NORTH - SOUTH VARIATIONS IN THE DISTRIBUTION OF FISHES IN THE MALDIVES

R.C. ANDERSON
Marine Research Section

INTRODUCTION

The atolls of the Maldives form a north-south chain, stretching some 870 km from Ihavandhipolhu in the north to Addu Atoll in the south. It is well established that there are significant gradients in climatic conditions and the physical attributes of atolls along this long chain. These gradients include the following:

a. Climatic Features:

1. Annual rainfall increases to the south.
2. Strength of the monsoonal reversal increases to the north.
3. Incidence of severe tropical storms increases to the north.

b. Atoll Features:

1. Depths of atoll lagoons increases to south.
2. Continuity of atoll rim increases to south.
3. Proportion of atoll rim with islands increases to south.
4. Occurrence of faroes (ring reefs) increases to north.
5. Heights of islands increase to the north.

Darwin (1842) and Gardiner (1903, 1906) were the first to discuss these north-south gradients, and Woodroffe (in press) has recently summarized much of the available information. Most discussion of these gradients has focused on the ways in which climatic trends may have caused the trends observed in atoll structure. For example, Guilcher (1988) suggests that the strong monsoonal reversal in the north of the Maldives may be responsible for the high frequency of faroes there, the seasonally oscillating currents promoting the growth of annular reefs.

There has, however, been virtually no work on marine biological trends from north to south. This in large parts reflects the lack of systematic sampling along the length of the Maldives archipelago: there is simply not enough information available. The two best studied groups of marine animals in the Maldives are perhaps the corals and the fishes. Rosen (1971) showed that the number of coral genera increases to the south along the Laccadives-Maldives chain. More detailed information on corals is not yet available.

The purpose of this report is to bring together some of the scattered information concerning the latitudinal variation in the abundance of fishes in the Maldives. Most of the information has come to light during the course of surveys of the existing tuna fisheries and exploratory surveys of underexploited fisheries resources both offshore and inshore.

METHODS AND DATA SOURCES

Catch and effort data for the pole and line and trolling tuna fisheries have been collected by species from 1970 by the

Ministry of Fisheries and Agriculture. Some analysis of regional trends has been carried out using this data (e.g. Anderson, 1985; Hafiz, 1985; Anderson and Hafiz, 1985; Rochepeau and Hafiz, 1990). For the purposes of this report the Maldives is divided into three regions: north (as far south as Baa and Lhaviyani), centre (Male' to Thaa) and south (Laamu to Seenu).

Detailed catch and effort data are not available for Maldivian fisheries other than those for tuna. For other fish varieties data are available from the results of an offshore fishing survey (Anderson and Waheed, 1988) and a reef fish resources survey (Van der Knapp et al., 1991; Anderson et al., 1992) both of which were carried out by the Marine Research Section (MRS) of the Ministry of Fisheries and Agriculture (MOFA). In addition to the published results some unpublished data held at MRS have been used. This is backed up with information from interviews with fishermen throughout the Maldives.

TUNAS

The Maldives is a tuna fishing nation, with some 95% of the recorded catch being tuna. The main species involved is skipjack (Katsuwonus pelamis), but significant catches of yellowfin tuna (Thunnus albacares), frigate tuna (Auxis thazard) and little tuna (Euthynnus affinis) are also made. Skipjack is abundant throughout the Maldives, but large skipjack, or godhaa, is relatively more abundant in the north than in the south (Table 1).

TABLE 1. *Average skipjack rates (kg/day) and size composition by major region.*

	North	Centre	South
Av. catch rate 1970-74 (sail P/L)	123	122	116
Av. catch rate 1979-83 (mech P/L)	197	149	282
% large skipjack (1970-83)	33%	24%	18%

There are, however, substantial seasonal, inter-annual, sub-regional, methodological and other sources of variation in the recorded abundance of skipjack (Hafiz, 1985; Hafiz and Anderson, 1988; Rochepeau and Hafiz, 1990). Therefore this gradient may not be as clear-cut as it appears.

The north-south gradient in the abundance of three other tuna species is, however, more clear-cut. The yellowfin tuna, the frigate tuna and the little tuna are all more abundant in the north than they are in the south (Anderson, 1985; Anderson and Hafiz, 1985). Data from the commercial fisheries are confirmed by MOFA survey trolling data (Anderson et al., 1992) for frigate and little tuna.

TABLE 2. *Average catch rates of Yellowfin tuna, Little tuna and Frigate tuna by region*

Fishery			
YELLOWFIN TUNA	North	Centre	South
Sail P/L (1970-74)	19 kg/d	16 kg/d	5 kg/day
Mech P/L (1979-83)	74 kg/d	41 kg/d	11 kg/day

LITTLE TUNA

Trolling (1970-83)	6.7 kg/d	5.5 kg/d	0.1 kg/d
Pole & line (1970-79)	1.8 kg/d	2.1 kg/d	0.1 kg/d
Survey data (1990-91)	0.44 kg/h	0.25 kg/h	0.14 kg/h

FRIGATE TUNA

Trolling (1970-83)	2.8 kg/d	1.4 kg/d	0.2 kg/d
Pole & line (1970-83)	33.4 kg/d	13.7 kg/d	3.5 kg/d
Survey data (1990-91)	0.14 kg/h	0.11 kg/h	0

There may also be a north-south gradient in the abundance of bigeye tuna (Thunnus obesus). Limited sampling to date (Anderson and Hafiz, 1991) suggests that this species may be commoner in the south of Maldives than the north, but much further work is needed to confirm this.

SHARKS

Information on the distribution and abundance of sharks within the Maldives is only available from MRS/MOFA exploratory fishing surveys. The offshore fishing survey (Anderson and Waheed, 1990; Anderson, 1990) deployed both longlines and gillnets off the eastern side of Maldives to catch both tunas and sharks. The two most abundant shark species caught were the silky shark (Carcharhinus falciformis) and the oceanic whitetip shark (Carcharhinus longimanus). The silky shark was most abundant off the northern and central regions of the Maldives, while the oceanic whitetip shark was most abundant off the south (Table 3).

TABLE 3. *Catches and catch rates of silky and oceanic whitetip sharks by longline and gillnet combined, in three areas off the east coast of Maldives.*

	North	Centre	South	Total
No. days fished	32	7	10	49
Silky Shark				
No. caught	192	39	18	249
No. per day	6.0	5.6	1.8	5.1
Oceanic Whitetip				
No. caught	44	9	30	83
No. per day	1.4	1.3	3.0	1.7

Information on inshore sharks is available from the reef fish resources survey, which was carried out in two phases. Phase 1 consisted of a survey of N. Male' Atoll (Van der Knaap et al., 1991). Phase 2 consisted of surveys of Shaviyani, Alifu and Laamu Atolls (Anderson et al., 1992). Most sharks were caught by a light reef fish longline set in the atoll basins, and by handline. Catch rates of two of the most commonly caught sharks (the silvertip shark Carcharhinus albimarginatus, and the grey reef shark Carcharhinus amblyrhynchos) did not appear to vary consistently between atolls.However, four other shark species did show variations in catch rates between atolls (Table 4).

TABLE 4. *Catch rates of four species of shark in four Maldivian atolls, estimated from exploratory fishing surveys.*
(Note: LL = longline; NHL = night handline).

	Shaviyani	N.Male	Alifu	Laamu	Units(Gear)
Loxodon macrorhinus	1.26	1.80	0.52	0.09	nos/100hks(LL)
Carcharhinus sorrah	0	0.02	0.02	0.14	nos/100hks(LL)
	0	0	0	0.13	nos/10hrs(NHL)
Carcharhinus limbatus	0	0	0	0.02	nos/100hks(LL)
	0	0	0	0.19	nos/10hrs(NHL)
Stegostoma varium	0.06	0.01	0.02	0	nos/100hks(LL)

The sliteye shark (Loxodon macrorhinus) was caught by longline in the atoll basins. It was very common in Shaviyani and N. Male' Atolls, relatively common in Alifu Atoll, but rare in Laamu Atoll (Table 4). Thus this species appears to be much commoner in the north of Maldives than in the south. Nearly 400 individuals were caught during the two phases of the reef fish survey, so it could be assumed that the catch rates estimated in Table 4 do give some reasonable index of the relative abundance of this species in the four atolls surveyed (although sexual segregation in this species will reduce the reliability of this index).

The same cannot be said with confidence for the three other species listed in Table 4, namely the spottail shark (C. sorrah), the blacktip shark (C. limbatus, not to be confused with the blacktip reef shark), and the variegated shark (S. varium). The total numbers of these species caught during both phases of the

reef fish survey were only 15, 4 and 8 respectively. In particular, the suggestion that the variegated shark is commoner in the north than in the south may be misleading. The relatively low level of fishing effort in Laamu Atoll during the reef fish survey means that reliance cannot be placed on the zero catch rate for the variegated shark there.

However, for the other two shark species (the spottail shark and the blacktip shark) there is reasonable additional evidence that they really are commoner in the south than in the north. First, these two species do not show up at Male' market or in resort catches, despite intensive fishing in this area. Secondly, shark fishermen from A. Dhangethi, who travel extensively throughout the Maldives on shark netting trips, report that these two species are rare or absent in the north but common in the south (Meemu and Faafu to Gaafu Dhaalu).

SNAPPERS

During the reef fish survey two species of snapper (the yellowfin red snapper Lutjanus guilcheri, and the Timor red snapper Lutjanus timorensis) were caught fairly commonly in the south (Laamu Atoll) but not at all in the centre and north of Maldives (Shaviyani, N. Male' and Ari Atolls). See Table 5 for details:

One other species of snapper (the many-toothed jobfish Pristipimoides multidens) appeared to be more common in the south than the north. However, the numbers involved are very small: only five specimens were caught in total. No specimens were taken in Shaviyani or Alifu Atolls. No specimens were taken in N. Male' Atoll during Phase 1 of the reef fish survey.

TABLE 5. *Catch rates of various species of snapper in three Maldivian atolls, estimated from exploratory fishing surveys.*

	Shaviyani	Alifu	Laamu	Units(Gear)
Lutjanus gibbus	0.41	0.28	0.01	Nos/hrs(NHL)
Lutjanus guilcheri	0	0	0.34	Nos/100hks(LL)
Lutjanus timorensis	0	0	0.10	Nos/100hks(LL)
P. multidens	0	0	0.05	Nos/100hks(LL)
Lutjanus bohar	0.93	0.38	0.15	Nos/hrs(NHL)
Aprion virescens	0.96	0.22	0.29	Nos/hrs(DHL)

One specimen was taken in about 150m outside N. Male' Atoll during Phase 2. The remaining four specimens were all taken from Laamu (three inside and one outside the atoll).

In contrast to these three species, three other species of snapper (Aprion virescens, Lutjanus bohar and Lutjanus gibbus) that are common around Male' and northern Maldives, appear to be less common in the south. It should be noted, however, that the decline in handline catch rates to the south was not clearly reflected in longline catch rates. In additional these species can be quiete patchily distributed, so the survey data may not be a true reflection of their abundance.

OTHER FISHES

Anderson et al. (1992) list a number of reef fish species that appear to show north-south variations in abundance from the reef fish survey data. One species that appears to be commonest in the north is the tomato grouper Cephalopholis sonnerati.

TABLE 5. *Catch rates of various species of snapper in three Maldivian atolls, estimated from exploratory fishing surveys.*

	Shaviyani	Alifu	Laamu	Units(Gear)
Lutjanus gibbus	0.41	0.28	0.01	Nos/hrs(NHL)
Lutjanus guilcheri	0	0	0.34	Nos/100hks(LL)
Lutjanus timorensis	0	0	0.10	Nos/100hks(LL)
P. multidens	0	0	0.05	Nos/100hks(LL)
Lutjanus bohar	0.93	0.38	0.15	Nos/hrs(NHL)
Aprion virescens	0.96	0.22	0.29	Nos/hrs(DHL)

One specimen was taken in about 150m outside N. Male' Atoll during Phase 2. The remaining four specimens were all taken from Laamu (three inside and one outside the atoll).

In contrast to these three species, three other species of snapper (Aprion virescens, Lutjanus bohar and Lutjanus gibbus) that are common around Male' and northern Maldives, appear to be less common in the south. It should be noted, however, that the decline in handline catch rates to the south was not clearly reflected in longline catch rates. In additional these species can be quiete patchily distributed, so the survey data may not be a true reflection of their abundance.

OTHER FISHES

Anderson et al. (1992) list a number of reef fish species that appear to show north-south variations in abundance from the reef fish survey data. One species that appears to be commonest in the north is the tomato grouper Cephalopholis sonnerati.

Species that appear to be common in the south are the African pompano Alectis ciliaris the Delagoa threadfin bream Nemipterus bipunctatus, and perhaps also the coastal trevally Carangoides caeruleopinnatus, and the coral groupers Plectropomus spp. (Table 6).

TABLE 6. *Catch rates of various species of fish in three Maldivian atolls, estimated from exploratory fishing surveys.*

	Shaviyani	Alifu	Laamu	Units (Gear)
C. sonnerati	0.40	0.53	0.03	Nos/100hks (LL)
Plectropomus spp.	0	0.02	0.14	Nos/100hks (LL)
A. ciliaris	0	0	0.17	Nos/100hks (LL)
C. caeruleopinnatus	0	0.01	0.90	Nos/100hks (LL)
N. bipunctatus	0	0	0.07	Nos/100hks (LL)

One final species for which some relevant information is available is the shorthead anchovy Encrasiacholina heteroloba. This species, known locally as miyaren, is an important livebait for the pole and line fishery. Anderson and Hafiz (1988) reported on the basis of anecdotal information from fishermen that this species appears to be commoner in the south than in the north. Further sampling since then has confirmed that finding. From interviews with fishermen on about 60 islands throughout the length of Maldives it is clear that the shorthead anchovy is common in the southern atolls (Thaa, Laamu, Gaafu Alifu and Gaafu Dhaalu), but occurs only irregularly in the north. However, it is also uncommon in Addu Atoll, which goes against the general trend.

DISCUSSION

Evidence is available for variations in the abundance of no less than 23 species along the Maldivian atoll chain (Table 7). For some of these species the data available is very limited, and further investigation may well show that there is no significant variation in abundance from the north to south. Nevertheless, the fish fauna of Maldives is very poorly known on a regional basis and sufficient data is available to look for north-south variation in little more than 100 species. That 23 of these do show some signs of regional variation therefore suggests that there are major latitudinal variations in the fish fauna of Maldives. On the other hand preliminary and qualitative snorkelling and diving observations suggest that the shallow reef fish fauna does not vary markedly along the length of the Maldives. Much further work will be needed to quantify these variations. Two other questions also need to be addressed. First, what are the ecological factors that cause some species to be commoner at one end of the Maldives than the other? Secondly, is there a more-or-less gradual change in species composition and/or abundance from north to south, or is there an abrupt change from "northern" to "southern" fish faunas, and if so where is the boundary?

Ecological factors

The wide variety of species that show north-south variation in abundance, from tunas and oceanic sharks to reef associated snappers, suggests that there must be many ecological factors involved in the promotion of this variation.

For some species the greater depth of atolls in the south may be an important factor. For example, both Alectis ciliaris and Pristipomoides multidens appeared in exploratory longline catches in the basin of Laamu Atoll. This atoll basin is relatively deep, large areas of bottom being at 60-70m. These two species were not caught in the shallower atoll basins of the three atolls investigated further north, although they did appear in deeper water outside these atolls.

For other atoll/reef species the great frequency of reefs within the atolls in the north, and the greater frequency of openings in the atoll rims may be important factors influencing their abundance.

In much of northern and central Maldives the atolls form a double chain. The southern-most Maldivian atolls in contrast form a single chain. With the major monsoon currents flowing to and from the east and west, the northern "double chain" atolls will therefore be for a part of each year exposed to the current, and for the other part "sheltered" from it. There appears to be considerable upwelling, mixing and stirring up of sediments as the monsoon currents pass over Maldive Ridge. As a result there is plankton bloom on the "downstream" or "sheltered" side of the Maldives. Two other factors may also play a role here. First, the Laccadives - Chagos Ridge underlying the Maldivian atolls tends to be shalllower in the north than in the south, therefore perhaps causing greater upwelling in the north. Secondly, runoff of nutrients from the Indian subcontinent may have some impact on productivity in the northern Maldives. It is not unreasonable to suggest therefore that the northern "double chain" atolls may have a higher average annual productivity than the southern "single chain" atolls. The findings of the reef

fish survey are certainly consistent with this hypothesis: the average longline catch of reef fish in atoll basins was approximately 20 kg/100 hooks in Shaviyani, Alifu and N.Male' atolls, but only 10 kg/100 hooks in Laamu Atoll. Oceanic sharks and inshore tunas are also more abundant to the north (Tables 2 and 3). However, skipjack, the important fish in the Maldives is not.

For oceanic sharks and tunas, the oceanographic factors apart from primary productivity that promote north-south variations in abundance are not well known. They do, however, need to be studied as they may have important implications for offshore fisheries development.

TABLE 7. *Summary of names of species that appear to show latitudinal variations in abundance in the Maldives.*

TUNA (KANDUMAS)

Scientific name	English name	Dhivehi name	Commonest in
Auxis thazard	Frigate tuna	Raagondi	North
Euthynnus affinis	Little tuna	Latti	North
Katsuwonus pelamis	Skipjack, small	Kalhubilamas	South
	Skipjack, large	Godhaa	North
Thunnus albacares	Yellowfin tuna	Kanneli	North
Thunnus obesus	Bigeye tuna	Loabodu kanneli	South?

SHARKS (MIYARU)

Carcharhinus falciformis	Silky shark	Ainmathi miyaru	North
Carcharhinus limbatus	Blacktip shark	?	South
Carcharhinus longimanus	Ocean whitetip	Feeboa miyaru	South
Carcharhinus sorrah	Spottail shark	?	South
Loxodon macrorhinus	Sliteye shark	Oashikuri miyaru	North
Stegostoma varium	Variegated shark	Hitha miyaru	North?

SNAPPERS (RAIYMAHUGE AAILA)

Aprion virescens	Green jobfish	Giulhu	North?
Lutjanus bohar	Two-spot red snapper	Raiymas	North?
Lutjanus gibbus	Humpback red snapper	Ginimas	North?
Lutjanus guilcheri	Yellowfin red snapper	?	South
Lutjanus timorensis	Timor red snapper	?	South
Pristipomoides multidens	Goldbanded jobfish	?	South

OTHERS

Cephalopholis sonnerati	Tomato grouper	Veli faana	North
Plectropomus spp.	Coral groupers	Faana	South
Alectis ciliaris	African pompano	Naruvaa handhi	South
Carangoides caeruleopinnatus	Coastal trevally	Vah boa handhi	South?
Nemipterus bipunctatus	Threadfin bream	?	South
Encrasicholina heteroloba	Shorthead anchovy	Miyaren	South

Boundaries

Since many climatic, physical and other ecological factors vary from north to south along the length of Maldives, it is

perhaps not surprising that the abundance of some species also vary from north to south. The MOFA/MRS reef fish survey (Van der Knaap et al., 1991; Anderson et al., 1992) showed that the fish fauna of Laamu Atoll in the south is very different from that of Alifu, N. Male' and Shaviyani Atolls further north (see Tables 4, 5 and 6). What is not clear, however, is the extent to which Laamu Atoll can be considered representative of a "southern" fish fauna, and if it is, the nature and position of the boundary between the "north" and the "south". At present, what little information there is suggests that the greatest changes seem to occur between Alifu / N. Male' Atolls in central Maldives and Laamu Atoll further south. Shark fishermen from A. Dungati suggest that the species composition of reef sharks is different in atolls south of Faafu / Meemu compared to atolls further north. Brown et al. (1989) note some significant differences between commercial handline catches from Dhaalu Atoll and Male'. However, Shepherd et al. (1992) did not note any significant regional differences in their analysis of shallow water reef fish surveys from Male', Alifu, Vaavu, Meemu and Dhaalu Atolls.

The Kudahuvadu Channel between Dhaalu and Meemu Atolls to the north and Thaa Atoll to the south is the dividing line between the northern double-chain atolls and the southern single chain atolls. It may thus mark a significant boundary for several species. This is undoubtedly the case, for example, for the anchovy Encrasicholina heteroloba.

In conclusion, there is clear variation in the abundance of many fish species from the north to south along the length of the Maldives. The full extent of this variation and its ecological bases are not yet known. However, this is an area that deserves further study as it will undoubtedly have significant implications for fish stock assessment and management.

REFERENCES

Anderson R.C. (1985) Yellowfin tuna in the Maldives. IPTP Coll.Vol. Work. Docs. 1 : 34 - 50.

Anderson R.C. (1990) Summary results of the offshore fishing survey. Rasain 10 : 126 - 130.

Anderson R.C. and Hafiz A. (1985) A review of the tuna fisheries of the Republic of Maldives. IPTP Coll.Vol. Work. Docs. 1 : 316 - 323.

Anderson R.C. and Hafiz A. (1988) The Maldivian livebait fishery. IPTP Coll.Vol. Work. Docs. 2 : 18 - 26.

Anderson R.C. and Hafiz A. (1991) How much bigeye in Maldivian yellowfin tuna catches? IPTP Coll.Vol. Work. Docs. 6 : 50 - 52.

Anderson R.C. and Waheed A. (1990) Exploratory fishing for large pelagic species in the Maldives. BOBP Madras REP/46 : 44pp.

Anderson R.C. Waheed Z., Rasheed M. and Arif A. (1992) Reef fish resources survey in the Maldives. BOBP Madras WP/ 80 : 51pp.

Brown B.E, Shepherd A.R.D., Weir I. and Edwards A. (1989) Effects of degradation of the environment on local reef fisheries in the Maldives. Rasain Newsletter 2 : 1 - 12.

Darwin C.(1842) The structure and distribution of coral reefs. London.

Gardiner J.S. (1903 & 1906). The fauna and geography of the Maldive and Laccadive Archipelagoes. Cambridge University Press. 2 vols.

Guilcher A. (1988) Coral reef geomorphology. John Wiley. 228pp.

Hafiz A. (1985) Skipjack fishery in the Maldives. IPTP Coll.Vol. Work. Docs. 1 : 1 - 20.

Hafiz A. and Anderson R.C. (1988) The Maldivian tuna fishery - an update. IPTP Coll. Vol. Work. Docs. 3 : 334 - 344.

Rochepeau S. and Hafiz A. (1990) Analysis of Maldivian tuna fisheries data 1970 - 1988. IPTP/90/WP/22 : 56pp.

Rosen B.R. (1971) The distribution of reef coral genera in the Indian Ocean. Symp. Zool. Soc., London 28 : 263 - 299.

Shepherd A.R.D., Warwick R.M., Clarke K.R. and Brown B.E. (1992) An analysis of fish community responses to coral mining in the Maldives. Envir. Biol. Fishes 33 : 367 - 380.

Van der Knaap M., Waheed Z., Shareef H. and Rasheed M. (1991) Reef fish resources survey in the Maldives. BOBP Madras WP/64 : 58pp.

Woodroffe C.D. (In press) Morphology and evolution of reef islands in the Maldives. Proc. 7th Int. Coral Reef Congress.