|---|---|---|---|---|
| Sample 1 | Baa Atoll | $L_\infty = 78$cm | $K = 0.625y^{-1}$ | (Hafiz, 1985) |
| Sample 2 | Malé | $L_\infty = 82$cm | $K = 0.45\ y^{-1}$ | (Hafiz, 1986) |

The differences between parameters estimated from the two samples by Hafiz (1985, 1986) are indicative of the differences in estimated growth rates for the two locations (Table 3). This, combined with the frequent observation of stationary modes in Maldivian skipjack tuna catches (*e.g.* Anderson and Hafiz, 1986) suggests that analysis of modal progression should not be relied upon to yield accurate estimates of skipjack growth rates.

Estimates of skipjack growth rates from tagging studies were made by Yesaki and Waheed (1992) and by Anderson, Adam and Waheed (1995). These estimates are summarized in Table 3. The authors of both studies had considerable reservations about their growth rate estimates on account the great variation in their tag recovery data. This, combined with the fact that the two studies, using almost identical methods, produced such different growth rate estimates suggests that tagging should not be relied upon to yield precise estimates of growth rates.

Adam, Stéquert and Anderson (1995) used tetracycline marking of tagged skipjack to determine the periodicity of microincrement deposition in the otoliths of Maldivian skipjack. They found that microincrement deposition was irregular, and concluded that otolith microincrements could not be used for aging skipjack.

The accurate and precise estimation of growth rates for Indian Ocean skipjack would appear to offer a major challenge for the future.

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