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MMRB - Editorial Board
Marine Research Centre
H. Whitewaves
Malé 20-06
Republic of Maldives

Tel: (+960) 322242 / 322328
Fax: (+960) 322509 / 326558
Email: marine@fishagri.gov.mv

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MINISTER'S PREFACE

I am honoured to be able to introduce this third volume of the Maldives Marine Research Bulletin. I am especially pleased because this volume focuses on the most important of our fisheries - the tuna fishery.

The tuna fishery has been the mainstay of our economy for centuries. Today our fishermen still practice the same type of pole and line fishing that our forefathers carried out at least more than thousand years ago. This is a great heritage, which we should be proud to carry forward into the next millennium.

Today, however, our fishery is threatened, both from without and within, as never before. High levels of fishing activity by other countries appear to be adversely affecting catch rates in some parts of the country. The details are highlighted in this volume, and are a matter of grave concern. At the same time, changing socio-economic conditions within the country are resulting in fewer young men entering the fishery. Already the number of masdhonis actively engaged in fishing has started to decline. This is a trend which, if it continues, will bring unwelcome changes to the fishery, to island life and to the nation's economy.

It is important to make the most of our tuna resources, and to encourage active participation in the fishery by the next generation, it is important that we full use of our entire EEZ in the future. But it is equally important that we strive to manage the fishery in a way that ensures that the tuna stocks on which we rely so heavily are sustained. This volume will be a vital aid in our efforts to ensure sustainability. By bringing together so much information, and highlighting the main areas of concern, it will help to focus our attention on the key management issues.

I congratulate the authors of this impressive document on our vital industry. The role played by Maizan Hassan Maniku in fostering an environment in which such research can be carried out also deserves special mention. In addition, it is a great pleasure to acknowledge the vision of my predecessors at this Ministry, Mr. Adbul Sattar Moosa Didi, Mr. Abdulla Jameel, Mr. Abbas Ibrahim and Mr. Hassan Sobir. They all encouraged the research efforts that have come to fruition with the publication of this volume.

Abdul Rasheed Hussein
Minister of Fisheries, Agriculture and Marine Resources

FOREWORD

It is a great pleasure to introduce this third volume of the Maldives Marine Research Bulletin. It deals exclusively, and in great depth, with those most important of fishes, the tunas. For at least one thousand years, the tuna fishery has been a mainstay of Maldivian island life and of our national economy. Indeed, it is difficult to overemphasize the importance of this fishery in our history and on our national development. It is therefore very appropriate that this entire volume is devoted to the tuna fishery resources of the Maldives.

Although building on and reviewing previous studies, this volume presents many new findings. Particularly exciting are new insights into the role of ocean variability on tuna abundance. These have enormous implications for stock assessment, development planning, and our economy. We are now at the stage of describing the effects of ocean variability (such as that associated with El Niño events) on Maldivian tuna catches. If we can understand the mechanisms involved and then learn to predict ocean variations and consequent variations in our tuna catches, there could be enormous benefits for our fishery and economy.

Declines in catch rates of large skipjack and yellowfin off the west coast are shown here to be correlated with the growth of the western Indian Ocean purse seine fishery. As the authors rightly point out, correlation is not proof of cause and effect. Nevertheless, this is a particularly worrying development. If fishing activity elsewhere in the Indian Ocean is having a negative impact on our catches, then the future of our fishery is endangered.

Papers in this volume also touch on the momentous socio-economic changes that are sweeping the country. These are having profound effects on the tuna fishery. The collapse of the northern troll fishery during the 1980s presents a salutary lesson as to what can happen, almost overnight and almost unnoticed, even to a well established and biologically sound fishery. New developments in the pole and line fishery, in particular those related to the shortage of fishermen, are likely to have enormous, and not always beneficial, effects on tuna catches and island life.

Despite the wealth of information presented here, much remains to be discovered about the tuna resources on which we rely so heavily. Therefore, this should not be thought of as a finished work. Rather, it is a progress report. Research on the status of the all-important tuna resources must continue if we are to continue to enjoy the benefits of the tuna fishery in the future as we have in the past.

Much of the tuna research work reported here has been carried out by the Marine Research Center (formerly the Marine Research Section, MRS) over the last few years and was funded by the World Bank / IDA Third Fisheries Project (Tuna Research Component). To the funding agencies and project directors we extend our sincere thanks.

A special thank you must also go to the former Ministers of Fisheries, and Fisheries and Agriculture, Mr. Abdul Sattar Moosa Didi, Mr. Abdullah Jameel, Mr. Abbas Ibrahim and Mr. Hassan Sobir, all of whom actively encouraged the research efforts that have culminated in the publication of this volume. We welcome Mr. Abdul Rasheed Hussein as Minister of Fisheries, Agriculture and Marine Resources, and look forward to further developing our research activities under his leadership.

The staff of MRC who have worked so hard are to be congratulated on their efforts. In addition to the authors of the various papers presented here, the work of other members of MRC who have contributed in many ways towards this publication deserves mention. MRC staff members have assisted in field work from tagging to gonad sampling; with the regular Malé market sampling programme; and with compilation of data. These unglamorous tasks provide the information from which volumes such as this one can grow. The importance of such work can only increase in the years ahead.

Maizan Hassan Maniku
Director General
Ministry of Fisheries, Agriculture and Marine Resources

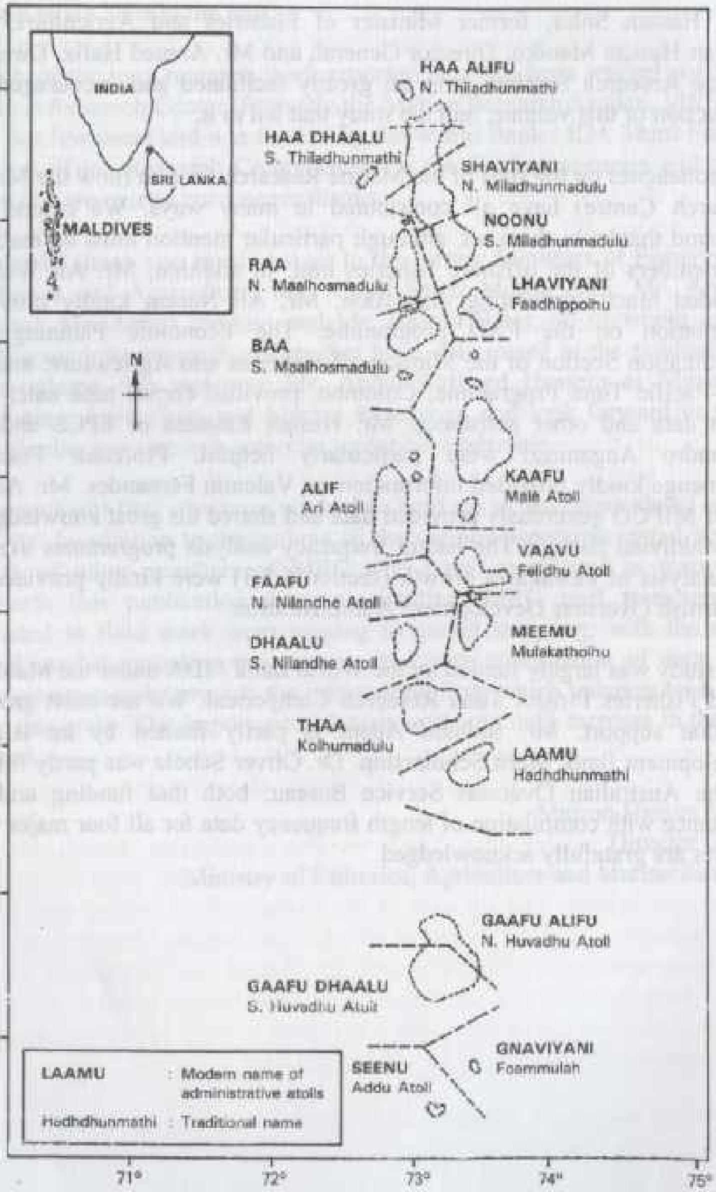
ACKNOWLEDGEMENTS

Hon. Hassan Sobir, former Minister of Fisheries and Agriculture, Mr. Maizan Hassan Maniku, Director General, and Mr. Ahmed Hafiz, Director, Marine Research Section, have all greatly facilitated and encouraged the production of this volume, and the study that led to it.

Our colleagues on the staff of the Marine Research Section (now the Marine Research Centre) have all contributed in many ways. We extend our profound thanks to them all, although particular mention must be made of the members of the offshore fisheries unit. In addition, Mr. Ali Waheed provided much stimulating discussion. Mr. Ali Naeem kindly provided information on the FAD programme. The Economic Planning and Coordination Section of the Ministry of Fisheries and Agriculture, and the Indo-Pacific Tuna Programme, Colombo, provided copies tuna catch and effort data and other assistance. Mr. Hassan Rasheed of EPCS and Dr. Alejandro Anganuzzi were particularly helpful. Professor François Doumenge kindly provided information on Valentin Fernandes. Mr. Adnan Ali of MIFCO generously provided data and shared his great knowledge of the Maldivian fishery. The length frequency analysis programmes used in the analysis of kawakawa growth (section 5.5.3) were kindly provided by the British Overseas Development Administration.

This study was largely funded by the World Bank / IDA under the Maldives Third Fisheries Project Tuna Research Component. We are most grateful for that support. Mr. Shiham Adam is partly funded by an Islamic Development Bank Merit Scholarship. Dr. Oliver Scholz was partly funded by the Australian Overseas Service Bureau; both that funding and his assistance with compilation of length frequency data for all four major tuna species are gratefully acknowledged.

Fig. 1.1. Map of the Maldives



THE TUNA FISHERY RESOURCES OF THE MALDIVES

1. INTRODUCTION

R. Charles Anderson, Zaha Waheed and M. Shiham Adam

1.1. BACKGROUND

The tuna fishery is one of the pillars of the Maldivian economy. It provides a major source of employment, a major source of food, and a major source of export earnings. Recent annual fish catches have been of the order of 100,000 t, of which tuna contributed nearly 90,000 t.

The Maldivian tuna fishery has been in existence for centuries. It is a livebait pole and line fishery, which targets surface swimming tunas, notably skipjack and juvenile yellowfin. Tuna remains the favourite food of most Maldivians to this day. In former times, much of the catch was processed to make *hikimas* or 'Maldive fish', a boiled, smoked and dried product. This was exported as far afield as Yemen and Sumatra, but mostly to Sri Lanka, where it was sold to buy rice and other necessities.

There is some evidence that tuna fishing was an important activity in the Maldives before the conversion to Islam in AH548 (AD1153-4). However, the first detailed record was provided by the great Arab traveller Ibn Battuta. He described the preparation and consumption of Maldive fish at the time of his visits in 1343-44 and 1346 (Gray, 1889; Gibb, 1929). A later Portuguese visitor, Valentin Fernandes, gave a clear description of livebait pole and line fishing and Maldive fish preparation in 1507 (Fitzler, 1935). François Pyrard de Laval, a Frenchman who was shipwrecked in the Maldives in 1602 and left the most comprehensive early account of the islands, also noted the fishery (Gray, 1889).

The tuna fishery as described by these early travellers remained almost unchanged right up until the early 1970s. During the following decade the fishery underwent a revolution. The basic fishing method, fishing with livebait pole and line, remained much as before, but most other aspects of the fishery changed dramatically. The stimuli for these changes were the collapse of the traditional Sri Lankan market for Maldive fish; the development of tourism in the Maldives; and the mechanization of the fishing fleet. The socio-economic consequences of these developments have been far reaching (see section 1.3).

Although the Maldivian tuna fishery has survived for centuries, the resources on which it is based are now being exploited at a higher level than ever before. Major tuna fisheries have developed in other coastal countries, notably India, Indonesia, Iran, Oman and Sri Lanka. Starting in the 1950s, large-scale tuna longlining has been carried out in the Indian Ocean by fleets from Japan, Taiwan and Korea. Starting in the 1980s, large scale tuna purse seining has been carried out by fleets from France and Spain (based in Seychelles) as well as vessels from other countries including Mauritius and Japan. For the Indian Ocean as a whole, total recorded tuna catch trebled from 378,000 t in 1984 to 1,107,000 t in 1995 (IPTP, 1996a & 1997). As a result of these developments, the Maldivian share of the total Indian Ocean tuna catch has declined from a historical level that may well have been in excess of 90% to roughly 10% now.

The two main species caught in the Maldives (skipjack and yellowfin tuna) are both considered to be highly migratory. As such, they are not confined to any one national jurisdiction, but freely move between different Exclusive Economic Zones (EEZs) and High Seas waters. A skipjack in Seychelles waters one season might be in Maldivian waters the next. Or a yellowfin tuna in the Sri Lankan EEZ one day might pass into the Maldivian EEZ the next.

Because the main species targeted are migratory, there is a real concern that Maldivian tuna catches will be adversely affected by the great increase in tuna fishing effort elsewhere in the Indian Ocean. Already there are signs that this may be happening. In recent years, skipjack catches have stagnated and average sizes have declined; in particular, catch rates of large skipjack on the northwest side of the Maldives have fallen in parallel with the rise of the western Indian Ocean purse seine fishery (section 2.3.1). For yellowfin tuna, the total Indian Ocean catch peaked in 1993, and may be close to the maximum sustainable yield. Once again, catch rates on the northwest side of the Maldives have dropped (section 3.3.2). However, it is not yet known for sure if these changes have been brought about by high levels of fishing elsewhere in the Indian Ocean, or by some other agency such as changing oceanographic conditions (section 1.4).

A collapse of the tuna fishery would be a catastrophe for the Maldives. There is therefore a clear need for a better understanding of the dynamics of

tuna populations in and around the Maldives, in order to provide the information required for managing sustainable utilization. The aims of this report are to present a summary of current knowledge of the tuna fishery resources in the Maldives, and to highlight areas where further research is required to meet this goal.

This introduction has two aims. First, to provide an overview of the fishery, so that the subsequent discussions of resources can be viewed in context. Secondly, to present data and information that apply to the fishery as a whole, so that they do not have to be repeated in each of the following chapters.

1.2. THE TUNA FISHERY

1.2.1. Species Composition

The tuna fishery is the most important fishery in the Maldives. The catch of the main tuna species together averages 89% of the total recorded national fish catch (Table 1.2). It should be noted, however, that the catches of non-tuna species are seriously underreported. The Maldivian tuna fishery is based on four main species, namely skipjack, yellowfin, frigate tuna and kawakawa (or eastern little tuna). In addition to these four main species, three other tuna species are caught in smaller quantities:

English Name	Scientific Name	Dhivehi Name	1997 Catch
Skipjack tuna	*Katsuwonus pelamis*	*Kalhubilamas*	69,015 t
Yellowfin tuna	*Thunnus albacares*	*Kanneli*	13,029 t
Frigate tuna	*Auxis thazard*	*Raagondi*	2,488 t
Kawakawa	*Euthynnus affinis*	*Latti*	2,088 t
Dogtooth tuna	*Gymnosarda unicolor*	*Woshimas*	490 t
Bigeye tuna	*Thunnus obesus*	*Loabodu kanneli*	(500 t)
Bullet tuna	*Auxis rochei*	*Raagondi*	(25 t)

Note: Catch data from MOFA/EPCS, numbers in brackets are estimates by MRS

Skipjack (*Katsuwonus pelamis*) is by far the most important fish species caught in the Maldives (section 2). Recorded catches in 1994-97 were about 69,000 t per year. Skipjack contributed an average of about 68% to the entire national fish catch, and about 75% to the recorded tuna catch during the period 1970-97. Skipjack tuna catch rates peaked in 1988-89, when skipjack contributed a record 86% to the total tuna catch. After that catch rates declined, and did not recover until 1994-95. Skipjack catches are made almost exclusively by pole and line, with mechanized pole and line vessels (*masdhonis*) now accounting for 99% of landings.

Yellowfin tuna (*Thunnus albacares*) is the second most important fish species in the Maldives (section 3). Yellowfin catches increased to record levels in 1994-97, when they averaged nearly 12,800 t per year. Yellowfin contributed an average of about 11% to the entire national fish catch, and about 13% to the recorded tuna catch during the period 1970-97. Until recently the yellowfin fishery was almost entirely for surface swimming juveniles. These occur seasonally, off the west coast during the southwest monsoon season and off the east coast during the northeast monsoon. In the last few years as new markets have developed, large yellowfin have been caught in increasing numbers. Juvenile yellowfin are caught almost entirely by pole and line, while large yellowfin are caught mainly by handline, troll and longline.

Frigate tuna (*Auxis thazard*) is the third most important tuna species in the Maldives in terms of catch weight (section 4). Recorded catches in 1993-96 averaged 5000 t per year, but dropped to 2500 t in 1997. Frigate tuna contributed an average of nearly 7% of the total tuna catch during the period 1970-97. In 1973 it contributed a record 20% to the total tuna catch. Although 1996 was another bumper year, the relative importance of frigate tuna has decreased in recent years, with its contribution to total tuna catch averaging less than 5% during the decade 1986-97. The bulk of the frigate tuna catch is made by livebait pole and line, although about 10% is caught by trolling.

Kawakawa, or eastern little tuna (*Euthynnus affinis*) is the fourth most important tuna species in the Maldives (section 5). Average recorded catch during 1993-96 was 3200 t per year, but this dropped to 2100 t in 1997. Kawakawa contributed an average of 3% to the total recorded tuna catch during the period 1970-97. It is more closely associated with the atolls than the other major tuna species, and in consequence is taken in larger quantities by inshore trolling vessels. 39% of the total kawakawa catch was made by trolling vessels during the period 1970-97, the rest being made by pole and line vessels. An even higher proportion of the catch (62%) was made by trolling vessels during the period 1970-85. Since the mid-1980s, trolling vessel activity has declined dramatically.

In addition to these four main tuna species, a number of other tunas do occur in Maldivian catches. Bigeye tuna (*Thunnus obesus*) is not

uncommon, but catches are not distinguished from those of yellowfin tuna. Current pole and line catches are estimated to be of the order of 500 t per year (Anderson, 1996). This species is discussed in section 3.10.1. Bullet tuna (*Auxis rochei*) is taken in both the troll and pole and line fisheries, but catches are not distinguished from those of frigate tuna. Current catches may be less than 100 t per year. This species is discussed in section 4.10.1. Dogtooth tuna, *Gymnosarda unicolor*, is a reef associated species. It is not taken in the pole and line fishery, and only small numbers are taken in the troll fishery. Catch statistics have been collected by MOFA since 1984 (Table 1.1). It is not considered any further here. Two other species that have been recorded from Maldivian waters are the albacore tuna (*Thunnus alalunga*) and the longtail tuna (*Thunnus tonggol*) (Anderson, Randall and Kuiter, 1998).

1.2.2. Species interactions

In this review, the four main tuna species are treated separately and more-or-less independently. It should be kept in mind, however, that they do not live in isolation. Tunas often school together, particularly when small and with other tunas of the same size, for example skipjack with juvenile yellowfin, and frigate tuna with kawakawa. The extent to which different tuna species compete for food is unknown, as is the extent to which they prey on smaller individuals of other tuna species, and indeed of their own species.

Not only do tuna species interact with each other, but they also interact with other types of marine animals, as predators, prey and competitors. Some fish species that are regularly associated with oceanic tuna schools are listed below:

English name	Scientific name	Maldivian name	Interactions
Silky shark	*Carcharhinus falciformis*	*Oivaali miyaru, aanu miyaru*	Predator
Oceanic whitetip shark	*Carcharhinus longimanus*	*Fee kanfaiy miyaru*	Predator
Rainbow runner	*Elagatis bipinnulata*	*Maaniyamas*	Competitor
Dolphinfish	*Coryphaena hippurus*	*Fiyala*	Competitor
Ocean triggerfish	*Canthidermis maculatus*	*Oivaali rondu*	?
Driftfish	*Psenes* spp.	*'Oimas'*	Prey
Flying fish	*Exocoetus volitans* (& others)	*Fulhangi*	Prey

Included above is an indication of the likely interactions of each species with tunas. Interactions will to a large extent depend on size: all species are likely to be competitors to tunas of the same size, while many fish will fall prey to tunas that are larger than themselves but be predators of tunas that are smaller.

Several of these species are taken as by-catch in the pole and line fishery. Rainbow runner is probably the most frequently taken, although there are no catch data. Silky sharks are also taken, the juveniles as by-catch in the pole and line fishery, and adults by longline. The interactions of silky sharks and tunas are believed to be of particular importance by Maldivian tuna fishermen (Anderson and Ahmed, 1993; Anderson, Hafiz and Adam, 1996). Fishermen consistently report that the taking of silky sharks from tuna schools reduces subsequent tuna catches. They also report that catching of oceanic sharks by longline reduces tuna catches. The reason for this is unknown, but suggests some as yet unknown behavioural or ecological interaction.

For Maldivian tunas, it is clear that inter-specific interactions are poorly understood, and so they are not dealt with further in this review. It is also clear, however, that a full understanding of tuna population dynamics will not be possible without some understanding of their ecological interactions. This is an area that requires further study. The interaction of large yellowfin tuna and dolphins is briefly discussed in section 3.10.2.

The selective effects of fishermen must also be kept in mind. For example, Maldivian pole and line fishermen favour skipjack tuna over any other species; therefore, when skipjack is abundant other tuna species may be caught in particularly low quantities, even though they may not be particularly scarce (section 4.3). As a second example, the low catch rates of yellowfin tuna by trolling vessels in the north of Maldives might be the result of high inshore catches of other species, notably kawakawa and frigate tuna, rather than being an indication of the scarcity of yellowfin tuna (section 3.3.1).

1.2.3. The Fishing Fleet

There are two main types of fishing vessel involved in the Maldivian tuna fishery. The larger type is the *masdhoni*. '*Mas*' means fish, or more specifically skipjack tuna, so a *masdhoni* is simply a tuna fishing boat. *Masdhonis* are made of wood and are typically about 9-14 m long (boats are traditionally measured in *riyan*, which are equal to 27 inches). There is a platform at the stern (*fenfilaa* or *filaagandu*), where the fishermen stand when pole and line fishing. Most of the rest of the boat is open. The hull can

be flooded (by pulling out bungs in the sides) so that livebait can be carried on board.

The *masdhoni* fleet was traditionally sail (and oar) driven. Mechanization of the fleet started in 1974 when a single *masdhoni* was equipped with an inboard diesel engine. Mechanization progressed rapidly, with over 800 *masdhonis* being mechanized by the end of 1980 (Table 1.3). Also by the end of 1980, 92% of the *masdhoni* tuna catch was made by mechanized vessels. Engines of 22-33 HP were used.

For several years after mechanization started, *masdhoni* design varied little from its traditional pattern. The only major modifications required were to the stern, to accommodate the propeller, and in the construction of a watertight engine compartment. A 'second generation *dhoni*' was introduced from 1983. These vessels are built to a standard design at a government boatyard at R.Alifushi (other vessels are usually built individually on the owners' islands). Second generation *dhonis* are 45' long (13.5 m) and have a number of design improvements over the original *dhonis*:

- They are built from planks of imported hardwood, rather than local coconut lumber. This requires much less wood.
- They are designed as mechanized vessels, rather than as modified sailing vessels. They are strengthened to carry an engine, and have a stern transom.
- Related to this, the stern fishing platform is an integral part of the structure of the second generation *dhonis*, rather than a separate addition. This gives more room for the fishermen to stand while fishing.
- Much of the deck is planked over, rather than left open, as in most traditional *masdhonis*.

Between January 1983 and December 1997, a total of 262 second generation *dhonis* were built at the Alifushi yard. Nearly all were sold as tuna fishing boats for use in the south of Maldives. Several of the design features have been adopted by traditional boat builders and are now incorporated in their designs, so that the distinction between the Alifushi 'yard *dhonis*' and those built elsewhere is diminishing.

Over the last decade there has also been a trend towards building larger and faster *masdhonis*. Fishermen like faster boats because they waste less time travelling, can go further in search of tuna, and can return to sell their catch ahead of other boats. Since skilled fishermen are in short supply on many islands (section 1.3), boat owners who want to stay in business have had to respond to this demand. The trend towards bigger and faster *masdhonis* is now entering a new phase. During 1994-96 about a dozen very large *masdhonis*, of about 20-25 m LOA, equipped with 85-140 HP diesel engines were built by private boatowners. Several have a small forward cabin, and some have forward wheel houses. In response to this demand for larger and faster vessels, in mid-1997 the Alifushi boatyard started production of a 'new version' *dhoni*, which is 50' long (15 m) and equipped with a 78 HP four cylinder engine.

Vadhu dhonis are built on very similar lines to the *masdhonis*, but they are smaller. They average about 5-8 m in length. '*Vadhu*' is a feather lure used in trolling, so a *vadhu dhoni* is a trolling boat. Most are still sail powered, but an increasing number have been mechanized in the last few years (Table 1.4), using both outboards and small diesel inboard engines. There are typically 2-3 crew when trolling for tunas. *Vadhu dhonis* are also used extensively for local transportation and reef fishing.

Small wooden rowing boats, or *bokkura*, are not normally used for tuna fishing. Instead they are used for transferring crew to and from *masdhonis* moored in island lagoons, and transporting the tuna catch to the island. In the far north of Maldives, a more stream-lined form of rowing boat, known as a *soki dhoni*, is sometimes used for trolling, particularly when the wind is too light to use a sailing *vadhu dhoni*.

Throughout this report the terms 'pole and line vessel' and *masdhoni* are used interchangeably, as are 'trolling vessel' and *vadhu dhoni*. Waheed and Zahir (1990) gave brief descriptions of Maldivian fishing vessels, and detailed descriptions of fishing gear. Shafeeg (1991) provides a thorough review of Maldivian boat construction. The total numbers of *masdhonis* and *vadhu dhonis* registered for fishing are presented in Table 1.4; the numbers actually engaged in fishing are presented in Table 1.5.

1.2.4. Livebait

Over 90% of the Maldivian tuna catch is taken by pole and line. The pole and line fishery in fact comprises two separate fisheries: an offshore one for tunas and an inshore one for livebait. The existence of abundant livebait resources is therefore vital to the prosecution of the Maldivian tuna fishery.

Livebait are normally caught first thing in the morning, adjacent to reefs inside the atolls. A simple liftnet is used. Livebait fishing at night using lights was not traditionally practiced in the Maldives, but it became established in Addu Atoll, apparently in the 1970s. It subsequently spread to other southern atolls and is now has started starting to spread through the rest of the country (Anderson, 1997b; Anderson, Waheed and Nadheeh, 1997). The current national catch of livebait is roughly estimated at just over 10,000 t per year (Anderson 1994 & 1997a). The major livebait species, together with rough estimates of their contribution to the total livebait catch (Anderson, 1997a) are listed below:

English name	Species	Maldivian name	Percentage
Silver sprat	*Spratelloides gracilis*	*Rehi*	38 ± 10 %
Fusiliers	Various Caesionids	*Muguraan*	37 ± 9 %
Cardinalfishes	Various Apogonids	*Boadhi & fatha*	10 ± 3 %
Anchovy	*Encrasicholina heteroloba*	*Miyaren*	7 ± 2 %
Blue sprat	*Spratelloides delicatulus*	*Hondeli*	5 ± 1 %
Others	Various species	*Nilamehi, hureki, gumbulha*	2 ± 2 %

Reviews of the Maldivian baitfishery are provided by Anderson and Hafiz (1988; later reprinted in a revised form by Maniku, Anderson and Hafiz, 1990) and Anderson (1997a). Some early descriptive accounts of the tuna fishery include some information on livebait (Jonklaas, 1967; Munch-Petersen, 1980). Accounts of livebait fishing methods are given by Anderson (1983 & 1995), Liews (1985) and Waheed and Zahir (1990). The major bait varieties used are described by Anderson and Hafiz (1984). The biology of some species is discussed by Blaber et al. (1990), Milton et al. (1990a & 1990b) and Anderson and Saleem (1994 & 1995). Estimates of the size of the livebait fishery are provided by Anderson and Hafiz (1988) and Anderson (1994 & 1997a). Management issues are discussed by Anderson and Hafiz (1988), Wright (1992), Anon (1997) and Anderson (1997a).

1.2.5. Pole and Line Fishing

Tuna fishing is carried out on day trips. Pole and line fishermen typically leave their islands around dawn to catch livebait on nearby reefs within the atoll. Once sufficient bait has been obtained the *masdhonis* move outside the atolls to search for tuna schools.

Tuna schools are located by the presence of seabirds, the presence of other fishing boats, near drifting objects and FADs, by trolling, and by surface activity of the tunas themselves. Seabirds are the most important indicators (Shafeeg, 1991 & 1993; Anderson, 1996), with perhaps as many as 90% of non-FAD associated schools being located in this way. Many species of seabirds are used as indicators of tuna, but the most important single species appears to be the Brown Noddy, *Anous stolidus*. The decline in numbers of some species of seabird in the Maldives is a matter of concern and deserves urgent attention.

Fishing takes place from the stern platform. 2-8 fishermen stand on the platform facing aft, and fish the area immediately astern of the boat. Water is sprayed from the stern. Traditionally, this was done by hand, with two or more crew members dedicated to the task. They used splashers made from coconut flower guards, known as *fenfulhafi*. Mechanical water sprayers were introduced in 1990 (Anderson and Waheed, 1990), and by 1995 had replaced hand-spraying throughout the country.

Livebait are thrown by the chummer (*en keyolhu*) over the sides of the *masdhoni*, towards the stern. These baitfish draw the tunas towards the boat and the fishermen's poles. If the bait are too active, and are moving away from the boat, the chummer will squeeze them before they are thrown into the sea.

Barbless hooks are used. The traditional Maldivian hook is C- or ?-shaped, has a broad flattened shank, and is tinned. The broad shank appears like a silvery fish when the hook is in the water, and so the hook acts as both lure and hook. Japanese-style hooks were introduced in the 1970s and locally made varieties (known as *Japan buli* or *Sato buli*) are now popular. These hooks have attached feathers, which act as a lure (Waheed and Zahir, 1990). Because both types of hook have integral lures, they are usually deployed unbaited, although baitfish may be put on the hook if the tunas are not biting well.

The hooks are attached to the poles with nylon fishing line of 60-180 lb (27-82 kg) breaking strain (Waheed and Zahir, 1990). The line is tied to the tip of the pole, and then again several inches below the tip; this prevents the loss of fish, line and hook if the tip of the pole breaks. The line is tied off to such a length that the hook just reaches the base of the pole; hooking it under the bottom rim of the pole prevents tangles when the poles are not in use.

Traditionally, fishing poles were of bamboo. Nowadays, glass fibre rods are more popular, because they are stronger. A variety of pole sizes are used, each vessel carrying 20-40 or more poles. Longer or shorter ones can be used, depending on how closely the tunas approach the vessel; stronger or finer ones are used, depending on the size of the tunas. The shorter and stronger poles have thicker lines and larger hooks.

Once hooked, the fish are pulled inboard. Because the hooks are unbarbed, the tunas come off the hooks once the strain is off the line. The fishermen try to have their fish come off the hook, fly forward, and hit the wooden board (*mas kandhu*) set up across the vessel between the mast and the engine. The tunas then drop back down into the fish well. The master fishermen have the prime positions at the very stern, with more junior fishermen standing behind them (i.e. further forward on the fishing platform). Junior fishermen have to dip their fishing poles to allow the tunas caught by fishermen standing in front (astern) of them to pass.

When fishing on a school is finished, the captured tunas are lifted out of the fish well and stacked, belly up, on shelves below deck or on deck (in which case they are often covered with the bait net). Searching continues for other tuna schools. The *masdhonis* return to their atolls in the afternoon or evening. Fish may then be sold to the cannery, to one of the two freezer plants or to a freezer or collector vessel, to Malé market, or taken back to the island for processing.

1.2.6. The Troll Fishery

As with pole and line fishing, trolling is carried out on day (or part-day) trips. Trolling is widely believed to be most successful in the early morning and late afternoon (Waheed and Zahir, 1990). Trolling speeds of about 4-5 knots are preferred (Waheed and Zahir, 1990), so wind conditions must be suitable. The main target species is kawakawa (*latti*) although frigate tuna and other species are also taken. When trolling for small tunas, nylon lines of about 30-50 lb (14-23 kg) breaking strain and small hooks (number 12-15) are used (Waheed and Zahir, 1990). Lures are locally made, traditionally using feathers, but these days more often using plastic. Two or three lines are normally towed at once, each with a single hook. However, some boats tow up to five lines using outriggers, and others use several hooks per line.

Vadhu dhoni fishing enjoyed a burst of popularity in the late 1970's during the period of *masdhoni* mechanization. Since then the troll fishery has almost collapsed, with the number of active trolling vessels and number of days fished by trolling vessels (Table 1.5 & 1.6) being now at their lowest level for, possibly, hundreds of years. The reasons for this collapse are thought to be socio-economic, but have not been studied.

Trolling was traditionally far commoner in the north of Maldives than in the centre and south. This is almost certainly because the main target species (kawakawa and also frigate tuna) are commoner in the north than in the south (Anderson, 1992 & 1993; sections 4 & 5). The collapse of the traditional troll fishery is therefore believed to have had a much greater socio-economic impact in the north of Maldives than in the centre and south.

Note that this section has dealt only with the traditional *vadhu dhoni* troll fishery for tunas. Trolling is also carried out by *masdhonis* and transport vessels, while travelling, and these days also by tourist boats. Separate records of these catches are not maintained. A small but growing big game fishery has started, which targets sailfish, wahoo and other larger species (Anderson, Hafiz and Adam, 1996).

1.2.7. The EEZ Fishery

The Maldives declared a 200 mile Exclusive Economic Zone (EEZ) in 1975. The outer boundaries of this area were rectangular and did not comply with the rules for designation of such boundaries set out under the Law of the Sea. Accordingly, new EEZ boundaries were declared in June 1996. These boundaries adjoin those of India (Lakshadweep) to the north, mainland India and Sri Lanka to the northeast and the British Indian Ocean Territory (Chagos) to the south.

Within the 200 mile EEZ, there is a central 'Coastal Fishing Zone' which extends for 75 miles in all directions from the atoll baseline. This area is reserved for Maldivian fishermen only. The area from 75-200 miles is commonly referred to in Maldives as the EEZ. Foreign fishermen are allowed to operate in this offshore area, under licence. Only longlining and trolling are allowed; purse-seining and gillnetting are specifically banned.

Far Eastern longliners operated in the area of what is now the Maldivian EEZ since about 1954. Klawe (1980) summarized some information on

longline activity in the area during the 1970s. Anderson and Waheed (1990) provide a summary of information obtained during an exploratory offshore fishing survey, carried out from 30-100 miles offshore from the eastern side of Maldives during 1987-88. Anderson, Hafiz and Adam (1996) provide information on EEZ fishing activity during 1994. Licences to fish in the EEZ are issued by the Ministry of Trade and Industries. Catches are supposed to be reported to the Ministry of Fisheries and Agriculture, but in practice are often not reported or under-reported. Better monitoring of the EEZ fishery would be desirable.

In recent years relatively large numbers of Sri Lankan fishing boats (combination longline-gillnetters) have been caught while fishing illegally in the Maldivian EEZ, most commonly during the northeast monsoon season.

1.2.7. Infrastructure, Processing and Exports

Tuna, and particularly skipjack tuna, is the favoured fish of most Maldivians, and so a large proportion of the tuna catch is consumed locally. The balance is exported. The traditional export product was 'Maldive fish' or *hikimas*, a boiled, smoked and dried similar to the Japanese *katsuobushi*. *Hikimas* was exported as far as Yemen to the west and Bengal and Sumatra to the east. However, for centuries the main market for *hikimas* was Sri Lanka, until that market collapsed in the early 1970s because of an economic crisis there. As a result, exports were swiftly changed to frozen and canned tuna.

There is a tuna cannery at Felivaru in Lhaviyani Atoll. Originally built in 1978 by a Japanese fishing company, it was taken over by the government of Maldives in 1984. The cannery was upgraded in 1986 and the associated freezers were upgraded in 1987. Present nominal canning capacity is 50 t per day, although 60 t per day has been achieved with large fish. Current freezer capacity is 750 t. During 1993-5, two other land-based freezer facilities were built. One at G.A.Koodhoo has a daily freezing capacity of 120 t, and a storage capacity of 1800 t. The other at L.Maandhoo has a daily freezing capacity of 50 t and a storage capacity of 1000 t.

In addition to these land-based facilities, MIFCO maintains a fleet of freezer and collector vessels. In 1998 there were:

- 10 freezer vessels with a total daily freezing capacity of 146 t and a storage capacity of 3020 t.
- 9 ice-carrying collector vessels with a total holding capacity of 138 t.
- 10 refrigerated seawater (RSW) collector vessels with a total holding capacity of 256 t.

A summary of tuna exports is provided in Table 1.8. The export weights presented are of actual weights; average yields from fresh fish are:

Maldive fish	20%
Salt dried tuna	33%
Canned tuna	33%.

1.3. SOCIO-ECONOMIC BACKGROUND

The Maldivian tuna fishery was probably little changed from before the time of Ibn Battuta's visits in the 14th century, right up until the beginning of the 1970's. Since then, however, there have been enormous changes in the fishery. The actual method of catching tunas, i.e. by pole and line using livebait, has always been extremely efficient. It remains unchanged in the essentials, although there have been many changes in the details, for example with the replacement of bamboo poles by glass fibre ones, the use of 'Japanese' hooks, and the use of mechanical instead of hand sprayers. Almost everything else related to the fishery has changed radically. Three things happened in the early 1970's that triggered these changes:

- In 1972, tourism started. This not only created new jobs, but also hastened the change to a cash economy and a consumer society.
- In 1974, the first *masdhoni* was mechanized. At a stroke, the catch of a *masdhoni* could be doubled. On top of this, the number of crew needed to man a mechanized *masdhoni* was less than that needed to man a sailing one.
- During the early 1970s, the traditional Maldive fish export market in Sri Lanka collapsed. The Government acted quickly (with foreign inputs) to identify alternative markets and to develop the infrastructure for collecting and exporting new products (notably frozen and canned tuna, see section 1.2.7).

Despite the potential benefits of mechanization and these other developments, the late 1970s saw a significant drop in actual *masdhoni*

fishing effort (Fig. 1.5) and a stagnation in catches (Fig. 1.2). The reasons for this included the following:

- Sailing *masdhonis* were unable to compete with mechanized *masdhonis* at tuna fishing, so dropped out of the fishery at a faster rate than they were replaced by mechanized boats.
- The mid- to late 1970s saw a rapid expansion of tourism in Maldives. This new industry created a large new labour market, employing many workers who might otherwise have been employed in the fishery. Whether the tourism industry simply soaked up excess workers who were being displaced from the fisheries sector by mechanization, or actively drew off workers is a moot point.
- At the same time, there were some early problems with the mechanization program, for example with fuel distribution, and with engine repair and maintenance. Also, some mechanized *masdhonis* were co-opted at least part time as transport vessels. As a result mechanized *masdhoni* effort did not increase as rapidly as it might have done.

Because of these problems, the benefits of mechanization in terms of increased total catch were not seen immediately. Indeed, in not one of the years 1975-83 did total tuna catch reach the level set in 1974 (Table 1.1). Nevertheless, the advantages of having an engine were so great that by 1983, 95% of *masdhoni* fishing effort was made by mechanized vessels. Sailing *masdhonis* had effectively been displaced from their traditional tuna fishing role and were relegated to reef fishing and other, non-fishing activities. This period of transition, during which the *masdhoni* fleet suffered many operational problems, left many pole and line fishermen underemployed, as a result of which trolling enjoyed a brief burst of popularity (see section 1.2.6).

Only after 1983 were early problems and constraints resolved, and then *masdhoni* fishing effort and fish catch soared (Tables 1.1, 1.2, 1.3 and Figs. 1.2, 1.5). More recently, however, a new trend has become apparent. The number of mechanized *masdhonis* active in fishing, which had increased every year up until 1993, is now declining (Table 1.4). This is thought to be a direct result of a national shortage of fishermen.

The numbers of fishermen are recorded in two separate datasets (Table 1.7). Occupation is recorded in the national census (now taken every five years). Numbers of fishermen are also recorded in MOFA's monthly catch and effort statistics. The two data sets should be more or less the same since both purport to record the number of active fishermen. Under the national census, occupation is recorded as the predominant income earning activity during the previous month. In the MOFA statistics, only full time fishermen should be recorded, but in practice many part time and 'potential' fishermen appear to be included as well. Whatever the differences between the two data sets, it is clear that the number of fishermen as a percentage of the total population has decreased dramatically over the last 20 years. The number of full time fishermen has also decreased, although the number of men who work in fisheries part time has increased.

Shortage of fishermen is one of the main problems facing the fishery today, and one that is almost certainly going to become much more serious in the future. Few young men are entering the fishery. The reasons for this include the low perceived status of fishermen; widespread education in the atolls (leading to increased expectations); increased employment opportunities in other sectors; and high reliance on remittances in some islands. Income is not believed to be a major factor in limiting entry to the fishery since fishermen can make a very good living, but many young men would rather be unemployed than go fishing.

The lack of fishermen is already leading to problems for many boatowners, who cannot find crew for their *masdhonis*. It is because of this constraint that the number of active mechanized *masdhonis* has been decreasing in recent years (Table 1.5). It has also led to changes in the traditional share system (Willmann, 1986; Ramsey, 1988): owners now take a smaller share in order to pay more to masterfishermen. Shortage of fishermen is also a factor in the development of the new class of large *masdhonis* (section 1.2.3). The advantages of larger and faster boats are that they can travel further for the best livebait, fish and markets; they can return quickly from fishing to sell their catch before other boats; and they are more comfortable. As a result of these advantages it is easier for owners of large boats to attract crew than it is for owners of more traditional *masdhonis*.

Owners report that these large boats are capable of landing 400-500 t of tuna each per year. It might therefore be possible to maintain the current national catch of about 100,000 t with about 250 large *masdhonis*, rather than the current fleet of 1400 vessels. The larger vessels require slightly larger crews, but it is nevertheless possible to envisage the national catch being maintained despite a further halving of the number of full-time fishermen. It certainly seems likely that the fishery will become more

concentrated, both in terms of numbers of active boats, and of numbers of active fishing islands. In the past, Maldives could be thought of as a country of some 200 tuna fishing islands; already today that is no longer true.

These changes in the fishery deserve detailed study. In the medium to long-term, they may have a greater impact on total Maldivian tuna catch than any variation in tuna stock size and availability. Furthermore, the socio-economic impact of these changes on the island communities is likely to be profound and not always beneficial.

1.4. OCEANOGRAPHY

Of all the fishes, the tunas are among the most supremely adapted to the oceanic environment. They are thus among the most responsive to its variations. An understanding of the changes in the distribution and abundance of tunas around the Maldives therefore requires an understanding of the variations in oceanographic conditions in the central Indian Ocean. For example, tunas are known to be sensitive to variations in temperature and oxygen content, and to aggregate in the vicinity of thermal fronts and of seamounts and oceanic islands (Fosberg, 1989; Sharp, 1978, 1979 & 1992; Sund, Blackburn and Williams, 1981).

1.4.1. Spatial Variations

The Maldivian atoll chain stretches nearly 900 km from Ihavandhipolhu at about 7°N to Addu at about 0°30'S (Fig. 1.1). Oceanographic conditions vary along this great length (Anderson, 1992; Woodroffe, 1992) and so too does the abundance of different tuna species. For example, frigate tuna and kawakawa are most abundant in the north of the Maldives (see sections 4.3.2 & 5.3.2), while bigeye tuna is commonest in the south (Anderson, 1996). Anderson (1992; Anderson and Saleem, 1994) suggested that the Kudahuvadhoo Channel at about 2°40'N, which separates the central double chain atolls from the southern single chain atolls, is an important boundary or transition zone for many Maldivian fish species. However, with more data now available for tunas it appears that for these species at least it is next channel south (the Veimandhoo Channel at about 2°10'N, between Thaa and Laamu Atolls) that marks an important ecological boundary (see sections 2.3.2, 3.3.2 and 4.3.2). The Veimandhoo Channel marks the southern boundary of the central Maldives plateau. Thaa Atoll, although not obviously one of the double chain atolls, lies on the southern end of the double chain platform. The Kudahuvadhoo Channel is about 300-500 m deep, while the Veimandhoo Channel is about 1800-2000 m deep. Exactly how this affects local oceanographic conditions and tuna abundance is unknown. However, the atolls north of the Veimandhoo Channel may experience greater seasonal upwelling and consequently higher productivity than the atolls further south.

To study regional variations in tuna abundance, and for the purposes of this report only, the Maldivian atolls have been divided into three latitudinal zones, as follows:

North: North of the Kaashidhoo Channel
Centre: South of Kaashidhoo Channel and north of Veimandhoo Channel
South: South of the Veimandhoo Channel

These three latitudinal zones are further subdivided into regional atoll groups, as follows:

Northern region: Haa Alifu, Haa Dhaalu (plus Sh. for skipjack only)
North-east region: Shaviyani, Noonu and Lhaviyani Atolls
North-west region: Raa and Baa Atolls
East-central region: Kaafu, Vaavu and Meemu Atolls plus Malé Island
West-central region: Alifu, Faafu, Dhaalu and Thaa Atolls
Southern region: Laamu, G.A., G.Dh., Gnaviyani and Seenu Atolls

Other spatial variations in tuna distribution and abundance include those associated with seamounts. Upwellings associated with seamounts encourage productivity (Boehlert, 1987), and so they are often areas that support high and regular tuna catches. The two best known sea mounts for tuna fishing in the Maldives are *Derahaa* near Laamu Atoll, and *Satorahaa* in the One-and-a-Half Degree Channel between Laamu and Gaafu Alifu Atolls. Maniku (1993) lists known seamounts in Maldivian waters, and discusses their tuna fisheries potential. The exploitation of these seamount areas increased in the late 1970s and early 1980s as a result of mechanization of the *masdhoni* fleet. In the last decade it has increased further as a result of increased power of mechanized vessels, and identification of new sites (such as *Addu Thila* in the far south, first located by local fishing vessels in the early 1990s).

More generally, the whole of the Maldives ridge may act like a giant seamount or FAD. Oceanic islands are known to increase productivity of the surrounding waters (Doty and Oguri, 1956; Wolanski and Hamner,

1988). Around the Maldives there are certainly considerable seasonal pulses in primary productivity associated with the seasonally oscillating monsoon currents.

1.4.2. The Monsoon Seasons

The Maldives are affected by the seasonal monsoons and their associated currents (Stéquert and Marsac, 1989; Molinari, Olson and Reverdin, 1990):

- During the southwest monsoon, the wind blows mainly from the west and southwest. The ocean current is also from the west, and is known as the Indian monsoon current (IMC) or southwest monsoon drift. The southwest monsoon lasts from about June to October.
- During the northeast monsoon, the wind blows mainly from the northeast. The current flows to the west and is known as the north equatorial current (NEC), or northeast monsoon drift. Off the west coast of India there is a strong northward surface flow, and the influence of this is felt off the northern Maldives, particularly in January. The northeast monsoon season lasts from about December to April.
- During the intermonsoon months of May and November, winds and currents change.

In the far south of the Maldives, near the equator, the weather (Stoddart, 1966) and current regime are different from the rest of the country:

- During the southwest monsoon, a band of cyclonic eddies develops along the equator between the eastward flowing IMC and the westward flowing south equatorial current (SEC) further south.
- During the northeast monsoon, the eastward flowing south equatorial counter current (ECC) develops south of the equator. A convergence zone develops along or just south of the equator between the ECC and westward flowing NEC further north.
- During both intermonsoon periods a strong eastward flowing equatorial jet develops (Wyrtki, 1973; Knox, 1976).

The side of the Maldives exposed to the monsoon (i.e. the western side during the southwest monsoon and the eastern side during the northeast monsoon) receives clear oceanic waters from offshore. In contrast, on the downstream or lee side of the Maldives the water is far from clear. Tidal mixing, upwelling and sediment stirring all bring nutrients into the surface waters, which leads to a plankton bloom on the lee side.

This effect is presumably enhanced in the central Maldives by the presence of the double atoll chain, hence annual productivity may be higher than in the southern Maldives, where the atoll chain is single. It should be noted that there has not been no oceanographic study of this phenomenon, although it is presumably a local manifestation of the well known 'obstruction effect' or 'island mass effect' (Doty and Oguri, 1956). Furthermore, the seasonal variation in productivity is well known to local fishermen and divers.

Pelagic fishes move seasonally from side to side of the Maldives in order to take advantage of the conditions that suit them best. Plankton-feeding fish such as manta rays, and among tunas the frigate tuna (section 4.6), are found on the downstream side. In contrast, oceanic fish such as juvenile yellowfin tuna (section 3.6) are brought to the exposed side. These fish on the exposed side tend to be concentrated under floating objects (known locally as *oivaali*) and along ocean slicks (*asdhandi*). Fishermen report that *asdhandi* only occur on the exposed side of the Maldives, that they see only one or a few per season, and that they move relatively slowly. The nature of *asdhandis* is not known; this is an area that needs further investigation.

Sea surface temperatures (SST) around the Maldives vary seasonally, but not by much (Fig. 1.7). The average annual SST (as recorded by Advanced Very High Resolution Radiometry, AVHRR, satellite) is 29.0°C. During the second half of the northeast monsoon season, winds are light and the sky is clear, leading to stratification of the water column and warming of the surface waters. SST rises to an average of 29.9°C during March-May, although temperatures of up to 2°C higher may be experienced at times. At the start of the southwest monsoon, when winds are strong, there is mixing of the surface layers, and SST drops. Temperature is lowest during the first half of the southwest monsoon, averaging 27.6°C in July and August. Temperatures rise very slightly towards the end of the southwest monsoon, but drop again in December with the onset of the northeast monsoon. These trends are more pronounced in the north of Maldives (where average annual SST range is about 2.3°C) than in the south (where the annual range is about 1.4°C).

Maldivian fishermen use a traditional calendar in which the year is divided into 27 periods, or *nakaiy* (Table 1.9), based on the constellations. The

nakaiy calendar is widely used by both fishermen and farmers (Maniku, 1989; Chamberlain and Jauhary, 1998). The southwest monsoon season (*hulhangu moosun*) traditionally starts on 8 April and is divided into 18 nakaiy. The northeast monsoon season (*iruvai moosun*) traditionally starts on 10 December and is divided into 9 nakaiy. Since 1980, 10 December each year has been marked as 'Fishermen's Day' in the Maldives.

1.4.3. El Niño-Southern Oscillation

In additional to seasonal and local effects, Maldivian waters and tunas are also affected by El Niño-Southern Oscillation (ENSO) events, which occur at irregular intervals every few years. El Niño is a periodic southward incursion of warm tropical water into the normally cold waters off the coast of Peru in the eastern Pacific Ocean. It is particularly well known because of its disastrous effects on the Peruvian anchovy fishery. This phenomenon has been recognized for well over one hundred years, and for most of that time was thought to be of local interest only. However, more recent events have shown that El Niño is but one particularly severe manifestation of a worldwide shift in atmospheric and oceanographic conditions. A shift in the atmospheric pressure gradient across the Indian and Pacific Oceans, known as the Southern Oscillation, is a key factor in the development of an El Niño. Hence, the whole development is often referred to as an ENSO event. Recent ENSO events occurred in:

1972-73	(severe)
1976-77	(weak)
1982-83	(very severe)
1987	(medium)
1991-95	(weak)
1997-98	(very severe)

When oceanic conditions shift in a reverse direction they give rise to the phenomenon known as La Niña, or the ENSO cold phase. Recent La Niña events occurred in:

1971	
1974-75	(medium)
1979-81	(weak)
1984-85	(weak)
1988-89	(severe)
1995-96	(medium)

In the Indian Ocean region, Walker (1924) first identified the atmospheric perturbations that are now known to be associated with ENSO events. More recently, Cadet (1985) and Tourre and White (1997) have reviewed changes in oceanographic conditions in the Indian Ocean associated with the development of ENSO events. In the tropical Indian Ocean, ENSO events have been shown to be linked with:

- Reduced rainfall during the summer (southwest) monsoon in India, which in turn affects rice production and in earlier times could bring famine (Bhalme, Mooley and Jadhov, 1983; Gadgil, 1995).
- Reduced rainfall in Indonesia (leading to devastating forest fires during recent events), and increased rainfall in east Africa (leading to flooding in Kenya and Somalia during recent events).
- Increased atmospheric pressure, sea surface temperatures and upper ocean heat storage, and reduced surface winds over large areas of the Indian Ocean (Cadet, 1985; Tourre and White, 1997). Increased sea surface temperatures have led to bleaching of corals on Maldivian reefs during some recent events. The reduction of winds may reduce surface mixing and affect seasonal upwellings, and hence reduce primary productivity in some areas.
- Increased yellowfin tuna catches by purse seiners in the western Indian Ocean (Hallier and Marsac, 1990; Marsac, 1992).

Maldivian tuna catches are also noticeably affected by ENSO events (Anderson, 1987, 1991, 1993 & 1997; Rochepeau and Hafiz, 1990; Hafiz and Anderson, 1994; MRS, 1996). Skipjack catches tend to be reduced during ENSO events, while those of the other main tuna species tend to increase.

During La Niña years, in general terms, climate anomalies are reversed. This is seen too in the Maldives, with skipjack catch rates tending to increase while those of the other major tuna species tend to decrease. There may also be some effect on baitfish. Anderson and Saleem (1994) noted that the use of anchovies (*miyaren, Encrasicholina heteroloba*) as livebait in the tuna fishery is most frequent during the intermonsoon periods. However, unusually high utilization was noted at G.Dh.Thinadhoo from the October-November intermonsoon of 1988 right through to July 1989. This may have been related in some way to the 1988-89 La Niña event.

1.4.4. Decadal Scale Variations

Over longer (decadal) time scales, cyclical shifts occur in the oceanographic climate regime with associated shifts in biological productivity and species composition. Examples of such cyclical changes include the Russell cycle in the English Channel (Russell, 1973), and the North Pacific Oscillation (Polovina et al., 1994; Trenberth and Hurrell, 1994). The latter has been shown to have had, among other things, a profound impact on north Pacific albacore tuna catches (Au and Cayan, 1998).

The Indian Ocean is the least well known of the major oceans, and there appear to have been no studies of decadal scale oceanographic cycles. However, Maldivian tuna catches do show signs of being affected on such scales (Anderson, 1993 & 1997; Hafiz and Anderson, 1994; MRS, 1996). On decadal time scales, as with ENSO related variations, skipjack catches tend to go up when yellowfin catches go down. The ratio of skipjack to yellowfin catch is therefore one measure of this variation (Fig. 1.6). The abundance of these two major species during different periods may be summarized as follows:

1970-72 high skipjack and low yellowfin abundance
1973-84 low skipjack and high yellowfin abundance
1985-92 high skipjack and low yellowfin abundance
1993-97 low skipjack and high yellowfin abundance

These time periods correspond rather closely to the periodicity of the decadal variations in the North Pacific. A major climate shift in the North Pacific started in about 1976 and lasted about 12 years, ending in about 1988 (Polovina et al., 1994; Trenberth and Hurrell, 1994). The Maldivian tuna data suggest a climate shift in the central Indian Ocean starting in about 1973, lasting about 12 years and ending in about 1985. The lag of 3 years between the presumed event in the Indian Ocean and that observed in the Pacific Ocean suggests that these decadal-scale events may be propagated from the Indian Ocean to the Pacific Ocean and not vice versa. At present, however, this is just speculation.

The oceanographic changes that promote these decadal scale variations in tuna abundance in Maldivian waters are not yet known. At present our understanding of 'normal' oceanographic conditions in the central Indian Ocean, let alone variations from the norm, is limited. Trying to understand tuna population dynamics without an understanding of oceanographic variability is impossible. There is therefore an urgent need to increase knowledge of the oceanography of Maldivian and adjacent waters.

1.5. FISHERY STATISTICS

1.5.1. Catch and Effort Data

The analyses of tuna resources presented in the following sections rely heavily on the time series of catch and effort data collected since 1970 by what is now the Economic Planning and Coordination Section (EPCS) of the Ministry of Fisheries and Agriculture (MOFA). We are most grateful to the staff of EPCS, and in particular to Mr. Hassan Rasheed, for their assistance in supplying these data. Details of the statistical system are given by Anderson (1986), Rasheed and Latheefa (1994), Parry and Rasheed (1995) and Anderson and Hafiz (1996). The statistics system was developed to record tuna catches. It does this with a reasonable degree of accuracy, although there are some inadequacies in the system which need to be noted. Catches of other varieties of fish (i.e. non-tunas, collectively referred to as 'reef fish') are not recorded reliably.

Tuna catch and effort data are recorded for each fishing boat on each fishing island. Some data have been collected since 1959, but catch by the full range of tuna species has only been recorded since 1970. Tuna catch is recorded in numbers, in a total enumeration system. Since tuna catches have traditionally been shared between the boat owner and crew, numbers of tunas caught are always well known. Fishing effort is recorded in numbers of trips, which is equal to numbers of days fished, with *masdhoni* and *vadhu dhoni* effort recorded separately. Mechanization of the *masdhoni* fleet started in 1974, but mechanized and sailing *masdhoni* catch and effort data were only recorded separately from 1979. Fishing gear has been recorded since 1985, but it is not comprehensively reported.

Data collected at the island level are compiled by atoll before submission to Malé. Numbers of fish are converted to weight using average weight conversion factors, and data are aggregated by month and by atoll. Since 1979, data have been compiled annually by what is now the Economic Planning and Coordination Section (EPCS) of MOFA (Anon, 1979-1997). Data for the years 1970-83 were compiled by Anderson (1986). Regular 5-year summaries are also produced by EPCS (Anon, 1989, 1992, 1994 & 1995).

The statistical system has been reviewed by Rasheed and Latheefa (1994), Parry and Rasheed (1995) and Anderson and Hafiz (1996). The system is believed to give a good estimation of both catch and effort for tunas. However, there are a number of problems with the system, the two major ones being:

- Under-reporting of catch. Not all catches are reported. Parry and Rasheed (1995) estimated that skipjack catches might be under-reported by something of the order of 5%, while yellowfin catches might be under-reported by about 15%.

- Inadequate catch conversion factors. Tuna catches are reported in numbers, and have to be converted to weights using some form of conversion factor. The conversion factors in use are widely recognized as inadequate. New conversion factors, taking into account seasonal and regional variations in average weights, have been estimated by Scholz, Anderson and Waheed (1997).

Regarding effort data, the diversification of fisheries over the last 20 years (Adam, Anderson and Shakeel, 1998) will have had some impact on the accuracy of tuna effort data, since an unknown proportion of fishing effort in later years will have been directed to non-tuna species. This may not be a particularly serious problem since non-tuna fishing trips appear to be grossly underreported. Nevertheless, this is an issue that requires further study.

In addition, a review of the data prior to the commencement of this study identified a number of specific problems. First, data from the years 1984-88 inclusive appear to contain numerous serious compilation errors; these data need to be recompiled. Secondly, data from other years have some minor errors, which appear to be mainly transcription mistakes; these data need to be rechecked. Despite these problems, the long time series of catch and effort data (in which such errors as there are are repeated more or less consistently year after year) is of immense value for studying the dynamics of the fishery and the tuna resources that it exploits.

1.5.1.1. Catch Per Unit Effort (CPUE)

Tuna catch by itself is not a good measure of tuna abundance. It does not take account of the amount of fishing being carried out. Some measure of catch per unit of fishing effort (CPUE) is required as an index of tuna abundance. In the case of the Maldivian tuna fishery, fishing effort data are available, as numbers of trips. Since one day trips only are undertaken, this is equivalent to numbers of days fished.

For the Maldivian pole and line fishery there are particular problems with using catch per day's fishing as a measure of tuna abundance. These problems are well known, but most are difficult to quantify. They include:

- Variations in availability of livebait. Seasonal and interannual variations in livebait availability (Anderson and Saleem, 1994 & 1995) affect the amount of bait available each day, and hence the quantity of tuna that can be caught. They also affect the amount of time spent baitfishing each day, and hence the amount of time left over for tuna fishing. When bait is particularly scare, fishermen may spend one day baiting and one day tuna fishing; this is recorded as only one day's fishing. Alternatively, when bait is plentiful but tuna are scarce, fishermen may go tuna fishing for a few days in a row with the same bait.

- Changes in the pattern of baitfishing. In recent years fishermen have adopted many new bait catching and holding practices, which have increased catch rates and decreased holding mortality (Anderson, 1997a). As a result, tuna catch per unit of livebait caught may have changed. In the southernmost atolls, a recent trend towards fishing at night for livebait with lights (Anderson, 1997b) is likely to have had a marked effect on CPUE.

- Increase in fishing power associated with mechanization. Mechanization of the previously sail-powered *masdhoni* fleet started in 1974-75. By the early 1980s the process was effectively complete, with 99% of the tuna catch by *masdhonis* being landed by mechanized *masdhonis* in 1984. Tuna catch rates by mechanized and sailing *masdhonis* are known, and so some correction can be made for this change (section 1.5.1.2). However, it is not known to what extent mechanization differentially affected catch rates of the different tuna species (see sections 3.3.1 and 4.3).

- Increase in fishing power of mechanized fishing vessels over the last decade. After the main period of mechanization, and particularly over the last decade, the fishing power of mechanized *masdhonis* has been steadily increasing. Factors affecting fishing power include

increasing horsepower of engines; increasing use of radios to communicate between boats; and increasing use of binoculars to locate schools (Hafiz and Anderson, 1994; Hassan, 1995). Over the last 2-3 years this trend has accelerated rapidly with the creation of what is essentially a new class of large *masdhoni* (section 1.2.3).

- Deployment of fish aggregating devices (FADs). The Ministry of Fisheries and Agriculture (MOFA) has a successful FAD deployment programme, which was initiated in 1981 (Peters, 1982; Naeem, 1988; Naeem and Latheefa, 1994). A design suitable for Maldivian conditions has been evolved, and by the mid-1990s, 32 sites around the Maldives had been identified as appropriate locations for FADs, taking into account bottom topography, proximity of fishing islands, and local tuna abundance. MOFA aimed to maintain FADs at all of these sites, with 28-30 FADs in place at any one time. By 1998, MOFA had increased its target to 42 sites, with 38 FADs in place at any one time (Ali Naeem, pers. comm., October 1998). The presence of FADs within reach of most fishing islands is likely to have had a profound effect on tuna CPUE.

- Variations in the abundance of seabirds. Maldivian fishermen use seabirds as indicators of the presence of tuna schools (Shafeeg, 1993; Anderson, 1996). Seasonal and interannual changes in seabird abundance are assumed to affect fishermen's ability to find fish, although this has not been quantified. Recent declines in numbers of some seabird species around Maldives (as a result of human activities) are believed by some fishermen to be a factor in reducing tuna catch rates (Anderson, 1996).

With the possible exception of the change in fishing power associated with mechanization, it is difficult or impossible to quantify the effects of these factors on tuna catch rates. Furthermore, it should be recognized that Maldivian CPUE data, even if corrected for all the variables noted above, is not strictly an index of tuna abundance. It is rather a measure of both abundance and catchability (a measure of the availability of fish to capture).

These problems are introduced here in order to demonstrate that tuna catch per boat day is a far from perfect measure of tuna abundance. Nevertheless, it is the only measure available, and since some of the biases associated with it may either cancel out, or be consistently repeated year after year, it is assumed to give a reasonable index of tuna abundance. Certainly, the consistency with which patterns of seasonal, regional and inter-annual changes in catch rates show up in the data suggests that the use of the available CPUE data as an index of tuna abundance is not without merit.

1.5.1.2. Standardized Pole and Line CPUE

Pole and line vessels are the most important type of tuna fishing vessels in the Maldives. The various caveats listed above concerning the use of *masdhoni* CPUE as an index of tuna abundance should be noted. Nevertheless, in the absence of other data, *masdhoni* CPUE remains the most useful index available. In order to make best use of these *masdhoni* data, it is necessary to standardize CPUE to take account of both the effects of mechanization, and the subsequent increase in fishing power of mechanized vessels.

A comparison of sailing and mechanized *masdhonis* operating in the same area (Raa and Baa Atolls) at the same time during the period of transition (1976) showed that catch rates by mechanized *masdhonis* were almost exactly twice those of sailing *masdhonis* (Anon, 1977). In addition, tuna catch rates by sailing *masdhonis* in the years immediately before mechanization were only half those of mechanized *masdhonis* during the period immediately after separate data became available, i.e. from 1979 (Anderson and Hafiz, 1985; Anderson, 1987; see also Sathiendrakumar and Tisdell, 1987). During the period 1978-84, sailing *masdhonis* were effectively displaced from the tuna fishery, and relegated to reef fishing and other non-fishing activities (Anderson and Hafiz, 1985a; Anderson, 1987). Once 25-35% of the *masdhoni* fleet in a given area was mechanized, the remaining non-mechanized masdhonis stopped tuna fishing (Anon, 1985: 57). By 1985, less than 1% of the national tuna catch was made by sailing *masdhonis* (Table 1.3). For the purposes of this study, it is therefore assumed that:

- sailing *masdhonis* caught half as much tuna per day as mechanized *masdhonis* did (or would have done) during the period 1970-1978 (as a direct result of mechanization);
- effective effort by the sailing *masdhonis* decreased regularly (i.e. by 12.5% per year) during the period 1978-84 (as sailing *masdhonis* were displaced from the tuna fishery);
- sailing *masdhoni* effort after 1984 was not directed towards tunas and is therefore ignored in calculating tuna CPUE (because sailing *masdhonis* were effectively excluded from the tuna fishery).

Regarding increase in fishing power of mechanized *masdhonis*, it is widely accepted that average fishing power has increased over the last 10-12 years (Hafiz and Anderson, 1994). However, there has been little attempt to quantify this increase. Engine size and vessel length data for of all fishing *masdhonis* are maintained by the Ministry of Transport and Communications. Hassan (1995) compiled available engine data for the years 1974-93, and used these data in an attempt to correct for increasing fishing power of mechanized *masdhonis*. However, there are a number of problems with the interpretation of Hassan's (1995) data and results. Furthermore, engine size is only one component of fishing power. In the absence of clear data, and only for our purposes here, it is assumed that:

- mechanized *masdhoni* fishing power has increased by 1% per year since 1985.

Standardized *masdhoni* effort data (based on these assumptions) are presented in Table 1.6. These standardized data are used in all the following analyses of *masdhoni* CPUE (sections 2, 3, 4 and 5). It should be noted that the creation and expansion of the new class of large *masdhonis* (section 1.2.3) will have a profound impact on *masdhoni* fishing power and CPUE. This development needs to be properly monitored and taken account of in future studies. It should also be noted that the standardised effort time series presented here (Table 1.5) differs from that presented by Hassan (1995: 41). In particular, there are major differences in the estimation of effective sailing *masdhoni* effort in the years 1970-75 and 1977-87, and in the inclusion of mechanized *vadhu dhoni* data by Hassan (1995). These differences point to the difficulties in standardizing *masdhoni* fishing effort, and the need for further, careful research.

1.5.1.3. Production Models

Production (or surplus yield) models are simple fisheries models that make use of time series of catch and effort data to estimate maximum sustainable yields (MSY) or optimum levels of fishing effort. Since there is a time series of catch and effort data available from the Maldivian tuna fishery, a number of production modelling attempts have been made (Anderson and Hafiz, 1985a; Sathiendrakumar and Tisdell, 1987; Hassan, 1995). The classic production models (Schaefer, 1954; Fox, 1970) fail to give meaningful results from Maldivian tuna fishery data, mainly because the models assume that the whole stock is being exploited, which is clearly not the case with the Maldivian fishery (Anderson, 1985; Anderson and Hafiz, 1985a & 1985d; Sathiendrakumar and Tisdell, 1987; Hassan, 1995). Therefore, while catch-effort relationships are used here to give some insights into the dynamics of the fishery (sections 2.3, 3.3, 4.3 and 5.3), no attempts are made at production model analysis.

Sathiendrakumar and Tisdell (1987) developed a 'production function' model which assumed that recruitment to the exploited stock will not be affected by the fishery, because the stock is very large; rather, above a certain threshold, catch rates will decline because of competition between vessels in their limited area of operation. This type of approach does appear to show promise (Sathiendrakumar and Tisdell, 1987; Hassan, 1995), although it is not clear that the Maldivian fishery has yet approached the hypothesized threshold for any species (sections 2.3.1, 3.3.1, 4.3.1 & 5.3.1). Sathiendrakumar and Tisdell (1987) further developed their analysis to estimate costs and revenues for the tuna fishery. However, a number of their original assumptions are now not tenable. For example, the assumption that travel costs are effectively constant for all trips may never have been valid, and is certainly not now with the development of the new class of large *masdhonis* which range widely for bait, tuna and markets. Such behaviour will have a profound impact on this type of economic analysis (Campbell and Lindner, 1989).

1.5.2. Length Frequency Data

Tuna length frequency data are collected by MRS. Data from Malé market have been collected by MRS staff on a regular basis since 1985. Data from other locations were collected on an ad hoc basis between 1983 and 1993. In late 1993 a systematic regional length frequency sampling programme was initiated. Pole and line catches were sampled in 7 fishing islands (representative of all regions) plus Malé. Since 1996, that programme has been cut back to cover 3 fishing islands plus Malé. Data are compiled annually. Details of sampling activities are given by Anderson Adam and Nadheeh (1996), Scholz, Anderson and Waheed (1997) and MRS (1997). During 1996-97, the entire MRS length frequency database was reviewed: all data (roughly one million records) were checked against original data sheets; corrections were made; and new were data entered and checked. Hard copies of the revised data set are maintained at MRS and EPCS (MRS, 1997).

1.5.3. Tagging Data

The Marine Research Section has carried out two major tuna tagging programmes, both concentrating on skipjack and yellowfin. The first was carried out during 1990 (Yesaki and Waheed, 1991 & 1992; Waheed and Anderson, 1994), and the second during 1993-95 (Waheed and Anderson, 1994; Anderson, Adam and Waheed, 1996). A total of over 17,700 skipjack and yellowfin tunas were tagged and released during the two programmes. Returns up to the end of August 1997 amounted to 2144 skipjack and yellowfin, or 12.1% of releases (Table 1.10). Release and recapture data are held by both MRS and IOTC.

Table 1.1. Recorded catches (metric tonnes) of tunas in the Maldives by species, 1970-97.

Source: MOFA, Economic Planning and Coordination Section.
Notes: Catch and effort data for 1995-97 may be subject to revision. 1997 data excludes 5590 t yellowfin caught in the EEZ fishery

Year	Skipjack	Yellowfin	Frigate	Kawakawa	Dogtooth	Total
1970	27,684	1,989	3,023	644	n/a	33,340
1971	28,709	1,227	3,015	473	n/a	33,424
1972	17,971	2,076	3,186	596	n/a	23,829
1973	19,195	5,475	6,626	1,088	n/a	32,384
1974	22,160	4,128	6,006	830	n/a	33,124
1975	14,858	3,774	4,057	415	n/a	23,104
1976	20,092	4,891	2,707	953	n/a	28,643
1977	14,342	4,473	3,080	927	n/a	22,822
1978	13,824	3,584	1,661	768	n/a	19,837
1979	18,136	4,289	1,701	721	n/a	24,847
1980	23,561	4,229	1,595	1,063	n/a	30,448
1981	20,617	5,284	1,606	1,274	n/a	28,781
1982	15,881	4,005	2,061	1,887	n/a	23,834
1983	19,701	6,241	3,540	2,087	n/a	31,569
1984	32,048	7,124	3,105	1,714	376	44,367
1985	42,602	6,066	2,824	2,177	182	53,851
1986	45,445	5,321	1,778	1,071	136	53,751
1987	42,111	6,668	1,921	1,232	105	52,037
1988	58,546	6,535	1,629	1,257	84	68,051
1989	58,145	6,082	2,146	1,322	108	67,803
1990	59,899	5,279	3,013	1,891	281	70,363
1991	58,898	7,711	2,582	1,677	234	71,102
1992	58,577	8,697	3,389	2,451	337	73,451
1993	58,740	10,110	5,456	3,569	628	78,503
1994	69,411	13,126	4,019	2,656	387	89,599
1995	70,372	12,504	3,938	2,694	439	89,947
1996	66,502	12,440	6,485	3,789	624	89,840
1997	69,015	13,029	2,488	2,088	490	87,110

Table 1.2. Recorded catches (t) of tunas and other fish species in the Maldives, 1970-97.

Sources: Anderson (1986); MOFA/EPCS.

Notes: Numbers may not add up exactly due to rounding. Totals for the years 1984-87 differ from those published in 'Basic Fisheries Statistics' because catch estimates for dogtooth tuna have been revised as a result of changed average weight estimates (Hafiz and Anderson, 1988). 1997 data exclude 5590 t yellowfin caught in the EEZ fishery.

Year	Tuna	Other fish	Total fish	Percentage tuna
1970	33,340	2,472	35,812	93%
1971	33,424	1,489	34,914	96%
1972	23,829	1,790	25,618	93%
1973	32,384	1,789	34,173	95%
1974	33,124	1,946	35,070	94%
1975	23,104	1,837	24,941	93%
1976	28,643	2,730	31,374	91%
1977	22,822	3,493	26,317	87%
1978	19,837	5,579	25,414	78%
1979	24,847	3,040	27,887	89%
1980	30,448	4,242	34,690	88%
1981	28,781	5,540	34,321	84%
1982	23,834	6,656	30,489	78%
1983	31,569	6,990	38,559	82%
1984	44,367	10,960	55,327	80%
1985	53,851	8,197	62,048	87%
1986	53,751	5,620	59,371	91%
1987	52,037	5,006	57,043	91%
1988	68,051	3,432	71,483	95%
1989	67,803	3,444	71,247	95%
1990	70,363	6,011	76,374	92%
1991	71,102	9,612	80,713	88%
1992	73,451	8,584	82,035	90%
1993	78,503	11,438	89,941	87%
1994	89,599	14,446	104,046	86%
1995	89,947	14,619	104,566	86%
1996	89,840	15,574	105,413	85%
1997	87,110	14,658	101,768	86%

Table 1.3. Tuna catches by major vessel type in the Maldives, 1970-97.

Source: MOFA/EPCS.

Note: Minor miscellaneous catches are included in the annual totals.

Year	Sailing P/L	Mech. P/L	Total P/L	Trolling	Total
1970	31,884	–	31,884	1,456	33,340
1971	32,350	–	32,350	1,074	33,424
1972	22,831	–	22,831	998	23,829
1973	31,009	–	31,009	1,375	32,384
1974	31,829	–	31,829	1,295	33,124
1975	21,122	1,032	22,154	950	23,104
1976	20,474	6,220	26,694	1,950	28,644
1977	11,440	9,691	21,131	1,691	22,822
1978	5,460	12,891	18,351	1,485	19,836
1979	2,865	20,227	23,092	1,755	24,847
1980	2,131	26,176	28,307	2,141	30,448
1981	1,110	25,528	26,638	2,143	28,781
1982	633	21,504	22,137	1,696	23,833
1983	473	29,184	29,657	1,912	31,569
1984	328	42,039	42,367	1,998	44,367
1985	429	50,702	51,131	2,659	53,851
1986	349	52,138	52,487	1,262	53,751
1987	257	50,377	50,634	1,402	52,040
1988	182	66,451	66,633	1,400	68,051
1989	162	66,485	66,647	1,134	67,802
1990	89	69,207	69,296	1,057	70,363
1991	57	70,244	70,301	777	71,102
1992	201	72,442	72,643	776	73,451
1993	178	77,336	77,514	957	78,502
1994	99	87,651	87,750	1,832	89,600
1995	166	88,119	88,285	1,633	89,921
1906	101	88,227	88,328	1,468	89,838
1997	129	85,652	85,781	1,324	87,109

Table 1.4. Numbers of fishing vessels registered in the Maldives, 1970-97.
Source: MOFA/EPCS.

Year	Sailing P/L	Mech. P/L	Total P/L	Trolling	Total
1970	1929	--	1929	2789	4718
1971	2011	--	2011	2898	4909
1972	2089	--	2089	2986	5075
1973	2146	--	2146	3012	5158
1974	2131	1	2132	3056	5188
1975	2040	42	2082	3154	5236
1976	1940	218	2158	3284	5442
1977	1801	413	2214	3385	5599
1978	1631	548	2179	3390	5569
1979	1485	767	2252	3386	5638
1980	1255	805	2060	3416	5476
1981	1061	970	2031	3364	5395
1982	952	1166	2118	3428	5546
1983	811	1231	2042	3448	5490
1984	651	1296	1947	3021	4968
1985	561	1202	1763	3115	4878
1986	507	1358	1865	3278	5143
1987	486	1574	2060	3206	5266
1988	449	1558	2007	3072	5079
1989	375	1647	2022	2960	4982
1990	320	1611	1931	2789	4720
1991	371	1754	2125	2680	4805
1992	315	1782	2097	2326	4423
1993	232	1657	1889	1985	3874
1994	262	1839	2101	2351	4452
1995	183	1994	2177	2144	4321
1996	179	1971	2150	2303	4453
1997	170	1971	2141	2246	4387

Table 1.5. Numbers of active fishing vessels operating in the Maldives, 1985-97.
Source: MOFA/EPCS.

Year	Pole and line (*Masdhonis*)			Trolling (*Vadhu dhonis*)			Total
	Sailing	Mech	Total	Sailing	Mech	Total	
1985	43	988	1031	NA	NA	963	1994
1986	32	1009	1041	NA	NA	753	1794
1987	21	1044	1065	NA	NA	655	1720
1988	16	1096	1112	NA	NA	505	1617
1989	14	1114	1128	398	16	414	1542
1990	11	1151	1162	336	7	343	1505
1991	6	1252	1258	340	12	352	1610
1992	38	1347	1385	255	15	270	1655
1993	15	1434	1449	274	25	299	1748
1994	42	1410	1452	241	83	324	1776
1995	5	1407	1412	209	48	257	1669
1996	6	1395	1401	166	59	225	1626
1997	9	1328	1337	139	102	241	1578

Table 1.6. Annual fishing effort (no. boat days) by vessel type, 1970-97.
Source: MOFA/EPCS.
Note: Pole and line effort standardized according to procedures outlined in section 1.5.1.2.

Year	Sail P/L	Mech P/L	Total P/L	Standard P/L	Trolling
1970	191,421	--	191,421	95,711	104,482
1971	169,237	--	169,237	84,619	67,378
1972	158,544	--	158,544	79,272	76,136
1973	215,278	--	215,278	107,639	90,461
1974	203,362	--	203,362	101,681	93,504
1975	171,808	4,200	176,008	90,104	90,100
1976	153,539	21,800	175,339	98,570	135,031
1977	104,943	41,300	146,243	93,772	157,949
1978	53,739	54,800	108,539	78,311	176,878
1979	24,615	74,904	99,519	84,135	132,903
1980	16,877	83,134	100,011	88,408	136,934
1981	13,852	83,731	97,583	87,194	130,362
1982	10,036	97,085	107,121	98,967	132,342
1983	6,339	117,172	123,511	117,964	118,639
1984	6,220	153,460	159,680	153,849	108,314
1985	4,681	162,430	167,111	164,054	110,061
1986	3,354	161,910	165,264	165,148	79,139
1987	2,355	158,785	161,140	163,549	69,380
1988	1,242	184,353	185,595	191,727	51,460
1989	911	183,944	184,855	193,141	39,725
1990	1,317	193,045	194,362	204,628	37,933
1991	424	198,320	198,744	212,202	35,814
1992	3,602	204,808	208,410	221,193	28,137
1993	1,057	222,548	223,605	242,577	34,507
1994	1,138	223,095	224,233	245,405	31,687
1995	623	240,858	241,481	267,352	30,826
1996	731	239,787	240,518	268,561	30,437
1997	580	237,661	238,241	268,557	32,106

Table 1.7. Numbers of Maldivian fishermen, 1970-97.
Sources: MOFA/EPCS and Ministry of Planning Human Resources and Environment census.

Year	No. Fishers (MOFA data)	No. Fishers (Census data)	Total pop (Census)	% Fishers (MOFA)	% Fishers (Census)
1970	17,094	NA	114,469	14.9	NA
1971	18,075	NA	118,818	15.2	NA
1972	18,535	NA	122,673	15.1	NA
1973	18,807				
1974	19,362	NA	128,697	15.0	NA
1975	19,666				
1976	21,381				
1977	21,594	19,385	142,832	15.1	13.6
1978	22,683				
1979	23,924				
1980	24,330				
1981	22,301				
1982	21,727				
1983	22,262				
1984	21,028				
1985	19,671	12,434	180,088	10.9	6.9
1986	22,245				
1987	22,387				
1988	21,880				
1989	22,025				
1990	21,725	11,498	213,215	10.1	5.4
1991	21,432				
1992	21,195				
1993	19,995				
1994	22,268				
1995	21,932	NA	244,644	8.9	NA
1996	22,109				
1997	22,463				

Table 1.8. Exports of tunas and tuna products from the Maldives (tonnes), 1970-97.

Source: Customs data compiled by MOFA; data for 1970-78 from GOPA (1980)
Note: Weights are actual weights not live weights.

Year	Frozen	Chilled	Smoke dried	Salt dried	Canned	Fish meal
1970	--	--	4,740	...	--	-
1971	--	--	5,389	...	--	-
1972	2,020	--	3,835	...	--	-
1973	4,447	--	3,098	...	--	-
1974	4,484	--	3,545	...	--	-
1975	5,763	--	1,961	...	--	-
1976	8,728	--	1,607	...	--	-
1977	10,941	--	990	...	--	-
1978	11,349	--	251	...	2	-
1979	12,634	--	75	...	4	-
1980	14,077	--	75	...	N/A	-
1981	13,791	--	12	975	N/A	-
1982	9,789	--	47	897	18	-
1983	7,853	--	285	778	43	-
1984	13,796	--	398	838	613	-
1985	17,091	--	796	1,814	722	-
1986	17,799	--	1,318	1,321	432	-
1987	13,671	--	1,215	2,837	1,919	736
1988	19,710	--	1,216	428	2,740	1,311
1989	19,689	--	1,987	1,229	5,535	1,877
1990	17,056	--	2,418	2,084	6,931	1,971
1991	10,085	--	3,285	2,298	7,188	3,110
1992	5,540	--	3,093	1,323	7,478	2,150
1993	9,869	--	3,578	1,657	4,877	3,200
1994	7,439	14	4,102	2,394	6,849	2,350
1995	3,011	17	3,888	1,909	7,781	2,101
1996	13,071	1,378	4,038	1,612	7,183	2,550
1997	13,280	2,969	3,865	1,483	6,826	2,440

Table 1.9. The *nakaiy* (Maldivian calendar)

Southwest monsoon season		Northeast monsoon season	
Nakaiy	Starting date	*Nakaiy*	Starting date
Assadha	8 April	*Mula*	10 December
Burunu	22 April	*Furahala*	23 December
Kethi	6 May	*Uthurahalha*	6 January
Roanu	20 May	*Huvan*	19 January
Miahelia	3 June	*Dhinasha*	1 February
Adha	17 June	*Hiyavihaa*	14 February
Funoas	1 July	*Furabadhuruva*	27 February
Fus	15 July	*Asbadhuruva*	12 March
Ahuliha	29 July	*Reyva*	26 March
Maa	11 August		
Fura	24 August		
Uthura	7 September		
Atha	21 September		
Hitha	4 October		
Hei	18 October		
Vihaa	1 November		
Nora	14 November		
Dhasha	27 November		

Table 1.10. Releases and recaptures of skipjack and yellowfin tunas during two tagging programmes in the Maldives.

Source: MRS
Note: includes recaptures up to end October 1998.

Species	Tagging Programme 1990	1993-95	Total
Releases			
Skipjack	8,033	6,474	14,507
Yellowfin tuna	1,908	1,303	3,211
Total	9,941	7,777	17,718
Recaptures			
Skipjack	1426	560	1,984
Yellowfin tuna	133	25	160
Total	1559	585	2,144
% recaptures			
Skipjack	17.7%	8.6%	13.7%
Yellowfin tuna	7.0%	1.9%	4.9%
Total	15.7%	7.5%	12.1%

Fig. 1.2. Annual catches of tuna by major species

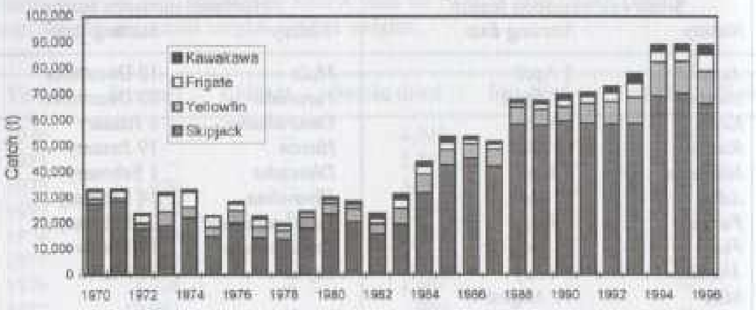


Fig 1.3. Percentage contributions of major tuna species to annual tuna catches

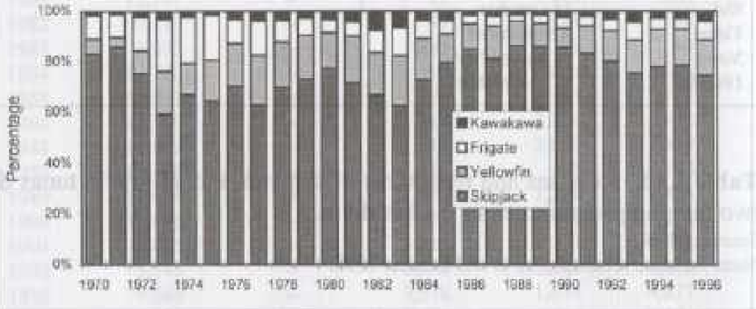


Fig. 1.4. Percentage contributions by major vessel types to annual tuna catches

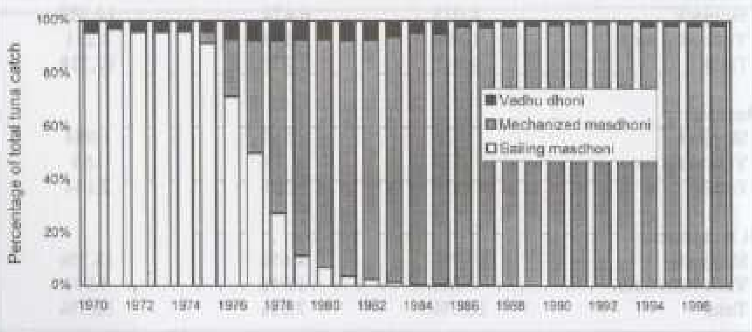


Fig. 1.5. *Masdhoni* fishing effort by year, 1970-97

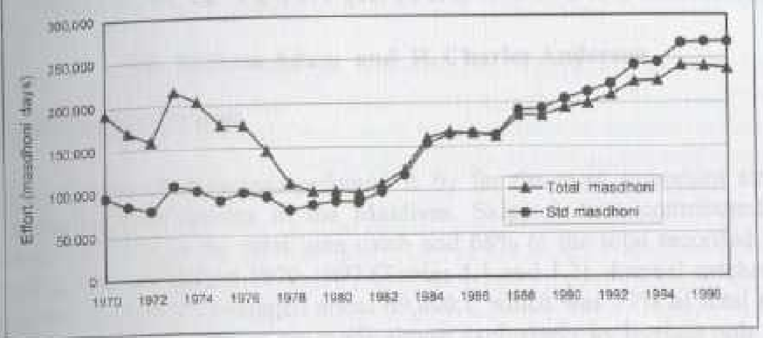


Fig. 1.6. Ratio of skipjack to yellowfin in *masdhoni* catches

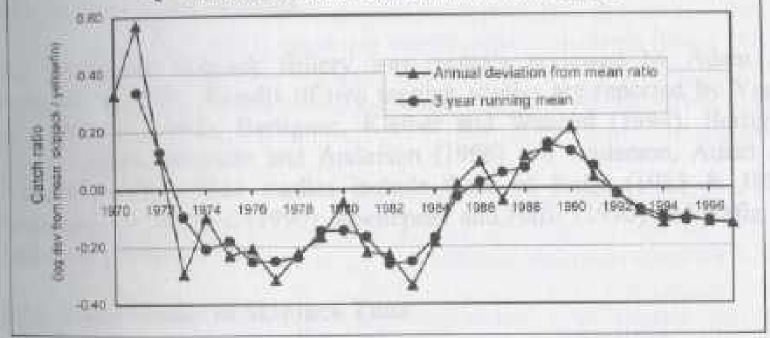
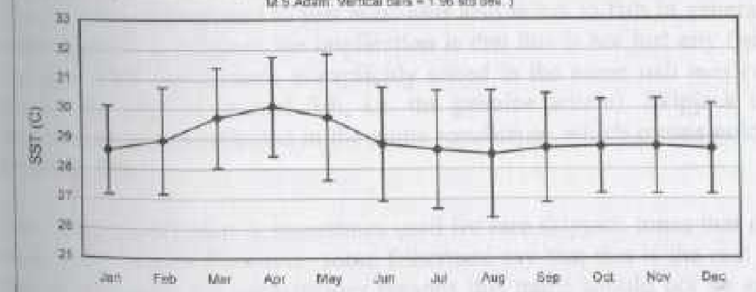


Fig. 1.7. Average monthly sea surface temperatures in Maldivian area (Source: AVHRR day time SST data, 5S-10N, 66E-80E, Nov 1981 - April 1998, compiled by M S Adam. Vertical bars = 1.96 std dev.)



2. SKIPJACK TUNA (*KATSUWONUS PELAMIS*)

M. Shiham Adam and R. Charles Anderson

2.1. INTRODUCTION

Skipjack tuna (*Katsuwonus pelamis*) is by far the most important single commercial fish species in the Maldives. Skipjack tuna contributed an average of 75% to the total tuna catch and 68% to the total recorded fish catch during the period 1970-1997 (Tables 1.1 and 1.2). Annual catches of skipjack in 1994-97 averaged about 69,000 t, which was 77% of total tuna landings. Skipjack catches are made almost exclusively by livebait pole and line, with mechanized pole and line vessels (*masdhonis*) accounting for 99% of the skipjack landings.

The Maldivian skipjack fishery was recently reviewed by Adam and Anderson (1996b). Results of two tagging studies are reported by Yesaki and Waheed (1992), Bertignac, Kleiber and Waheed (1994), Bertignac (1994), Adam, Stéquert and Anderson (1996) and Anderson, Adam and Waheed (1996). Other studies include those of Hafiz (1985 & 1986), Anderson and Waheed (1990), Rochepeau and Hafiz (1990) and Hafiz and Anderson (1994).

2.1.1. Local Names of Skipjack Tuna

As befits a species of such importance, skipjack tuna has a host of names in Dhivehi, the Maldivian language. It is usually referred to as *kalhubilamas*. This is often abbreviated to just *mas*. *Mas* also refers to fish in general, but when applied to skipjack the implication is that this is not just any fish, but *the* fish. This significance is explicitly stated in the name *asli mas* (which means the original or real fish, i.e. the genuine article). Skipjack tuna's importance is also reflected in the name *randhimas*, which means golden or precious fish.

The name *kunbilamas* is sometimes used for rare skipjack tunas that do not have belly stripes. However, some fishermen say that this is the real name for all skipjacks; for superstitious reasons this name should not be spoken aloud too often, so *kalhubilamas* is used instead. These names are undoubtedly ancient ones which have been in use in one form or another for centuries. When Ibn Battuta visited the Maldives in the 1340s, he noted that Maldivians ate and exported a red-fleshed fish which was cut into four pieces. prepared by cooking, smoking and drying, and called *kulbalmás* (transliteration of Gray, 1889) or *qulb-al-más* (Gibb, 1929).

Skipjack's belly stripes are referred to specifically in the names *fasrongumas* (five-stripe fish) and *rongudhemimas* (striped fish). More generally, skipjack is often referred to as *kandumas* (ocean fish, or tuna, a generic name that applies to all the major tuna species).

Different sizes of skipjack have different names. Normal, small skipjack (up to about 45-50cm FL) are called *mas*. Large skipjack (larger than about 55-60cm FL) are called *godhaa*. These size based categories are believed to have a strong biological basis, since skipjack in Maldivian catches show a marked bimodal distribution (Hafiz and Anderson, 1988; Fig. 2.3). Intermediate sized skipjack are relatively uncommon in Maldivian catches, and some people do not recognize them as a distinct category. However, fishermen call them *fufalamas* (thick rear/base skipjack) or just *falamas* (stout skipjack) in the north of the country, *boadhigumas* (long head skipjack) in the south, and *dhiboamas* (an abbreviation of *boadhigumas*) in the centre.

2.2. CATCHES AND CATCH TRENDS

2.2.1. Catches and Catch Trends

Maldivian skipjack tuna catches by vessel type for the years 1970-1997 are presented in Table 2.1 and Fig. 2.1. Total recorded skipjack catches varied irregularly without any obvious trend until the early 1980s. Then from 1982 to 1988 annual skipjack catches soared from 15,900 t to 58,600 t, an increase of 270%. From 1988 to 1993, however, annual catches remained more or less constant at about 59,000 t. Then catches jumped again, to a new plateau of nearly 70,000 t per year in 1994-97.

The percentage contribution to annual skipjack catch by major vessel type is illustrated in Fig. 2.2. Pole and line *masdhonis* are clearly the most important vessel class for skipjack tuna in the Maldives. Prior to 1974 the *masdhoni* fleet was entirely sail-powered. Mechanization started in 1974 and sailing vessels were rapidly replaced. In 1977, skipjack catch by mechanized *masdhonis* exceeded that by sailing *masdhonis*. By about 1982 skipjack catch by sailing vessels was insignificant. The mechanisation of the *masdhoni* fleet proved immensely successful in terms of increasing the

efficiency of the fishing vessels, but it did not bring an immediate increase in total catches (section 1.3).

The rapid increase in skipjack catch between 1982 and 1988 is partly attributed to an increase in effective fishing effort. The number of mechanised pole and line vessels increased during this period by 34%, from 1166 to 1558 (Table 1.3). More importantly the number of days fished, which is a more useful index of fishing effort, increased steadily from 107,000 days in 1982 to 185,00 days in 1988, a jump of 73% (Table 1.6; Fig. 1.4). An increase in the fishing power of pole and line vessels, over and above that attributable to mechanisation, may also have been significant during this period (section 1.5.1.1).

However, the increase in skipjack catches during 1982-88 cannot be explained by increases in fishing effort and fishing power alone. While effective fishing effort might have increased by something of the order of 100% (Table 1.6), skipjack catches increased by about 270% (Table 2.1). This suggests that there was a substantial increase in availability of skipjack around Maldives during this period, presumably related to changes in oceanographic conditions (section 2.4).

From 1988-93 there was continued increase of fishing power and effort (by 27%, from 191,700 standardized mechanized *masdhoni* days in 1988 to 242,600 days in 1993). In contrast, skipjack catches remained roughly constant at about 59,000t per year. The stagnation of catches during this period is believed to be a result of a decrease in skipjack availability around the Maldives (section 2.4). In 1994-95 skipjack catches jumped again to a new record level of about 70,000t. The reasons for this second jump in catches are not clear. It has been reported that this was partly the result of a change in the system of compiling catch statistics (Anderson and Hafiz, 1996), but this may not be the case (Hassan Rasheed, EPCS, pers. comm., 1997).

2.2.2. Accuracy of Catch Estimates

General problems relating to the accuracy of Maldivian tuna fishery statistics are discussed in Section 1.5. For skipjack tuna, statistical inaccuracies are of special significance since this species makes up roughly two thirds of the total recorded fish catch. There are three major problems for skipjack (Anderson, 1986; Parry and Rasheed, 1995; Anderson and Hafiz, 1996; Anderson et al., 1996; Scholz et al., 1997):

- the use of inadequate average weight conversion factors;
- misreporting of size categories;
- underreporting of catches.

Skipjack in the Maldives are traditionally recorded either as large (*godhaa*) or small skipjack (*mas*). There is some overlap in these two sizes classes (Fig. 2.3), but the cut-off point is about 55-60 cm FL (which corresponds to about 4kg). Two conversion factors are therefore used for skipjack. Since 1959 four pairs of conversion factors have been used (Table 2.2; section 2.5.2). They all suffer from a number of problems (section 1.5). In an attempt to overcome these problems, a regional sampling programme was initiated by MRS in 1993-4 (Anderson et al., 1996; Scholz et al., 1997). During 1994-96 a total of over 420,000 skipjack tunas were measured from pole and line catches, at eight locations. A new series of regional and seasonal conversion factors for both large and small skipjack have been estimated (Scholz et al., 1997). These revised conversion factors (Table 2.2) have not yet been adopted by EPCS/MOFA. For small skipjack tuna the old conversion factors (1.963-2.12 kg/fish) are well with the range of the new conversion factors (mostly within the range 1.8-2.2 kg/fish). For large skipjack tuna, the old conversion factors (5.7-7 kg/fish) are nearly all higher than the new conversion factors (mostly within the range 4.6-5.8kg/fish). The reason(s) for this discrepancy are not known; it may be due to inadequate sampling in the past, or to a recent decrease in the average size of large skipjack (see sections 2.5.2 and 2.9).

While the conversion factors themselves are subject to question, there are also problems associated with the reporting of the two skipjack size categories. In particular, the traditional classification of large and small skipjack has become somewhat blurred since the government started buying fresh tuna in the 1970s. In recent years this has amounted to 19-34% of the skipjack catch (Table 2.4), in other words a substantial proportion of the total. The agencies responsible for buying tunas (currently MIFCO) have classified skipjack, for most part, into small (1.5-2 kg) and large (above 2 kg). These categories are significantly different from the traditional size categories, for which there is a dividing line of about 4 kg. It is believed that some fishermen who sold their catch either to the Felivaru tuna cannery or to the collector/freezer vessels, reported their daily catches according to the details on the sales receipt. As a result, there appears to have been an increase in the proportion of 'large skipjack' being reported to MOFA, and a consequent overestimation of total skipjack catch. Parry and Rasheed

(1995) showed that there was indeed an increase in the proportion of large skipjack reported to MOFA from two atolls with major fresh tuna purchasing activities (Lhaviyani and Gaafu Dhaalu Atolls). Because of this problem care must be exercised in the interpretation of skipjack size category data. For example, it may not be possible to distinguish between this 'artificial' increase in large skipjack catch and a real one, caused for example by changing fishing patterns or oceanographic variability. Alternatively, the 'artificial' increase in large skipjack may tend to mask declines in large skipjack catch resulting from overfishing. Based on the proportions of large skipjack in mechanized pole and line vessel catches during 1979-1982, Rochepeau and Hafiz (1992) estimated that total skipjack catch may have been overestimated by about 6-11% in 1984-88. However, this estimate failed to take account of either misreporting of size categories during 1979-82, or the possibility of a real increase in catch of large skipjack during 1984-88.

The third major problem with skipjack catch statistics relates to underreporting of catches. Reporting of skipjack catches is likely to be more accurate than that of other tuna species, because of the great importance attached to skipjack in the Maldives. There may even have been some overreporting of skipjack catches: from the mid-1950s to 1981 the government gave prizes to top crews and islands in order to encourage production, and this might have encouraged inflated catch reports (Anderson, 1986). Nevertheless, some underreporting of skipjack catches must have occurred at all times, and, along with other species, this may have become more prevalent in recent years. In an attempt to estimate the accuracy of reported catches, Parry and Rasheed (1995) matched over 1000 individual vessel trip records in the MOFA database with MIFCO collector vessel purchase records for the period January-June 1994. They estimated that skipjack catches were underestimated by about 5%, as a direct result of underreporting.

In summary, there has been both overestimation (due to confusion over skipjack size categories, and possible earlier overestimation of the average weight of large skipjack) and underestimation (due to underreporting) of skipjack catches. To some extent these biases may tend to cancel out, and it seems possible that skipjack catch estimates may be accurate to within about ± 5%.

2.3. CATCH PER UNIT EFFORT TRENDS

2.3.1. National trends

Skipjack tuna catch rates by *masdhonis* for 1970-1997 are illustrated in Fig 2.4, as both actual pole and line CPUE and as standardized pole and line CPUE. Actual pole and line catch rates for skipjack declined from a high of about 150 kg/day in 1970-71 to an average of only 100 kg/day in 1972-77. Standardized (mechanized *masdhoni*) skipjack CPUE also declined by about half after 1970-71. This decline cannot be explained by any known change in fishing efficiency. Although cash prizes were given to top tuna fishing crews during 1970-71 to encourage high catches, which probably resulted in some over-reporting of skipjack catches (Anderson, 1986), this is thought unlikely to have resulted in a 50% increase in reported catch in 1970-71. Rather, the decline after 1970-71 is thought to be the result of changing abundance or availability of skipjack associated with changes in oceanographic conditions (section 2.4).

During the mid-1970s, skipjack catch rates were low. From 1977 to 1988, actual pole and line catch rates for skipjack increased dramatically, but irregularly, from just 100 kg/day to over 300 kg/day. This increase in *masdhoni* CPUE can be partly attributed to the effects of mechanization (section 1.2.3): while actual CPUE tripled, standardized CPUE only doubled. The balance of the increase during 1977-88, as well as the fluctuations in 1980 and 1982-83, are thought to be due to oceanographic variations (section 2.4).

Since 1988, standardized skipjack catch rates declined gradually and irregularly from over 300 kg/day to about 250 kg/day in 1996-97. This drop in standardized skipjack catch rates since 1988 is thought to be due to a decrease in skipjack availability (to pole and line) or abundance around the Maldives. Such changes in earlier times might have been attributed to changes in oceanographic conditions alone. However, in the last decade changes in fishing activity within the region have introduced other possible causes for such a decline in Maldivian skipjack catch rates (Anderson and Adam 1996b). These include:

- increased negative interactions from the expanding fisheries around the Maldives, notably in the western Indian Ocean. This possibility is discussed in section 2.9.

- increased local competition among *masdhonis* in the limited range fishery of the Maldives.

Regarding the second point, Maldives has the highest skipjack catch per unit area in the World (Fonteneau, 1997a: Fig. 6 & 1997b: Fig. 5.8). Maldivian pole and line fishing effort is at an all-time high (Table 1.6). It seems possible that there may be some negative interactions between *masdhonis* at such high levels of catch and effort, as indeed is predicted in the production-function model of Sathiendrakumar and Tisdell (1987). However, the available data show no evidence of any such interaction so far. There is no leveling off of catch at high levels of fishing effort (Fig. 2.5), nor is there any decrease in catch rate at high levels of catch (Fig. 2.6).

2.3.2. Latitudinal Trends

Fig. 2.7 shows the catch rates of small skipjack, large skipjack and total skipjack by regions (as defined in section 1.4.1). CPUE trends for total skipjack, in all the regions except for northeast region, follow the same general pattern of national CPUE trends (Fig. 2.4). Standardized *masdhoni* catch rates by latitudinal zone for the period 1970-95 were:

Zone	Small skipjack	Large skipjack	Total skipjack
North	133 kg/day	100 kg/day	233 kg/day
Centre	149 kg/day	54 kg/day	203 kg/day
South	191 kg/day	108 kg/day	299 kg/day

Small skipjack catch rates are highest in the south of the Maldives and lowest in the north. From the early 1970s until about the beginning of 1980s, annual average small skipjack CPUE decreased in all the regions, except in the south (Fig. 2.7). However, a slight increase was observed in late 1970s, particularly in the north and eastern regions. Since the early 1980s small skipjack CPUE has increased slightly in most regions. In the south small skipjack CPUE remained more or less constant, at about 200kg/day, throughout out the period.

Large skipjack catch rates are highest in the south of the Maldives and lowest in the centre (see also section 2.5.1). Large skipjack CPUE gradually increased in all the regions during the 1980s (Fig. 2.7), but declined during the early 1990s in all regions except the north. The huge increase in large skipjack CPUE in the northeastern region in 1980 and in 1984-1990, which is not seen in any other region, is difficult to explain. It might be that fishermen in this region, particularly in Lhaviyani Atoll which houses the Felivaru cannery, reported their 'large skipjack' catch according to the MIFCO's commercial classification, not MOFA's size classification. In this case the large skipjack catch would be overestimated. Parry and Rasheed (1995) showed that Lhaviyani Atoll was reporting over 60% above the national average catch of large skipjack during this period, indicating this is likely to be the case. They also showed that fishermen in Gaafu Dhaalu Atoll, in the southern region, were also reporting more than the average proportion of large skipjack during the same period. However, if this is the sole reason for high large skipjack catch rates during that period, it is difficult to explain the subsequent decrease in catch rates. It might be that the increase in production of Maldive fish by private parties has led to a decrease in reporting of large skipjack under the commercial size categories. It is also likely that the decline of large skipjack CPUE after 1990, reflacts an overall reduction in availability of large skipjack around Maldives, related to oceanographic changes (section 2.4.2).

2.3.3. Seasonal Trends

Seasonal movements and variations in abundance of skipjack in Maldivian waters have not been fully worked out. Several earlier studies have discussed some observations (Hafiz, 1985a; Anderson and Waheed, 1990; Rochepeau and Hafiz, 1990; Anderson, 1991; Yesaki and Waheed, 1992; Anderson et al., 1996) but there has been no comprehensive review. Figs. 2.8 and 2.9 show average monthly catch rates for small and large skipjack respectively, for all six regions during 1989-95. Fig. 2.10 shows monthly catch rates for the two size categories, by region, during the same period.

For **small skipjack** the following generalizations can be made:

1. In the far north there was no obvious seasonal variation in catch rates of small skipjack (Fig. 2.8.a).

2. On the western side of Maldives, peak catch rates were observed during the southwest monsoon and preceeding intermonsoon i.e. in April-May to September-October (Figs. 2.8.b & 2.8.d). Catch rates were low during the northeast monsoon season and preceeding intermonsoon (November to March). This agrees with the findings of Hafiz (1985a) who noted that catch rates of small skipjack in the area of Alifu to Thaa Atolls during 1980-81 were high in the southwest monsoon season and low in the northeast monsoon season. This is also consistent with reports from fishermen in Raa Atoll who report the arrival of small skipjack in April-May, and peak catch rates during the southwest monsoon season. These may be the same as the skipjack that fishermen in Lhaviyani Atoll call *kethi kuri mas*, i.e. the skipjack that arrive before early May (Adnan Ali, MIFCO, pers. comm.).

3. On the eastern side of Maldives, low catch rates were obtained during March to June, i.e. during the end of the northeast monsoon and start of the southwest monsoon (Figs. 2.8.c & 2.8.e). Catch rates were high during August to February, i.e. during the second half of the southwest monsoon and first half of the northeast monsoon. This result differs somewhat from the findings of previous studies. Hafiz (1985a) noted that catch rates of small skipjack in Noonu and Lhaviyani Atolls during 1980-81 were high during December to March, and low at other times; in contrast, in the area from Kaafu to Laamu Atolls, catch rates were high from May to August and again from November to January. Anderson (1991) noted that catch rates of small skipjack in the area of the Watteru Channel (between Vaavu and Meemu Atolls) during 1985-90 peaked in June to August, and were lowest in January to April.

4. In the far south seasonal variation is limited, although the lowest catch rates are observed in March-April, and the highest in December-February (Fig. 2.8.f). Hafiz (1985a) noted considerable variation from month to month during 1980-81, but discerned no obvious seasonal pattern (see also Fig. 2.10.f).

For **large skipjack** the situation during 1989-95 was slightly different:

1. In the north and on the eastern side of Maldives, high catch rates were made from about October to March, i.e. during most of the northeast monsoon season and the preceding intermonsoon (Figs. 2.9.a, 2.9.b, 2.9.c & 2.9.e). The highest monthly catch rates were usually observed in November, as was previously noted by Rochepeau and Hafiz (1990) using data from 1970-88. Low catch rates were made from April-May to about September, i.e. from the end of the northeast monsoon to the latter part of the southwest monsoon. Anderson (1991) noted that catch rates of large skipjack in the area of the Watteru Channel (between Vaavu and Meemu Atolls) during 1985-90 were highest during the northeast monsoon (November to March) and lowest in the southwest monsoon (May to October).

2. In the centre-west (i.e. from Ari to Thaa) peak catch rates were observed in June, at the beginning of the southwest monsoon, with a second peak in November (Fig. 2.9.d).

3. In the south the highest catch rates were observed during the two intermonsoon periods, March to May and October-November (Fig. 2.9.f). Both Hafiz (1985a) and Rochepeau and Hafiz (1990) recorded the same pattern, although the former also noted high catch rates in February 1980.

There are clearly some general patterns that are repeated from year to year, but also much inter-annual variability. Further detailed study is required to elucidate the full extent of seasonal and regional variation in skipjack catch rates in the Maldives.

2.4. OCEANOGRAPHIC VARIATIONS AND SKIPJACK CATCHES

2.4.1. El Niño Southern Oscillation Events

Skipjack tuna catches in the Maldives are clearly affected by ENSO events (Anderson, 1987 & 1993; Rochepeau and Hafiz, 1990; Hafiz and Anderson, 1994; Adam and Anderson, 1996). 1972-1973, 1976, 1982-1983, 1987 and 1992-1994 were all El Niño years. During each of those years (with the exception of 1994) skipjack catches and catch rates were noticeably depressed (Figs. 1.5, 2.1 and 2.11). In contrast, record catch rates were recorded in 1971 and 1988-89; these were both periods of La Niña or cold events.

In the western Indian Ocean, El Niño years bring increased sea surface temperatures, low wind mixing and strong vertical gradients in the thermocline (section 1.4.3). It is not known how these conditions affect skipjack in Maldivian waters. One possibility is that increased sea surface temperatures may reduce larval survival and consequently recruitment to the Maldivian fishery. Forsberg (1989) noted a decrease in skipjack larval abundance at temperatures above 29°C in the eastern Pacific. However, if recruitment were adversely affected during the El Niño years, then one might expect to observe a drop in small skipjack catch rates after an appropriate time lag (i.e. in the year following an ENSO event). This is not obvious in the data available.

Alternatively, increased sea surface temperatures may have an effect on the availability of skipjack to surface fishing gear such as pole and line. Large

skipjack are known be intolerant of high temperatures and to inhabit deeper waters in the tropics (Wild and Hampton, 1994). Since sea surface temperatures around the Maldives are elevated during El Niño years, it is possible that there is a direct effect on availability of large skipjack to pole and line vessels. There is clearly a drop in large skipjack CPUE during El Niño years (Figure 2.13); note that the El Niño of 1976-77 was a relatively weak event. This relationship is currently under further investigation.

2.4.2. Decadal Scale Variations

Anderson (1993) and Hafiz and Anderson (1994) identified medium-term changes in Maldivian skipjack catch rates and suggested these might be linked to decadal-scale changes in the oceanographic conditions in the Indian Ocean. The mean proportion of skipjack in the Maldivian tuna catch is 75%. Fig. 2.11 shows the annual proportion of skipjack in the tuna catch during the period 1970-97. During the very early 1970s, skipjack contributed more than the average to the total Maldivian tuna catch. From 1972-84 the contribution of skipjack to the total tuna catch was consistently below average. Then since 1985 skipjack has again contributed more than the average to the total tuna catch. It is not yet clear whether a new period of low skipjack catches is being entered now. This same pattern is seen with skipjack catch rates (Fig. 2.4) and with the ratio of skipjack to yellowfin in the pole and line catch (Fig. 1.6); by presenting the contribution of skipjack to total tuna catch, problems associated with standardizing fishing effort are circumvented.

The most likely cause for this pattern of change, with catch rates being consistently high or low for several years in a row, would seem to be decadal scale oceanographic variation (section 1.4.4). The Indian Ocean is not very well known oceanographically. The nature of such decadal scale variations in the Indian Ocean is not known, nor are the mechanisms by which such variations might impinge upon skipjack populations. There is clearly a need for further research into the effects of the oceanographic variations on the distribution and abundance of skipjack in the central Indian Ocean.

2.4.3. The 1980 and 1990 anomalies

Much of the observed variation in Maldivian skipjack tuna catch rates can be explained by a combination of the effects of ENSO (including La Niña) events and decadal-scale variations. However, 1980 and to a lesser extent

1990-91 stand out as anomalous years. While both apparent anomalies might be no more than noise in the data, they deserve further study for the light they might shed on the causes of variability in skipjack abundance.

1980 was a year of high skipjack catches during a period of low catch rates. Examination of the catch and effort database shows that the anomalously high catches were largely the result of high catch rates of large skipjack in the northeast Maldives, particularly but not exclusively in Lhaviyani Atoll (Fig. 2.7.c). The reason(s) for this are not known. If an oceanographic or climatic explanation is sought, it should be noted that 1980 was in the middle of a prolonged but weak La Niña event. The 1980 anomaly might also be linked to the explosion of Mt. Saint Helens in May 1980. (Major volcanic eruptions are known to have an impact on global weather, and the eruption of Mt. Pinatubo in the Philippines in June 1991 may possibly have contributed to higher than average sea surface temperatures in the Maldives in late 1991). However, high catch rates of large skipjack had been reported from the southern Maldives as early as February 1980 (Hafiz, 1985a). Alternatively, it may be that the major ENSO event of 1982-83 depressed skipjack catch rates to such an extent that it effectively disguised the start of an upswing in the decadal scale cycle starting in the late 1970s, delaying its apparent start until the mid-1980s.

1990 was also a year of high, indeed record, large skipjack catch rates. Particularly high catch rates for large skipjack were achieved in the north and centre of the country at the end of the year; a particularly high proportion of large skipjack was recorded in the catch on the west coast; and 1990 was the only year in which national large skipjack catch rates exceeded those of small skipjack. However, in the south of Maldives, record catch rates for large skipjack were made in 1991, not 1990. If El Niño conditions reduce skipjack recruitment (section 2.4.1), El Niña events might be expected to lead to an increase in skipjack recruitment. Under this scenario, the 1990 peak in large skipjack abundance might be the result of high recruitment during the 1988-89 La Niña event.

2.5. SIZE AND GROWTH

2.5.1. Length Distribution

The great majority of the skipjack caught in the Maldivian fishery are within the range 35 to 65cm FL (Hafiz, 1985a & 1986; Adam and Anderson, 1996b). The overall size distribution of skipjack (Fig. 2.3) is

strongly bimodal, as has been observed previously by several authors (Hafiz, 1985a & 1986; Hafiz and Anderson, 1988; Anderson and Waheed, 1990; Rochepeau and Hafiz, 1990; Scholz et al., 1997). The reason for this bimodal distribution is the relative under-representation of medium sized skipjack of length 50-60 cm FL. For eight sampling locations in 1994-96, the modal length of small skipjack in all islands was 45-50 cm, while for large skipjack it was about 63 cm FL.

It has been previously reported, on the basis of analysis of catch data (Hafiz, 1985a & 1986; Rochepeau and Hafiz, 1990; Anderson 1992 & 1993), that the proportion of large skipjack in the catch is greater in the north than in the south. As has been noted above (section 2.2.2), the reporting of skipjack size categories in the catch data is not without problems. Therefore, we look here at the proportion of large skipjack in length frequency samples taken by field officers at eight locations during 1994-96 (MRS, 1997). These length frequency data do not support the contention that large skipjack are commoner in the north than in the south (Table 2.3). Large skipjack were most abundant in skipjack catches in the south of Maldives, and least abundant in the centre of Maldives:

North:	21.4% of skipjack measured were large
Centre:	9.2% of skipjack measured were large
South:	34.3% of skipjack measured were large

In all the islands sampled, large skipjack were most abundant in 1995, and the increased ratio is strikingly similar for all the atolls indicating that there was perhaps a general increase in large skipjack abundance in that year (Table 2.3 and see below).

2.5.2. Average Weights

Tuna catches are reported by fishermen in numbers, and are converted to weights using average weight conversion factors. For skipjack tuna, separate conversion factors are used for large and small sizes. The conversion factors that have been used by the Ministry of Fisheries and Agriculture at different times are summarized in Table 2.2 (Anderson, 1986; Anderson and Hafiz, 1996).

Average weights of small skipjack calculated for different regions and quarters during 1994-96 were mostly within the range 1.8 to 2.2 kg/fish

(Scholz et al., 1997). The conversion factors for small skipjack used in the past and at present (1.96 to 2.12 kg/fish) lie within this range.

Average weights of large skipjack calculated for different regions and quarters during 1994-96 were mostly within the range 5.3 to 5.8 kg/fish (Scholz et al., 1997). These average weight estimates are mostly lighter than the conversion factors for large skipjack used in the past and at present (7 to 5.7 kg/fish). Thus, while the possible effects of sampling error cannot be discounted, there is a suggestion that the average weight of large skipjack has decreased in recent decades.

Cook (1995) reported a decrease in average weight of skipjack purchased by MIFCO during 1990-1994. The mean weight of the skipjack purchased in 1990 was about 4kg but dropped to 2.7kg in 1993. During this period MIFCO purchased 27% of the total recorded skipjack catch (Table 2.4). Note that MIFCO started buying smaller sized fish (<1.5 kg) from September 1993.

2.5.3. Growth

Growth rates have been estimated for Maldivian skipjack tuna using both length frequency and tag release and recovery data. Hafiz (1985a & 1986) used length frequency data from Baa Atoll to estimate von Bertalanffy parameters (Table 2.5). There are large differences in the growth parameter estimates between these two studies suggesting some inaccuracy. Estimation of growth rates from length frequencies is one of the least reliable methods for skipjack tuna (Fosberg, 1989). This is for most part due to their continuous spawning and recruitment and also due to their migratory habits. As a result, representative sampling is difficult to achieve over long time periods.

Yesaki and Waheed (1992) estimated growth rates of 2.4 cm/month for 40 cm fish and 1.7 cm/month at 70 cm, using tag release and recovery data from the Maldives' first tagging programme. Anderson et al. (1996) also estimated skipjack growth rates but using two different screening criteria, with tag release and recovery data from the second tagging programme. Their first estimate excluded negative growth (length at recovery being greater than the length at release) following the procedure used by Yesaki and Waheed (1992). In their second estimate, negative growth was included. Despite the rigorous screening and correction procedures used in adjusting for the measured length at recovery (Adam and Anderson, 1996b), growth rate estimates varied greatly (Tables 2.5 and 2.6). The problem is further complicated because of the narrow size range available among the recaptured skipjacks, and their relatively short periods at liberty. One of major problems in growth estimates from tag release and recovery data is the uncertainty in lengths, both at recapture and recovery. In addition, it was found during the second tagging programme (Adam and Anderson, 1996b) that live tunas are highly tensed during handling and consequently that measurements taken before release are less than those when the fish is dead. However, because of the limited length measurements from 'dummy tagging' (measured and tagged in normal manner, but 'released' into the fish hold for later measuring), correction was not made for this effect. In order to get reliable growth estimates from tagging studies, efforts have to be concentrated in future on obtaining accurate length measurements at both release and recapture.

Adam, Stéquert and Anderson (1996) attempted to validate the microincrements of skipjack otoliths recovered from the tetracycline-injected fish. The results were discouraging as it was found that microincrement deposition was non-daily. Furthermore, since the number of microincrement deposited per day varied greatly between individuals it was concluded that otoliths could not be used for skipjack ageing (Adam, Stéquert and Anderson, 1996).

2.6. MIGRATION

The movements of skipjack around the Maldives are not yet fully understood. Analysis of recovery data from the first tagging programme has, however, clarified some movements within the Maldives. Skipjack tagged in the May intermonsoon tended to move north within the Maldives during the subsequent southwest monsoon, while those tagged during the October-November intermonsoon tended to move south in the following northeast monsoon (Yesaki and Waheed, 1992). A more detailed analysis using a spatial tag attrition model produced similar results, demonstrating a net southward movement during the northeast monsoon and a net northward movement during the southwest monsoon (Bertignac, 1994).

The recoveries made from outside the Maldivian EEZ clearly showed that long-distance movements were current related, i.e. westward during the northeast monsoon and eastward during southwest monsoon (Yesaki and Waheed, 1992). This was confirmed during the second tagging programme (Anderson et al., 1996).

Results of the first tagging programme suggested that skipjack tagged offshore (½° x ½° squares without land) were more migratory than skipjack tagged inshore (½° x ½° squares with land) (Yesaki and Waheed, 1992). This was not confirmed by the second tagging programme (Anderson et al., 1996). It was suggested that such an 'offshore-inshore' dichotomy could be highly subjective, depending in part on the definition of offshore and inshore. It was found that recoveries of skipjack tagged offshore and inshore could be highly affected by the large variations observed in recovery rates between tagging cruises, much of which could be explained by differences in recaptures during the first month at liberty (Adam and Anderson, 1996b).

On the basis of size-dependent movements observed during both tagging programmes, and observations of the sizes of skipjack caught in the Maldivian and Sri Lankan fisheries, Anderson et al. (1996) proposed a model of skipjack migration within the central Indian Ocean. In the Maldives, small skipjack (40-50 cm FL) are very common, and may be quasi-resident. When they reach about 50 cm FL they move offshore with the prevailing currents. During the southwest monsoon period, when the surface currents are predominantly eastward flowing, 50-60 cm FL fish move east and are caught in the Sri Lankan gillnet fishery. Skipjack of this size are relatively common in the Sri Lankan fishery (Amarasiri and Joseph, 1987; Maldeniya and Suraweera, 1991; Maldeniya and Dayaratne, 1994). Maldeniya and Suraweera (1991) note that female skipjack are unusually abundant at this time of the year, while they are under-represented in Maldivian catches (Hafiz, 1985a; Anderson and Waheed, 1990). During the northeast monsoon period, when the surface flow is predominantly westward, 50-60 cm FL skipjack move in to western Indian Ocean and are caught in the purse seine fishery. It is not known whether it is the attainment of sexual maturity, or just the attainment of a certain size, that promote this apparent change in skipjack behaviour.

It is proposed that at least some these fish may return to Maldives at later stage, since 60+ cm skipjack are relatively well represented in the Maldivian catches (Hafiz, 1985a; Anderson and Waheed, 1990; Anderson and Adam, 1996b). Large skipjack are particularly abundant off the northern Maldives in October-March and off the southern Maldives during the intermonsoon periods (sections 2.3.2 and 2.5.1). These results are consistent with reports from fishermen. They say that large skipjack enter the northern waters of Maldives from the east during the northeast monsoon

season. Large skipjack are said to enter the southern Maldives from the south in November (Adnan Ali, MIFCO, pers. comm.).

Skipjack tuna are constrained in their distribution by their physiological requirements, notably oxygen and temperature. Temperature requirements in particular change with size, since larger fish need to find cooler waters than small fish in order to dissipate excess metabolic heat (Wild and Hampton, 1994). Regional and seasonal variations in oceanographic conditions (in particular SST, thermocline depth and oxygen availability) in waters around the Maldives need to be taken into account in any further considerations of skipjack migrations.

2.7. REPRODUCTION

A number of studies have shown that skipjack tuna in the Indian Ocean reach first maturity at about 39-43cm, with females maturing at a slightly smaller sizes than males (Hafiz, 1985a; Amarasiri and Joseph, 1987; Stéquert and Ramcharrun, 1996; Timohina and Romanov, 1996). However, in the Atlantic, the reverse has been observed, with males maturing at a smaller size than females (Cayré and Farrugio, 1986). There is wide variation in fecundity despite a relatively narrow size range at first spawning. From the broad western Indian Ocean, Timohina and Romanov (1996) showed that batch fecundity ranged from 0.91 million to 2.77 million eggs for fish between 52cm to 69cm. Stéquert and Ramcharrun (1996) showed that in a sample of 281 fish from northwest Madagascar and Seychelles, fecundity ranged about 0.8 million to about 1.25 million eggs for size range 43-73cm FL. These observed variations in batch fecundity are perhaps partly due to methodological differences between studies, as well as being a real indication of natural variability.

Skipjack tuna spawn throughout the year in the Indian Ocean, with periods of peak activity (Amarasiri and Joseph, 1987; James and Pillai, 1988; Stéquert and Ramcharrun, 1996; Timohina and Romanov, 1996). In the western Indian Ocean, Stéquert and Ramcharrun (1996) found that peak spawning periods occurred from June to the end of August in the southwest monsoon season and November to March in the northeast monsoon. In the same area, Timohina and Romanov (1996) observed peak spawning during April to June and November to January. At Minicoy, Lakshadweep, peak spawning occurs during March to May (James and Pillai, 1988). In Sri Lankan waters, spawning occurs throughout the year, except during November to January (Amarasiri and Joseph, 1987).

In general, there is a preponderance of males in the skipjack population, and this sex ratio bias is greatest in larger sizes. This predominance of males is also more noticeable during the peak spawning periods (Stéquert and Ramcharrun, 1996).

2.8. STOCK RELATIONSHIPS

The stock structure of skipjack tuna in the Indian Ocean is not well known. However, skipjack is often considered to be a highly migratory species (although this characterization may not be entirely valid), and it is often assumed that there is a single Indian Ocean stock. With the western Indian Ocean purse seine fishery bordering the Maldivian EEZ to the west and south, and the Sri Lankan gillnet fishery to the east, a high level of interaction between the Maldivian fishery and neighbouring fisheries is likely. Tagging studies conducted in the Maldives have shown that skipjack released in Maldivian waters are being caught by these neighbouring fisheries within a short period of time (Yesaki and Waheed, 1992; Anderson, Adam and Waheed, 1996). A modelling study carried out on the tag recaptures from the first tagging programme also showed that emigration may be significant, and more important than natural mortality in the area (Bertignac, 1994). In order to obtain a better understanding of the interactions of the various skipjack fisheries, large-scale tagging in other areas has to be carried out.

2.9. STOCK STATUS

The tuna fishery of the Maldives has been in existence for centuries. Before the 1980s there were few other nations in the Indian Ocean fishing for skipjack tuna, and the catches taken were not sufficient to cause any concern to the Maldives. With increasing development and expansion of tuna fisheries in the Indian Ocean, particularly by distant water fishing nations, understanding the impacts of, and interactions between, the various fisheries has become vital for the rational management of the skipjack resource.

To date there has been no comprehensive assessment of Indian Ocean skipjack tuna stock status. It is assumed that there is one Indian Ocean stock and that is "in good shape" (IPTP, 1995: 22). Certainly, many fisheries scientists believe that skipjack stocks are very large and should be able to sustain high levels of fishing effort. Skipjack tuna are highly fecund, mature early and have a relatively short life span. In addition, spawning takes place over extensive areas and periods of time. Because of these biological characteristics it is thought that large adult populations are not so important for sustaining recruitment and maintaining the fishery. Fonteneau and Soubrier (1996) state that reduced recruitment due to overfishing (recruitment overfishing) has never been observed for species such as skipjack.

However, there do appear to be some worrying signs in the Maldivian skipjack fishery. Skipjack catches have stagnated in recent years (Fig. 2.1) and catch rates have declined (Fig. 2.4). This might be due (at least partly) to increasing skipjack catches elsewhere in the Indian Ocean. Adam and Anderson (1996b) showed that there was a negative correlation between the Maldivian *masdhoni* skipjack catch rates and western Indian Ocean skipjack catches during the period 1988-93 ($r = -0.343$). Given the migration model of Anderson, Adam and Waheed (1996) (section 2.6), and assuming that the purse seine fishery does have an impact on Maldivian skipjack catches, then it would seem logical to expect the greatest impact on large skipjack catch rates. For the period 1988-95, the relationship between Maldivian large skipjack CPUE and western Indian Ocean skipjack catch (Fig. 2.12) is much stronger ($r = -0.75$). While there is no proof of cause and effect, this is clearly a cause of concern for the Maldives.

From an analysis of data for the years 1970-85, Hafiz (1986) noted that the catch of large skipjack was greatest in the north and northeast of the country (his Stratum 4). This is no longer the case (section 2.3). Again, this is circumstantial evidence for a possible impact of foreign fishing on Maldivian catch rates.

Fig. 2.13 shows the proportion of large skipjack in catches on the western and eastern sides of the Maldives. Before 1986, when western Indian Ocean purse seine fishery activity was low, the proportions of large skipjack on both sides followed same pattern, and the proportion of large skipjack in east coast catches was higher than that in west coast catches for exactly the same number of years that the opposite occurred (8 years out of 16). However, from 1986, with increased purse seining activity, the proportion of large skipjack on the west coast declined relative to that on the east coast. West coast catch rates were lower than east coast catch rates in 11 out of 12 of years during the period 1986-97. This might have been the result of a reduction in immigration of large skipjack to the west coast from the western Indian Ocean.

The government agency MIFCO buys a large proportion of the skipjack caught in the Maldives (Table 2.4). From its purchasing records the average weight of a substantial skipjack sample can be estimated. Prior to 1993 this was a biased estimate of the average weight of the catch because MIFCO only bought weighing more than 1.5 kg/fish. However, this bias would have been similar in all the years and any trends in the time series should reflect changes in the average size of the larger skipjack caught in the fishery. The bias would have been reduced from the beginning 1993, when MIFCO started to buy fish of under 1.5 kg. There is a clear decrease in the average weight of skipjack purchased by MIFCO, during the period 1990-93 (Cook, 1995). This corresponds to the time when large skipjack CPUE also started to decline.

These various lines of evidence are all suggestive of a negative impact on Maldivian skipjack catches by overseas fishing activity. The decline in large skipjack catch rates and sizes has certainly occurred at the same time as the expansion of the western Indian Ocean purse seine and the Sri Lankan gillnet fisheries. In the Pacific there have been several studies of tuna fishery interactions (cited in Shomura, Majkowski and Langi 1994; Shomura, Majkowski and Harman 1996). For example, modelling of tag recovery data combined with analysis of fishing effort in the southwest Pacific has shown that a decline in pole and line yield of as much as 20% can occur as a result of the activities of purse seine fisheries (Sibert et al., 1996).

However, in the case of the Maldivian skipjack fishery it is not possible to prove that the two are directly related. This is because other changes have been occuring at the same time:

- There have been changes in oceanographic conditions (section 2.4), which must certainly have affected the skipjack resource.
- Maldivian pole and line fishing effort has increased to record levels (Fig. 1.4), and the effect of this on local resources is not well understood. Sathiendrakumar and Tisdell (1987) suggested that in the Maldivian tuna fisheries increased fishing effort should produce increased catches, until some threshold level. Thereafter, further increases in effort should produce diminishing catch rates. While there is no evidence for this occurring yet in the Maldivian tuna fisheries, in other areas it has been shown that local increase in catches can effect local abundance of pelagic fish stocks (Boggs, 1994).

There is clearly much uncertainty regarding the stock status of Maldivian skipjack tuna. But so great is the importance of this one species of fish to the Maldivian economy, and so traumatic would be a collapse of this fishery, that every effort should be made to improve understanding of its population dynamics.

Table 2.1. Annual Maldivian catches (tonnes) of skipjack tuna by vessel type, 1970-97.
Source: MOFA/EPCS

Year	Sailing *masdhoni*	Mechanized *masdhoni*	Total *masdhoni*	*Vadhu dhoni*	Total
1970	27,068	0	27,068	616	27,684
1971	28,200	0	28,200	509	28,709
1972	17,634	0	17,634	337	17,971
1973	18,761	0	18,761	434	19,195
1974	21,760	0	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	337	31,930
1985	165	42,005	42,170	435	42,605
1986	169	45,099	45,268	181	45,449
1987	196	41,676	41,872	240	42,112
1988	142	57,966	58,108	456	58,564
1989	135	57,671	57,806	352	58,158
1990	47	59,724	59,771	133	59,904
1991	46	58,715	58,761	144	58,905
1992	93	58,269	58,362	230	58,592
1993	107	58,452	58,559	188	58,747
1994	67	68,452	68,519	892	69,411
1995	115	69,338	69,453	851	70,304
1996	77	65,793	65,870	632	66,502
1997	117	68,066	68,183	833	69,015

Table 2.2. Average weight conversion factors for large and small skipjack used by MOFA/EPCS.
Source: Adapted from Anderson and Hafiz (1996).

Period of application	Conversion Factor (kg/piece) Large skipjack	Small skipjack	Source
1959 -1975	7.0	1.963	Shiji & Sato, 1966
1976 -1983	6.18	2.12	Unknown, 1975
1984 -1987	5.87	2.01	Unknown, 1983
1988 - present	5.7	2.1	Anderson , 1988

Table 2.3. Percentage of large skipjack in regional skipjack length frequency samples, 1994-96.
Source: MRS (1997)

Atoll / Island	Percentage of large skipjack in the sample 1994	1995	1996	94-95
H.A. Kulhudhuffushi	15.2	30.5	6.4	18.8
R. Alifushi	21.0	29.8	--	26.0
K. Malé	11.9	21.6	15.3	16.8
M. Maduvvari	4.6	6.7	2.7	5.0
Dh. Kudahuvadhoo	6.6	7.5	--	7.1
L. Maamendhoo	13.3	47.8	--	22.8
G.A. Villingili	35.5	45.9	43.2	41.5
G.Dh. Thinadhoo	26.8	49.3	21.2	34.2
Average	19.0	34.5	16.6	25.3

Table 2.4. Maldivian Government purchases of fresh skipjack, 1975-94.
Sources: MIFCO and MOFA/EPCS

Year	Gov. purchases (t)	Total skipjack catch (t)	% Gov. purchased
1975	1,085.7	14,858	7.3 %
1976	5,504.2	20,092	27.4 %
1977	4,341.4	14,342	30.3 %
1978	4,971.4	13,824	36.0 %
1979	6,936.5	18,136	38.2 %
1980	8,028.9	23,561	34.1 %
1981	6,356.6	20,617	30.8 %
1982	5,176.4	15,881	32.6 %
1983	3,857.2	19,701	19.6 %
1984	5,961.5	32,048	18.6 %
1985	8,203.7	42,602	19.3 %
1986	9,839.4	45,445	21.7 %
1987	10,436.0	42,111	24.8 %
1988	16,826.6	58,546	28.7 %
1989	17,107.3	58,145	29.4 %
1990	20,431.1	59,899	34.1 %
1991	13,850.0	58,898	23.5 %
1992	16,941.5	58,577	28.9 %
1993	16,875.6	58,740	28.7 %
1994	15,359.3	69,411	22.1 %

Table 2.5. Estimates of von Bertallanfy growth parameters and length-at-age of skipjack tuna in the central Indian Ocean, from length frequency studies.

	Maldives	Maldives	Sri Lanka	Sri Lanka	Sri Lanka	Minicoy
L_∞ (cm)	78	82	76	85	77	90
k (yr)	0.625	0.450	0.440	0.640	0.520	0.490
t_0	0	0	0	0	0	0
L1 (cm)	36	30	27	40	34	35
L2 (cm)	55	49	44	61	43	56
L3 (cm)	66	61	56	72	52	69
L4 (cm)	72	68	63	78	63	77
L5 (cm)	75	73	68	81	71	82
L Range	20-76	20-76	22-80	26-82	---	24-72
Source	Hafiz, 1985a	Hafiz, 1986	Joseph & Amar., 1987	Amar & Joseph, 1985	Sivasubram-anium, 1985	James and Pillai, 1988

Table 2.6. Growth rate at length for skipjack tuna in the Indian Ocean.

Area	Growth rate (cm/mo at fork length, ± 95% CI) 40 cm	50 cm	60 cm	70 cm	Method	Source
Maldives	2.0	1.5	0.9	0.4	L/F	Hafiz (1985)
Maldives	1.6	1.2	0.8	0.4	L/F	Hafiz (1986)
Sri Lanka	1.3	0.9	0.6	0.2	L/F	Joseph & Amarasiri (198
Sri Lanka	2.5	1.9	1.4	0.7	L/F	Amarasiri & Joseph (198
Sri Lanka	1.6	1.1	1.9	0.3	L/F	Sivasubramanium (1985)
Minicoy	2.1	1.5	1.3	0.8	L/F	James and Pillai (1988)
Maldives (1)	2.4	2.1	1.8	1.4	Tagging	Yesaki & Waheed (1992)
Maldives (2)	1.4 ± 0.2	1.1±0.1	0.9±0.3	—	Tagging	Anderson et al. (1996)
Maldives (3)	0.8 ±0.11	0.5±0.07	0.2±0.14	—	Tagging	Adam & Anderson (1996)

Notes:

1. Recoveries measured by tape and release measured with board but discrepancy not corrected. Negative growths eliminated.

2. Recoveries measured by tape and release measured with board but corrected using a tape to board conversion ratio. Negative growths eliminated

3. Recoveries measured by tape and release measured with board but corrected using a tape to board conversion ratio. Negative growths NOT eliminated

Fig. 2.1. Skipjack tuna - annual catches by vessel type

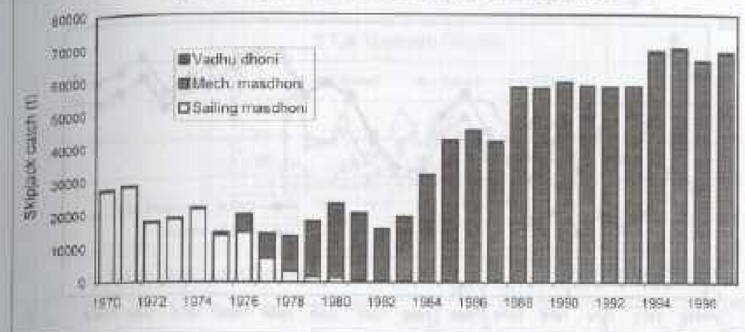


Fig. 2.2. Skipjack tuna - % contribution to annual catches by major vessel types

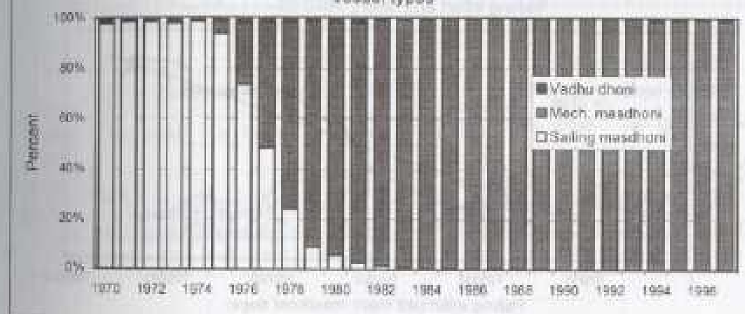


Fig. 2.3. Skipjack tuna - length frequency distribution of pole and line catches at five localities in the Maldives, 1994-96 (N=367,183)

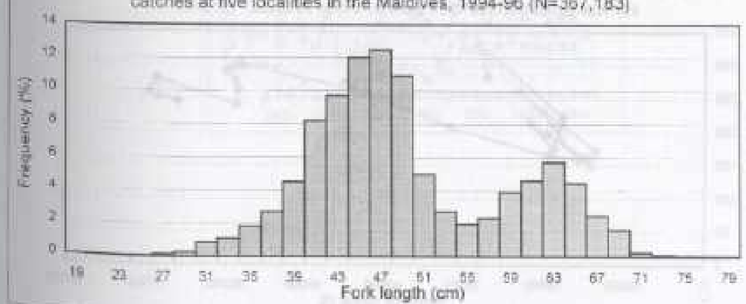


Fig. 2.4. Skipjack tuna - pole and line catch rates, 1970-97

Fig. 2.5. Skipjack tuna - relationship between standardized *masdhoni* fishing effort and catch, 1970-97

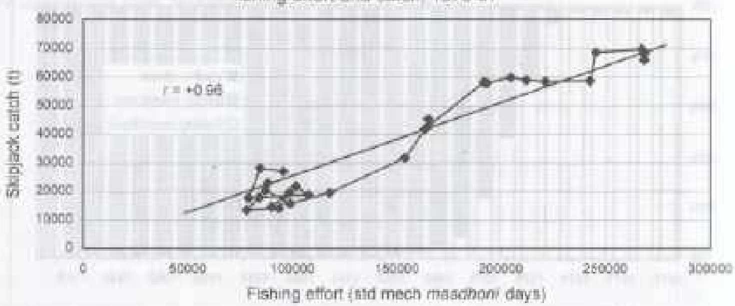


Fig. 2.6. Skipjack tuna - relationship between catch and catch rate for standardized mechanized pole and line vessels, 1970-97

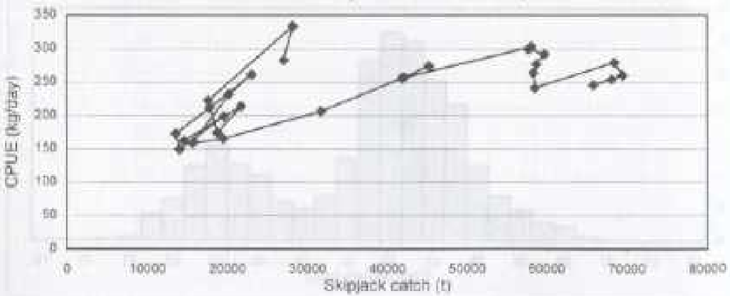


Fig. 2.7. Skipjack tuna - standardized *masdhoni* catch rates for large and small skipjack by region, 1970-1995

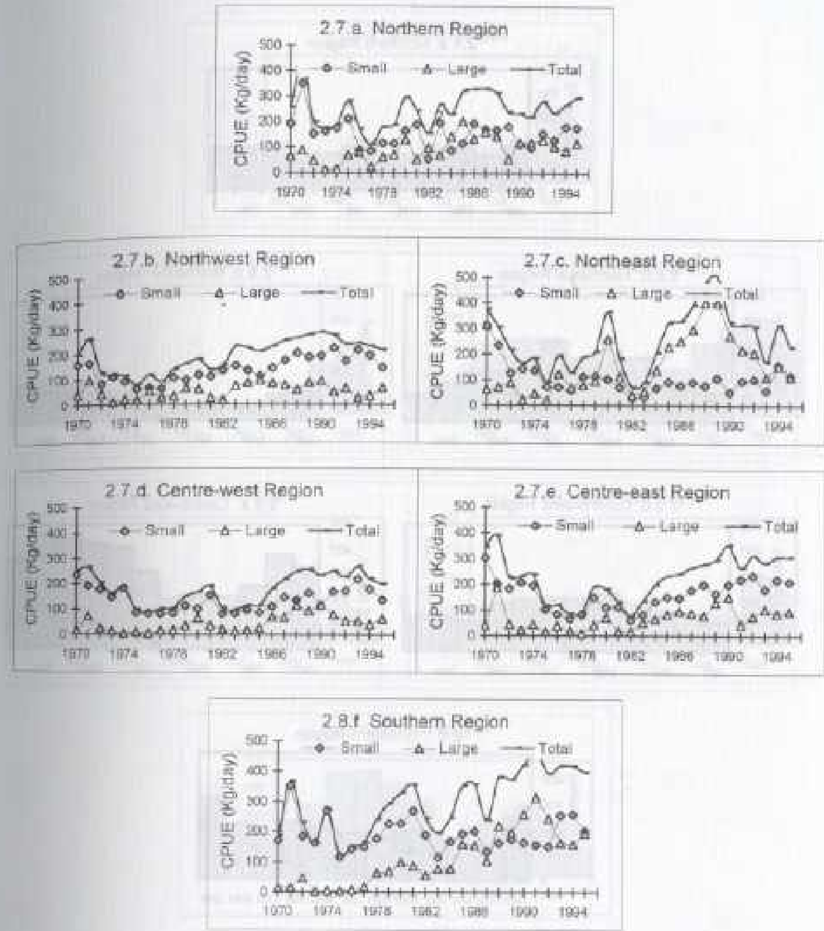


Fig 2.8. Skipjack tuna - average monthly mechanized *masdhoni* catch rates for SMALL skipjack, by region, 1989-95

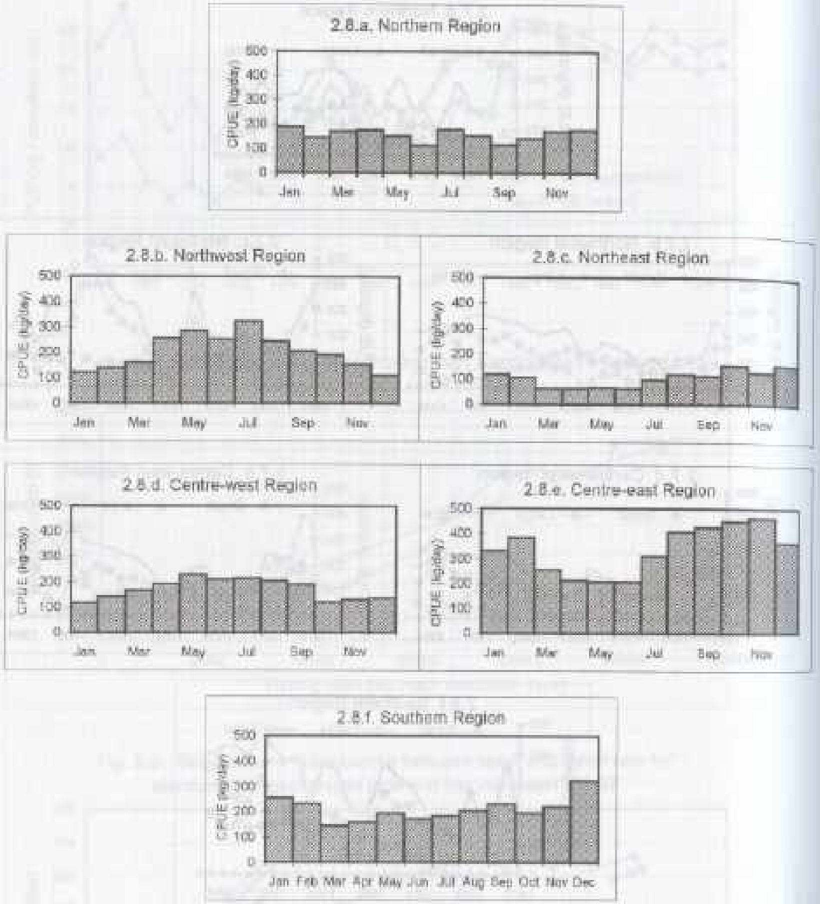


Fig 2.9. Skipjack tuna - average monthly mechanized *masdhoni* catch rates for LARGE skipjack by region, 1989-95

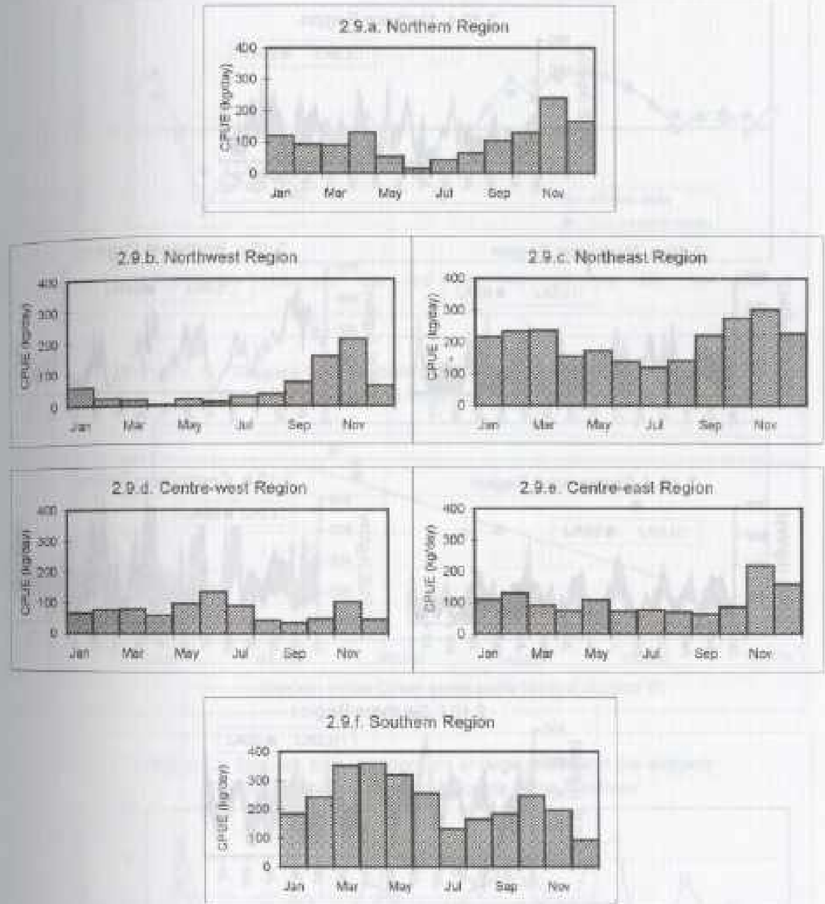


Fig. 2.10. Skipjack tuna - monthly mechanized *masdhoni* catch rates for large and small skipjack by region, 1989-95

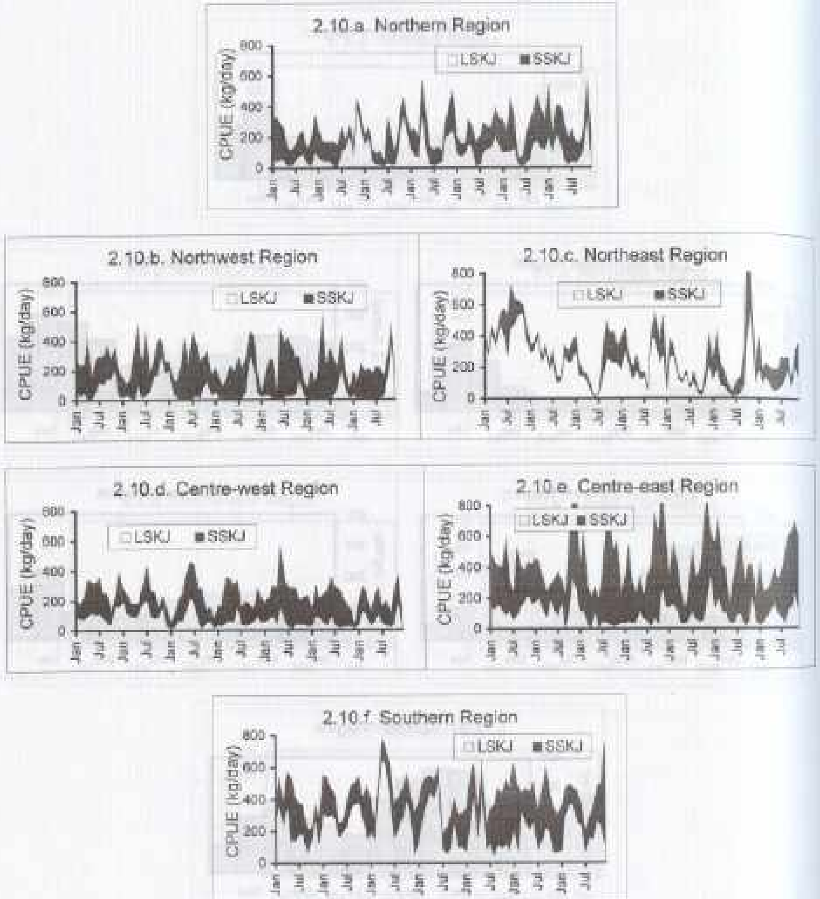


Fig. 2.11. Skipjack tuna - % contribution to annual tuna catch

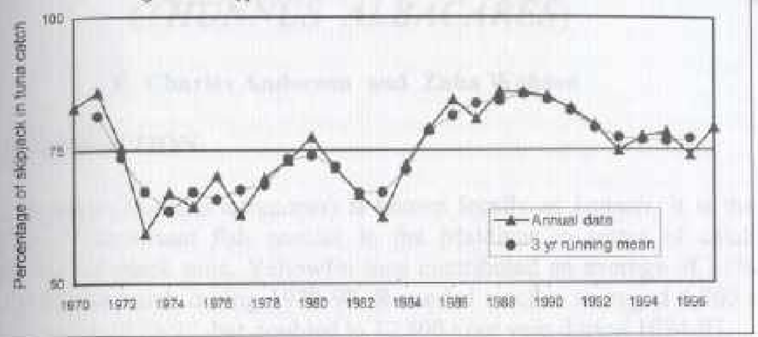


Fig. 2.12. Skipjack tuna - relationship between western Indian Ocean purse seine catches and Maldivian catch rates, 1988-95

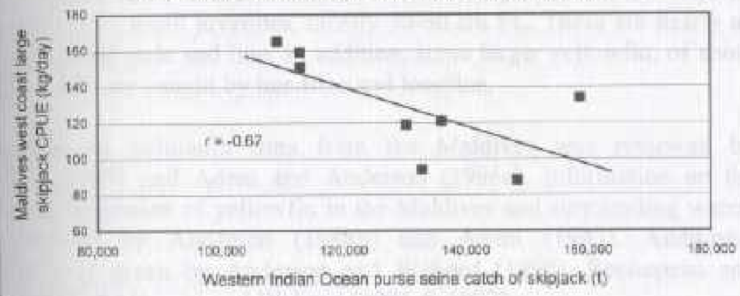
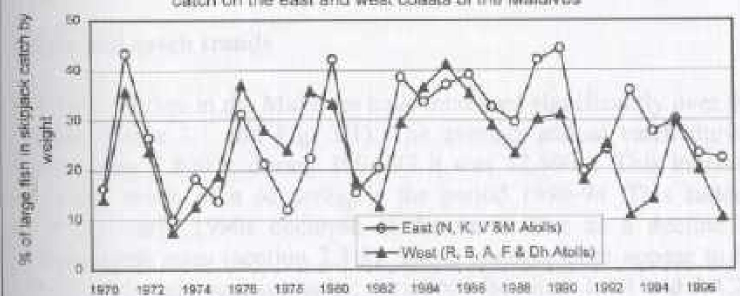


Fig. 2.13. Skipjack tuna - proportions of large skipjack in the skipjack catch on the east and west coasts of the Maldives



3. YELLOWFIN TUNA
(*THUNNUS ALBACARES*)

R. Charles Anderson and Zaha Waheed

3.1. INTRODUCTION

Yellowfin tuna (*Thunnus albacares*) is known locally as *kanneli*. It is the second most important fish species in the Maldives in terms of catch weight, after skipjack tuna. Yellowfin tuna contributed an average of 13% to the total tuna catch during 1970-97. Recorded catches averaged 6,300 t per year during 1970-97, but doubled to 12,800 t per year during 1994-97.

Yellowfin tuna is a large species, growing to a maximum of over 2 m in length (Collette and Nauen, 1983). In the Maldives, however, the majority of the catch is of small juveniles, mostly 30-60 cm FL. These are nearly all taken by livebait pole and line. In addition, some larger yellowfin, of about 60-160 cm FL, are caught by handline and longline.

Information on yellowfin tuna from the Maldives was reviewed by Anderson (1985) and Adam and Anderson (1996a). Information on the growth and migration of yellowfin in the Maldives and surrounding waters was reviewed by Anderson (1988b) and Adam (1993). Additional information is given by Anderson and Waheed (1990), Rochepeau and Hafiz (1990) and Yesaki and Waheed (1991 & 1992).

3.2. YELLOWFIN TUNA CATCHES AND CATCH TRENDS

3.2.1. Catch and catch trends

Yellowfin tuna catches in the Maldives have increased significantly over the last 25 years (Table 3.1 and Fig. 3.1). The average annual catch during 1970-72 was only 1,800 t, during 1994-97 it was 12,800 t. This increase was not steady, much of it occurring in the period 1990-94. This sudden increase in the early 1990s occurred at the same time as a decline in skipjack tuna catch rates (section 2.3.1). These changes both appear to be related to decadal-scale oceanographic variations (sections 1.4.4 and 3.4.2). In addition, the decline in skipjack catch rates may have prompted fishermen to catch more yellowfin to compensate for reduced skipjack landings.

The relative contributions of the main vessel types to annual yellowfin catches are illustrated in Fig. 3.2. Pole and line vessels (*masdhonis*) are by far the most important vessel type for yellowfin in the Maldives. Sailing *masdhonis* were rapidly replaced by mechanized *masdhonis* during the late 1970s. However, mechanization did not lead to an immediate increase in tuna catches (including those of yellowfin tuna), for the reasons outlined in section 1.3.

Pole and line catches of yellowfin tuna have increased irregularly with increased *masdhoni* fishing effort over the entire period 1970-97 (Fig. 3.4). There is no suggestion of a levelling off of catch at high levels of fishing effort. Thus, there is no support, at the levels of fishing seen so far, for a threshold relationship of the type proposed by Sathiendrakumar and Tisdell (1987).

Pole and line is by far the most important gear type for yellowfin in the Maldives. Roughly 90% of the catch is taken by pole and line. Longline, troll and livebait handline are also used. MOFA does collect data on catch by fishing gear, but these data are not reported accurately and do not give a true reflection of catches by minor gears. Significant catches of yellowfin tuna were made by trolling *vadhu dhonis* up until the mid-1980s, but since then their contribution to total yellowfin catch has been minimal (Fig. 3.2, see also sections 1.2.3 and 1.3).

Traditionally, Maldivian fishermen have targeted small yellowfin (i.e. those of less than about 60 cm FL). Large yellowfin tuna have presumably always been present, but were not taken in any numbers, perhaps because there was no market for them. Over the last decade, catches of large yellowfin have increased as markets have developed. These markets are both domestic (resorts and Malé teashops) and export (mostly canned or frozen for canning, but also some for sashimi). Large yellowfin are caught mainly by handline or tolling, but also by longline. MOFA has recorded catches of large yellowfin separately from those of small yellowfin since 1992, but does not normally report them separately. Recent catches of small and large yellowfin are summarized by region in Table 3.2.

3.2.2. Accuracy of catch estimates

Recorded catches of yellowfin tuna, as shown in Table 3.1, are likely to differ from the true catch as a result of inadequacies in the fisheries statistics system (section 1.5.1). For yellowfin tuna the main problems are:

- under-reporting,
- inadequate conversion factors,
- problems with size classification, and
- species specificity.

Parry and Rasheed (1995) estimated that yellowfin catches might be underestimated by about 15% as a result of underreporting. It is possible that yellowfin catches for the years 1970-71 may have been even more seriously underreported. Between 1959 and 1969, tuna statistics were collected using only three species categories: large skipjack; small skipjack and yellowfin; kawakawa and frigate tuna (Anderson, 1986). From 1970, yellowfin was reported separately from small skipjack for the first time. It is not known to what extent this may have contributed to greater than average underreporting or misreporting of yellowfin catches. However, it should be noted that the apparently low level of yellowfin catches in the years 1970-72 may reflect a truly low level of catch resulting from oceanographic variations (section 3.4.2) and/or inflated skipjack catches as a result of overreporting (section 2.2.2; Anderson, 1986).

Tuna catches are reported by fishermen in numbers, and are converted to weights using average weight conversion factors. For yellowfin tuna, a single conversion factor has been used for the whole country (section 3.5.2), despite the fact that there are clear regional and seasonal differences in average weights. While these problems apply to all tuna species, for yellowfin a very large size range is landed (section 3.5.1), which makes the use of a single conversion factor particularly inappropriate.

The collection of separate catch data for large and small yellowfin started in 1992 (Parry and Rasheed, 1995; Anderson and Hafiz, 1996). Separate conversion factors for large and small yellowfin were introduced at the same time. However, the conversion factor now used for small yellowfin was estimated as a conversion factor for all yellowfin (Anderson, 1988a; Anderson and Hafiz, 1996). The use of this conversion factor will tend to result in an overestimation of yellowfin catches.

Regional length frequency sampling was started in 1993 in an attempt to overcome some of these problems (Anderson et al., 1995; Scholz et al., 1996). Although seasonal and regional conversion factors have been estimated, they have not been applied.

A final problem with the yellowfin tuna statistics is the presence of bigeye tuna (*Thunnus obesus*) in the catch. The catch of bigeye tuna is the north and centre of the country is very small, but in the south may amount to 15% of the total *Thunnus* catch. This issue is discussed in section 2.10.

In summary, yellowfin catches are likely to be underreported by about 15%. Inadequate conversion factors added an unknown degree of error to catch estimates during 1970-91. Since 1992 the conversion factors used may tend to overestimate catch weight. In the south, these problems are compounded by the presence of a small but significant component of bigeye tuna in the catch.

3.3. CATCH PER UNIT EFFORT (CPUE) TRENDS

3.3.1. National Trends

Annual *masdhoni* catch rates for yellowfin tuna are illustrated in Fig. 3.3. Both actual and standardized catch rates were particularly low during the period 1970-72. The possible reasons for this include prevailing oceanographic conditions (section 3.4) and underreporting of yellowfin catches (section 3.2.2; Anderson, 1986) at that time.

Actual *masdhoni* catch rates doubled from about 20 kg/day to about 40 kg/day during the late 1970s, as a direct result of mechanization. During the period 1973-97, standardized *masdhoni* yellowfin tuna catch rates have varied between about 30-50 kg/day. Standardized catch rates appear alternate between periods when they are relatively high and periods when they are relatively low. The relationship between catch and catch rate (Fig. 3.5) also shows evidence of this pattern of alternating periods of relatively low and high catch rates. This is believed to be the result of changes in relative abundance and/or availability of yellowfin tuna, related to decadal scale oceanographic variations (sections 1.4.4 and 3.4.2).

Fig. 3.5 also suggests that catch rate is independent of catch over a relatively large range of catch. This is to be expected if the stock(s) being exploited are very much larger than the catch of the Maldivian fishery. The particularly low catch rates at low levels of catch (1970-71) might be explained in a number of ways, including:

- underreporting of yellowfin catch, but not fishing effort, and hence underestimation of yellowfin catch rates in the first years of a new catch reporting system (section 3.2.2);
- genuinely reduced catch rates as a result of unfavourable oceanographic conditions (section 3.4); or
- inadequacies in the standardization of *masdhoni* effort data: although sailing *masdhonis* caught half the total tuna taken by mechanized *masdhonis*, it may be that sailing *masdhonis* were relatively less efficient at catching yellowfin than they were at catching other species. This, however, seems unlikely since in the first three years after mechanization for which data are available (1979-81), sailing *masdhonis* caught twice as much yellowfin in proportion to their skipjack catch as did mechanized *masdhonis*.

3.3.2. Latitudinal Trends

Average catch rates for different time periods, for both trolling and pole and line vessels, are presented in Table 3.3. Summarizing, actual average catch rates for pole and line vessels by region during the period 1970-83 were:

North	54 kg/day
Centre	31 kg/day
South	10 kg/day

These data would appear to support previous reports that yellowfin tuna appears to be commoner in the north and centre of the Maldives than in the south (Anderson, 1985 & 1992). However, during the period 1989-95, this latitudinal trend in pole and line catch rates was less clear cut (Table 3.3), although the lowest catch rates were still obtained in the south:

North	48 kg/day
Centre	55 kg/day
South	37 kg/day

The relative decrease in northern catch rates between 1970-83 and 1989-95 can be largely attributed to a decrease in catch rates off Raa and Baa atolls during the southwest monsoon season (Table 3.4). This might possibly be the result of competition for fish from the western Indian Ocean purse seine fishery (section 3.9). The relative increase in catch rates in the south might be attributed in part to the effects of mechanization, allowing pole and line vessels there to visit offshore seamounts where yellowfin are particularly abundant. Note, however, that catches of small yellowfin by mechanized *masdhonis* during 1994-97 were consistently highest in the north and lowest in the south (Table 3.2).

For trolling vessels, for the periods 1970-83 and 1989-95 combined, actual average catch rates for yellowfin tuna by latitudinal region were:

North	1.7 kg/day
Centre	5.0 kg/day
South	4.6 kg/day

The reasons for the difference in latitudinal distribution of catch rates between trolling and pole and line vessels are not known. However, the particularly low trolling catch rates in the north of the country may be related to the abundance there of other target species, notably kawakawa and frigate tuna (sections 4.3.2 and 5.3.2).

In summary, evidence from pole and line catch rates suggest that yellowfin tuna is more abundant in the north and centre of the Maldives than in the south. However, this pattern does not hold for trolling vessel catch rates. Note that this discussion refers to juvenile yellowfin tuna only.

The latitudinal trends in the abundance of large yellowfin are not well known. Recent regional catches of large yellowfin are summarized in Table 3.2. During 1995-97 the highest catches were recorded in the central region, reflecting high landings to Malé market. It is not possible to calculate reliable CPUE indices from these catch data, because the available effort data apply to all fishing trips, not just the relatively few trips that targeted large yellowfin tuna. There are seasonal fisheries for large yellowfin, which are discussed below.

3.3.3. Seasonal Trends

Yellowfin tuna catches and catch rates show marked seasonality in the Maldives. Deraniyagala (1956) appears to have been the first to record this. During a visit to Maldives in 1932 he noted that fishermen reported that yellowfin were most abundant near Malé in the northeast monsoon season. Anderson (1985) reviewed yellowfin catch and effort data for the whole country and noted that there are two major seasonal components to the pole and line fishery for juvenile yellowfin tuna:

1. Southwest monsoon fishery off the west coast during June to September.
2. Northeast monsoon fishery off the east coast during December to March.

This pattern has been confirmed by Anderson (1988) and Rochepeau and Hafiz (1990). In both seasons juvenile yellowfin are carried towards the Maldives by the prevailing monsoon currents. These small yellowfin are frequently associated with drifting objects (*oivaali*), and also with ocean slicks (*asdhandhi*) and seamounts. They are typically in the size range 25-55 cm FL. Anderson and Hafiz (1986) mapped the approximate extent of these seasonal fisheries. Anderson (1988) subsequently extended the analysis to adjacent waters and developed a migration model for juvenile yellowfin in the central Indian Ocean (Fig. 3.7; section 3.6).

Seasonal catch rates for pole and line vessels are listed by area in Table 3.4, and for trolling vessels in Table 3.5. For pole and line vessels, on the east side of Maldives (from Shaviyani to Meemu), catch rates tend to be higher in the northeast season than in the southwest season. The difference between the seasons is more marked for the east-central atolls (Lhaviyani to Meemu) than for the northeastern atolls (Shaviyani and Noonu). This is because vessels from Shaviyani can easily fish on both sides of the country. On the west side of Maldives (Raa to Thaa), catch rates are consistently higher in the southwest season than in the northeast season. In the far north, there is no consistent seasonal pattern, with juvenile yellowfin catch rates being higher in the northeast season in some years, and higher in the southwest season in others. In the south, catch rates are low, and inter-seasonal variation is not great, although the highest catch rates tend to be seen in the southwest season.

The discussion above refers only to juvenile yellowfin tuna. The seasonal distribution of large yellowfin tuna is not so well known. This is an area where further work is needed. However, there is a seasonal fishery for large yellowfin in the far south of Maldives off Fuvah Mulaku and Addu Atolls in November and December each year (Anderson, 1985; Anderson, Adam and Waheed, 1993). Off Malé, large yellowfin were caught mostly in March-April, but in recent years as demand has grown they are taken in all months. In the far north of Maldives, off Haa Alifu Atoll, large yellowfin are taken during January to April (Adam and Anderson, 1996a).

3.4. OCEANOGRAPHIC VARIATIONS

3.4.1. El Niño Southern Oscillation Events

Maldivian yellowfin catches and catch rates tend to increase during ENSO events (Anderson, 1987, 1991 & 1993; Hafiz and Anderson, 1994; Rochepeau and Hafiz, 1990). High catch rates were recorded in each of the ENSO events: 1972-73, 1976, 1982-83, 1987 and 1992-94 (Figs. 1.5, 3.3 and 3.6). Note, however, that during ENSO events that last for more than one year, elevated catch rates are only apparent during the latter part of the event (i.e. in 1973, 1983 and 1994, but not in 1972, 1982 and 1992-93).

During La Niña events, yellowfin tuna catch rates may be depressed. However, this effect is not as obvious as the effect of ENSO events on yellowfin catch rates. Catch rates were reduced during the 1971 and 1974 La Niña events, but not during the 1988-89 event.

An analysis of monthly pole and line catch rates by atoll for the period 1989-95 showed that yellowfin catch rates increased in both the east and west coast fisheries during ENSO events. Only in the far south of the Maldives (G.Dh., Gn. and S. Atolls) was there no obvious increase in yellowfin catch rates associates with ENSO events.

Anderson (1991) carried out a study of mechanized *masdhonis* catches in the region of the Vatteru Channel between Vaavu and Meemu Atolls during the six year the period 1985-90. He noted elevated catch rates for yellowfin tuna during June to September 1987. This corresponds to the period of the southwest monsoon fishery on the west coast. He suggested that the catches of yellowfin made in the Vatteru Channel in mid-1987 derived in part at least from these 'west coast' fish. Alternatively, the reduced winds associated with ENSO events may result in 'east coast' fish being less likely to move away from the east coast during the southwest monsoon.

Elsewhere in the western Indian Ocean, oceanographic conditions associated with ENSO events (see section 1.4.4) have been hypothesized to promote the survival of yellowfin larvae (Marsac and Hallier, 1990; Marsac, 1992). This would presumably result in increased recruitment to the Maldivian pole and line fishery. The time lag between effects on larval survival and consequent effects on recruitment might go some way towards explaining the observation that yellowfin catch rates are high during the latter part of multi-year ENSO events.

3.4.2. Decadal Scale Variations

As has already been noted above (sections 1.4.4, 2.4.2 and 3.3.1), yellowfin tuna catches in the Maldives appear to be affected by decadal scale oceanographic variations. Catches of yellowfin were higher than expected for the level of pole and line fishing effort expended during 1973-84 and from 1994-97. Lower than expected catches were obtained in 1970-72 and 1985-91. The same pattern is apparent in Figs. 3.5 and 3.6.

1992 and 1993 are years with intermediate yellowfin catch rates. New average weight conversion factors were introduced in 1992, which will have led to an increase in estimated catch (sections 3.2.2 and 3.5.2). Therefore, 1992 and perhaps also 1993 might best be considered as years with low yellowfin catch rates.

3.5. YELLOWFIN TUNA SIZE AND GROWTH

3.5.1. Length Distribution

A summary length frequency distribution for yellowfin tuna measured at six sampling sites during 1994-96 is given in Fig. 3.8. Of the 146,285 yellowfin tuna measured, 95% were within the range 25-62 cm FL. 50% were within the range 40-49 cm FL. The modal length of the sample measured was 49cm FL, and the mean length was 45cm FL. The smallest yellowfin tuna measured was 17cm FL. The largest was 189cm FL, although the second largest was only 165cm FL, and 99% were shorter than 75cm FL. These size ranges are similar to those reported in previous studies of Maldivian yellowfin (Anderson, 1985; Adam and Anderson, 1996a). Thus the majority of the yellowfin tunas caught are small juveniles taken by the pole and line fishery. These are for the most part somewhat smaller than the yellowfin caught elsewhere in the Indian Ocean (see IPTP, 1992; Fig. 30).

3.5.2. Average Weights

Tuna catches are reported by fishermen in numbers, and are converted to weights using average weight conversion factors. For yellowfin tuna, the following conversion factors have been used by the Ministry of Fisheries and Agriculture at different times (Anderson, 1986; Anderson et al., 1996; Scholz et al., 1997):

1959-1975	1.963 kg/fish	(Shiji and Sato, 1966)
1976-1987	2.12 kg/fish	(Source unknown)
1988-1996	2.6 kg/fish	(Anderson, 1988)

The first two conversion factors applied to small yellowfin only, whereas the third conversion factor was supposed to apply to all yellowfin. It has, however, been applied to small yellowfin since 1992, when a conversion factor of 20 kg/fish for large yellowfin was introduced (Parry and Rasheed, 1995; Anderson and Hafiz, 1996).

The use of single conversion factors for the whole country is recognized as inadequate (Anderson, 1986; Parry and Rasheed, 1995; Anderson et al., 1996; Scholz et al., 1997). This is particularly the case with yellowfin tuna, which has a large size range and shows marked seasonal variations in size composition and abundance. In an attempt to overcome these problems, more comprehensive regional sampling of catches was started in late 1993. Annual average weight estimates of small yellowfin tuna landed at seven locations during 1994-96 ranged from 1.8-2.1 kg/fish (Scholz et al., 1997). These estimates are close to the original yellowfin conversion factors of 1.963 and 2.12 kg/fish. The current use of a 2.6 kg/fish conversion factor for small yellowfin is clearly inadequate.

The average weights of large yellowfin sampled during 1994-96 ranged widely, from 10-24 kg/fish. The lower average weight estimates were from regional locations which sampled pole and line vessels only, while the highest average weights were from Malé, where handline as well as pole and line vessels were sampled (Scholz et al., 1997). The single conversion factor of 20 kg/fish for large yellowfin currently in use clearly fails to take account of these wide regional variations in average weight.

3.5.3. Growth

The growth of yellowfin tuna in the Maldives has been studied by analysis of both length frequency data (Anderson, 1988b; Adam, 1993) and tagging data (Yesaki and Waheed, 1991 & 1992). These studies concentrated on juvenile yellowfin, because large yellowfin are under-represented in Maldivian catches, and so they were unable to develop growth models for the full size range of the species. From the length frequency studies, a linear growth rate of 2.9±0.4 cm/mo between 30-70 cm FL was estimated (although growth at half that rate could not be discounted). From tagging studies, a compatible growth rate of 2.4 cm/mo at 70 cm FL was estimated.

As part of this present study, monthly length frequency histograms of all available data were produced. No attempts were made to fit von Bertalanffy growth parameters (or those of any other growth model) to these data because of the limited size range sampled. Inspection of the histograms showed many periods of modal stasis, and no extended periods of unambiguous modal progression.

The use of length frequency data to estimate tuna growth rates can certainly be problematic. Although length frequency data may show clear modal progression, it may be impossible to distinguish between real growth and apparent growth resulting from migration of different sized/aged fish through the sampling area. This problem is exemplified in the case of juvenile yellowfin in the western Indian Ocean by some studies producing 'fast' growth rate estimates of about 3 cm/mo (Marcille and Stéquert, 1976; Anderson, 1988b; Yesaki, 1992) while others favour 'slow' growth at about half that rate (Marsac and Lablanche, 1985; Marsac, 1992; Firoozi and Carrara, 1994). There is a need for further work to resolve this issue.

Otolith microincrement analysis may have value in estimating growth rates, providing that the periodicity of microincrement deposition is validated (Wild, 1986; Yamanaka, 1988). A total of 737 juvenile yellowfin were injected with tetracycline, tagged and released near Baa Atoll in August 1995 (Anderson, 1995b; Anderson, Adam and Waheed, 1996). Unfortunately, recaptures were very poor, and no tetracycline-marked otoliths were recovered (Anderson, 1996a).

3.6. YELLOWFIN TUNA MIGRATION

Anderson (1988b) proposed a model of yellowfin tuna migration in Maldivian and adjacent waters based on an analysis of CPUE and length frequency data. He proposed that there is a broad band of juvenile yellowfin in the equatorial central Indian Ocean, and that these fish move back and forth in phase with the seasonally oscillating monsoon currents. Concentrations of juvenile yellowfin are therefore found off exposed coasts. Thus, peak catches are made off the western coasts of Maldives, Sri Lanka and south India during the southwest monsoon, and off the eastern coasts of Maldives and Sri Lanka as well as Minicoy during the northeast monsoon (Fig. 3.7).

This migration model was subsequently confirmed by tagging studies, which showed that juvenile yellowfin do indeed move in phase with the seasonally oscillating monsoon currents (Yesaki and Waheed, 1991 & 1992; Anderson et al., 1996). Of 3211 yellowfin tagged in both tagging experiments, 158 (4.9% of releases) were recovered up to the end of October 1998 (Table 1.10). Of these, 25 (15.8% of recoveries) were recovered outside of the Maldives. Six tagged yellowfin (3.8% of recoveries) were recaptured by Sri Lankan vessels, to the east of Maldives; five of these were recaptured during the southwest monsoon season. Nineteen tagged yellowfin (12.0% of recaptures) were recaptured by purse seiners operating to the west of Maldives; of these, all 6 for which accurate date of recapture was reported were caught during the northeast monsoon season.

It has been suggested (Anderson, 1988b; Adam, 1993; Adam and Anderson, 1996a) that yellowfin tuna of intermediate size may migrate northwards from the Maldives into the northern Arabian Sea. These yellowfin are presumed to return southwards as they mature. This would explain the abundance of small and large yellowfin but scarcity of intermediate sized yellowfin in equatorial waters, and the abundance of intermediate sized yellowfin at the head of the Arabian Sea.

Adam and Anderson (1996a) noted that there was no obvious sign of change with latitude in the size of yellowfin caught by pole and line within the Maldives. They therefore suggested that if there is a northward migration, it does not start until the yellowfin have grown to a size greater than that at which they are normally taken by pole and line (i.e. greater than 60 cm FL). For western Indian Ocean yellowfin, a change in body proportions determined by detailed analysis of length-weight data has been noted at about 64-68cm FL, and this has been interpreted as a "turning point ... in the life of this fish" (Montaudouin, Hallier and Hassani, 1990; Hallier, 1991). Along the west coast of Sri Lanka a northward movement of yellowfin was demonstrated by Maldeniya and Joseph (1988), mainly on the basis of changes in relative abundance of 60-80 cm FL fish.

The migrations of large yellowfin tuna within Maldivian waters are not well known. Seasonal fisheries are noted in section 3.3.3. From Japanese longline data, a model of large yellowfin migration was proposed by Morita and Koto (1971). They suggested that there is a movement of large yellowfin up past the south of Maldives during October to March each year. This corresponds to the annual large yellowfin fishery off Fuvah Mulaku

and Addu Atolls in November-December (Anderson, Adam and Waheed, 1993), and suggests that these large yellowfin are highly migratory. However, results from the the second Maldivian tagging programme in 1993-95 give a very different picture. Of 83 large yellowfin tagged in the southern Maldives, 10 (12%) were recovered there; no recoveries were made in other localities (Anderson, Adam and Waheed, 1996).

3.7. YELLOWFIN TUNA REPRODUCTION

The majority of the catch is of immature juveniles. A single sample of yellowfin was sampled for gonad maturity at Felivaru cannery in 1985; the majority of the sample was of small fish of indeterminate sex (Anderson, 1985). There has been no other study of yellowfin reproduction in the Maldives.

In the wider Indian Ocean yellowfin reproduction has been the focus of numerous studies (e.g. Joseph and Maldeniya, 1987; Hassani and Stéquert, 1991; Timochina and Romanov, 1991). Maturity is reached at about 100-110cm FL. Sex ratios are roughly equal up to about 110-140 cm FL, although males predominate in some areas and females in others. At larger sizes males always predominate, and females longer than 160 cm FL are particularly rare. Spawning probably occurs year-round in many areas, particularly in equatorial regions. In the western Indian Ocean purse seine grounds, the major reproductive period is between November and March, with a secondary spawning period from July to September. Fecundity is high. It increases with size, but varies greatly between individuals and has been estimated at 1.5 – 8 million eggs per female per spawning.

3.8. YELLOWFIN TUNA STOCK RELATIONSHIPS

The stock structure of yellowfin tuna in the Indian Ocean is not well known. For some purposes a single ocean-wide stock has been assumed (IPTP, 1992). However, it is likely that there are at least two Indian Ocean stocks. Morita and Koto (1971) concluded, from an analysis of Japanese longline data, that there were separate eastern and western stocks with a boundary at about 100°E. Nishida (1992) proposed a multiple stock model from an analysis of longline fishery data. He also suggested that there are two major stocks in the Indian Ocean: a western and an eastern stock, but with an area of overlap between about 70° - 90°E.

This migration model was subsequently confirmed by tagging studies, which showed that juvenile yellowfin do indeed move in phase with the seasonally oscillating monsoon currents (Yesaki and Waheed, 1991 & 1992; Anderson et al., 1996). Of 3211 yellowfin tagged in both tagging experiments, 158 (4.9% of releases) were recovered up to the end of October 1998 (Table 1.10). Of these, 25 (15.8% of recoveries) were recovered outside of the Maldives. Six tagged yellowfin (3.8% of recoveries) were recaptured by Sri Lankan vessels, to the east of Maldives; five of these were recaptured during the southwest monsoon season. Nineteen tagged yellowfin (12.0% of recaptures) were recaptured by purse seiners operating to the west of Maldives; of these, all 6 for which accurate date of recapture was reported were caught during the northeast monsoon season.

It has been suggested (Anderson, 1988b; Adam, 1993; Adam and Anderson, 1996a) that yellowfin tuna of intermediate size may migrate northwards from the Maldives into the northern Arabian Sea. These yellowfin are presumed to return southwards as they mature. This would explain the abundance of small and large yellowfin but scarcity of intermediate sized yellowfin in equatorial waters, and the abundance of intermediate sized yellowfin at the head of the Arabian Sea.

Adam and Anderson (1996a) noted that there was no obvious sign of change with latitude in the size of yellowfin caught by pole and line within the Maldives. They therefore suggested that if there is a northward migration, it does not start until the yellowfin have grown to a size greater than that at which they are normally taken by pole and line (i.e. greater than 60 cm FL). For western Indian Ocean yellowfin, a change in body proportions determined by detailed analysis of length-weight data has been noted at about 64-68cm FL, and this has been interpreted as a "turning point ... in the life of this fish" (Montaudouin, Hallier and Hassani, 1990; Hallier, 1991). Along the west coast of Sri Lanka a northward movement of yellowfin was demonstrated by Maldeniya and Joseph (1988), mainly on the basis of changes in relative abundance of 60-80 cm FL fish.

The migrations of large yellowfin tuna within Maldivian waters are not well known. Seasonal fisheries are noted in section 3.3.3. From Japanese longline data, a model of large yellowfin migration was proposed by Morita and Koto (1971). They suggested that there is a movement of large yellowfin up past the south of Maldives during October to March each year. This corresponds to the annual large yellowfin fishery off Fuvah Mulaku and Addu Atolls in November-December (Anderson, Adam and Waheed, 1993), and suggests that these large yellowfin are highly migratory. However, results from the the second Maldivian tagging programme in 1993-95 give a very different picture. Of 83 large yellowfin tagged in the southern Maldives, 10 (12%) were recovered there; no recoveries were made in other localities (Anderson, Adam and Waheed, 1996).

3.7. YELLOWFIN TUNA REPRODUCTION

The majority of the catch is of immature juveniles. A single sample of yellowfin was sampled for gonad maturity at Felivaru cannery in 1985; the majority of the sample was of small fish of indeterminate sex (Anderson, 1985). There has been no other study of yellowfin reproduction in the Maldives.

In the wider Indian Ocean yellowfin reproduction has been the focus of numerous studies (e.g. Joseph and Maldeniya, 1987; Hassani and Stéquert, 1991; Timochina and Romanov, 1991). Maturity is reached at about 100-110cm FL. Sex ratios are roughly equal up to about 110-140 cm FL, although males predominate in some areas and females in others. At larger sizes males always predominate, and females longer than 160 cm FL are particularly rare. Spawning probably occurs year-round in many areas, particularly in equatorial regions. In the western Indian Ocean purse seine grounds, the major reproductive period is between November and March, with a secondary spawning period from July to September. Fecundity is high. It increases with size, but varies greatly between individuals and has been estimated at 1.5 – 8 million eggs per female per spawning.

3.8. YELLOWFIN TUNA STOCK RELATIONSHIPS

The stock structure of yellowfin tuna in the Indian Ocean is not well known. For some purposes a single ocean-wide stock has been assumed (IPTP, 1992). However, it is likely that there are at least two Indian Ocean stocks. Morita and Koto (1971) concluded, from an analysis of Japanese longline data, that there were separate eastern and western stocks with a boundary at about 100°E. Nishida (1992) proposed a multiple stock model from an analysis of longline fishery data. He also suggested that there are two major stocks in the Indian Ocean: a western and an eastern stock, but with an area of overlap between about 70° - 90°E.

Adam and Anderson (1996a) noted that if there are two main yellowfin stocks, then the yellowfin caught off the west coast of Maldives during the southwest monsoon were probably recruited from the western stock, while those caught off the east coast during the northeast monsoon might come from the eastern stock. Adam and Anderson (1996a) found no obvious correlation between southwest monsoon fishery CPUE and northeast monsoon fishery CPUEs (previous year, same year and following year). This finding does tend to support the two stock hypothesis. The similarity in CPUE trends over the period 1970-97 for the two fisheries (section 3.3.3) might still be attributed to large scale variations in oceanographic conditions.

3.9. STOCK STATUS

The stock status of yellowfin tuna in the Indian Ocean is not well known. In the Indian Ocean as a whole, yellowfin tuna is the most important tuna species caught, in terms of catch weight. Yellowfin catch in 1995 was 310,500 t, which was 34% of the total recorded Indian Ocean tuna catch (IPTP, 1997).

Only one regional stock assessment of Indian Ocean yellowfin has been carried out. That was in 1991 (IPTP, 1992). No firm conclusions could be reached about the status of Indian Ocean yellowfin at that time, largely because of problems with standardizing catch and effort data and lack of some key biological information. Nevertheless, under some assumptions, some assessment models suggested high and perhaps unsustainable levels of fishing effort and mortality.

In 1995, the IPTP Expert Consultation concluded, without conducting a rigorous stock assessment exercise, that Indian Ocean yellowfin tuna stock status was still uncertain (IPTP, 1995). This was largely because of uncertainties over stock structure. If there is a single Indian Ocean stock then it was thought likely that the then current level of fishing was moderate and probably not in the range to adversely affect the stock. However, if there are two major stocks, the then current high level of fishing in the western Indian Ocean was likely to be close to or in excess of the maximum sustainable yield (MSY) for that stock.

Since 1995, new catch data have become available (IPTP, 1997). They show that Indian Ocean yellowfin catches peaked in 1993 (at 380,500 t), since when they have declined (to 288,300 t in 1994 and 310,500 t in 1995).

These data need to be interpreted in the light of particularly high levels of longline activity in 1993. Nevertheless, the drop in catches in 1994-95 should be a cause for concern.

Adam and Anderson (1996a) noted that although Maldivian yellowfin catches and total catch rates had been increasing in recent years, catch rates for the major west coast fishery had declined during the period 1984-1993. Yellowfin CPUE for the west coast, southwest monsoon fishery is now lower than that of the east coast, northeast monsoon fishery, whereas the opposite had always been true before (Tables 3.7 and 3.8). One possible explanation for this is that increasing catches of yellowfin tuna by other nations in the western Indian Ocean is adversely affecting recruitment to the southwest monsoon fishery in the Maldives (Adam and Anderson, 1996a).

In summary, the status of yellowfin tuna in the Indian Ocean remains uncertain. However, the very high levels of fishing activity in the western Indian Ocean, the recent drop in Indian Ocean catches, and the decrease in catch rates of yellowfin tuna in the Maldivian west coast fishery are all causes for concern.

3.10. OTHER INFORMATION

3.10.1. Bigeye tuna

Bigeye tuna (*Thunnus obesus*) is very similar in appearance to yellowfin tuna. In the Maldives, catches of the two species are not distinguished. Any bigeye tuna caught is lumped with yellowfin tuna in the national statistics.

The presence of bigeye tuna in Maldivian catches was noted by Anderson (1986), Hafiz and Anderson (1988) and Yesaki and Waheed (1991). Information on the occurrence of bigeye tuna in Maldivian catches up to 1990 was summarized by Anderson and Hafiz (1991). They noted that bigeye tuna makes up a relatively small proportion of the Maldivian tuna catch, and that it appears to be commoner in the south of the Maldives than in the north.

Anderson (1996b) reviewed information on the occurrence of bigeye tuna in yellowfin catches up to 1994. Bigeye tuna was found to make up about 15% of the *Thunnus* (i.e. combined yellowfin and bigeye) catch by numbers in the south of the Maldives, but only just over 1% in the north and centre of the country. Nearly all the bigeye tuna caught in the Maldives are relatively small, surface-swimming juveniles, taken by pole and line. The modal length in the south was about 58 cm FL, with an estimated mean weight of 3.6 kg. In the north and centre, the modal length of bigeye catches was about 36 cm FL, with an estimated mean weight of 1.1 kg.

Anderson (1996b) estimated annual catches of bigeye tuna for the south and north-central Maldives separately, using the Kudahuvadhoo Channel north of Thaa Atoll as a dividing line. These data are reproduced here (Table 3.9), and updated to include catch estimates for 1995-97. Annual average catch is estimated to have risen from about 100 t per year in the early 1970s to about 500 t per year in the mid-1990s. Note that the Veimandhoo Channel south of Thaa Atoll may be a more appropriate dividing line, as it is for other tuna species (see section 1.4.1), but further sampling is required to confirm this for bigeye tuna.

3.10.2. Yellowfin tuna and dolphins

Yellowfin tuna (*Thunnus albacares*) is a major target of tropical pelagic fisheries around the world, including the Indian Ocean. In some areas of their range, most notably in the eastern tropical Pacific (ETP), large yellowfin tunas frequently associate with dolphins. The main dolphin species involved are the pantropical spotted dolphin (*Stenella attenuata*), the spinner dolphin (*Stenella longirostris*) and the common dolphins (*Delphinus* spp), although other species are also involved. The targeting of dolphin-associated yellowfin tuna schools by tuna purse seiners in the ETP, and consequent mortality of the dolphins has been a major issue since the early 1970s.

Maldivian fishermen have traditionally targeted juvenile yellowfin and other small surface-swimming tunas. Although large yellowfin were present in Maldivian waters, most fishermen did not target them. This was because the fishermen could achieve higher catch rates using pole and line and because there was no specific market for such large fish. Within the last few years, however, markets (both domestic and export) have developed for large yellowfin. As a result, some Maldivian tuna fishermen are now targeting these fish, and it has become apparent that large yellowfin do associate with dolphins in Maldivian waters.

This association has recently been reported on by Anderson and Shaan (1998). They note that large yellowfin tuna (*Thunnus albacares*) are regularly found in association with dolphins in Maldivian waters. The

species involved are the spotted dolphin (*Stenella attenuata*) and the spinner dolphin (*Stenella longirostris*). Maldivian fishermen targeting large yellowfin use the presence of dolphin schools to locate the tunas. The yellowfin are caught using simple handlines, and are mostly within the length range 70-160 cm FL. No dolphins are caught or harmed.

Table 3.1. Annual Maldivian catches (t) of yellowfin tuna by vessel type, 1970-97.
Source: MOFA/EPCS.

Year	Sail P/L	Mech P/L	Total P/L	Trolling	Misc	Total
1970	1,799	--	1,799	190	...	1,989
1971	1,081	--	1,081	146	...	1,227
1972	1,940	--	1,940	136	...	2,076
1973	5,234	--	5,234	241	...	5,475
1974	3,868	--	3,868	260	...	4,128
1975	3,348	164	3,512	262	...	3,774
1976	3,569	912	4,481	410	...	4,891
1977	2,530	1,593	4,123	350	...	4,473
1978	1,324	1,890	3,214	370	...	3,584
1979	733	2,959	3,692	597	...	4,289
1980	471	3,176	3,647	582	...	4,229
1981	273	4,467	4,740	544	...	5,284
1982	167	3,603	3,770	234	...	4,004
1983	112	5,872	5,984	257	...	6,241
1984	76	6,818	6,894	230	...	7,124
1985	82	5,715	5,797	242	27	6,066
1986	22	5,178	5,200	121	0	5,321
1987	9	6,522	6,531	137	2	6,670
1988	12	6,366	6,378	154	3	6,535
1989	6	5,972	5,978	103	1	6,082
1990	5	5,225	5,230	50	0	5,280
1991	5	7,649	7,654	55	2	7,711
1992	11	8,628	8,639	57	1	8,697
1993	17	10,006	10,023	83	4	10,110
1994	8	12,859	12,867	259	0	13,126
1995	32	12,319	12,351	154	0	12,504
1996	11	12,275	12,286	151	3	12,440
1997	9	12,838	12,847	184	0	13,028

Table 3.2. Recent recorded catches of large and small yellowfin tuna, by region.

Source: EPCS/MOFA data compiled by MRS

		1994	1995	1996	1997
Small yellowfin					
	North	5,824 t	5,138 t	4,263 t	5,089 t
	Centre	4,639 t	3,882 t	3,548 t	4,061 t
	South	1,640 t	1,638 t	2,213 t	1,902 t
	Total	12,103 t	10,658 t	10,024 t	11,052 t
Large yellowfin					
	North	471 t	352 t	262 t	357 t
	Centre	175 t	1,115 t	1,212 t	1,037 t
	South	377 t	379 t	942 t	581 t
	Total	1,023 t	1,847 t	2,216 t	1,976 t
Total Yellowfin					
	North	6,295 t	5,490 t	4,524 t	5,447 t
	Centre	4,814 t	4,997 t	4,760 t	5,098 t
	South	2,017 t	2,017 t	3,155 t	2,483 t
	Total	13,126 t	12,504 t	12,440 t	13,028 t

Table 3.3. Average regional catch rates (kg/day) for yellowfin tuna by different vessel types and time periods

Source: MOFA/EPCS data compiled by MRS

Note: North includes atolls from HA to Lh; Centre from K to Th; South from L to S

Vessel Type	Propulsion	Years	Catch Rates (kg/day) North	Centre	South
Trolling	Sail	1970-74	1.1	2.9	4.0
	Sail	1975-78	2.8	9.9	6.4
	Sail	1979-83	1.9	7.2	5.7
	Sail & Mech	1989-95	1.3	2.2	3.1
Pole and line	Sail	1970-74	16.2	16.1	5.2
	Sail & Mech	1975-78	70.7	35.8	13.4
	Mechanized	1979-83	78.8	42.8	10.9
	Mechanized	1989-95	48.1	54.6	36.9

Table 3.4. Average seasonal catch rates (kg/day) for yellowfin tuna by pole and line vessels for different areas and time periods

Source: MOFA/EPCS data compiled by MRS

Note: SW monsoon season lasts from June to October; NE monsoon from December to April

Area	1970-74 Sailing P/L SW	NE	1975-78 Mixed P/L SW	NE	1979-83 Mech P/L SW	NE	1989-95 Mech P/L SW	NE
North (HA-HDh)	9.9	17.2	58.9	169.2	121.0	26.6	57.2	49.8
NE (Sh-N)	3.1	15.9	31.6	56.5	13.5	41.7	51.6	46.9
Centre-east (Lh-M)	1.7	17.7	5.7	59.8	4.2	42.4	31.3	71.4
NW (R-B)	61.1	6.4	196.1	22.5	182.3	44.1	71.5	21.1
Centre-west (A-Th)	35.8	6.9	88.6	27.0	118.6	39.3	100.1	36.8
South (L-S)	5.4	4.6	19.5	11.7	10.9	10.9	38.8	34.6

Table 3.5. Average seasonal catch rates (kg/day) for yellowfin tuna by trolling vessels for different areas and time periods

Source: MOFA/EPCS data compiled by MRS

Note: SW monsoon season lasts from June to October; NE monsoon from December to April

Area	1970-74 SW	NE	1975-78 SW	NE	1979-83 SW	NE	1989-95 SW	NE
North (HA-HDh)	1.5	1.1	2.7	3.4	1.1	0.6	1.4	3.4
NE (Sh-N)	0.6	1.8	2.1	5.7	1.0	0.5	0.7	1.4
Centre-east (Lh-M)	2.1	5.9	13.7	14.2	1.5	0.8	1.3	1.2
NW (R-B)	0.4	1.7	3.4	5.2	4.3	0.5	2.2	2.8
Centre-west (A-Th)	4.8	1.3	20.2	6.1	6.4	2.0	1.7	1.4
South (L-S)	2.5	5.3	4.6	7.2	3.6	0.8	3.4	2.2

Table 3.6. Catch and catch per unit effort (CPUE) for yellowfin tuna by standardized (mechanized) pole and line vessels.
Source: MOFA/EPCS data, compiled by MRS
Note: Catch is total *masdhoni* catch, and *masdhoni* effort is standardized as in section 1.5.1.2.

Year	Catch (t)	Standardized Effort (days)	CPUE (kg/day)
1970	1,799	95,711	19
1971	1,081	84,619	13
1972	1,940	79,272	24
1973	5,234	107,639	49
1974	3,868	101,681	38
1975	3,512	90,104	39
1976	4,481	98,570	45
1977	4,123	93,772	44
1978	3,214	78,311	41
1979	3,692	84,135	44
1980	3,647	88,408	41
1981	4,740	87,194	54
1982	3,770	98,967	38
1983	5,984	117,964	51
1984	6,894	153,849	45
1985	5,797	164,054	35
1986	5,200	165,148	31
1987	6,531	163,549	40
1988	6,378	191,727	33
1989	5,978	193,141	31
1990	5,230	204,628	26
1991	7,654	212,202	36
1992	8,639	221,193	39
1993	10,023	242,577	41
1994	12,867	245,405	52
1995	12,351	267,352	46
1996	12,286	268,561	46
1997	12,847	268,557	48

Table 3.7. Indices of catch per unit effort (kg per mech. *masdhoni* day) for yellowfin tuna caught on the EAST coast during the NORTHEAST monsoon.
Source: MOFA/EPCS data compiled by MRS
Location: Kaafu Atoll, Male town, Lhaviyani Atoll. Months: Dec, Jan, Feb and March

Year	Catch (t)	Effective effort (mech *masdhoni* d)	CPUE (kg/day)
1969-70	132	3,967	33
1970-71	68	4,558	15
1971-72	147	4,682	31
1972-73	430	6,227	69
1973-74	327	6,555	50
1974-75	776	5,674	137
1975-76	296	5,954	50
1976-77	688	5,787	119
1977-78	418	6,255	67
1978-79	278	4,045	69
1979-80	396	6,807	58
1980-81	539	7,037	77
1981-82	186	6,463	29
1982-83	517	7,947	65
1983-84	1,234	12,373	100
1984-85	1,108	11,183	99
1985-86	1,516	11,571	131
1986-87	1,165	11,219	104
1987-88	984	11,800	83
1988-89	571	12,360	46
1989-90	506	11,711	43
1990-91	1,047	12,025	87
1991-92	892	10,705	83
1992-93	1,213	12,156	100
1993-94	1,802	12,066	149
1994-95	1,082	10,738	101
1995-96	1,399	12,492	112
1996-97	1,159	13,169	88

Table 3.8. Indices of catch per unit effort (kg per mech. *masdhoni* day) for yellowfin tuna caught on the WEST coast during the SOUTHWEST monsoon.

Source: MOFA/EPCS data compiled by MRS

Location: Raa and Baa Atolls. Months: June, July, Aug and Sept

Year	Catch (t)	Effective effort (mech *masdhoni* d)	CPUE (kg/day)
1970	827	6,345	130
1971	376	4,976	76
1972	1,022	5,535	185
1973	1,814	6,671	272
1974	1,294	5,555	233
1975	1,644	12,393	133
1976	1,909	11,420	167
1977	1,358	9,336	145
1978	1,131	9,079	125
1979	1,075	6,449	167
1980	1,378	6,313	218
1981	1,160	5,047	230
1982	1,898	5,897	322
1983	2,175	6,706	324
1984	1,527	8,805	173
1985	1,591	7,820	203
1986	1,053	8,804	120
1987	2,226	8,244	270
1988	1,062	7,513	141
1989	915	10,334	89
1990	479	10,199	47
1991	778	9,547	81
1992	990	10,010	99
1993	1,178	11,387	103
1994	1,437	12,684	113
1995	730	12,886	57
1996	997	13,045	76
1997	1,202	12,567	96

Table 3.9. Annual Maldivian catches (t) of yellowfin tuna and bigeye tuna (*Thunnus albacares* and *T. obesus*) combined, and estimates of bigeye tuna catch, by region, 1970-97.

Sources: Anderson (1996) and MOFA/EPCS.

Note: The North and Centre includes atolls from HA to Dh; the South from Th to S

Year	Total *Thunnus* Catch			Estimated Bigeye Catch		
	North	South	Total	North	South	Total
1970	1,530	459	1,989	8	73	81
1971	940	287	1,227	5	45	51
1972	1,770	306	2,076	10	48	58
1973	4,822	653	5,475	27	103	130
1974	3,462	666	4,128	19	105	124
1975	3,257	517	3,774	18	82	100
1976	4,135	756	4,891	23	119	142
1977	3,584	889	4,473	20	140	160
1978	2,935	649	3,584	16	103	119
1979	3,579	710	4,289	20	112	132
1980	3,696	533	4,229	20	84	105
1981	3,965	1,319	5,284	22	208	230
1982	3,505	500	4,004	19	79	98
1983	5,383	858	6,241	30	136	165
1984	4,965	2,159	7,124	27	341	368
1985	4,208	1,858	6,066	23	294	317
1986	4,113	1,208	5,321	23	191	213
1987	4,824	1,846	6,670	27	291	318
1988	4,691	1,844	6,535	26	291	317
1989	4,296	1,786	6,082	24	282	306
1990	3,544	1,735	5,280	19	274	294
1991	4,817	2,894	7,711	26	457	484
1992	6,469	2,228	8,697	36	352	388
1993	7,163	2,947	10,110	39	466	505
1994	10,281	2,845	13,126	57	450	506
1995	9,851	2,653	12,504	54	419	473
1996	8,758	3,682	12,440	48	582	630
1997	9,923	3,105	13,029	55	491	546

Fig. 3.7. Yellowfin tuna - major surface fishing areas for juvenile yellowfin in the central Indian Ocean during the two monsoons (after Anderson, 1988).

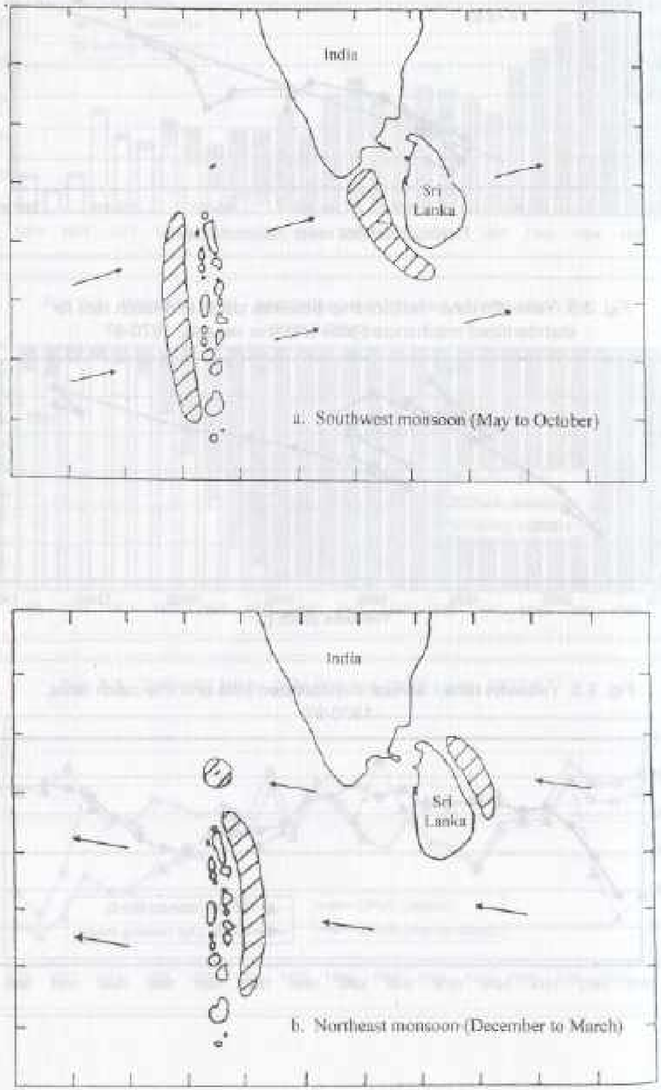
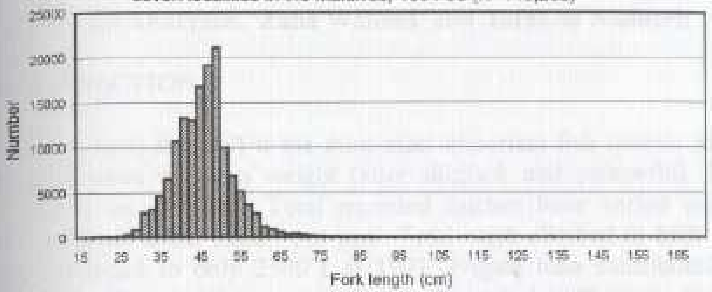


Fig. 3.8. Yellowfin tuna - length frequency distribution of catches at seven localities in the Maldives, 1994-96 (N=146,285)



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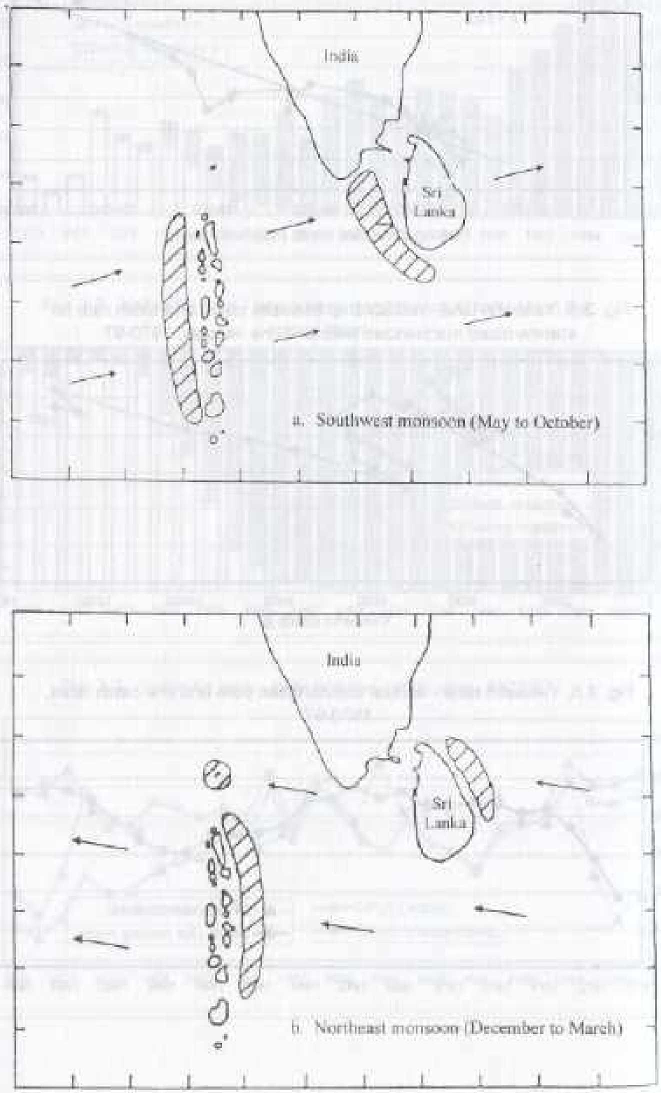

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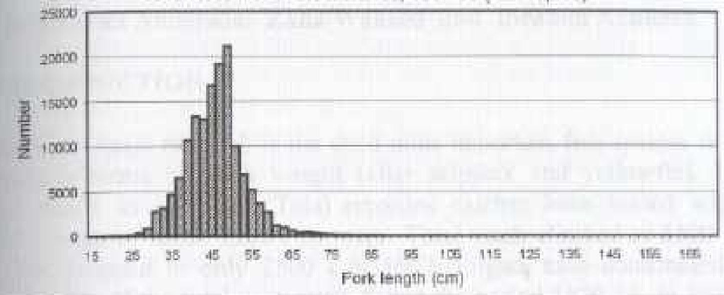


4. FRIGATE TUNA (*AUXIS THAZARD*)

R. Charles Anderson, Zaha Waheed and Ibrahim Nadheeh

4.1. INTRODUCTION

Frigate tuna (*Auxis thazard*) is the third most important fish species in the Maldives in terms of catch weight (after skipjack and yellowfin). It is known locally as *raagondi*. Total recorded catches have varied widely around a mean of about 3200 t per year. Total catch climbed to 6500 t in 1996, but dropped to only 2500 t in 1997. Frigate tuna contributed an average of 8% of the total tuna catch during the period 1970-97. In 1973 it contributed a record 20% to the total tuna catch. In recent years the relative importance of frigate tuna has decreased, with its contribution to total tuna catch averaging less than 5% during the decade 1987-96, dropping to a record low of only 3% in 1997. The bulk of the frigate tuna catch is made by livebait pole and line, although about 10% is caught by trolling.

Frigate tuna is a small species. It grows to a maximum of about 58 cm FL in the Indian Ocean (Collette and Nauen, 1983), but only very rarely exceeds 49 cm FL in Maldivian catches. Frigate tuna is found in both neritic and oceanic waters, although it is certainly commoner inshore than offshore.

4.2. FRIGATE TUNA CATCHES AND CATCH TRENDS

4.2.1. Catch and catch trends

Frigate tuna catches by vessel type for the years 1970 to 1997 are presented in Table 4.1 and Fig. 4.1. Total recorded catches have varied considerably over the years, without obvious trend. Peaks have occurred roughly every decade, in 1973-74, 1983-84 and 1993-96. The greatest recorded annual catches occurred in 1973-74 when they reached over 6000 t per year, dropping to an average of only 1640 t per year during 1978-81. Only in 1996 did catches again approach the record levels set in 1973-74. However, in 1997 catches dropped to a low of only 2500 t.

The percentage contributions of the main vessel types to annual catches are illustrated in Fig. 4.2. Pole and line vessels (*masdhoni*) are by far the most important vessel type for frigate tuna catches, accounting for an average of about 90% of recorded catches.

Trolling vessels (*vadhu dhoni*) also make significant catches of frigate tuna (Fig. 4.3), accounting for an average of 10% of recorded catches over the entire period 1970-97. The relative importance of trolling vessels rose during the transitional period of *masdhoni* mechanization, averaging 14% of frigate tuna catches during 1976-1985, and rising to about 20% in peak years (1980-81 and 1985). During more recent years (1989-97) trolling vessel catches have been less important, accounting for an average of only 5% of the total frigate tuna catch. This reflects the general decline of the troll fishery (section 1.2.3).

Frigate tuna catches by trolling vessels (Fig. 4.3) have not varied over the years in the same way as pole and line vessel catches have (Fig. 4.1). For trolling vessels, annual catches increased irregularly up to a peak in 1985, after which there has been an irregular decrease. This reflects the growth and decline of troll fishing effort. In contrast, pole and line vessel catches have varied without obvious trend. There are thought to be a variety of reasons for these differences, which are mentioned in the following sections.

4.2.2. Accuracy of catch estimates

Recorded catches of frigate tuna, as presented in Table 4.1 and Figure 4.1, are likely to differ from true catches as a result of inadequacies in the fisheries statistics system (section 1.5). For frigate tuna there are two main problems: underreporting and inadequate conversion factors.

There has been no sampling to estimate underreporting of frigate tuna. Frigate tuna is considered by Maldivian fishermen to be the least valuable of the major tuna species, so the degree of underreporting is likely to be greatest for this species. Parry and Rasheed (1995) estimated that skipjack and yellowfin catches might be underestimated by about 5% and 15% respectively, as a result of underreporting. It is therefore suggested that underreporting of at least 20% occurs for frigate tuna catches. It is possible that underreporting is a more serious problem now than in the past (i.e. during the 1970's) because the changing pattern of island life has resulted in less importance being attached to civic duties such as reporting fish catch (Anderson and Hafiz, 1996).

During the period 1970-87, single average weight conversion factors were used for both kawakawa and frigate tuna. These were higher than current estimates of average weight for frigate tuna, 0.95-1.0 kg/fish then, as against 0.6 kg/fish now (see section 4.5.2). It seems likely therefore that the use of inappropriate conversion factors may have inflated catch estimates during 1970-87. This overestimation may not be as high as it appears, since recent regional sampling (Scholz et al., 1997) has shown that an average weight conversion factor of about 0.82 kg/fish may have been appropriate for the years 1994-96.

In summary, during 1970-87 underreporting of frigate tuna catches may have been less than it is now, and may have been roughly compensated for by the use of inflated conversion factors. Since 1988, underreporting has continued (and possibly got worse) while conversion factors are thought to be more appropriate, or even on the low side, and so reported catches are likely to be underestimates of true catches.

Note that the recorded catch of frigate tuna by trolling vessels in 1985 differs greatly between the MOFA (683t) and IPTP (397t) databases; the IPTP figure is used in Figure 4.3, but the MOFA figure is used elsewhere. The reason for the discrepancy between the two databases is not known.

4.3. CATCH PER UNIT EFFORT (CPUE) TRENDS

4.3.1. National trends

Problems with using CPUE as an index of abundance for tunas are mentioned in section 1.5.2. In the case of frigate tuna there is an additional problem that should be kept in mind. Of the four main tuna species, frigate tuna is probably the least valued by Maldivian fishermen. It is not favoured for home consumption, nor it is favoured for processing. Because of this, frigate tuna schools are sometimes not fished by Maldivian fishermen, especially if good catches of other species can be made. Therefore, CPUE estimates might be particularly poor indicators of abundance for this species.

Actual pole and line vessel catch rates have varied considerably since 1970, but mostly within the range 10-25 kg/day (Figure 4.4). CPUE peaks in 1973-74, 1983-84, 1993 and 1996 correspond to the peaks in total catches as shown in Figure 4.1. With the exception of 1996, these peaks correspond with El Niño events (see section 4.4 below). There was also a minor peak in pole and line CPUE in 1977. Peak annual average catch rates were nearly 30 kg/day for sailing *masdhonis* in 1973, and roughly 25 kg/day for mechanized *masdhonis* in 1983 and 1993. Sailing *masdhoni* data are only included up to 1985, by which time the majority of the remaining non-mechanized vessels are believed to have diverted from pole and line tuna fishing to reef fishing. The annual average catch rate for mechanized *masdhonis* during the decade 1986-95 was about 13 kg/day.

Standardized pole and line catch rates are also shown in Fig. 4.4. Even allowing for the particularly high catch rates in 1972-73, there appears to have been a net decrease in standardized pole and line catch rates over the period 1970-97. If this is a true reflection of a decrease in local abundance of frigate tuna it is a cause for concern. However, it may to some extent be the result of underestimation of catch in recent years (see section 4.2.2, above). In addition, the assumption that mechanized *masdhonis* caught twice as much frigate tuna as sailing *masdhonis* may not be correct. Frigate tuna is most abundant close to the atolls on the lee side of the atoll chain (see below); as such it may have been readily available to sailing *masdhonis*. In contrast, mechanized *masdhonis* are more able to venture offshore and off exposed sides of the atoll chain in search of skipjack and yellowfin, and so will tend to catch relatively less frigate tuna. The possibility of a major regime shift, from conditions favouring frigate tuna in the 1970s to less favourable conditions in the 1990s should also be borne in mind (section 5.3.1).

Trolling vessels catch rates were low during the period 1970-82, averaging only 2 kg/day (Fig. 4.5). Since then they increased to an average of about 7.4 kg/day during 1994-96. However, *vadhu dhoni* CPUE dropped to just 2.2 kg/day in 1997. The increase in catch rates during 1982-96 coincided with a dramatic drop in trolling vessel numbers and fishing effort (see section 1.2.3 and Tables 1.4 and 1.5). The increase in catch rates might be a result of the least efficient vessels and fishermen withdrawing from the troll fishery. The recent mechanization of some trolling vessels does not appear to have contributed to increased catch rates. The average annual frigate tuna catch rate by trolling for sailing *vadhu dhonis* during 1990-95 was 4.7 kg/day, compared to 3.6 kg/day for mechanized *vadhu dhonis*. The reason for this difference is not known, but mechanized *vadhu dhonis* may be more likely to target either larger pelagic fishes (e.g. wahoo and sailfish) or reef fishes. The reason for the dramatic drop in catch rates in 1997 is not known.

The relationships between fishing effort and frigate tuna CPUE for pole and line and trolling vessels are illustrated in Figs 4.6 and 4.7. Although there is considerable variability, over the entire period 1970-97 standardized *masdhoni* fishing effort has increased, and CPUE has decreased. In contrast for trolling vessels, fishing effort has decreased and CPUE has increased. A decrease in CPUE with increase in fishing effort (or vice versa) is a classic effect of exploitation on a fished stock. The implication here might be that the frigate tuna stock is small enough to be affected by the Maldivian fishing effort. In other words it is a local stock, not an ocean-wide one, as is the case with skipjack (section 2.8) and yellowfin (section 3.8). However, this conclusion may not be valid.

There is a mismatch between the catch rate trends for the *masdhoni* and the *vadhu dhoni* fleets. Standardized *masdhoni* CPUE decreased from the 1970s to the 1990s, while *vadhu dhoni* CPUE increased over the same time period. There is no suggestion that the two fleets are exploiting separate stocks, although it is possible that the two fishing methods are targeting different components of the same stock. For example, trolling may on average take different size (age) fish than pole and line. There are few data to test this hypothesis, since length frequency data from trolling and pole and line catches are not normally recorded separately. However, limited sampling at B.Eydhafushi in 1983-84 (Anderson and Hafiz, 1985b) where catches by the two gears were kept separate, does suggest that trolling tends to catch smaller frigate tuna than pole and line. This is something that requires further investigation.

Alternatively, there may well be some problem with the estimation and/or interpretation of catch rates. For *vadhu dhonis*, it is possible that the recent increase in trolling catch rates associated with the drop in fleet size is a result of the least efficient trolling vessels (or fishermen) leaving the troll fishery. In addition, mechanization of some trolling vessels will have increased the average fishing power of the fleet (although as noted above this may not have had a direct positive effect on frigate tuna catch rates). In the case of the pole and line fleet, it is likely that mechanization of the fleet allowed fishermen to catch more of the more desirable tuna species and thus to be able to ignore some frigate tuna schools.

4.3.2. Latitudinal Trends

Frigate tuna appears to be commoner in the north of the Maldives than in the south (Anderson and Hafiz, 1985a; Anderson, 1992). Catch rates for three latitudinal zones during four time periods are summarized in Table 4.2. The pattern of change from north to south is remarkably consistent. In each of four time periods, for both trolling vessels and pole and line vessels, catches were highest in the north and lowest in the south. For both vessel types, catch rates in the central Maldives were only about half of those in the north. In the south, catch rates were on average only one tenth of those in the north.

Which factors influence the latitudinal cline in frigate tuna abundance are at present unknown, but this issue is discussed in section 1.4.1. For frigate tuna, the Veimandhoo Channel between Thaa and Laamu Atolls appears to mark a division line between north/central and southern regions. Thaa Atoll has a moderately high average catch rate typical of the central atolls, and a pattern of seasonal abundance shared with Ari, Faafu and Dhaalu Atolls. In contrast, Laamu Atoll has a low frigate tuna abundance typical of southern atolls.

Although the general trend is for frigate tuna to be more abundant in the north and centre than in the south of the Maldives, there are exceptions. For example, Lhaviyani Atoll in the north tends to record relatively low frigate tuna catches. The reasons for this may be that Lhaviyani fishermen have not only (in recent the past) sold most of their catch directly to the tuna cannery at Lh.Felivaru (which purchases only skipjack and yellowfin) but also have easy access all year round to 'offshore' fishing areas. In contrast, Gaafu Dhaalu Atoll in the south tends to record relatively high frigate tuna catches. The reason for this may be that fishermen in the south of that atoll sometimes have difficulty obtaining enough livebait for pole and line fishing and therefore carry out trolling for small tunas from *masdhonis* (Ibrahim Shakir, MOFA field officer, pers. comm., December 1996).

4.3.3. Seasonal Trends

Frigate tuna appears to show a fairly consistent pattern of seasonal distribution in the Maldives. It occurs most commonly on the western side during the northeast monsoon and on the eastern side during the southwest monsoon. This seasonal pattern was first noted by Anderson and Hafiz (1985b).

Anderson (1991) studied tuna distribution and abundance in the region of the Vatteru Channel (between Vaavu and Meemu Atolls) during the period 1985-90. He found the average catch rate for mechanized *masdhonis* was about 11.3 frigate tuna per day during June to November, but only 1.3 frigate tuna per day during January to May. Catch rates peaked at nearly 20 frigate tuna per day at the start of the southwest monsoon in June-July.

In this study, monthly frigate tuna catch rates in all atolls for all fishing vessel types each year during the periods 1970-84 and 1989-97 were examined. Atolls with similar seasonal distribution patterns were grouped. The atoll groups are detailed in section 1.4.1 (see also map, Fig. 1.1). Selected seasonal summaries are presented in Tables 4.3 and 4.4. The main findings of this analysis are:

- In the far north of Maldives, in Haa Alifu and Haa Dhaalu Atolls, catch rates are high year round. In some years peaks occur in the southwest season, in other years in the northeast season.
- On the eastern side of Maldives, from Shaviyani all the way down to Meemu Atoll, catch rates are higher in the southwest monsoon than in the northeast monsoon. Catch rates usually peak in June-July at the start of southwest season. Catch rates sometimes stay fairly high into the beginning of the northeast season.
- On the western side of the Maldives catch rates are highest during the northeast monsoon season. In Raa and Baa Atolls, catches tend to peak in December-January, while further south in Ari, Faafu and Dhaalu Atolls catches tend to peak slightly later in January-March.
- In the south of the Maldives, from Laamu to Seenu Atoll, catch rates are always low, but they do tend to be highest during the northeast monsoon season.

The seasonal distribution of frigate tuna may be explained by a combination of migration and recruitment (Anderson, 1991). Frigate tuna presumably move from side to side of the double atoll chain in synchrony with the seasonally oscillating monsoon currents. In addition, at Malé, there is often an increase in the numbers of small frigate tuna (less than 30cm FL) at the end of the northeast monsoon season and beginning of the southwest monsoon season, i.e. during April to July (Figure 4.9). This suggests that recruitment at the beginning of the southwest monsoon season is an important factor in maintaining high catch rates during that season. (See section 4.7 for further discussion of recruitment).

Off the southwest coast of Sri Lanka, frigate tuna are most abundant during the southwest monsoon season (Maldeniya et al., 1987). This is consistent with the seasonal pattern recorded in Maldives.

4.4. OCEANOGRAPHIC VARIATIONS

4.4.1. El Niño Southern Oscillation Events

Frigate tuna catches and catch rates tend to increase during El Niño years (Anderson, 1987 & 1993; Hafiz and Anderson, 1994; Anderson, Hafiz and Adam, 1996). Pole and line vessel catches and catch rates show peaks during the strong El Niño years of 1972-73 and 1983 and in 1993 (the latter being during the prolonged 1991-95 event). In these cases, high catches were also recorded in subsequent years (1974, 1984 and 1996). During the weak El Niño years of 1976-77 and 1987, peaks in pole and line catches and catch rates were only barely discernible (Fig. 4.4).

More detailed investigation shows that the greatest increase in catch rates during El Niño years is seen on the western side of the country during the early part of the southwest monsoon season (i.e. May or June to August). This effect was particularly pronounced during the strong ENSO events in 1972-3 and 1982-3.

The oceanographic factors that might cause an increase in frigate tuna catch rates during ENSO events are not known (see section 1.4.3). It is not even certain whether they affect recruitment or catchability. At Malé, and elsewhere, May-June is the period of peak recruitment (see section 4.7). Elevated catch rates at this time therefore suggest increased recruitment during ENSO events. High catches of frigate tunas in the year after an ENSO event might therefore reflect fishing on a strong year class. In this context, the drop in catch rates in 1997 might be interpreted as a return to 'normal' levels after the prolonged El Niño of 1991-95, and consequent high catches in 1996. However, the rather limited length frequency data available from Malé (1985-1996) show no obvious increase in the frequency of small frigate tuna during El Niño years.

Frigate tuna catches and catch rates by trolling vessels do not show obvious peaks during ENSO events. The reasons why trolling vessel catches should differ from pole and line vessel catches in this way are not known.

4.4.2. Decadal Scale Variations

The medium-term trends in catches and catch rates of frigate tuna are discussed in sections 4.2.1 and 4.3.1. Major changes in *vadhu dhoni* catches and catch rates (Figs. 4.3 and 4.5) are most easily explained by changes in

fishing effort. Frigate tuna catches and catch rates by *masdhonis* (Figs. 4.1, 4.4 and 4.6) have varied without clear trend over the period 1970-97. The peaks in 1973, 1983 and 1996 can be explained by increased catchability and/or abundance during or immediately after ENSO events (see section 4.4.1, above). The decadal scale pattern of variations that are so obvious in skipjack (section 2.4.2) and yellowfin (section 3.4.2) catches are not readily apparent with frigate tuna. However, Anderson (1993) did note that frigate tuna catch rates declined over the period 1983-90, at the same time as yellowfin catch rates also declined and skipjack catch rates increased. Furthermore, inspection of Fig. 4.6 does show some concordance between patterns of *masdhoni* CPUE for frigate tuna and those for the other major species: for the level of effort expended, frigate tuna catch rates were relatively low during 1984-92, and relatively high thereafter. Thus, it seems likely that frigate tuna catch rates are influenced by the same decadal scale oceanographic variations that affect skipjack (section 2.4.2) and yellowfin (section 3.4.2) catch rates, albeit perhaps less dramatically.

4.5. SIZE AND GROWTH

4.5.1. Length Distribution

Frigate tuna tends to have a rather limited size range in Maldivian catches (Fig. 4.8). 95% of the 57,000 frigate tunas measured in Maldives during 1994-96 (excluding suspect data from G.A.Vilingili) were within the range 27-41 cm FL. 50% were within the range 31-37 cm FL. The average (mean, mode and median) length sampled was 34 cm FL. Only four of 57,000 frigate tunas were longer than 49 cm FL. The largest frigate tuna measured was 56 cm FL. The largest frigate tuna recorded from the Indian Ocean by Collette and Nauen (1983) was 58 cm FL.

4.5.2. Average Weights

Tuna catches are reported by fishermen in numbers, and are converted to weights using average weight conversion factors. For frigate tuna, the following conversion factors have been used by the Ministry of Fisheries and Agriculture at different times (Anderson et al., 1996; Scholz et al., 1997):

1959-1975	1.0 kg/fish
1976-1987	0.95 kg/fish
1988-date	0.6 kg/fish

Average weights of frigate tuna landed at seven locations during 1994-96 ranged from 0.57-0.93 kg/fish, with a mean of 0.82 kg/fish (Scholz et al., 1997).

4.5.3. Growth

There have been no previous studies of frigate tuna growth in the Maldives. As noted by Anderson (1987a) frigate tuna length frequency data show periods of modal progression, modal stasis and modal regression; these are the result of the interaction of growth, migration and recruitment. Attempting to resolve the growth component alone is problematic.

As part of this study, monthly length frequency histograms of all available data were produced. In view of the limited size range sampled, the problem of seasonal migration, and the often inadequate sample sizes, it was decided not to attempt fitting von Bertalanffy parameters (or those of any other growth model) to the data. Instead, the histograms were scrutinised for signs of model progression from which growth rate estimates were made by eye. This analysis of modal progression was limited to the size range 27-41 cm FL. Within this relatively small range it was assumed that growth is roughly linear.

Numerous examples of modal progression were noted, with apparent growth rates ranging from 0.5 to 3.0 cm/mo. However, there was a clear mode at 1.0 cm/mo within the size range 27-39 cm FL, with a secondary mode at 2.0 cm/mo. Note that the preponderance of integer values is probably an artefact of the use of 1 cm histogram class widths combined with the fact that very few modes could be followed for more than a few months.

While other growth rate estimates cannot be discounted, it is seems likely that an estimated growth rate of about 1.0 cm/mo is closest to the true rate. This value is certainly consistent with the results of other studies within the region:

Country	Length at age (cm) 1	2	3	Growth rate in 2nd year (cm/mo)	Source
Sri Lanka	24.9	38.7	46.8	1.15	Joseph et al. (1988)
India (Kerala)	29.2	42.2	50.3	1.08	Silas et al. (1985)
Thailand	26	37	43	0.92	Yesaki (1982)

These results suggest that frigate tuna recruit to the Maldivian fishery at an age of nearly 1 year; that most frigate tuna are caught between the ages of about 1 and 2.5; and that very few frigate tuna over the age of about 3 years are caught.

4.6. MIGRATION

On the basis of analysis of seasonal shifts in catch rates, Anderson (1991) suggested that frigate tuna migrated from side to side of the Maldivian atoll chain in phase with the seasonally oscillating monsoon currents. The results of the present analysis are consistent this interpretation. Frigate tuna are commoner on the 'down-stream' or lee side of the Maldives than on the 'up-stream' or exposed side (section 4.3.3). This is presumably related to food availability (section 1.4.2), primary productivity and plankton abundance being greater on the lee side of the Maldives than on the exposed side.

In addition to these season movements there may also be a net southward movement of frigate tuna, in some seasons and areas. As noted above, the peak of frigate tuna catches during the northeast monsoon season in Raa and Baa Atolls occurs a month or two before it occurs in Ari, Faafu, Dhaalu and Thaa Atolls just to the south. Also, sizes of frigate tuna landed at Malé market tend to be consistently smaller than those landed further south at M.Maduveri. It should be noted, however, that comparisons of catch rates and sizes between other sampling locations do not show evidence of such latitudinal movements.

There has been no tagging study of frigate tuna movements in Maldivian waters. A single frigate tuna was accidentally tagged in 1994 during skipjack tagging operations (Anderson, Adam and Waheed, 1996). It was not recovered.

4.7. REPRODUCTION

There have been no studies of frigate tuna reproduction in the Maldives. From fish caught off the west coast of Thailand, Yesaki (1982) estimated that female frigate tuna begin to develop sexually at 33 cm, and reach sexual maturity at 38 cm.

Analysis of length frequency data shows two annual peaks of recruitment (i.e. peaks of occurrence of small frigate tuna less than 30 cm FL), which suggests two peaks of reproductive activity. At Malé market these small fish are most abundant during April to June, at the end of the northeast monsoon and beginning of the southwest monsoon (Fig. 4.9). A second peak in abundance of small fish occurs during September to December, at the other monsoon changeover.

At G.Dh.Thinadhoo, in the southwest of the Maldives, peaks of abundance of small fish again occur during the monsoonal changeover periods (Fig. 4.10). Greatest recruitment occurs at the end of the southwest season (August to November) with a second peak at the end of the northeast monsoon (April). At both Malé and G.Dh.Thinadhoo, peak recruitment occurs in the months before the start of the monsoon season during which peak catch rates are made.

At M.Maduveri, south of Malé, there are again two peaks in the occurrence of small fish, but these do not occur during the monsoon changeover periods. Rather, peaks occur in February and August (Fig. 4.11). Furthermore the frequency of occurrence of small fish in frigate tuna catches at M.Maduveri is much lower than at Malé. The significance of these observations is not known.

4.8. STOCK RELATIONSHIPS

There has been no study of the stock relationships of frigate tunas caught in Maldivian waters. During an exploratory offshore fishing survey carried out off the east coast of Maldives, some frigate tuna were caught offshore, up to 100 miles from the atolls (Anderson and Waheed, 1990). This suggests that there may be some mixing with 'Sri Lankan frigate tuna' and therefore that Maldivian frigate tuna belong to an Indian Ocean or central Indian Ocean stock.

On the other hand, higher catch rates tend to be made close to the atolls rather than further offshore. During the exploratory fishing survey carried out off the east coast of Maldives, although frigate tuna were caught offshore, the numbers involved were relatively small (Anderson and Waheed, 1990). Furthermore, frigate tuna larvae are apparently not widely distributed across the ocean, but rather are concentrated close to continental margins or around island groups (Stéquert and Marsac, 1989). This suggests

that for some purposes, Maldivian frigate tuna might be considered to be a separate 'sub-stock.'

4.9. STOCK STATUS

The catch and effort data available for Maldivian frigate tuna are not thought to be appropriate for use in production model analysis. The reasons for this include:

- uncertainties over stock boundaries (see section 4.8);
- uncertainties over the accuracy of catch data (as mentioned above) and effort data (as a result of changes in fishing power of the Maldivian fleet);
- the seasonal nature of the fishery (see below), which makes the use of national and annual totals of catch and effort for such analysis suspect;
- the large variations in catches and catch rates apparently related to variations in oceanographic conditions rather than changes in fishing effort (see section 4.4 above).

Anderson and Hafiz (1985a) did carry out surplus production model analysis of frigate tuna catch and effort data for the years 1970-1983. The data suggested a maximum sustainable yield of about 3700t per year. However, it was noted (Anderson and Hafiz, 1985a,b & d) that the many inadequacies of the data and of the models used made the interpretation of this result problematic.

Despite these uncertainties, some observations suggest that frigate tuna around the Maldives are being exploited at a high rate:

- The dramatic and as yet unexplained drop in frigate tuna catches between 1996 and 1997.
- Frigate tuna catch rates by pole and line vessels have stagnated during recent years (Figs. 4.4 and 4.5). Catches have not increased by much over the last 10-15 years despite an enormous increase in pole and line fishing effort.
- Trolling vessels catch rates tend to decrease with increased fishing effort (Fig.4.6).

On the other hand, some observations suggest that frigate tuna may not be being overexploited:

- Frigate tuna is for many Maldivian fishermen little more than by-catch. As a result changes in catch may not accurately reflect changes in abundance.
- As mentioned above, there are statistical problems. In particular, the use of apparently inappropriate average weight conversion factors may have artificially inflated catch and CPUE estimates in earlier years and/or deflated them in later years.
- Also as mentioned above, there are very large variations in apparent abundance of frigate tuna associated with oceanographic changes (see section 4.4). This suggests that oceanographic variations may be more important than local fishing activity in determining local frigate tuna abundance.

4.10. OTHER INFORMATION

4.10.1. Bullet Tuna

Bullet tuna (*Auxis rochei*) is very similar to frigate tuna in appearance (see Collette and Nauen, 1983). It is caught in Maldives (Anderson and Hafiz, 1985b; MRS, 1988), but catches are not distinguished from those of frigate tuna. The proportion of bullet tuna in the frigate tuna catch is small, probably less than 1% overall (Anderson, 1987a; Hafiz and Anderson, 1994). However, the numbers of bullet tuna in Maldivian catches do appear to vary from place to place and season to season, so a systematic sampling programme to estimate its contribution to catches would be desirable.

4.10.2. Raagondi koli

In Dhivehi, the Maldivian language, frigate tuna is known as *raagondi*. Pufferfishes are known as *koli*. Pelagic pufferfishes of the genus *Lagocephalus* are known as *raagondi koli*. Two species have been recorded from Maldives: *Lagocephalus lagocephalus* and *Lagocephalus sceleratus* (Randall and Anderson, 1993). *Raagondi koli* are, very rarely, caught by fishermen trolling for small tunas (Anderson and Hafiz, 1985c; Hafiz, 1985).

There are old reports of people dying from eating *raagondi koli*, and most Maldivians know that it is poisonous. However, there is widespread confusion as to what *raagondi koli* really is. Many people believe that *raagondi koli* is a type of *raagondi*. It is said to be almost impossible to distinguish between the poisonous and non-poisonous forms. One way to do so is said to be by putting crushed lime (*huni*, calcium oxide) on the fish's cut flesh: the lime will turn blue if the fish is poisonous. It seems likely that confusion has arisen between tetrodotoxic (pufferfish) poisoning and scombrotoxic (tuna/histamine) poisoning. Frigate tuna might be particularly prone to developing scombrotoxicity because of its relatively high proportion of dark meat and its relatively small size (promoting rapid putrefaction) compared to other Maldivian tunas. Partly because of fear of poisoning, and partly because of its small size and boniness, frigate tuna always fetches a lower price on Malé fish market than other tuna species. Detailed accounts of scombrotoxic and tetrodotoxic poisoning are given by Halstead (1988).

Table 4.1. Annual Maldivian catches (t) of Frigate Tuna by vessel type, 1970-97.
Source: MOFA/EPCS.

Year	Sail P/L	Mech P/L	Total P/L	Trolling	Misc	Total
1970	2775	--	2775	248	...	3023
1971	2849	--	2849	166	...	3015
1972	3004	--	3004	182	...	3186
1973	6440	--	6440	186	...	6626
1974	5804	--	5804	202	...	6006
1975	3713	181	3894	163	...	4057
1976	1971	448	2419	289	...	2707
1977	1863	953	2816	264	...	3080
1978	720	735	1455	206	...	1661
1979	435	994	1429	272	...	1701
1980	207	1084	1291	304	...	1595
1981	141	1156	1297	309	...	1606
1982	80	1750	1830	231	...	2061
1983	141	3048	3189	351	...	3540
1984	66	2701	2767	338	...	3105
1985	70	2071	2141	683	...	2824
1986	130	1309	1439	339	...	1778
1987	25	1580	1605	316	...	1921
1988	14	1373	1387	239	3	1629
1989	5	1944	1949	192	5	2146
1990	21	2760	2781	228	3	3012
1991	2	2421	2423	154	5	2582
1992	32	3219	3251	130	8	3389
1993	34	3216	5250	200	6	5456
1994	12	3755	3767	242	10	4019
1995	8	3715	3723	202	0	3925
1996	10	6227	6237	243	5	6485
1997	2	2415	2417	71	1	2488

Table 4.2. Average regional catch rates (kg/day) for frigate tuna by different vessel types and time periods
Source: MOFA/EPCS data compiled by MRS
Note: North includes atolls from HA to Lh; Centre from K to Th; South from L to S

Vessel Type	Propulsion	Years	Catch Rates (kg/day) North	Centre	South
Trolling	Sail	1970-74	3.1	2.1	0.1
	Sail	1975-78	2.0	1.4	0.5
	Sail	1979-83	3.4	1.1	0.1
	Sail & Mech	1989-95	5.3	1.8	0.3
Pole and line	Sail	1970-74	30.3	16.3	3.8
	Sail & Mech	1975-78	29.6	9.6	4.4
	Mechanized	1979-83	34.9	16.9	2.4
	Mechanized	1989-95	26.7	14.9	2.5

Table 4.3. Average seasonal catch rates (kg/day) for frigate tuna by pole and line vessels for different areas and time periods
Source: MOFA/EPCS data compiled by MRS
Note: SW monsoon season lasts from June to October; NE monsoon from December to April

Area	1970-74 Sailing P/L		1975-78 Mixed P/L		1979-83 Mech P/L		1989-95 Mech P/L	
	SW	NE	SW	NE	SW	NE	SW	NE
North (HA-HDh)	7.8	27.5	17.4	38.9	39.5	27.2	12.6	12.6
NE (Sh-N)	63.5	27.6	62.0	25.7	149.7	52.8	84.9	23.7
Centre-east (Lh-M)	16.9	5.4	28.2	4.2	41.4	4.6	27.8	5.8
NW (R-B)	14.0	62.9	12.9	35.5	14.4	49.5	10.6	34.2
Centre-west (A-Th)	8.8	27.0	2.8	24.9	3.1	7.6	3.3	16.4
South (L-S)	1.9	4.5	1.4	7.9	0.6	4.4	0.9	4.5

Table 4.4. Average seasonal catch rates (kg/day) for frigate tuna by trolling vessels for different areas and time periods
Source: MOFA/EPCS data compiled by MRS
Note: SW monsoon season lasts from June to October; NE monsoon from December to April

Area	1970-74		1975-78		1979-83		1989-95	
	SW	NE	SW	NE	SW	NE	SW	NE
North (HA-HDh)	1.3	2.2	1.4	1.5	2.3	2.6	2.3	5.0
NE (Sh-N)	3.8	3.4	3.3	2.4	5.1	3.0	7.5	4.2
Centre-east (Lh-M)	2.4	1.2	1.4	0.8	0.6	0.1	1.2	1.8
NW (R-B)	2.7	5.7	1.1	1.8	1.2	4.5	7.8	5.6
Centre-west (A-Th)	0.7	3.8	0.6	2.5	0.8	1.4	1.0	2.7
South (L-S)	0.0	0.1	0.0	1.1	0.1	0.1	0.2	0.4

Fig. 4.1. Frigate tuna - annual catches by vessel type, 1970-97

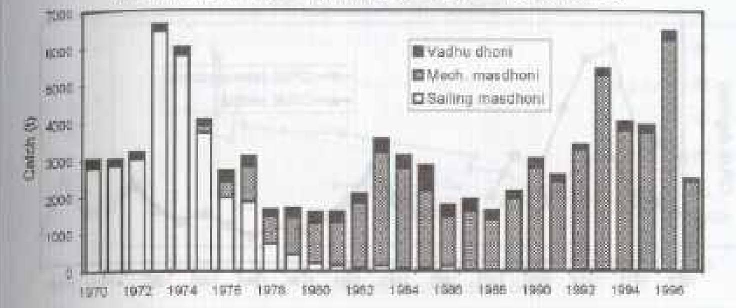


Fig. 4.2. Frigate tuna - percentage contribution to annual catches by different vessel types, 1970-97

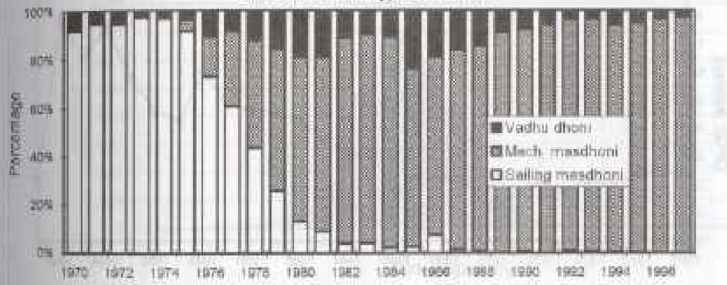


Fig. 4.3. Frigate tuna - annual catches by trolling *vadhu dhonis*

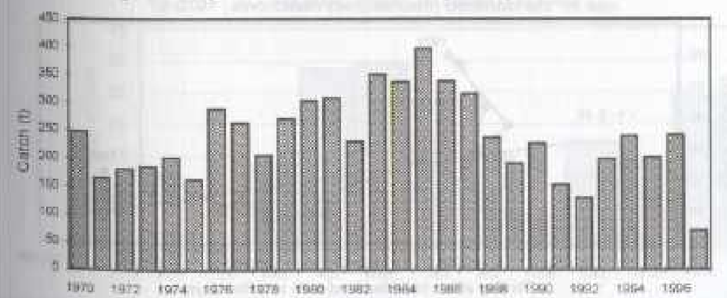


Fig. 4.4. Frigate tuna - catch rates by pole and line *masdhonis*

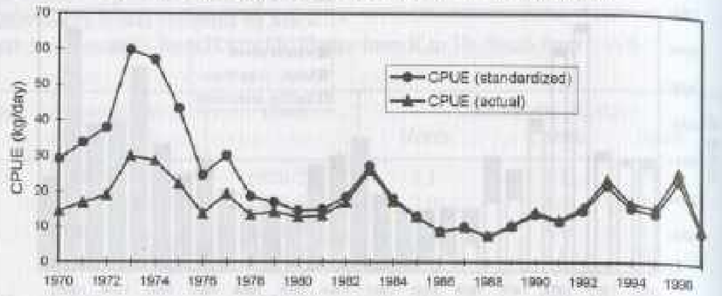


Fig. 4.5. Frigate tuna - catch rates by trolling *vadhu dhonis*

Fig 4.6. Frigate tuna - relationship between fishing effort and catch rate for standardized (mechanized) *masdhonis*, 1970-97

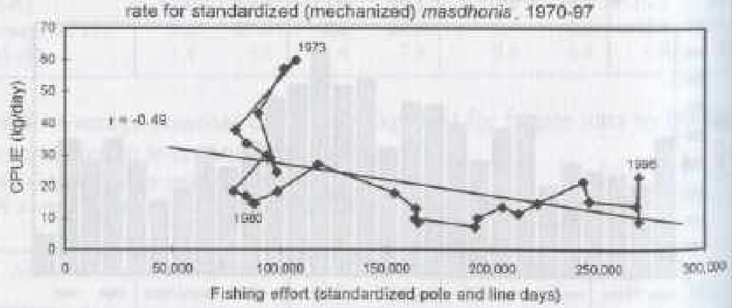


Fig. 4.7. Frigate tuna - relationship betweeen fishing effort and catch rates for trolling *vadhu dhonis*, 1970-97

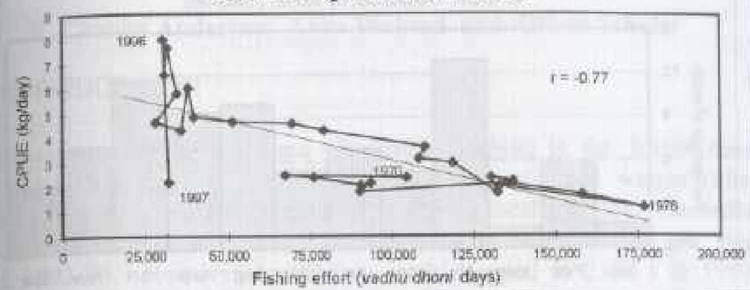


Fig. 4.8. Frigate tuna - length frequency distribution of catches at six locations in the Maldives, 1994-96 (N=56,955)

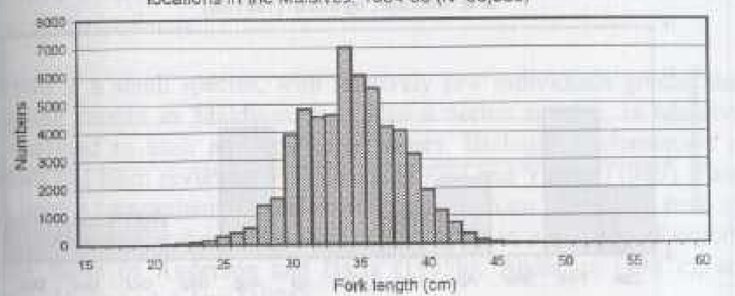
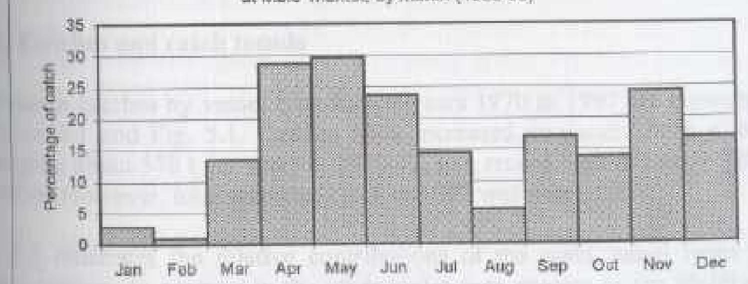
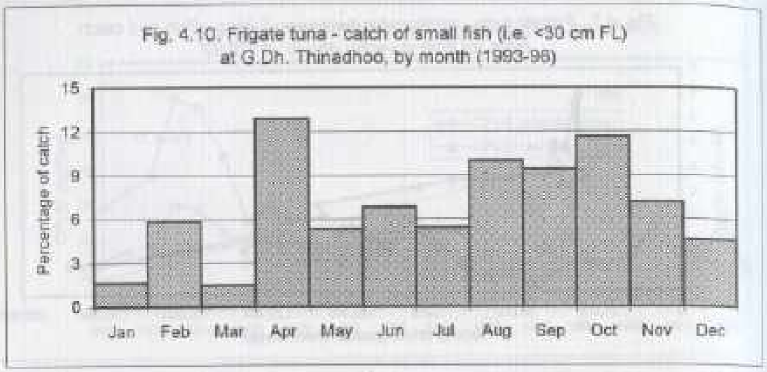
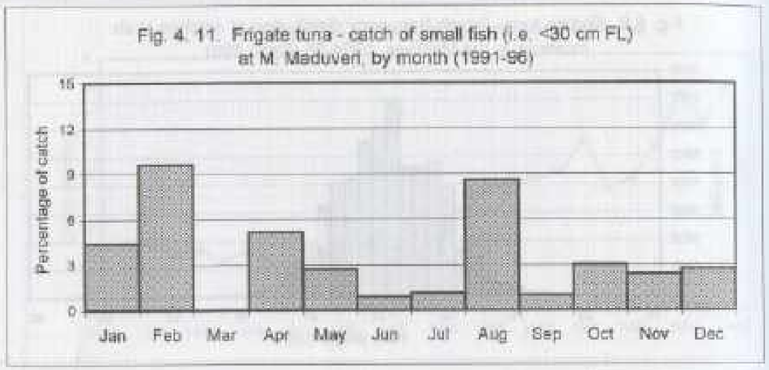


Fig. 4.9. Frigate tuna - landings of small fish (i.e. <30 cm FL) at Male' market, by month (1985-96)







5. KAWAKAWA (*EUTHYNNUS AFFINIS*)

R. Charles Anderson, Zaha Waheed and Oliver Scholz

5.1. INTRODUCTION

Kawakawa or eastern little tuna (*Euthynnus affinis*) is the fourth most important fish species in the Maldives in terms of catch weight (after skipjack, yellowfin and frigate tuna). It is known locally as *latti*. Recorded catches have increased in recent years, averaging about 3200 t per year during 1993-96. However, kawakawa catch dropped to 2100 t in 1997. Kawakawa contributed about 3% of the total national tuna catch throughout the period 1970-97. An average of nearly 40% of the total kawakawa catch during 1970-97 was taken by trolling *vadhu dhonis*. The rest is taken by pole and line *masdhonis*.

Kawakawa is a small species, with relatively few individuals greater than 50cm being caught in Maldives. It is also a neritic species, in Maldives being confined to atoll and near-atoll waters. Biological information on kawakawa has been reviewed by Yoshida (1979) and Yesaki (1989). There has not been a comprehensive review of information on kawakawa from the Maldives, although some information is presented in a number of reports, including those of Anderson and Hafiz (1985b), Anderson (1987a), and Anderson, Hafiz and Adam (1996).

5.2. KAWAKAWA CATCHES AND CATCH TRENDS

5.2.1. Catches and catch trends

Kawakawa catches by vessel type for the years 1970 to 1997 are presented in Table 5.1 and Fig. 5.1. Catches have increased erratically from a low (averaging about 570 t per year) in 1970-72, to a record high of nearly 3800 t in 1996. However, total recorded catch in 1997 was only 2100 t.

Fig. 5.2 illustrates the relative contributions of the main vessel types to annual catches. In contrast to the other major tuna species in the Maldives (which are taken mainly by pole and line *masdhonis*), the trolling *vadhu dhoni* is of great importance for kawakawa catches. A total of over 38% of the total kawakawa catch during 1970-97 was taken by *vadhu dhonis*. This figure actually underestimates the traditional importance of *vadhu dhonis*, since the troll fishery has all but collapsed since the mid-1980s (section

1.2.3). During the period 1970-85, *vadhu dhonis* accounted for an average of 62% of the kawakawa catch. In 1977-78, when *vadhu dhonis* fishing effort was at its peak and *masdhoni* fishing effort was at a low ebb during the transitional period of *masdhoni* mechanization, *vadhu dhonis* accounted for a record 83% of total kawakawa catch. Actual catch of kawakawa by *vadhu dhonis* peaked in the early 1980s (Fig. 5.3), when the catch averaged over 1000 t per year. Since then *vadhu dhoni* catches have declined, to just 220 t in 1997. During 1992-97, since the collapse of the troll fishery, *vadhu dhonis* have accounted for an average of just 13% of the total kawakawa catch. During the same period, mechanization of the *vadhu dhoni* fleet has proceeded apace and the catch of kawakawa by sailing *vadhu dhonis* has dropped to just a half of the total *vadhu dhoni* catch (Table 5.2).

Pole and line *masdhonis* accounted for an average of 62% of the total kawakawa catch during the period 1970-97, but just 41% during the two decades 1970-89. The replacement of sailing *masdhonis* by mechanized *masdhonis* following the start of mechanization in the mid-1970s is reflected in kawakawa landings (Fig. 5.2). However, for kawakawa the changeover was less dramatic than it was for other species. During 1980-85, sailing *masdhonis* caught 15.5% of the total *masdhoni* catch of kawakawa, but only 1.7% of the total *masdhoni* catch of skipjack tuna. This difference illustrates the marginalization of the sailing *masdhonis* and their relegation to trolling and reef fishing (section 1.3).

Since the mid-1980s, while the *vadhu dhoni* catch has decreased (Fig. 5.3), the catch by mechanized *masdhonis* has increased greatly (Fig. 5.2). Average annual catch of kawakawa by mechanized *masdhonis* during 1984-87 was just 620 t. During 1992-97, kawakawa catch by mechanized *masdhonis* averaged nearly 2500 t per year, which was 86% of the total. Mechanized *masdhoni* catches peaked at 3360 t in 1996, but dropped to just 1860 t in 1997.

5.2.2. Accuracy of Catch Estimates

Recorded catches of kawakawa, as shown in Table 5.1, are likely to differ from the true catch as a result of inadequacies in the fisheries statistics system (see section 1.5). For kawakawa there are two main problems: underreporting and inadequate conversion factors.

Parry and Rasheed (1995) estimated that skipjack and yellowfin catches might be underestimated by about 5% and 15% respectively as a result of underreporting. There has been no sampling to estimate underreporting of kawakawa, but it is considered by Maldivian fishermen to be a less important species than skipjack. On this basis alone, it is suggested that the degree of underreporting of kawakawa catches is likely to be greater than 5%. In addition, it is likely that trolling catches are underreported to a greater degree than pole and line catches. It is also likely that the degree of underreporting has increased in recent years as a result of changing attitudes to civic duties in the islands (Anderson and Hafiz, 1996). It is therefore suggested that underreporting of at least 10% occurs for kawakawa catches.

Tuna catches are reported by fishermen in numbers, and are converted to weights using average weight conversion factors. For kawakawa, recent sampling suggests that an average weight conversion factor of about 1.1kg/fish is appropriate (Anderson, 1988; Scholz et al., 1997). However, for the years 1970-1987 conversion factors of 1.0 and 0.95kg/fish were used (section 5.5.2). It is possible therefore that the weight of kawakawa catches may have been underestimated by about 10% in those years.

In summary, it is suggested that there is underreporting of kawakawa catches. During 1970-87 this source of error may have been compounded by the use of deflated conversion factors. Since 1988, conversion factors are thought to be more appropriate (although still far from perfect), but underreporting may have increased. Therefore, reported catches of kawakawa are likely to be underestimates of true catches, perhaps by about 20%.

5.3. CATCH PER UNIT EFFORT TRENDS

5.3.1. National Trends

Pole and line catch rates have increased erratically since 1970 (Fig. 5.4). The irregular increase in kawakawa catch rate with increasing *masdhoni* fishing effort is illustrated in Fig. 5.6. CPUE peaks in 1973, 1982-83, 1993 and 1996 all correspond to catch peaks (Fig. 5.1). With the exception of 1996, these were all El Niño years (section 5.4.1). During the decade 1970-79, sailing *masdhonis* averaged catch rates of about 1.6 kg kawakawa per day. During 1993 and 1996 mechanized *masdhoni* catch rates peaked at about 14 kg kawakawa per day. It is difficult to explain this enormous increase simply in terms of increased fishing power. Other factors to be taken into account include:

- Possible large-scale oceanographic influences affecting kawakawa abundance or availability. Decadal-scale variations are discussed in section 5.4.2. However, an additional consideration is the possibility of a shift from a regime of high frigate tuna catch rates (Fig. 4.4) and low kawakawa catch rates in pole and line fishing areas in the 1970s, to the opposite in the 1990s.

- Increased marketability of kawakawa in recent years affecting fishermen's willingness to target this species. MIFCO started buying kawakawa in late 1993, and private businessmen have been buying it to make Maldive fish.

- Inadequacies in the method of standardizing *masdhoni* effort. This is based on total tuna catches (section 1.5.1.2), and may not be entirely appropriate for kawakawa. If the peak catch rates associated with ENSO events are excluded, the net increase in standardized kawakawa catch rate by *masdhonis* from about 2.5 kg/day in 1970-71 to just over 6 kg/day in 1997 can be accounted for by a 3.5% per year increase in efficiency (over and above that already accounted for in the standardization process).

Vadhu dhoni catch rates have also increased erratically since 1970 (Fig. 5.5). Most of the increase has occurred since 1978. Since that time, *vadhu dhoni* fishing effort has dropped dramatically, from some 177,000 days fishing in 1978 to only 30,000 in 1996 (Fig. 5.8). It is likely that the least efficient vessels dropped out of the fishery first, and this is thought to be the most important single factor contributing to the rise in catch rates during the 1980s. The increase in kawakawa catch rates over time by trolling *vadhu dhonis* is seen in all regions (Table 5.3). In the last few years both *vadhu dhoni* fishing effort and kawakawa catch rates have stabilized. However, the 1997 drop in *masdhoni* catch rates is also seen in *vadhu dhoni* catch rates.

5.3.2. Latitudinal Trends

Kawakawa is commoner in the north and centre of the Maldives than in the south (Anderson and Hafiz, 1985b; Anderson, 1987a & 1992).

Average catch rates for different time periods, for both trolling and pole and line vessels, are summarized in Table 5.3. Trolling catch rates tend to be slightly higher in the north than in the centre, while pole and line catch rates tend to be slightly higher in the centre then in the north. Overall there appears to be little difference in kawakawa abundance between the north and the centre. In contrast, catch rates in the south of the Maldives are 10-100 times lower than in the north and centre.

The latitudinal distribution of kawakawa is very similar to that of frigate tuna (section 4.3.2). Both species are relatively uncommon south of the Veimandhoo Channel, which separates Thaa and Laamu Atolls (section 1.4.1).

5.3.3. Seasonal Trends

Kawakawa catches and catch rates tend not to show the marked seasonality so characteristic of the other major tuna species in the Maldives.

Catch rates for pole and line vessels are listed by area and season in Table 5.4, and for trolling vessels in Table 5.5. For pole and line vessels there is no obvious pattern of seasonal variation in kawakawa catch rates throughout most of the country, particularly in the north and south of the country. However, in the centre-east (i.e. Lhaviyani to Meemu) average catch rates are consistently higher in the southwest monsoon season than in the northeast season. Part of the explanation for this seasonal difference may be that fishermen (in Malé Atoll at least) report fishing closer to the atolls during the southwest monsoon season (when the sea is rough) than during the northeast season (when they venture further offshore in search of yellowfin and large skipjack schools). In other words, the seasonal variations in catch rates may be the result of changing patterns of fishing activity, rather than seasonal variations in abundance of kawakawa. Alternatively, there may be a real increase in kawakawa abundance in the southwest monsoon season in this region, perhaps associated with a peak in recruitment (see section 5.7) and/or inter-atoll migrations (see section 5.6).

Whatever the explanation for the apparent increase in pole and line catch rates for kawakawa during the southwest monsoon in the centre-east Maldives, this is in direct contrast to the findings of Anderson (1991). He reported no seasonal variation in mechanized pole and line catch rates in the region of the Vatteru Channel (between Vaavu and Meemu Atolls) during the period 1985-90. In that study, variation between years for particular months was found to be greater than monthly variation within years. The discrepancy between the findings of the two studies may in part be due to differences in the way the data have been lumped.

In contrast to the pole and line vessel catch rates, trolling vessel catch rates show clear seasonal variation. Throughout the entire north and centre-east of the country, trolling catch rates are consistently higher in the southwest monsoon season than in the northeast season (Table 5.5). Since most trolling has been carried by sailing vessels, this may be a result of better sailing conditions during the southwest season (when wind speeds tend to be higher) than in the northeast season. The highest catch rates tend to be made at the beginning of the southwest monsoon season (May and June), when large numbers of small kawakawa are present (section 5.7). Table 5.5 shows that trolling catch rates in the centre-west of the country (Ari to Thaa Atolls) tends to be higher in the northeast season than in the southwest season. Closer inspection of the data shows that trolling catch rates for Ari, Faafu and Dhaalu Atolls actually peak in May, during the transition from the northeast to the southwest monsoon.

In summary, much of the variation in kawakawa catch rates that does occur may be related to seasonally changing patterns of fishing activity. There might be relatively little seasonal variation in abundance of kawakawa as a result of seasonal migrations between Maldivian atolls. Since kawakawa is not an open ocean species, but is closely associated with the atolls, this is not unexpected. However, it is possible that there are relatively small-scale movements of kawakawa (e.g. from side-to-side of individual atolls) that cannot be resolved with the data available (which are aggregated by atoll), but which would be known to experienced fishermen. Strongly seasonal recruitment patterns also play a role in determining seasonal catch rates (section 5.7).

5.4. OCEANOGRAPHIC VARIATIONS

5.4.1. El Niño Southern Oscillation Events

Kawakawa catch rates tend to be higher than normal during ENSO events (Anderson, 1987a, 1991 & 1993; Hafiz and Anderson, 1994; Anderson, Hafiz and Adam, 1996). Anderson (1991) noted elevated catch rates for kawakawa by mechanized pole and line vessels in the region of the Vattaru Channel (between Vaavu and Meemu Atolls) in September, October and November during the 1987 ENSO event.

In this study, increased catch rates in El Niño years are confirmed. However, no obvious seasonal or regional change in catch rates associated with ENSO events are discerned. Catch rates of kawakawa during El Niño and non-El Niño years are summarized in Table 5.6. Over the entire period 1970-97, catch rates by *masdhonis* were nearly 60% higher during El Niño years than during non-El Niño years. For *vadhu dhonis*, catch rates were on average 11% higher during El Niño years. Because there have been great changes in fishing patterns and fishing power over the period 1970-97, comparisons over such a long time period may be misleading. Therefore, comparisons are also made between catch rates during ENSO events and the average of the catch rates in the years immediately before and after. For *masdhonis*, catch rates during El Niño years were 3-85% higher than the average of catch rates in the years immediately before and after. For *vadhu dhonis*, catch rates were 6-44% higher during El Niño years.

5.4.2. Decadal Scale Variations

Variations is kawakawa catches over the period 1970-97 are dominated by the rise and fall of *vadhu dhoni* catches during the 1980s, the rise of mechanized *masdhoni* catches during the 1990s, and the effects of ENSO events. It is less easy to discern other trends in kawakawa catches that might be attributed to decadal-scale oceanographic variations than it is for skipjack and yellowfin tuna (sections 1.4.4, 2.4.2 and 3.4.2).

Nevertheless, it is clear from Fig. 5.6 that *masdhoni* catch rates were somewhat lower than expected for the amount of fishing effort carried out during 1984-91, but higher than expected during 1992-96. These periods correspond closely with the alternating periods of high and low skipjack and yellowfin catch rates that have been associated with decadal-scale oceanographic variations. The decrease in kawakawa catch rates by *masdhonis* during the early and mid-1980s and subsequent increase in the late 1980s and early 1990s has been noted previously, and attributed to decadal scale oceanographic variations (Anderson, 1993; Hafiz and Anderson, 1994; Anderson, Hafiz and Adam, 1996). Maldivian kawakawa catch rates (and therefore presumably also abundance) do, therefore appear to be influenced by the same decadal scale oceanographic variations that affect catch rates of the other main tuna species.

The possibility of a regime shift, from a period of high frigate tuna and low kawakawa catch rates in the 1970s to the reverse in the 1990s is mentioned above in section 5.3.1. With no independent evidence to support this hypothesis it is not discussed any further here.

5.5. KAWAKAWA SIZE DISTRIBUTION

5.5.1. Length Distribution

A summary length frequency distribution for kawakawa measured at six sampling sites during 1994-96 is given in Fig.5.8. 95% of the 13,000 kawakawa measured were within the range 26-48cm FL. 50% were within the range 32-42cm FL. The mean length of the sample measured was 38cm FL. The smallest kawakawa measured was 15cm FL, and the largest was 63cm FL.

These size ranges are similar to those reported in previous studies (Anderson and Hafiz, 1985b; Anderson, 1987a; Anderson, Hafiz and Adam, 1996). However, the largest kawakawa reported by Anderson (1987a) was 74cm FL. That individual was measured at Malé market in January 1986; a second individual of 74cm FL was measured at Malé market in January 1992. These are the largest kawakawa recorded so far in the Maldives.

The size range caught in the Maldives is comparable to the sizes caught elsewhere in the Indian Ocean (Yesaki, 1989). However, individuals of at least 87 cm FL have been recorded in the Seychelles (Steinberg et al., 1982). The maximum length for this species is reported to be about 100cm FL (Collette and Nauen, 1983).

On the basis of limited catch sampling at B.Eydafushi during 1983-85, Anderson and Hafiz (1985b) noted that there was no obvious size difference between catches made by trolling vessels and those made by pole and line vessels.

5.5.2. Average Weights

Tuna catches are reported by fishermen in numbers, and are converted to weights using average weight conversion factors. For kawakawa, the following conversion factors have been used by the Ministry of Fisheries and Agriculture at different times (Anderson and Hafiz, 1996; Anderson et al., 1996; Scholz et al., 1997):

1959-1975	1.0 kg/fish
1976-1987	0.95 kg/fish
1988-1996	1.1 kg/fish

Average weights of kawakawa landed at seven locations during 1994-96 ranged from 0.6-1.5kg/fish, with a mean of 1.12kg/fish (Scholz et al., 1997). This mean weight estimate is in good agreement with the average weight conversion factor currently being used by EPCS. However, the relatively large seasonal variations in average size (sections 5.5.3 and 5.7; also Fig. 5.9) mean that the use of annual average weight conversion factors is likely to produce significant errors in catch estimates. As an example, kawakawa landed at Malé market during the first quarter of the year weigh an average of 1.51 kg each, while in the second quarter the average weight is only 0.88 kg each (Scholz et al., 1997). See also Fig. 5.9.

5.5.3. Growth

There have been no previous studies of kawakawa growth in the Maldives. As noted by Anderson (1987a), Maldivian kawakawa length frequency data do show periods of clear modal progression, but cases exist where two separate sets of modes converge. Such cases are the result of the interaction of growth, migration and recruitment; it is difficult to resolve the growth component alone.

As part of this study, monthly length frequency histograms of all available data were produced. An example, illustrating sizes of kawakawa measured at Malé market between January 1994 and December 1995, is presented in Fig. 5.10. Attempts were made to fit von Bertalanffy growth parameters to these data using a range of length frequency data analysis programmes (ELEFAN, Projection Matrix and Shepherd's Length Composition Analysis, all available on a Length Frequency Data Analysis package, Version 3.10, developed by the Marine Resources Assessment Group, Imperial College, London, and provided by the British Overseas Development Administration). Robust results were not obtained. For Malé data from March 1994 to January 1995 (when clear modal progression was apparent: Fig. 5.10), no programme gave an unequivocal estimate of von Bertalanffy parameters. All models gave best fits for unacceptably high values of $L\infty$ (i.e. in the region of 120 cm FL, while the largest kawakawa measured in Maldives were 74cm FL). Estimates of $L\infty$ within the relatively limited range 71-80cm FL could be obtained, but corresponding estimates of K spanned the unacceptably wide range 0.37-0.86.

More simply, growth rates were estimated by eye for periods during which clear, linear modal progression was apparent (Fig. 5.10). For both the periods March to December 1994 and March to June 1995, average growth rate was estimated at about 1.6 cm/mo. This growth estimate applies within the length range 28-45 cm FL.

Yesaki (1989) reviewed kawakawa growth studies in the Indian Ocean. A wide range of growth rate estimates have been made. The rate estimated here of 1.6 cm/mo (roughly 19 cm/year) within the size range 28-45 cm FL is higher than that obtained by most other studies (roughly 1.25 cm/year). However, comparable results have been obtained from the Seychelles using modal progression analysis (Ommanney, 1953).

5.6. KAWAKAWA MIGRATION

There has been no study of kawakawa movements in Maldivian waters. No tagging has been carried out. Analysis of seasonal changes in kawakawa CPUE (see section 5.3.3) does not give a clear indication of migratory activity. Kawakawa catch rates in the east-centre of Maldives are higher in the southwest monsoon than in the northeast monsoon. This might be taken as evidence of migration from side to side of the atoll chain, in a manner similar to that proposed for frigate tuna (section 4.3.3). However, these CPUE changes might also be explained in terms of seasonal changes in fishing activity. Furthermore, there is no corresponding out-of-phase change in CPUE on the west coast. The nature and extent of kawakawa migrations within the Maldives therefore remain unknown. It is quite likely that there are seasonal migrations within atolls, but data are not available to test this possibility.

5.7. KAWAKAWA REPRODUCTION

There has been no study of kawakawa reproduction in the Maldives. No gonad studies have been carried out. From length frequency studies, the largest numbers of small kawakawa (i.e. <30 cm FL) are seen at Male market in March and April (Fig. 5.10; MRS, 1997: Vols. 1,3 & 4). High proportions of small kawakawa were also caught at Baa Atoll in April and May 1986 (Anderson and Hafiz, 1985b: 1988 revision) and at Laamu Atoll in April 1994 during the second tuna tagging programme (MRS, 1997: Vol. 2). It therefore appears that there is a major and widespread peak in recruitment at this time. This is followed in some areas by a peak in trolling catch rates in May and June (section 5.3.3). Many Maldivian fishermen report the regular appearance of large numbers small kawakawa in April-May. They refer to these fish as *assidha kashi latti* (or sometimes *assidha kethi latti*). *Assidha* and *kethi* are *nakaiy* (section 1.4.2) in April and May.

A second peak in recruitment in September-November is apparent from Male length frequency data (MRS, 1997: Vols. 1, 4 & 5). This suggests that there are two main spawning periods. However, the presence of a few small kawakawa in all months also suggests that at least some spawning occurs year-round.

5.8. KAWAKAWA STOCK RELATIONSHIPS

There has been no study of kawakawa stock structure in the Indian Ocean. However, kawakawa is generally regarded as a neritic species (Yoshida, 1979, Collette and Nauen, 1983, Yesaki, 1989). In Maldives, kawakawa is closely associated with the atolls. It is also found between the atolls, but is not normally found offshore. During a 12 month exploratory offshore fishing survey carried out off the east coast of Maldives (Anderson and Waheed, 1990), only four kawakawa were caught offshore (30-60 miles east of Lhaviyani Atoll in November 1988). Larvae are found offshore, but are commonest near continental margins and islands (Yoshida, 1979; Yesaki, 1987). It is therefore suggested that for most purposes the kawakawa found around the Maldives may be considered to be a single unit of stock. The extent of mixing between the Maldives and the Lakshadweep to the north is not known.

5.9. KAWAKAWA STOCK STATUS

As mentioned above, the kawakawa found in Maldivian waters are thought to be a discrete unit of stock. There has been no rigorous stock assessment of the Maldivian kawakawa resource. However, there is no evidence prior to 1997 that the stock was being exploited at a level greater than its sustainable yield (Anon, 1997). There is certainly little suggestion of a decrease in catch rates at current high levels of fishing effort (Fig. 5.6). The reason for the drop in catches and catch rates in 1997, for both *masdhonis* and *vadhu dhonis*, is not known. The fact that the drop in 1997 followed a record high catch in 1996 is suggestive of overexploitation. However, the dynamics of the kawakawa population, and in particular the effects of oceanographic variations, are so poorly understood that it is not yet possible to interpret the decline in catch in 1997 with any confidence.

Table 5.1. Annual Maldivian catches (t) of kawakawa by vessel type, 1970-97.
Source: MOFA/EPCS.

Year	Sail P/L	Mech P/L	Total P/L	Trolling	Misc	Total
1970	242	--	242	402	...	644
1971	220	--	220	253	...	473
1972	253	--	253	343	...	596
1973	574	--	574	514	...	1088
1974	397	--	397	433	...	830
1975	140	7	147	268	...	415
1976	157	34	191	762	...	953
1977	112	48	160	767	...	927
1978	78	55	133	634	...	768
1979	94	79	173	548	...	721
1980	104	191	295	768	...	1063
1981	119	284	403	871	...	1274
1982	172	671	843	1044	...	1887
1983	98	895	993	1094	...	2087
1984	49	646	695	1019	...	1714
1985	99	811	910	1267	...	2177
1986	23	476	499	572	...	1071
1987	18	548	566	666	...	1232
1988	11	690	701	547	9	1257
1989	13	811	824	485	13	1322
1990	15	1238	1253	631	7	1891
1991	4	1244	1248	413	16	1677
1992	65	1998	2063	376	12	2451
1993	20	3061	3081	475	13	3569
1994	11	2217	2228	421	7	2656
1995	11	2274	2285	404	3	2692
1996	3	3364	3367	260	23	3789
1997	1	1864	1865	220	3	2088

Table 5.2. Annual catches of kawakawa by trolling vessel, 1989-97
Source: MOFA/EPCS.

Year	Catch by type of trolling vessel (t) Sailing	Mechanized	Total	Percentage by Sailing
1989	463	22	485	95%
1990	614	17	631	97%
1991	395	18	413	96%
1992	356	20	376	95%
1993	446	29	475	94%
1994	313	109	422	74%
1995	322	82	404	78%
1996	242	156	398	61%
1997	115	105	220	52%

Table 5.3. Average regional catch rates (kg/day) for kawakawa by different vessel types and time periods
Source: MOFA/EPCS data compiled by MRS
Note: North includes atolls from HA to Lh; Centre from K to Th; South from L to S

Vessel Type	Propulsion	Years	Catch Rates (kg/day)		
			North	Centre	South
Trolling	Sail	1970-74	6.1	4.3	0.1
	Sail	1975-78	9.3	7.5	0.1
	Sail	1979-83	7.8	8.0	0.2
	Sail & Mech	1989-95	14.8	10.3	1.1
Pole and line	Sail	1970-74	1.8	2.7	0.1
	Sail & Mech	1975-78	2.9	2.0	0.1
	Mechanized	1979-83	3.1	9.6	0.1
	Mechanized	1989-95	7.1	10.3	0.3

Table 5.4. Average seasonal catch rates (kg/day) for kawakawa by pole and line vessels for different areas and time periods

Source: MOFA/EPCS data compiled by MRS

Note: SW monsoon season lasts from June to October; NE monsoon from December to April

Area	1970-74 Sailing P/L		1975-78 Mixed P/L		1979-83 Mech P/L		1989-95 Mech P/L	
	SW	NE	SW	NE	SW	NE	SW	
North (HA-HDh)	0.7	0.5	3.9	1.8	4.4	5.0	4.5	3.5
NE (Sh-N)	5.7	2.1	3.5	9.4	0.7	9.9	16.6	12.1
Centre-east (Lh-M)	2.4	1.3	1.8	0.5	4.1	1.1	7.5	6.5
NW (R-B)	1.1	2.0	2.0	0.7	1.2	3.0	3.2	8.0
Centre-west (A-Th)	2.6	2.6	3.6	1.5	7.7	0.9	8.3	17.2
South (L-S)	0.1	0.1	0.1	0.1	0.2	0.4	0.2	0.3

Table 5.5. Average seasonal catch rates (kg/day) for kawakawa by trolling vessels for different areas and time periods

Source: MOFA/EPCS data compiled by MRS

Note: SW monsoon season lasts from June to October; NE monsoon from December to April

Area	1970-74		1975-78		1979-83		1989-95	
	SW	NE	SW	NE	SW	NE	SW	NE
North (HA-HDh)	4.8	3.0	7.5	5.9	8.0	7.3	14.4	14.2
NE (Sh-N)	7.0	3.5	10.9	7.4	8.3	5.8	16.8	11.2
Centre-east (Lh-M)	2.8	1.6	6.5	3.0	5.0	1.9	7.7	4.7
NW (R-B)	10.6	7.1	12.2	9.4	8.7	7.0	19.6	10.7
Centre-west (A-Th)	3.4	3.0	6.2	8.4	7.7	7.8	9.4	10.5
South (L-S)	0.1	0.1	0.1	0.1	0.2	0.1	1.1	1.1

Table 5.6. Comparison of kawakawa catch rates (kg/day) during El Niño Southern Oscillation events and 'normal' years

Source: MOFA/EPCS data compiled by MRS

Years compared		Standardized *masdhoni* catch rates			*Vadhu dhoni* catch rates		
ENSO	Non-ENSO	ENSO	Non-ENSO	ENSO increase	ENSO	Non-ENSO	ENSO increase
1970-97		6.8	4.3	59%	9.0	8.1	11%
72-73	71&74	4.3	3.3	31%	5.2	4.2	23%
76	75&77	1.9	1.7	16%	5.6	3.9	44%
82-83	81&84	8.5	4.6	85%	8.6	8.0	6%
87	86&88	3.4	3.2	3%	9.6	8.9	8%
92-94	91&95	10.2	7.2	42%	13.5	12.3	9%

Fig. 5.1. Kawakawa - annual catches by vessel type, 1970-97

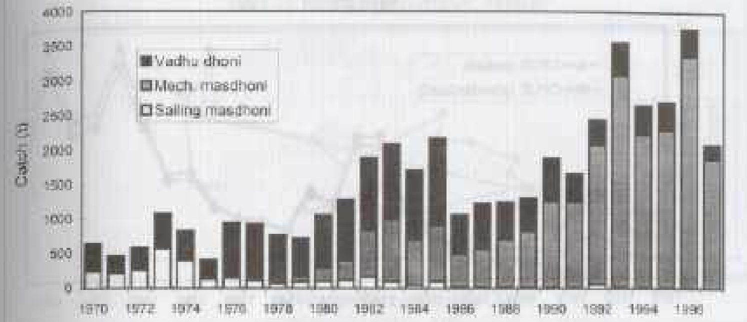


Fig. 5.2. Kawakawa - percentage contribution to annual catches by different vessel types, 1970-97

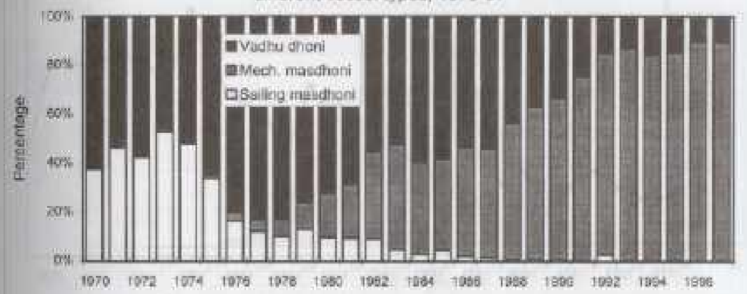


Fig. 5.3. Kawakawa - annual catches by trolling *vadhu dhonis*

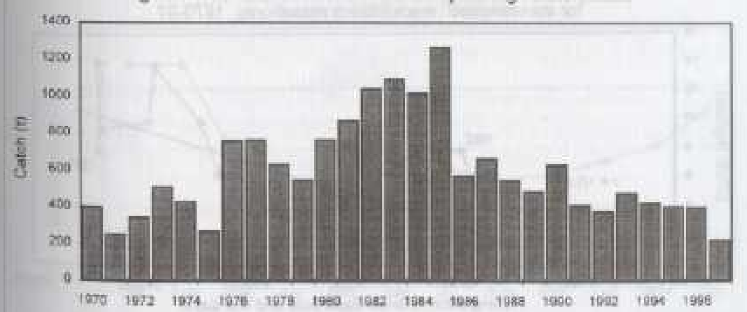


Fig. 5.4. Kawakawa - annual catch rates by pole and line *masdhonis*, 1970-97

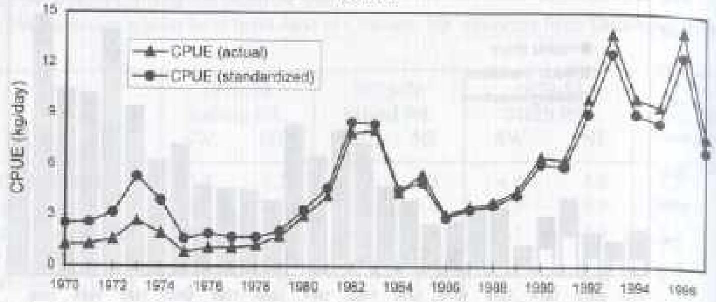


Fig. 5.5. Kawakawa - annual catch rates by trolling *vadhu dhonis*

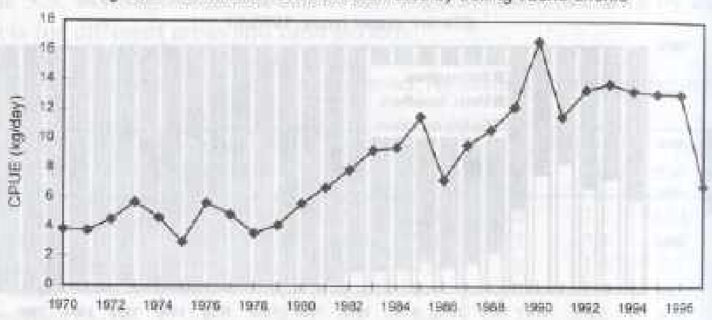


Fig. 5.6. Kawakawa - relationship between fishing effort and catch rate for standardized (mechanized) *masdhonis*, 1970-97

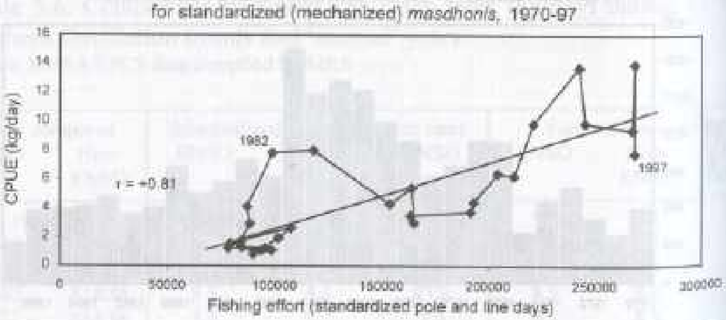


Fig. 5.7. Kawakawa - relationship between fishing effort and catch rates for trolling *vadhu dhonis*, 1970-97

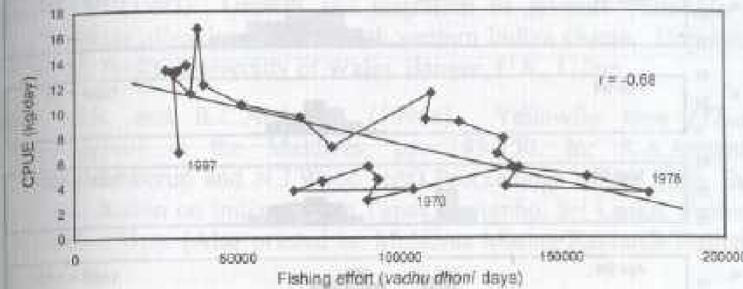


Fig. 5.8. Kawakawa - length frequency distribution of catches at seven locations in the Maldives, 1994-96 (N=12,972)

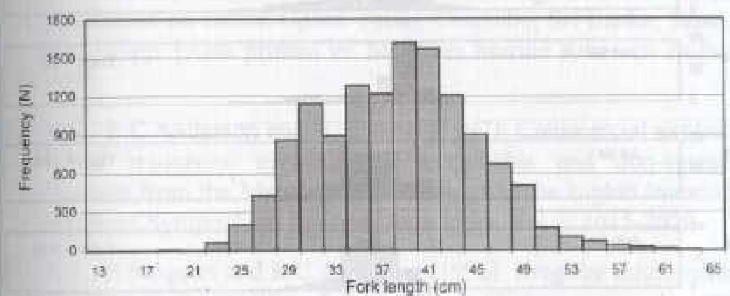


Fig. 5.9. Kawakawa - average size landed at Male' market, by month (source: MRS data, 1985-96)

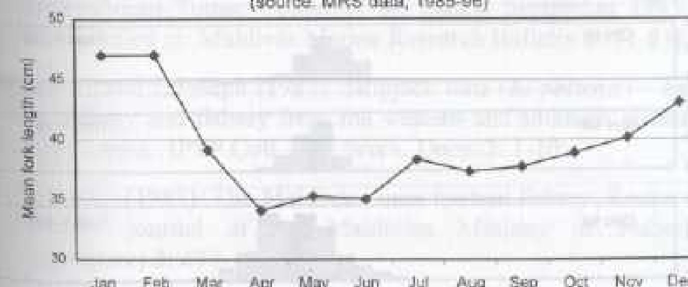
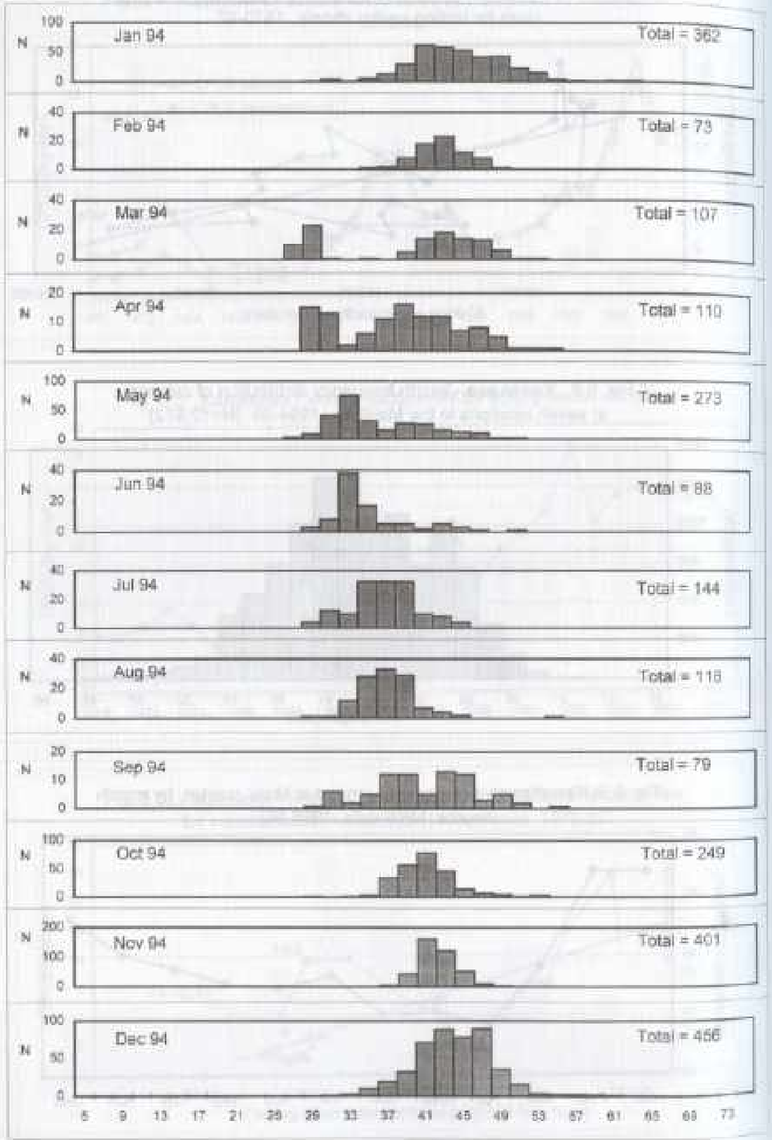


Fig. 5.10. Kawakawa - Monthly length frequency distributions at Malé, 1994 (FL in cm)



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މަސްވެރިކަން ކުރުވާ މިންވަރު

މަސްވެރިކަން ކުރުވާ މިންވަރު ބޮޑުކުރުމުގައި ދިރިތަކެއްގައި ކުރިހަމަވާއެވެ. ރާއްޖޭގެ މަސްވެރިކަން ވައިގަޔާތުތައްގައި ބޮޑުކަމަކަށް ދެވޭތީ މަސްވެރިކަމުގެ ފުރަތަމަ މަސްވެރިކަމުގައި ކުރިކަން ވަގުތު އެކިއެކި މަސްވެރިކަމުގައި ބަލާފައި ފުރިހަމަ ކުރެވިފައެވެ. މަސްވެރިކަން ކުރުވާ މިންވަރު ދިރުމަށް ކުރުމުގައި ދިރާސާ ބޮޑުވެ ދިރިތަކެއް ތިރީގައި ފުރަތަމަ ކުރުވައިފައެވެ.

* ކަނޑުފަހަރުގެ މަސްވެރިކަން މައިގަނޑު ގޮތެއްގައި ބަރޯސާވެފައި އޮންނަ މަސްވެރިކަމުގެ މަސްވަރެވެ. ފުރަތަމަ އެހެންނަމަވެސް މަސްވެރިކަން ކުރުވާ މިންވަރު އަށް މީހުން އިތުރުގައި މަސްވެރިކަން ކުރެވޭން އެކި މީހުން މިންވަރު ކުރުމުގައި އަސްވެރިކަން ކުރެވޭ މަސްވެރިކަން ރާއްޖޭ ގޮތުގެ ބޭނުންވެއެވެ. އަސްވެރިކަން ކުރުމުގައި ގިނަވެގެން ރާއްޖޭގައި ކަނޑުފަހަރުގެ މަސްވެރިކަން ކުރުމުގެ ބައިގައި ރާއްޖޭ ކުރުމާ ވަގުތު ކުޑަވެއެވެ. ހަމަ އެއްކަލަ ކަނޑުމަސްވެރިކަން ކުރުމުގެ ބައިގައި އެއް ފަހަރު އެކި ދުވަހު އަނެއް ފަހަރު ވަރަށް ދުރަށް ވެސް އުޅެއެވެ. އަދި އެކި ގިނަމީހުން މީގެ ދެފަހަރު ކަނޑުމަސްވެރިކަން ދުވަހު ދަތުރު ސަބަބުން ވެސް އެކި ހިފެހެއްޓުން އިތުރު ދެފަހަރު މަސްވެރިކަން ކުރުން ވަރަށް އޮޅެއެވެ.

* އަސްވެރިކަން ކުރެވޭ އަދި ގޮތަށް ވެސް ފަހަރު ބަދަލުކުރެވޭ އައިސްފައެވެ. މިގޮތުން ގިނަ އަހަރުތަކުން އަސްލުގައި އަދި އެކި ރާއްޖޭގައި ވަގުތުގައި ގިނަ ދުވަހުން ފަހަރުގެ ތަފާތު އުސޫލުތަކެއްގައި ހުރިހާއެވެ. އަދި ދުވަހުގެ އަހަރުތަކުގައި ރާއްޖޭގެ ފަހަރުތަކެއް އެކި ދުވަހެއްގައި މަސްވެރިކަން ކުރުމުން ވެސް މަސްވެރިކަން ކުރުވާ މިންވަރު ބަލާފައި ވާނެއެވެ.

* އެމަސްދުވަހު ބޮޑު ބާރަށް ދުވާ އިންޑިޔާ އެކުރުން ވެސް މި މިންވަރު ބަދަލުވާނެއެވެ.

* އޮއިވާ ކަނޑުމަތިގެ ސަބަބުން އަދި ވައި ދުނިޔޭގެ ސަބަބުން ވެސް އައިސް ފެނުނެވެ. މިއީވެސް އައިސް ކުރުވާ

ދުނިޔޭގެ މޫސުމަށް ބޮޑެތި ކަމުގައިއުވަސް މިކަން ފެނުނުއެވެ. އަދި އިންޑިއާ ކަނޑު ފެސިފިކް ކަނޑުގެ ދެމެދު "އެލްނީނޯ ސަދަރން އޮސިލޭޝަން" އޭގެއިތުރުން ބަހައްޓައި މިހިސާބު އެކުލެ "ސަދަރން އޮސިލޭޝަން"އެވެ. ބަލާފައި އަހަރުތަކުގައި އޮސިލޭޝަން ސަދަރން އޮސިލޭޝަން ގެ އަސަރު ކަނޑުތަކަށް ފޯރުވައި ވަނީ ބަލާފައި މިންވަރަށްވެ. އެލް ނީނޯގެ އަސަރު އެކި އަހަރުތަކުގައި ފޯރުވާފައިވާ މިންވަރު ތިރީގައިވާ ތާވަލުގައި ބަޔާންކޮށްފައިވާނެއެވެ.

އެލް ނީނޯގެ އަސަރު އެކި ފަހަރުމަތިން ކޮށްފައިވާ މިންވަރާއި އަހަރުތައް

އަހަރު	އަސަރުކުރި މިންވަރު
1973-1972	ވަރުގަދަ
1977-1976	ދެރަ
1983-1982	ވަރަށް ވަރުގަދަ
1987	މެދުމިން
1995-1991	ދެރަ
1998-1997	ވަރަށް ވަރުގަދަ

އަދި މީގެ އިތުރުން "ލާ ނީނާ" އަހަރުތަކުގައި ކަނޑުގެ ފިނިމިން ދިރުވެއެވެ. މިގޮތުން 1971، 1974 އަދި 1988އިން1989ގެ އަހަރުތަކަކީ "ލާ ނީނާ"ގެ ގޮތުގައި ފާހަގަ ކުރެވިފައިވާ އަހަރުތަކެވެ. އަދި މިހިސާބުން 1998ވަނަ އަހަރަކީ ވެސް މިފަދަ އަހަރެކެވެ. އިންޑިއާ ކަނޑުގެ ސަރަހައްދުގައި އޮޑިނަރީ ސަދަރން އޮސިލޭޝަން ގެ ސަބަބުން ޖެހޭ ގޮތުން ހުރިކަން ވަނީ 1924 ގެ އަހަރުތަކުގައި ފާހަގަކުރެވިފައެވެ. މިކަން އިންޑިއާގެ ހުޅަނގު ދޮށްވެރިގައި ވެސް ވޮޑާ އާއި ގުޅުން ހުރިކަން ފާހަގަ ކޮށްފައިވެއެވެ. އަދި ރާއްޖޭގައި އޮޑިނަރީ ސަދަރން އޮސިލޭޝަން ގެ އަހަރުތަކުގައި ކަޅުބިލަ މަހުގެ މަސްވެރިކަން ވަނީ ދެރަވެ ބޮޑުވެސް ފައެވެ. ނަމަވެސް އެހެން އަހަރުތަކުގައި ކަޅުބިލަ މަސްވެރިކަން ވަނީ ރަނގަޅުވެފައެވެ. ހަމަ އެއާއެކު ލާ ނީނާ އަހަރުތަކުގައި ކަޅުބިލަ މަހުގެ މަސްވެރިކަން އިތުރުވެފައިވެއެވެ.

ބޮޑެތި ޤައުމުތަކާއި ހިމާޔަތުގެ ކަން ހުޅުވާލަނީ ކުރިން ބޮޑުކުރާ ޤައުމުތަކާއި އަތޮޅުތަކުގެ ބިމާއި ވައިގެ ދަރަޖަ ދަށްކުރުމަށް ބޭނުންކުރެވޭ ކަމަށް ފެންނަ ކަމެއް ނެތެވެ. އެއީ ގޮތަކަށް ކަނޑުގެ ފެނުގެ ހޫނުމިން މަތިވެ ހުރުމުގެ ސަބަބުން ދިޔަ ބޮޑުވެ އަލުން ކަނޑުތަކުގެ މޫސުމަށް އަސަރުކުރެއެވެ. އަދި ހަމަ ފަދައިން ކަނޑުގައި ވިލާ ގަނޑުތައް ހުރިގޮތް އަނެއްކާ ހަމަ ގޮތް ބަދަލުކުރާތީ އެކި ގަޑިގަޑީގައި ވިއްސާރަ ބޮޑުވާ ގޮތް ބަދަލުވަނީ ވަރަށް ބޮޑަށެވެ. އަދި ތަފާތު މޫސުމުގެ ގޮތުން ދުނިޔެ ގުޅިފައި ހުރުމުން ބަދަލުވާ ގޮތްވެސް ތަފާތެވެ.

ކަނޑުގެ ފަތި ހޫނުމިނުގެ ދުރު މިންވަރު ބަދަލުވެފައިވާ ގޮތުން ބަލާއިރު ގިނަ ސަރަހައްދުތަކުގައި 29.0°C އެވެ. މިހެންވީ ޚުސޫޞީ ހޫނުމިނުގެ ބަދަލުތަކާއި ގުޅިގެންނެވެ. މިއީ ބަދަލުވާ ސަބަބެކެވެ. ކަނޑުގެ ގޮތް ހޫނުމިނާއި ގުޅޭ ހޫނުމިނުގެ ޝިދްދަތުން ވަރަށް ބޮޑަށް ވާނެއެވެ. ތަފާތު ގޮތްތަކުގައި ގޮތް ހޫނުމިނުގެ ތަފާތު މިންވަރު ކަނޑުގެ ސަރަޙައްދުގެ ބޮޑުމިނުގައި 29.9°C އަށް ބޮޑުވެއެވެ. ދުނިޔޭގެ ހޫނުމިނުގެ ރޭޓުން ބަލާއިރު ދުރު ހޫނުމިނަށް ވުރެ ގިނައިން ދަރަޖަ އަށް ހޫނުމިން އިތުރުވެއެވެ. ދެންނެވި ހޫނުކަން ދަށްވާ ހޫނުމިން ބޮޑުވުމާއި ބޮޑުމިނުގައި ގިނަ ސަރަހައްދުގައި 27.6°C އެވެ. ދުނިޔޭގެ ހޫނުމިނުގެ ގިނަ ހޫނު ވެސް ވަރަށް ހޫނުމިން ދެމިހުރެ ދައްކައެވެ. އަދި މިސާލަކަށް ބޭރުގައި ގިނަ ހޫނު ވެސް އަޑީން ދަރަޖަ ދައްކައެވެ. އެއީ އިތުރުވެ ދުނިޔޭގެ އެތެރޭގައެވެ. އަދި ހޫނުމިން ވަރަށް ދިގުކޮށް ބަދަލުވުމާއި ގުޅިގެން ފަރާތްތަކުން ބަދަލުވެއެވެ.

އެލް ނީނޯ ސަދަރަން އޮސިލޭޝަން

"އެލްނީނޯ" އަކީ ޕެސިފިކުގައި ކަނޑުގެ ހޫނުގަދަކަން އަރާ ބަދަލުވުންތަކުގެ ސަބަބުން ދެކުނު އެމެރިކާގެ ކަނޑުގެ ދުނިޔޭގެ އެތެރޭގެ ބަދަލުވުމެވެ. މިކަން ކުރިމަގުގައި ފާހަގަކުރެވޭ ކަމަކަށް ވެއެވެ. ކަނޑުގެ ސައިންސްވެރިންގެ ދިރާސާ ތަކުގައި ވަނީ ދުނިޔޭގެ ހޫނު ދަރަޖަ ދަށްވާނެ ކަމަށް ގިނަ އަހަރު ތެރޭގައި ފާހަގަކުރެވިފައެވެ. ދުވަސް ތަފާތު ވަރަކަށް ހޫނުމިން ފެންނަ ކަމަށް ދެކެވެއެވެ. އަދި ބޭރުގެ ޤައުމުތަކުން ފެނުނު ބަދަލުތަކުގައި އެވެ. މިއީ ކުރެވޭ ކަނޑުގެ އަސަރާއި ސަރަޙައްދުތައް ބަދަލުވާ ގޮތެވެ. އިސްރާއީލުގެ ގައުމުތަކުގެ ބަދަލުވުމުގެ ސަބަބުން އަހަރެއްގައި އެކި ދުވަސްވަރުގެ ގޮތްތައް ބަދަލުވެއެވެ. 1997 ވަނަ އަހަރުން ފެށިގެން

ކަމެއް ކުރިމަތިވެގެން ދިޔައީ ގިނަ ޤައުމުތަކުގެ ސަރަޙައްދުތަކަށް ވަރަށް ބޮޑަށް އަސަރުކޮށްފައެވެ.

* ދުނިޔޭގެ ދެކުނުގައި ހުރި ސައިންސްވެރިން ކަމަށް ބަލައިގެން، ޕެސިފިކްގެ ދެކުނު ހިސާބުގައި ސަރަޙައްދުތަކުގެ އިސްކަން ދެމިހުރެ، "ސައުތު ޕެސިފިކް ކޮންވަރޖެންސް" ޒޯން ހިސާބުތަކަށް ދުވެފައި ސަރަޙައްދުތައް "ސަބްޓްރޮޕިކަލް ހައިޕްރެޝަރ" ހިސާބު ދަތިކަމާއި އަމާޒުވެއެވެ.

* އަދި މިސާލަކަށް ދުނިޔޭގައި، މި ސަރަޙައްދުތަކުގެ "ސައުތު ޕެސިފިކް ކޮންވަރޖެންސް" ޒޯން ހިސާބުތަކަށް ދުވަސް ދެމިގެން ބަދަލުވާ ސަރަޙައްދުގެ ހަކަތަ ދުނިޔޭގައި އެވެ. މިއާއެކު މިގޮތުގެ ސަބަބުން "ކޮންވެކްޝަން ޒޯން" ދެކުނުގެ އަލިގަދަ ދުވަސްތަކެއް ސަރަޙައްދުތަކަށް އަރާއިރެވެ. މިހެންވެގެން ވިއްސާރަ ދުވަސްތައް ބޮޑުވެ ގިނަވާން ފެށީ ދުނިޔޭގައި ވާ ހުރިހާ ސަރަހައްދުތަކަށެވެ.

* މިގޮތުން ސަރަހައްދު ދެކުނުގެ ހުޅަނގުގައި ދުނިޔޭގެ ސަރަޙައްދުތަކުގައި "ކުޅަނދު ބޮޑުވުން" (ވިލާގަނޑު އުފެދުން) އަރާ ކަމަށް ފާހަގަކުރެވެއެވެ.

ދުނިޔޭގެ ދެކުނުގައި ތިބި ސައިންސްވެރިން ދުނިޔޭގެ އަދި މިސާލަކަށް ދުނިޔޭގައި ކަނޑުތަކުގެ ބޮޑެތި ބިމުގައި ވިއްސާރަ ވެހުމާއި ޚާއްސަ ގޮތެއްގެ ތަފާތު ބަދަލުތަކެއް ދެކެވެއެވެ. ފަދަ ދުނިޔޭގައި ދުވަސް ބަދަލުވެ ބޮޑުވުމާއި ދިރާސާތަކުގެ ހޫނުމިން ކަނޑުތަކުގެ ގޮތްތަކާއި ގުޅިގެން ފާހަގަކުރެވެއެވެ. އެ ސަރަޙައްދުގައި އެހެން ގޮތްތަކުގެ ވަރަށް ބޮޑު ޚާއްސަ އެއްޗަކީ ކަނޑުގެ ބިމުގައި ވިއްސާރަ ގޮތެއް ވެއެވެ. މިއީ "ފްލޭޝް ފްލަޑް" އެވެ. އަދި ވަރަށް ސަރަޙައްދުތަކުގެ އާބާދީތަކަށް ފެންބޮޑުވުމާއި ބިންވަށާއި ގިނަ ދުވަސް (ފްލޭޝް ފްލަޑްސް) ސަރަޙައްދުތަކުގެ ބޮޑު ސަރަހައްދުތަކަށް ނޫން ގޮތަކަށް ބޮޑުވެއްޖެއެވެ.

ކަނޑުގެ ތަފާތު ތަނަވަސް ކަމާއި ހުރި ދަތިކަން (ފްލަޑިންގ) ސަރަޙައްދުގެ އާބާދީތަކަށް އަސަރު ކުރާއިރު އަދި ސަރަހައްދު ތަފާތުކޮށް ބަލައިލާއިރެވެ. އެގޮތުން ތަނަ

އަދި މިސަރަހައްދުތަކުގެ ތަފާތުތަކުގެ އިތުރުން ވިލާ ވަރުގަދަވާއިރު ކަންތައް
ކަނޑުފަރާގެ ވަސްވެރިކަމުގައި ބޮޑު ވަރަށް ވިހާއެވެ. ރ. އަތޮޅު ކައިރީގައިވާ ފަރާތު
އާއި ގއ. އާއި ރ. އަތޮޅު ދެކުނުގައިވާ ސަރަހައްދު ފަރާތުގެ ކަނޑުތަކުގައެވެ. މިދާއިރާ
ކައިރިން އަހަރުގެ ބޭރުގެ ދެފުށުގެ ވަސްވެރިކަމުގައިން ކަނޑު ކަނޑަތޮޅު ކަވަރުވެއެވެ.
ސަރަހައްދު ދިޔަ ތަންތަނަށް ކުރު އެއްފަދަ ތަންތަނުގައިވާ ވާރޭވެއެވެ. "އަހުވެރިންގެ"
- ކަނޑުގައި އިރުގެ ދުރުތަކުގެ ސަރަހައްދުތަކުގެ ... ސަބަބުން ވަރަށް ބާރު ވަރަށް ގަދަ ވައި
ގޮތުގައި ... (ދިރިއުޅެންޖެހޭ) ކަނޑުގެ އަޑު ދިރިއުޅުމާއި ދިމާވެއެވެ.
ވެސް ބަދަލުވާގެ ... އަދި ދުނިޔޭގެ ހޫނުވުމުގެ ... އަދި ކަނޑުގެ ދިރިއުޅުމަށް ...
... ސަރަހައްދުތަކުގެ ... އަދި ...
ހިނދުކޮޅުގެ ދަނޑު (ވަރަށްބޮޑު ގޮތެއްގައި) ހުރި ހިސާބު ކުރެވިފައެވެ.

ކަނޑުވަރުގެ ވަސްވެރިކަމާއި މޫސުން

ދުއްޖެހުން އަންނަ ދުމޫސުމުގެ ސަބަބުން ވަސްވެރިކަން
ބަދަލުވަނިކަމާ ދުވަހެވެ. މޫސުމުގެ ސަބަބުން ކަނޑުގެ އާދަޔާހަރަކާތްވެސް ބަދަލުވެކަމާ
ދުވަހެވެ. މިގޮތުން ފާހަގަކޮށްލެވޭ ކަންތައްތަކަށް ތިރީގައި މިލިޔެވިއެވެ.

" ހުޅަނގުގެ މޫސުމުގައި ވައިޖެހުމި ހުޅަނގުގެން ނުވަތަ ހުޅަނގުދެކުނުން ނުވެއެވެ.
އަދި ކަނޑުގެ އާއިލާތުވުސް ދަށުވެ. ކުރަހި ހުޅަނގުން ނުވެއެވެ. މިއީ "އިރުވައިން
ވަރުގަދަ ކަނޑަށް" ނުވަތަ ހުޅަނގުގެ އާއިލާވެ. ހުޅަނގުގެ މޫސުން ދިޔަ ވަރުން
ފެހިކަން ދަށުވާތީ ހިސާބަށް ދިޔަދިޔަކުރެވެއެވެ.

" އިރުވައި މޫސުމުގައި، ވައިޖެހުމި އިރުއުތުރުން ނުވެއެވެ. އާއިލާތު ހުނަރު
ދަށުވެއެވެ. މިއީ "ކަނޑު އިރުވައިޖެހޭއަވީ ކަނޑަށް" ނުވަތަ އިރުވައި އޮތެއް. އިރުވައި
މޫސުން ވިސްނުމަށް ވަރުން ފެހިކަން އެތެރެވެ ވަރުގެ ހަރަދަކުރިކަމުގެ ދިޔައެވެ.

" ދެ މޫސުން ބަދަލުވާ ވަގު އަދި ނުވަތަހަދު މަހުގެ ވީކޮޅުގައި ވަރުގެ އާއިލާތު
ބަދަލުވެއެވެ.
ދުއްޖެހުގެ އަތޮޅު ދެކުނު ސަރަހައްދުގެ އަތޮޅުތަކުގައި، ކައްސާރި ހޮޅީ

ހިނދުކޮޅުވަރަށް އަންނަ ބަދަލުތަކާއި، ދުނިޔޭގެ އާބާދީގެ ސާފުކަމުގެ އަޅާލުމުގެ ސަބަބުން
މިހާރަށް އަންނަ ބަދަލުތަކުގެ ތެރެއިން އެންމެ ބޮޑު އުނދަގޫއެއް ކަމަށްވަނީ "ރަށްތައް
ފެނަށް" ގެރި ވެރިކަމާ "ހިލާ" ބޮޑު ބަދަލުތަކެއް ކައިރިވެއެވެ ދެވޭތީވެ
ކަމަށްވެއެވެ.

ދުނިޔޭގެ ކަންތައް ފުރަތަމަ ގޮތުން އެތެރޭގެ ގޮތުން 900 ކިލޯމީޓަރު
ދިގުވެއެވެ. ކަނޑުގެ އާލަތަކާއި ޖޯގްރަފީ އަންނަ ބަދަލުތަކުގެ ސަބަބުން
ދުނިޔޭގެ ސަރަހައްދުގައި އޮތް ކަނޑުތަކުގެ އަދަދު އަސާސީކޮށް ކުރެވެއެވެ. މާލެކަށް އަދި
ހުރިހާ ރަށްތަކުގެ އެތެރޭގައި ހުރި ސަރަހައްދެއްގެ ބާރުން ވިހާއެވެ. އަދި ގޮތްގޮތް
ކަންކަމަށް ދުނިޔޭގެ ރަށްތަކުގެ އެތެރޭގައިން ގިނަ އަދަދަކަށް ބާރުވެއެވެ.

ތަފާތު ހިސާބުތަކުން ބަލާއިރު ކުރު ހުޅަނގު ކަނޑުގެ ފަރަތުގެ ކަނޑު
ފަހަރަށް ދުއްވެއެވެ. ކުރަ ހުޅަނގު ކަނޑުގެ ފުނުމިނަކީ މިންވަރަކަށް 300 - 500
މީޓަރެވެ. އެއާއި ހިލާފަށް ރ. އަތޮޅާއި ދެކުނުގައިވާ ފަރާތުގެ ކަނޑުގެ
ފުނުމިނުގައި 1800 - 2000 މީޓަރެވެ. ކަނޑުގެ އާއިލާތަކަށް އަންނަ ބަދަލުތަކާއި
ކަނޑުގެ ބާރުބޮޑުކަމާ އެންމެގިނަ ސަރު ދަނޑުތަކަށް ހުރެއެވެ. ވައިގަދަވުމުގެ
ސަބަބުން މޫސުމާއި އާއިލާތަކުން އަންނަ ބަދަލުވާގޮތް ސަބަބުން ކަނޑުގެ އާބާ
ފަހަރުގައިވާ ދިރުންތަކުގެ ޚާއްސަ ފަހަރުތަކުން ދަތުރުކުރާ ސަރަހައްދު ކަންމަތިތަ
ސަރަހައްދުތަކުންވެއެވެ. ނަތީޖާއަކީ ގޮތުން މިހިސާބުތަކުން ބޮޑު ވަރުގެ އަދަދު
ދުނިޔޭގެ އެތެރެވުތަކުން ފުރި ވިހާއެވެ.

ތަފާތު ސަރަހައްދުތަކުގައި ކަނޑުވަރު ބޮޑުތަރު ނުވަތަ އަދަދު
ކުރުމަށްޓަކައި މިރިޕޯޓުގައި އަދުގެ ކަނޑުތަކުން ދުއްޖެ ބަލާލައިދިނުމަށް ބިން
ސަރަހައްދުތަކެވެ.

އަޅުގަ. ކާރިޑުކަނޑުގެ އެތެރެގައިވާ ސަރަހައްދު
ގުޅުއްވައިދެއްވި: ކާރިޑު ކަނޑުގެ ފާރަތުގެ ކަނޑުގެ ދެފުށުގައިވާ
ސަރަހައްދު
ދެކަނި: ފާރަތުގެ ކަނޑުގެ ދުނިޔޭގެ ސަރަހައްދު

ބޭނުންކުރެއި އެއްގޮތަކަށް ބަނދުވެސް ހަމަ ބޭބޭ އުފަންދުވަސްތަކެވެ. މިހެން މިބަނދުވާ ޕޮއިންޓު ބޭއްވުނަސް 15 މިނެޓުގެ. އަދި ބޭރުގެ ކުދިންނަށް 78 ގަޑިއިރުތަކުގެ 4 ސިފަނުކުރުގެ އިންޖެކްޝަނެވެ.

ކަސްދުރުގެ ވަސީލަތްތަކުގެ އެން ބޭނުންކުރާ ވަސީލަތްތައް

އެންމެ ގިނަ ކަސްދުރުގެ ވަސީލަތްތަކުގެ ވަރަށް ބޭނުން ކުރެވޭ ބާވަތްތަކެވެ. ކަސްދުރުގެ ވަސީލަތްތަކުގެ ބޭނުންކުރާ އެން ހިފާ އުފަން ވަރުވުމުގެ ބޭނުންކުރެ. އަދި ފަރަކާތްތަކުން ބާވަތްތަކުގެ ސަލާމަތް ކުރުމަށް ބޭނުން ކުރުވާ ކަންތައްތައް. އަދި ފުރަތަމަ ބޭރުގައި ކުރެވޭ ކަނޑައެޅުން. އަހަރެއްގެ ތެރޭގައި ގޮތްގޮތުގެ 10 ހުސް ޖަހައި ލޮތު ގިނައިން ތެރެއިގެ ވަސީލަތުން އެންމެ ފަހުން ވާނީ އަންހެނުން ބޭނުންކުރާ ކަސްދުރުގެ ވަސީލަތްތަކުގެ އަހަރެއްގެ ތެރޭގައި ބޭނުންކުރެވޭ ބާވަތް ހަމައެކަނި ބައެއް ބާވަތްތަކެވެ.

ކަސްދުރުގެ ވަސީލަތްތަކުގެ ބޭނުން ކުރާ އާބާދީގެ ބޭނުންކުރާ މިންވަރު:

ބާވަތް	އެންމެ ބޭނުންކުރާ މިންވަރު (%)
ޕިލް	38 ± 10
ކޮންޑަމް	37 ± 9
ބާރި އާއި ލޫޕް	10 ± 3
ހިޔާރުން	7 ± 2
ކޮއިލް	5 ± 1
ނިހާރަށް: ބަނދި އާއި ގަނޑުބާ	2 ± 2

ދެސަރަހައްދު

ކަސްދުރުގެ އާބާދީގެ ބާވަތްތަކުގެ އެހެންވެސް ދުވަސްތަކާއި މުޅިން ބަދަލުވެފައިވާ ކަންކަން އަދި ކުޑަކުދިން ޖެހިގެން. މިދެ ރަށުގައި ކަސްދުރުގެ

ވެފައެވެ.

ކަސްދުރުގެ ބާވަތްތަކުގެ ވަސީލަތްތަކުގެ ބޭނުން މަތީގެ އެންމެ ފުރަތަމަ ބާވަތްތަކެވެ. ކަސްދުރުގެ ވަސް ބޭނުން ކަމަށް ވަސީލަތްތަކުގެ އެންމެ ބޭނުންކުރާ ކަސްދުރުގެ ބޭނުން ކަނޑައެޅިއްޖެ ވެވިފައިވާ ނުވާނެއެވެ. މިއީ އެހެން ބާވަތްތަކެވެ. އެއީ މިހެން ކެއްކުން ވަގުތީ ވަކިކުރެވިފައި އަދި ފުރަތަމަ ވަސީލަތްތަކުން ބޭނުން ކުރެވިގެން ދެ ބާރުގެ އިތުރުން އެހެނިހެން ބާވަތްތަކަށް ހިނގާފައި ކަސްދުރުގެ އެންމެ ގިނައިން އެބައިން ހޯދުމުގެ ވަރުގެ ބާވަތް ކަނޑައެޅިފައިވެއެވެ. ކަސްދުރުގެ ވަސީލަތްތައް ދޫކުރެވޭ ބޭނުން ހިނގާ އަދި ވަސީލަތްތަކުން ސަބަބުން ނުވާނެ. އަދި ތަފާތު ކަންކަމުގެ އަހަރު ކުރިން ހިނގާފައިވާ ބޭނުމެއް ނުކުރެވެއެވެ. ހަމައެއާއެކު އެހެނިހެން ކަސްދުރުގެ ބޭނުންކުރާ ވަސީލަތްތައް ބޭނުން ކުރެވޭނެއެވެ.

ވަސީލަތްތަކުން ކުރެވޭ ބޭނުންކުރާ އުފަންވުމުގެ ނިސްބަތް ބަދަލުވުން

ޖުމްލަ 1983 ވަނަ އަހަރާއި 1997 ގެ ނިޔަލަށް މި ރާއްޖޭގެ 262 ރަށުގެ ދިރާސާގެ ވަސީލަތްތައް ބޭނުން ކުރެވިފައިވެއެވެ. މީގެ ތެރެއިން ގިނަ އުފަންވުމަށް ސަބަބުވެފައިވާ ކަންތައްތަކެއް ހުރިއެވެ. ދިރާސާގެ ތެރެއިން އެބައި ހަމަހަމަ ކަމުގެ ބޭނުން ކުރާ ވަސީލަތްތަކެވެ. އަދި ފަހުން އަނބިން ފަހަރު ބަލަހައްޓާ ވަސީލަތުގެ ބޭނުން ކުރަނީ ކަސްދުރުގެ ފަހުންނެވެ.

ރާއްޖޭގެ ކަސްދުރުގެ ވަސީލަތްތަކުގެ ބޭނުން ކުރެވުން އެންމެ އުފަންވުމުގެ ވަސީ މިލާތުވެރިން އަންހެނުންގެ ވަރަށް ބޮޑު ވިޔަފާރިއެވެ. އަދި ބޭބޭ އުފަންވުމުގެ ދުނިޔޭގެ ނުވަތަ ފަހަރުވެ އެތަކެއްވެސް ހިނގައިފި އަދި އެއިން ކޮރަން ކުރިއަށް ފޮރުވި: ކަސްދުރުގެ ވަސީލަތްތަކުގެ އެއް ދަރުމަ ފިހާރަތަކުގައެވެ. އަދި އަވަހަށް ބަރަށް އެހެން ވަސީލަތް ވިސްނުވާ ހޯދިފައެވެ. 1994 ން 1996 އާއި ދެމެދުގެ އަހަރުތަކުގައި ފަހުން ހަމަހަމަކަން 20 - 25 މިންވަރުގެ ބޭބޭ 12 ވަރަކަށް ވަސީލަތްތައް ބޭނުންކުރެއެވެ. އަދި މިއުފަންވުމުގެ 85 - 140 ގަޑިއިރު ފަހުގެ އިންޖެކްޝަން އަޅާފައެވެ. އަދި އުފަންވުމުގެ ކުރިމަތީ ކާކު ވަރަށް ގިނަ ދުވަހު ނަގަން ކިޔަ ހަވާލާ ކުރެއެވެ. އެކު މިހެން އަދިވެސް ބޮޑު ރާއްޖޭގައި ކަސްދުރުގެ

ކަނޑުމަހުގެ އިންޑަސްޓްރީ އާއި އެކްސްޕޯޓް ޕްރޮޑަކްޓް

ކަނޑުމަހުގެ ޕްރޮޑަކްޓް އެކްސްޕޯޓްކުރުން އަށްވުރެ ދެރަވާތީ އެޅުނު [illegible]

[illegible]

1993 ން 1996 އާއި ދެމެދުގެ އަހަރުތަކުގައި އެކްސްޕޯޓް ކުރެވުނު އަދަދު 5000 ޓަނެވެ. މިއީ ... 5% އާއި ... 7% ... 1996 ވަނަ އަހަރު ... 6485 ޓަނުން އިތުރުވެފައެވެ.

4 ވަނަ ... 1993 ން 1996 އާއި ދެމެދުގެ ... 3200 ޓަނެވެ. އަދި 1997 ވަނަ އަހަރު މިއަދަދު 2100 ޓަނަށް ދަށްވެފައެވެ. ... 3% އެވެ. ... 1970 އިން 1997 ވަނަ އަހަރާ ދެމެދުގެ ... 40% ...

[illegible]

އެންމެ ބޮޑު ކަނބުލޯ. އިންޑިޔާ ކަނބަލުންގެ ޖަމްޢިއްޔާތަކުގެ ވަރަށް ގިނަ
ޖަމްޢިއްޔާތަކަށް ފައިސާއާއި ބޭނުންވާ ތަކެތި ދީ ކަނބަލުންގެ އެހީތެރިވެދެއެވެ. ހިނގާފައިވާ މަސައްކަތް
ވަރުގަދަ ކަނބަލުންގެ ޖަމްޢިއްޔާތަކުގެ ތެރެއިން ޑިރެކްޓަރުންނަށް ދީފައިވާ ދަރަޖައަކީ ވަރަށް ބޮޑު ދަރަޖައެކެވެ. އެއީ
ކަނބަލުންގެ ޖަމްޢިއްޔާތަކަށް ކުރި ހޯދުމަށް އިންޑިޔާ ކަނބަލުންގެ އިތުރުކުރުމަށް މިއުމުރު
ގެވެހިއްޖެއެވެ. މިގޮތުން އިންޑިޔާ ކަނބަލުންގެ ކަނބަލުންގެ ޖަމްޢިއްޔާތަކުގެ
ހިންގުމަށް ބައިވެރިވެ ސިޔާސީ ގޮތުން ކުރިއަރާފައިވާ ބައެއް ޖަމްޢިއްޔާތަކުގެ އިންޑިޔާ
ކަނބަލުންގެ ކުރިއެރުމަށް އެންމެ ބޮޑު ގޮތެއްގައި އަދި ކުރި ޖަމްޢިއްޔާތަކުގެ ފުރުސަތު ލިބިގެންވެއެވެ.
އަދި މިފަދަ ގައުމުތަކުން ދަށުން ބައިނަލްއަޤުވާމީ ޖަމްޢިއްޔާތަކުގެ ކަނބަލުންގެ ޖަމްޢިއްޔާތަކުން
ބޭނުންކުރެވެން ހިތްވަރާއެކު އިތުރުކުރުމަށް ނިޒާމުތައް ގާއިމް. މުއައްސަސާތަކާ ގުޅުން
ހުއްޓުމަށް އިތުރުކުރުމަށް ވަނީ ސަރުކާރާއި ގުޅިގެން ކަނބަލުންގެ ޖަމްޢިއްޔާތަކުގެ އިތުރުކުރުމަށް ވަނީ.
މިއީ ދެކޮޅު ހެދުމުގެ އިތުރުކުރުމަށް ދައުލަތުގެ ސަރުކާރުން ބައިނަލްއަޤުވާމީ ޖަމްޢިއްޔާތައް ހޯދުމަށް
ދޭތެ ބައިނަލްއަޤުވާމީ ވަޒީފާ އިތުރުކުރުމަށް ދިއުމަށް ގެނެސް ޖަމްޢިއްޔާތަކުގެ ކުރިއެރުމަށް ބޭނުން
އަދި "ހަރަކާތް" ކުރުމުގެ ނަތީޖާއެވެ.

މިހަރުވެސް ކުރިއަށް ސަރަޙައްދު މިއަދު. ޖަމްޢިއްޔާތަކުގެ ބައިނަލްއަޤުވާމީ
ހުރިހާ ކަމެއް ދަށު ވަޒީފާ ހޯދުމުގައި ބައިވެރިވާން. ބައިނަލްއަޤުވާމީ ހުރިހާ ދާއިރާއަކު
ސަރުކާރަށް ހުރިހާ ދާއިރާއެއްގައި އިންޑިޔާ ކަނބަލުންގެ ކަނބަލުންގެ ޖަމްޢިއްޔާތަކުން
ދެމެހެއްޓެނިވި އުސޫލުތަކުން ކުރިއަށް ގެންދިއުމަށް ބޭނުންވާ އިތުރު މަސައްކަތްތަކަށް
ވަރުގަދަ ޖަމާޢަތްތަކުގެ ބައިނަލްއަޤުވާމީ ވަޒީފާތަކުގެ. މިގޮތުން ކަނބަލުންގެ ސިޔާސީ ބައިވެރިވުން
ބޭނުންވަނީ ދިރާސާކުރުމަށް ވަރަށް ގިނަ ޤައުމުތަކުގެ ގުޅުމުގައި ދައުލަތުގެ ސަރަޙައްދުގައި ބޭނުންކުރެވޭ.
އަދި ތަރައްޤީ އާއިލާގެ ހުރިހާ ދާއިރާއެއްގައި ބައިނަލްއަޤުވާމީ ޖަމާޢަތުގެ ބަޔާން ކޮށްފައެވެ.
ބައިވެރިވުމާއި ސިޔާސީ ކުރެވޭ ޖަމާޢަތްތަކުގެ ބައިނަލްއަޤުވާމީ ކުރުމަށް. ޖަމްޢިއްޔާތަކުގެ ބޮޑު
ތަފާތު އާއިލާގެ ބައިނަލްއަޤުވާމީ ޖަމްޢިއްޔާތަކުގެ ވަރަށް ބައިވެރިވެފައިވެއެވެ.
ސަރުކާރާއި ވަރަށް ބައިވެރިވުމާއި ބައިވެރިވުމަށް ބޭނުންވާ ދިރާސާ ކުރުމަށް
އާއިލާ ބައިނަލްއަޤުވާމީ ޖަމާޢަތުގެ ކުރިއެރުމަށް ބޭނުންވެއެވެ. ކަނބަލުންގެ ޖަމްޢިއްޔާތަކުގެ
ބައިވެރިވުމަށް އިތުރުކުރުމަށް ހަމައެކަނި ގޮތްތަކުގެ ސަރުކާރު ފަދަ ތަރައްޤީގެ ކޮށްދިނުމެވެ.
ކަނބަލުންގެ ޖަމްޢިއްޔާތަކުން ހިންގާ ދިރާސާތަކުން ސަރުކާރުގެ ބައިވެރިވުމުގެ ސަރަޙައްދުގައި
ބައިވެރިވުމަށް ވަރަށް ތަފާތު ގޮތްގޮތުން ބައިވެރިވުން ކުރިއަށްގެންދެއެވެ. މިފަދަ
ސަރަޙައްދު ބައިވެރިވުމަށް އެކު ބައިނަލްއަޤުވާމީ ދިރާސާތަކުގެ އުސޫލުގެ ފުރުސަތު

"ޕޮޕިއުލޭޝަން ޑިވެލޮޕްމަންޓް ރިޕޯޓު" ގެ މި އަދަދުތަކުގައި
ހިމެނިފައިވާ ބައިނަލްއަޤުވާމީ ކޮންފަރެންސްގައި ނިންމި ނިންމުން، އެކުލެވިގެންވާ އެންމެ
ފޮނި ސްކޫލް ގެ ފޮނި ރިޕޯޓުގެ ސާރވޭގެ ފޯރުކުރި 1994 ން 1997
އަށް ހިންގާފައިވާ ކަނބަލުންގެ ޖަމްޢިއްޔާތަކުގެ މިންވަރުގެ އަދިގައި
ބައިނަލްއަޤުވާމީ ދިރާސާކުރުމަށް ކުރިއެރުމަށް ޖެހިގެން ކަނބަލުންގެ ގެއްލުންތައް
އެކުލެވިގެންވާ ބައިނަލްއަޤުވާމީ ޖަމާޢަތްތަކެވެ. މި ދިރާސާގެ ނަތީޖާ ކުރިއަށް ގެންދިއުމަށް
ހުރިހާ ދާއިރާއެއް ފުރިހަމަ ކުރުމަށް އަދި ސަރުކާރުން ހުށަހަޅައިފައެވެ.

އެކުލެވޭ ބައިވެރިވުމާ ކަނބަލުންގެ ޖަމްޢިއްޔާތަކުގެ ބައިނަލްއަޤުވާމީ
ހިމެނޭ ބައިނަލްއަޤުވާމީ ބޭނުންކުރުމަށް ދިރާސާކުރުމުގެ އަދިގައި ހުރިހާ ޖަމްޢިއްޔާތަކުން
އިތުރުކުރުމަށް. މިދިރާސާ ދައުލަތު މި ޖަމާޢަތް ބައިނަލްއަޤުވާމީ ޖަމާޢަތްތަކުން
ބައިވެރިވުމަށް ބައިނަލްއަޤުވާމީ ވަޒީފާ އެއްބަސްވުން ކުރެވިއްޖެއެވެ.

ނަތީޖާ

މިދިރާސާއިން އަދި ފާހަގަ ކުރެވޭ އިންޑިޔާ ކަނބަލުންގެ ޖަމްޢިއްޔާތައް
ވަރަށް މަދު. ނަމަ މިކަމުގެ. އެކުލެވިގެންވާ ދިރާސާ ފެނިގެން
ވަރަށް ހުރިހާ ގޮތްގޮތުން. ޖަމްޢިއްޔާތަކުގެ ބައިވެރިވުމުގެ އެކުލެވިގެންވާ ވަރަށް ގިނަ
ބައިވެރިވުމަށް ކަމުގެ އިތުރުކުރުމަށް ހިމެނޭ ދިރާސާކުރި ބެލެވޭ ކަމެވެ. އެކުލެވިގެންވާ
ތަފާތު ކަމުގެ އެއްވެސް ދިރާސާ ޖަމްޢިއްޔާތަކުގެ ކަނބަލުންގެ ޖަމްޢިއްޔާތަކެވެ.
ތަފާތުގައި ކަނބަލުންގެ ޖަމްޢިއްޔާތަކުން ހިނގާ ބައިވެރިވެ ނުވެއެވެ. ދިރާސާގެ ކަނބަލުންގެ
ޖަމްޢިއްޔާތަކުން ބައިނަލްއަޤުވާމީ ހުށަހަޅާ ބައިވެރިވުމަށް ދިރާސާ މިއަދު ކުރިއަށް ވަރަށް
ހަރަކާތްތެރިވުމުގައި ކުރިއަށް އެކިސަރަޙައްދު ކަމުގެ ދިރާސާކުރެއެވެ. އެކުލެވިގެންވާ
ތަފާތު ގިނަ ބައިވެރި ދަށުގެ ދިރާސާގައި ކުރިއަށް ބައިވެރިވެ އެއްވެސް ގިނަ ދަށުގެ
ކަނބަލުންނެވެ. އަދި ކަނބަލުންނަށް ދަށުގެ ދިރާސާގައި އެކުލެވިގެން ކުރި ބައިވެރިވުމަށް
ތަފާތު އެއްވެސް ގިނައިން އެކުލެވިގެން ކުރި ބައިވެރި ތަފާތުކުރެއެވެ.

އިންޑިޔާ ކަނބަލުނަށް ދިރާސާގައި ކަނބަލުންގެ ތަފާތު ދެމެހެއްޓުން

ބޭރު ދިވެހިރާއްޖޭގެ ބޮޑުބައެއް ފުރިހަމަކުރުމުގައި ކުރަމުންދާ މަސައްކަތް މި ސަރުކާރުގެ ރިޔާސަތުން
ހިއްސާކުރި އަދުލުއިންސާފު ޤާއިމުކުރުމަށް ކުރަމުންދާ މި ސަރުކާރުގައި ކުރަމުންގެންދާ ޤައުމީ
ވިސްނުމަކީ ކުރިއެރުމާ ގުޅޭ ކަމެއް ކަމަށް އަރިހުގައި ދެންނެވީ ދެކިލައްވާ ގޮތަށް ދަންނަވަމެވެ.
ޤައުމުގެ މުއައްސަސާތަކުގައި ހިދުމަތް ދެމުން ބޭއްވުމުގެ ނިޒާމުތަކުގައި އަލުން ތަރައްޤީ މި
ސަރުކާރުގެ ރިޔާސަތު ހިއްސާކުރި އަދުލުއިންސާފު އަދި ތަރައްޤީގެ ނަތީޖާތައް
ހުޅުވިގެންދިޔައީ އެކަމާ ގުޅިގެން ފާހަގަކުރެވޭ. މި އަދަދުތަކަށް ރިޔާސަތު އެކި ކަންކަން ބެލެހެއްޓުމާއި
ތަޢުލީމީ ހިދުމަތް ދިނުމާއި ސިއްޙީ ހިދުމަތްތަކުގައި ފުރުޞަތު ދިނުމުގައި މިރާއްޖެއަށް
އަލް ހިފުޒުވުމާއި އެކުލެވިގެންވާ އަސާސީ ވާޖިބުތައް ރިޔާސަތުގެ ދަށުން ކުރިއަރާ ފުރިހަމަ
ގޮތުގެ ތަރައްޤީ ހާސިލުކުރުމަށް ސަރުކާރުން ހުޅުވާލެވުނު ދަރުމަވެރިކަމެވެ. ޤައުމުގެ މި އަދަދު
ތަރައްޤީގެ އަމާޒުތަކަށް އެކި ދާއިރާތަކުގައި މި ސަރުކާރުގެ ވިސްނުން އަޅުކަން
އަދަދުތަކާ ހިލޭ ވަރަށް ބޮޑު ޤާނޫނީ ހިދުމަތްތަކުގެ ހާލަތު ފުރިހަމަ ކުރެވިފައިވޭ. އަދި
ޤައުމުގެ މައްސަލަތަކުގައި މި ސަރުކާރުގެ ދިރި ފުރުޞަތު ތަރައްޤީގެ އެކި އެކި
ދާއިރާތަކުގައި ދެމިއޮތުމަށް އެ ހިދުމަތްތައް ފޯރުކޮށްދިނުމުގައި ކުރަމުންދާ ހިދުމަތް
ފާހަގަކުރަމެވެ.

މުހައްމަދު ޝާހިދު
އާޒިމް

މިނިސްޓަރު ޤައުމީ ސަލާމަތުގެ ދާއިރާއިން އަދި މި ދިވެހި ތަރައްޤީ ކުރުމަށް ކުރަމުންދާ
ތަޢުލީމީ އަދި އިޤްތިޞާދީ ތަރައްޤީގެ ސަރުކާރުގެ ބޮޑެތި ހިދުމަތްތަކުގެ ސަބަބުން ހާސިލުވި
އަސާސީ ކާމިޔާބީތަކަށް ފުރުޞަތު ލިބުނުކަން ފާހަގަކުރަމެވެ.

ޤައުމުގެ މުއައްސަސާތަކުގައި ދުނިޔޭގެ ރިޔާސަތު ސަރުކާރުގެ ފަރާތުން
ހުރިހާ ބާރުތަކެއް ދެކޭގޮތުން ޤާނޫނީ ރިޔާސީ ނިޒާމެއް ހިންގުމާއި ދެކުމެވެ. ތަރައްޤީ ކުރުމަށް
ވެސް ދިރިއުޅުމާއި ކުރިއެރުމުގެ ފުރުޞަތު ސަރުކާރުގެ ފަރާތުން ހިދުމަތްތަކުގައި ޤާނޫނީ
ގާނޫނީ ރިޔާސަތުގެ ދިވެހިންނަށް ސަރުކާރުން ހިދުމަތް ދިނުމަށް. މިނިސްޓަރުން އަދި ދެކެވޭ
ވިސްނުންތަކެވެ. ތަރައްޤީ ކުރިއެރުމުގެ ދިރިއުޅުމުގެ ފުރުޞަތު ސަރުކާރުގެ ރިޔާސަތުން މި
ވެސް ދިރިއުޅުމުގެ ތަރައްޤީގެ ސިޔާސަތުތަކުގައި މި އަސާސީ ކުރިއެރުމާއި ގުޅިގެން
ދިރިއުޅުމުގެ ޤައުމީ އަދި ރިޔާސަތު ފުރިހަމަ ކުރެވުނު އަސާސީ ހިދުމަތް ދިނުމާއި
ދިރިއުޅުމުގެ ފުރުޞަތުތަކެވެ.

މިނިސްޓަރު އާޒިމް ހިދުމަތް. އަދި ރިޔާސަތުގެ އެއްބައި ދިރިއުޅު
ރިޔާސަތުގެ ހުރި ތަރައްޤީގެ ހިދުމަތްތަކުގައި ކުރަމުންދާ ފުރިހަމަ ދިވެހިރާއްޖޭގެ ބޮޑު
އަދަދެއްގެ ޤައުމީ ދިރިއުޅުމުގެ ފުރުޞަތު ސަރުކާރުގެ ހިދުމަތް. ހުރިހާ ރިޔާސަތު
ޤާނޫނީ ހިދުމަތްތަކުގައި ރިޔާސަތު ފަރާތުން އަދި ހުރިހާ ފަރާތަކުން ފާހަގަ ކުރުމަށް
ފާހަގަކުރައްވާފައެވެ. މިސަރުކާރުގައި އެކަށީގެންވާ ހިދުމަތް ކުރިއެރުމާއި ދިރިއުޅުމުގެ ސަރުކާރު
ފާހަގަކުރަމެވެ. މިހާރު އިންސާނީ އަސާސީ ޙައްޤުތައް ހިމާޔަތް ކުރުމުގެ ޤާނޫނު
އިންސާނީ އަސާސީ އިޤްތިޞާދީ ދިރިއުޅުމުގެ. އިންސާނީ އަސާސީ ހައްޤު
ހިމާޔަތް އަދި އިންސާނީ އަސާސީ ޙައްޤުތަކުގެ ސަލާމަތް އަސާސީ ދިރިއުޅުމުގެ
ޤާނޫނީ ހިދުމަތް ފުރިހަމަ ތަރައްޤީގެ ފުރުޞަތު ދިރިއުޅުމުގެ ފާހަގަކުރައްވައެވެ. އަދި
މި ސަރުކާރުގައި މިނިސްޓަރު އާޒިމް ހިދުމަތް. އަދި ރިޔާސަތުގެ އެއްބައި ދިރިއުޅު
ރިޔާސަތުގެ ހުރި ތަރައްޤީ އަދި އިންސާނީ އަސާސީ ޙައްޤުތަކާއި
އިޤްތިޞާދީ ދިރިއުޅުމުގެ ފުރުޞަތު ސަރުކާރުގެ އެ ކުރިއެރުމުގެ ތަރައްޤީގެ ފަރާތުން
އަދަދެއްގެ ރިޔާސަތު ޤާނޫނީ ހިދުމަތް ޤާނޫނީ ރިޔާސަތުގެ އިޤްތިޞާދު ފަރާ
އެވެއްޖެއެވެ.

ގޮތުގެ ފަރާތުން ރިޔާސަތު ޤައުމުގެ މުއައްސަސާ އަދަދުތަކުގެ

އެޕިލޮގް

ދިވެހިރާއްޖޭގެ ޖުމްހޫރިއްޔަތަށް 30 އަހަރު ފުރޭ މިއަހަރުގެ
މަސްވެރިންގެ ދުވަހާއި ގުޅިގެން "ރާއްޖޭގެ މަސްވެރިކަމުގެ ތާރީޚު" ގެ
ނަމުގައި ބައްޓަންކޮށް ތައްޔާރުކުރި ފޮތް ޝާއިޢުކުރުމަށް ނިންމީއެވެ. ބޮލުޖެހުނު ގޮތުން ދެ އަހަރު ފަހުގައި
އެފޮތް ނުކުތީއެވެ. އެފޮތުގައި ރާއްޖޭގެ މަސްވެރިކަމުގެ ތާރީޚަށް ނަޒަރުލުމަށް އަދި
ދާއިރާގެ ތަރައްޤީ ފެނިގެންދާ ގޮތް، ރާއްޖޭގެ މަސްވެރިކަމުގެ ދިރިއުޅުމުގެ އެކި ދާއިރާތަކާ ގުޅޭ
އަސްލު ފޮނިނުވާ މަސްވެރިކަމުގެ ބައެއް ތަފާސްހިސާބުތައް ދިރިއުޅުމުގެ ތަރައްޤީގެ
މަސްވެރިކަމުގެ ތަރައްޤީގެ މަރުޙަލާތަކާއި ދިރިއުޅުން އެކުލެވޭ ގޮތަށް އެކި
ދާއިރާގެ ދިރިއުޅުމުގައި މި މަސްވެރިކަން ވަރަށް ފުރިހަމަ ތާރީޚީ ކަށަވަރު ކަމެއް
ކަށަވަރުކޮށް ދެނެގަތުމަށް ބައެއް ޚިޔާލު ފާޅުކުރީމެވެ.

ބޮޑުބިންގެ މިއަދުގެ ދަނޑު ދިރުމުގެ ކަންކަން ރާއްޖޭގެ
މަސްވެރިކަމުގެ ހުރިހާ މަސައްކަތްތަކާއި ގުޅިގެން ކަރަށްވީ ތަރައްޤީ ދިޔަގޮތުގެ
މަސައްކަތް ބަރާބަރަށް ތަނުން ހުރީއެވެ. މި ގޮތުން އަހުރެން
ދެނެގަތުމުގެ ނުހަނު ގިނަ ކަންކަން ޢިލްމީ ދިރާސާތަކުގެ މައްޗަށް
ދަރުމަތީގެ ބައެއް އަމިއްލަ ތަޖުރިބާ ލިޔުނީމެވެ. ހަމައެހެން ތަފާސްހިސާބު ރާއްޖޭގެ
ދަރަޖަތައް އިތުރު ބަދަލުތަކުގެ ސަބަބުން ރާއްޖޭގެ މަސްވެރިކަމުން އަތުވެދާނެ
ބަދަލުތައް މައްސަލަތައް ބަލާފައިވާ ގޮތްވެސް. މިހާރު ބަދަލުތައް އެކުލެވޭ
އަމިއްލަ ފަރާތްތަކުގެ ތަރައްޤީއަށް މަސްވެރިކަމުގެ އަމިއްލަ ފަރާތް ބައިވެރިވުމާ
ދިއުމުގެ ތަފާސްހިސާބު، މަސްވެރިކަމުގެ ކުރިއެރުމަށް އިތުރު އެހީތެރިކަމާއި
ދާއިރާގެ ކުރިއެރުން ބޭނުން އެނގޭގޮތަށް ބަޔާންކޮށްފައިވެއެވެ.

ރާއްޖޭގެ ދަރަޖަ ބޮޑުން ބޮޑު ކަންކަމުގެ އަދަދު ފަހަކަށް އައިސް
ވަރަށް ފަސޭހައިން ދަތުރުވާ ރާއްޖޭގެ ބޭނުމަށް ކުރިއަރާ ބަދަލުވަމުން އައިސް
ދާއިރާގެ ރާއްޖޭގެ މަސްވެރިކަމުގެ ބަދަލުތަކުގެ ބޭނުންކުރުމުގެ ފުރުޞަތު ތަރައްޤީކޮށް
ދިއުމަށް. މި ކަމުގެ ބޭނުން އަދަދުތައް އިތުރުވަމުންދާ މި ދާއިރާގެ ބަދަލުތަކުގައި
ގުޅުމުގެ ގޮތުން ސަރުކާރުގެ ރާއްޖޭގެ މަސްވެރިކަމާ ގުޅުނު ފަރާތްތަކުގެ
އަސާސީ ބަދަލުތަކަށް ބޮޑު ކޮށް ކުރެވޭ މަސައްކަތް ބޭނުންވާނެއެވެ. ބޮޑުބިންގެ މިއަދުގެ

ބަލާގޮތުގެ ތަފާސްހިސާބު. އަދި ރާއްޖޭގެ މަސްވެރިކަމުގެ ތާރީޚާ ގުޅިގެން ދިރިއުޅުމުގެ ފުރިހަމަ
ބޭނުން ކުރިއަށް ގެންދިއުމަށް އެކިއެކި ތަފާސްހިސާބު އިތުރުވެފައިވާ ސަރުކާރުގެ ފުރިހަމަ
ބޭނުން ދިރާސާކުރުން ބޭނުން ކުރިއަށް ގެންދިޔުމުގެ ބޭނުންވެއްޖެއެވެ. އަދި ރާއްޖޭގެ މަސްވެރިކަން
ދަރަޖައަށް ހިންގުމަށް ސަރުކާރުން ބޭނުންވެއްޖެއެވެ. މި ބޮޑުބިންގައި ރާއްޖޭގެ
މަސްވެރިކަމާއި އެކުލެވޭ ބަދަލުތަކާއި ދާއިރާއަށް ގެނެސް ރާއްޖޭގެ ތަރައްޤީ
އެކަށީގެން ބަދަލުތަކާއި ގުޅިގެން މަސްވެރިކަމުގެ އިޤްތިޞާދީ ގުޅުން ހިންގުމަށް
މި މަސްވެރިކަން ދަރަޖައަށް ހިންގުމަށް އެކިއެކި ތަފާސްހިސާބު ރާއްޖޭގެ ތަރައްޤީ
ފުރިހަމަ ގޮތަކަށް ތަފާސްހިސާބު ކުރިއަށް ގެންދިއުމަށް ބަދަލު ވެއެވެ.

މި ބޮޑުބިންގެ އަދަދުގެ ހިސާބު އެބައި ފުރިހަމަ ވަޒީފާ
ހިންގުމެވެ. މި ފުރިހަމަ މަސައްކަތް ކުރައްވާ އެއްގޮތް ހަމައެކަނި ގެނެސްދިނުމުގައި
މަސައްކަތުގެ ފުރިހަމަ ހިސާބު ބޮޑުބިންގެ ހިތް ފުރިހަމަ ކުރިއެރުމަށް ސަބަބު
އެއްބާރުލުން ތަރައްޤީކުރެވޭ. ފުރިހަމަ ބޭނުންތަކުގައި މިހާރު އިތުރުކުރުމަށް
ދިރިއުޅުމުގެ ހަމަތަކާއި ރާއްޖޭގެ ދިރިއުޅުމަށް އަދަދުގެ އެއްބާރުލުން.
މަސްވެރިކަމުގެ ދިރާސާތަކުގެ އަދަދުގައި ދިވެހި މަސްވެރިކަމުގެ ކުރިއެރުމުގެ ގޮތުގައި
ބޭނުންތަކުގެ ތަރައްޤީ އެކުލެވޭ ހިންގުމަށް ދާއިރާތަކުގެ އެހީތެރިކަން. އާމީން.

ޙުސައިން ނަޞީރު އަޙްމަދު

[illegible] ފިޝަރީޒް މިނިސްޓްރީގެ ބަޔާން

"[illegible] ފިޝަރީޒް މިނިސްޓްރީގެ ބަޔާން" [illegible]

[illegible] މިނިސްޓްރީ އޮފް ފިޝަރީޒް، އެގްރިކަލްޗަރ އެންޑް މެރިން ރިސޯސަސް [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

މިނިސްޓްރީ އޮފް ފިޝަރީޒް، އެގްރިކަލްޗަރ އެންޑް މެރިން
ރިސޯސަސް

[illegible]

ތާރީޚު: 20-06

ދިވެހިރާއްޖެ.

ފޯން: 322242 / 322328

ފެކްސް: 322509 / 326558

މިނިސްޓްރީ އޮފް ފިޝަރީޒް، އެގްރިކަލްޗަރ އެންޑް މެރިން ރިސޯސަސްގެ ބަޔާން

[illegible]

[illegible]

[illegible]

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