Asian Fisheries Science 2(1989):163-175.
Asian Fisheries Society, Manila, Philippines

https://doi.org/10.33997/j.afs.1989.2.2.004

An Appropriate Management Policy for the Domestic Tuna Fishery in the Maldives

R. SATHIENDRAKUMAR

School of Economics and Commerce
Murdoch University
Western Australia 6150

Abstract

The main prospect for economic development of the Maldives lies in the possibility of exploitation of the economic potential of its marine resources. Tuna fishing plays an important role in the development of the Maldives. In this article various policy instruments available to the Maldivian tuna fishery authorities are reviewed in order to select those best suited for the economically efficient exploitation of tuna within the range of operation of the domestic tuna boats. In the Maldivian context, price control is selected as the appropriate policy instrument, even though licensing of tuna boats is also a possibility in the short-run. Price control is based on levying a tax on catches and is oriented towards economic efficiency. The article explains the methodology used in determining the optimal tax which would maximize the economic benefit of the fishery to the Maldivian society.

Introduction

Fishing is the mainstay of the economy of the Republic of Maldives and tuna is the most abundant and most valuable commercial fish in its territorial waters. In the absence of any control, due to the common property nature of the resource, competition for the resource will lead to excess investment and economic rents will be dissipated. "Private harvesting decisions generally fail to maximize the social value of a resource exploited through open-access" (Anderson and Wilson 1977, p. 701). The operation of the free market system in the tuna fishery in the Maldives, given common access, will not lead to a rational allocation of resources as far as the society is concerned even though it may appear to the individual crew to be rational. Therefore, it is important to consider the socially optimal allocation of effort for the tuna fishery in the Maldives in order to maximize the benefits to the Maldivian society.

The price paid to tuna fishermen in the Maldives for their catch is generally well below the export price of tuna realized by the Maldivian State Trading Organisation (STO) even after accounting for the cost of fish collection and export. The STO is owned by the Maldivian government and has a monopoly on the export of tuna. In an earlier article (Sathiendrakumar and Tisdell 1987), it was shown that with the present world price of tuna and in spite of a 50% resource rent being extracted by the STO, the number of boats involved in tuna fishing within 25 km from the shore (Sathiendrakumar and Tisdell 1986) except in the northern atolls, is in excess of the number required to produce the optimum economic yield. Various policy instruments available for management of the existing tuna fisheries are considered in this paper.

Fisheries Objectives for the Maldives

The stated objectives of the Maldivian Fisheries Authority (Ministry of Planning and Development 1985) are:

- To achieve higher catch levels, particularly to reach the upper levels in the wide range of 40,000-70,000 t for the traditional sector; or more specifically, 30,000-40,000 t of nearshore tuna and 10,000-30,000 t of reef fish (e.g., kingfish, snappers and groupers).
- To develop the catch of high-value reef fish.
- To tap the Exclusive Economic Zone (EEZ) potential of fish estimated to range from 9,000 to 21,000 t.
- To protect the fishery resources for the nation's own use and to strengthen surveillance suitably.
- To increase the country's earnings from exports of fishery products.

The overall national goal of the Maldives is to raise the national income and the levels of living, revitalize the economy of the atolls, and maintain a resource base for future growth. To achieve these overall national goals, two important objectives should be included:

- Socioeconomic efficiency: that is achieving the socioeconomically optimal level of catch so that rent will not be dissipated on the one hand, and employment in the fisheries sector will be optimal on the other. The latter can be determined by using shadow cost for labor and capital.

- Redistribution: namely, to redistribute earnings amongst fishermen equitably in a manner different from the existing system.

Since some of these objectives are in conflict with the previously stated objectives, some priority in objectives has to be established.

Selection Criteria for Alternative Fishery Management Strategies for the Republic of Maldives

Skipjack tuna *(Katsuwonus pelamis)* is the major species caught. It is a highly migratory species widely distributed in tropical oceans. In the Maldives, the pole-and-line tuna fishermen do not fish beyond 25 km from the atolls. The unfished skipjack, outside the Maldivian range of fishing, are sufficient to prevent the stock from reaching levels where recruitment declines (Sathiendrakumar and Tisdell 1987). Thus, stock externalities which alter the fish population (Agnello and Donnelly 1976) are not relevant. However, crowding and density-reduction externalities, due to congestion and intensity of fishing on the fishing grounds, occur in the Maldivian tuna fishery, especially in the central and southern atolls (Sathiendrakumar and Tisdell 1987).

In addition to economic efficiency, the practicability of achieving the desired objective must also be considered. However, other criteria, in particular the distributional effects of different policy instruments, are of great concern to many policymakers and must be included in the selection criteria. Pearce (1980) proposed a framework for the comparison of policy instruments in terms of seven criteria:

- effectiveness in controlling fleet capacity;
- implications for technological efficiency;
- adaptability to changing conditions;
- effect of distribution of effort;
- distribution of benefits;
- dislocation and employment effects;
- administrative complexity and cost.

The above can be grouped into four categories; namely (a) efficiency, that is, the cost of enforcement should be less than the benefits to be gained from regulating; (b) acceptability and effectiveness in controlling effort, i.e., the policy instrument should have the support of the majority of fishermen; (c) equity, that is, its effect on the distribution of wealth and on other supplementary goals such as employment must be considered; and (d) flexibility, it should be flexible enough to allow for proper reaction to changes in economic and biological conditions and also encourage innovation and research into new methods.

Fig. 1 illustrates the above framework. With the help of this framework, we can analyze existing or proposed fisheries management policies in order to select the policy or policies that may be suitable for the present Maldivian tuna fishery. Even though some of the measures discussed in the following sections (closed season, size limits, etc.) are stock protection measures (that is, to prevent the breeding stock from falling to levels where recruitment declines) and are therefore not relevant to the Maldives, they are considered here in order to analyze completely all available fishery management measures.

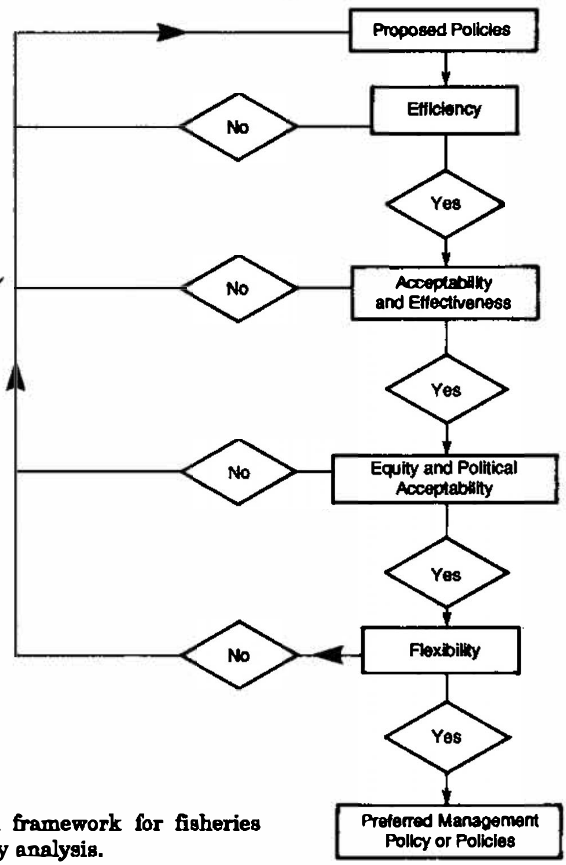

Fig. 1. Suggested framework for fisheries management policy analysis.

Choice of Management Methods

Management measures can be grouped under several broad categories. For example, Anderson (1980) lists four categories, McConnell and Norton (1978) consider five, Gulland (1977) lists six. We will examine five principal management mechanisms (Anon. 1986), which might also be applied to the artisanal tuna fishery of the Maldives.

Limited Entry

A limited entry system enables the achievement of economic efficiency in the fisheries sector (Christy 1976) in the long-run, by controlling all dimensions of effort so as to achieve the optimal level of effort, where rent will not be dissipated.

Some form of licensing is required. The selection criterion for effective licensing could be made to exclude inactive or less active boats. Another way of selecting the initial licenses is through auctioning. Even though auctioning the initial number of licenses desired has the economic advantage of selecting the most efficient fleet (Crutchfield 1986), it will not be socially and politically acceptable in a Muslim country such as the Maldives (Muslim religion does not allow for such auctions especially by the state).

Economic theory predicts that in the absence of zero elasticity of substitution between the restricted and the unrestricted dimensions of effort, the unrestricted dimensions will be substituted for the restricted ones. Examples of restrictive licensing of just a few effort components resulting in the expansion of other components such that neither the objective nor the least cost combination is achieved, are documented by Pearce and Wilen (1979), Fraser (1979) and Kailis (1982). In the Maldivian context, to prevent any further change in capacity after licensing, the boat as well as the engine would have to be licensed.

Sathiendrakumar and Tisdell (1987) give the methodology for estimating the number of boats that would have to be licensed to achieve the optimum economic yield. At 1984 world prices for tuna, the number of boats to be licensed would have been 940 to 960. The number of boats present in 1984 was 1,296.

Catch Quotas

Catch quotas may be either open quotas or individual transferable-quotas. Either type of quota can be effective in achieving the biological goal of stock protection. However, as mentioned earlier, the skipjack tuna stocks that migrate through the Maldives do not appear to need such protection at present. Also, administrative capabilities are limited, making implementation of a quota system difficult. Therefore, catch quotas will not be considered in the Maldivian context.

Gear Restrictions

In the Republic of Maldives, use of nets in tuna fishing is prohibited by law and only pole-and-line fishing is allowed. To a great extent the prohibition of the use of nets prevents the catching of young fish. In pole-and-line fishing the size of fish caught can be influenced by the size of the hooks, but the relationship is not exactly known (Anderson 1977). With the ban on the use of nets, any more stock protection measures are likely only to increase cost.

The value of management of controlling the size and/or the number of hooks in the Maldivian tuna fishery will depend largely on the extent of crowding in the fishery, the degree to which *real* fishing effort depends on the size and/or the number of hooks and the practical enforceability of the system. In the Maldivian context this is not a preferred management option because of the significant surveillance and enforcement difficulties and because stock protection is not of great concern at present. Also if implemented successfully it would affect the economics of vessel operation.

Area Control

Area control, the restriction to particular areas of certain types of fishing, is of no practical significance to the Maldives, since most of the tuna fishing is carried out by very similar types of mechanized pole-and-line boats (Sathiendrakumar and Tisdell 1986) within the 25 km range. In the future, when foreign fishing is allowed in the EEZ of the Maldives, or when large powerful private boats or state-owned boats are allowed to fish in the region, area closure will become an important management tool in protecting the small-scale fishermen.

Financial Controls

Management by financial controls involves providing access to all vessels subject to the payment of an appropriate tax. The use of taxes to control the level of effort makes the private cost equal to the social cost unlike the case in an open-access situation (Crutchfield 1986).

Tax based on inputs. This approach to management is based on the fact that a tax on effort will increase the cost of fishing, which in turn will reduce the total effort by removing those fishermen who are unwilling or unable to pay the tax. Such a tax could induce changes in the method of production, leading to higher total costs for society (Anderson and Wilson 1977) and would amount to a regulation-induced inefficiency. Furthermore, effort is difficult to define and measure (Treschev 1978), especially because it is subjected to continuous revision as technology changes. Since this management measure does not satisfy the efficiency and flexibility criteria, it is not recommended as a management measure for the Maldivian tuna fishery.

Tax based on catch. The tax on catches is oriented towards economic efficiency. The economic effect of imposing such a tax is to increase the cost of fishing. This increased cost deters the marginal vessels in the fleet from fishing, and thus reduces the effort to those which are the most efficient.

Since the function of tuna export in the Republic of Maldives is a monopoly of STO, enforcement would be quite easy. The only catches that might escape this tax would be those for domestic consumption. But in the case of the Maldivian fishing villages, whenever fish are landed on each island an official from the island chief's office will be there to sort the fish based on size and then record the catch in terms of number of fish belonging to each size category. A conversion table is then used to estimate the fish catch in weight. Therefore, it might be possible to impose a tax on the fish that are used for domestic consumption.

A tax on tuna exports is not new to the Maldives. A tax policy was adopted to subsidize imported staple commodities to consumers from the resource rent extracted from the fisheries (Sathiendrakumar and Tisdell 1987). Therefore, a tax satisfies the other conditions for a preferred management policy (Fig. 1). Of the alternatives discussed, it is the only one to do so. (Note that in the short-run, limited entry through licensing also satisfies all the conditions, but in the long-run, it prevents any flexibility with regard to technical progress).

Determination of Optimal Tax for the Maldivian Tuna Fishery

It was shown previously (Sathiendrakumar and Tisdell 1987) that the relationship between catch of tuna and effort in the Republic of Maldives is of the form:

$$C_t = A - B\, e^{(-Kf_t)}$$

where C_t = total landing of fish at time t, f_t = fishing effort at time t, and A, B and K are parameters. Parameter A is the limiting value of the function corresponding to the maximum catch and in practice may correspond to the abundance of fish in the area being fished. Totals costs (TC) may be expressed as $f_t \cdot \varepsilon$, where ε is cost per unit of effort.

Rearranging and substituting the value of f_t, the total cost function expressed in terms of catch will be:

$$TC = -1/K \,Ln\, \{(A - C_t)/B] \cdot \varepsilon \qquad \text{... 1)}$$

Therefore, marginal cost of effort in terms of catch (MC) will be of the form:

$$MC = dTC/dC_t = (-\varepsilon/K) \cdot [1/\{(A - C_t)/B\}] \cdot (-1/B) \qquad \text{... 2)}$$

and average cost of effort in terms of catch (AC) will be of the form:

$$AC = [-1/K \,Ln\, \{(A - C_t)/B\} \cdot \varepsilon]/C_t \qquad \text{... 3)}$$

Since the Maldivian tuna fishing is a small supplier of tuna in the world market, the world price for Maldivian tuna will be used. If we assume that the domestic price of tuna is determined by the world price for Maldivian tuna, then the average revenue curve will be equal to the marginal revenue curve.

The socially optimal economic yield will be when social marginal cost is equal to social marginal revenue. Fig. 2 illustrates the procedure in determining the optimal tax.

Curve MC represents the marginal cost function (equation 2). Curve AC represents the average cost function (equation 3). Line P MR represents the marginal revenue curve (which is equal to the average revenue). The marginal revenue is assumed to be constant

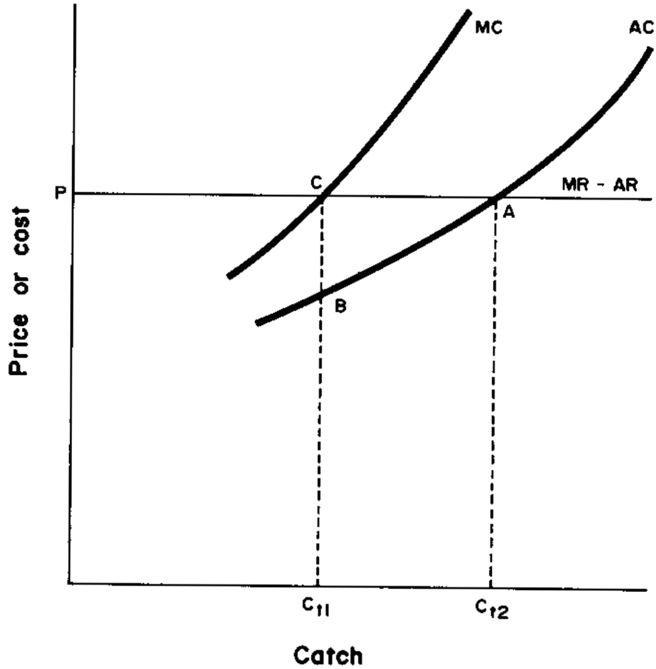

Fig. 2. Determining the optimal tax on fish catch so as to achieve the socially optimal level of catch. See text for details.

because the Maldives is a price "taker" in that it has no influence on the world market price of tuna. In the absence of tax or some form of limit on the catch of tuna, the catch would reach open-access equilibrium at point A with catch equal to C_{t2}. To maximize social welfare for the Maldives, the marginal cost (MC) must be equated to the marginal revenue (MR). This will be at a catch level of C_{tl}. In a long-term open-access situation it will intersect average cost (AC) at point B. Therefore the optimal tax is given by the distance CB and the optimal level of catch will be C_{tl}.

Thus, the optimal level of catch will be when MC = MR, which is:

$$(\varepsilon/K) \cdot \{1/(A - C_t)\} = MR \qquad \text{... 4)}$$

$$C_t = A - (\varepsilon/\{K \cdot MR\}) \qquad \text{... 5)}$$

The value of 'A' was estimated to be around 47,500 t (Sathiendrakumar and Tisdell 1987). Values of Σ are given in Table 1. The value of K is 0.00001772 and MR (the world price of Maldivian tuna) is Rf. 2,904. Calculated values of C_t in equation (5) are given in

Table 1. Optimal catch level and optimal tax rate for the tuna fishery in the Republic of Maldives for six levels of cost per unit of effort (ε).

Cost per unit of effort (ε) in Rf.[1] (per boat trip)[2]	World price for Maldivian tuna ($Rf.t^{-1}$) AR = MR	Optimal catch (C_t) (t)	Av. cost per unit of catch ($Rf.t^{-1}$)	Optimal tax (%)
I	II	III[3]	IV[4]	V[5]
194.2	2,904.0	43,721.8	869.81	70.0
213.9	2,904.0	43,338.59	939.58	67.7
294.2	2,904.0	41,776.35	1,218.37	58.2
313.9	2,904.0	41,393.09	1,279.31	55.9
344.2	2,904.0	40,803.61	1,379.15	52.5
363.9	2,904.0	40,420.34	1,448.16	50.8

Source: Based on equations (3) and (5) when value of A = 47,500, K = 0.0000177, B = 120,952.11.

[1] Rufia (Rf.) is Maldivian currency (K and B are parameter estimates for the regression equation $L_n (A-C_t) = a - bf_t$, where b = k and a = L_nB). 1US\$ = 7Rf in 1985.

[2] Based on an average number of trips per boat of 180 per year.

[3] $III = C_t = A - (\varepsilon/(K \cdot MR))$

[4] $IV = AC = [-1/k\ L_n\ ((A - C_t)/B) \cdot \varepsilon]/C_t$

[5] $V = II\text{-}IV/II \times 100$

Table 1 with the average cost per unit of catch for six values of cost per unit of effort (Σ) for three opportunity costs of labor (Rf. 0, Rf. 1,800 per year, Rf. 2,700 per year) and accounting rates of interest (ARI) of 10% and 15%. Equation (3) is used in the estimation of average cost per unit of catch. Table 2 shows how the cost per unit of effort is estimated using these variables for mechanized pole-and-line boats in the Maldives.

Conclusion

The general objectives of the Republic of Maldives marine policy include increasing national income, generating employment, increasing the living standard of the fishing communities, and conserving the marine environment. However, the overall objective of maximizing the social benefit of the Maldives from tuna fishing has not been considered.

Because biological overfishing is not a problem at present in the Maldives due to the limited range of domestic tuna fishing, the management policy should be to control economic overfishing in order to prevent rent dissipation. In the Maldivian context, two management policies, namely licensing and financial control, are the ones that will help in achieving the economic objective. In the long-run, licensing of boats to control effort might not be beneficial

Table 2. Cost of operating a mechanized pole-and-line boat for two alternative rates of interest (ARI) for capital and three alternative levels of opportunity cost for labor.

1) Capital cost item	Ave. cost[1] (Rf)	Life span[2] (years)	Annual sum to be provided[3] for replacement at 10% ARI	15% ARI
Hull	50,937.50	25	5,618.53	7,889.87
Engine	20,750.00	10	4,719.60	5,776.31
Equipment	5,500.00	05	3,169.06	3,383.14
Total capital[4] cost			13,510.00	17,050.00
2. Operating cost (for 180 trips)				
2a) With zero opportunity cost of labor				
Fuel costs			18,720.00	18,720.00
Repair and Maintenance cost		2,730.00	2,730.00	
2a(i) Total operating cost			21,450.00	21,450.00
2b) With Rf. 10 as opportunity cost per[5] unit of labor				
Labor cost (10*10*180)			18,000.00	18,000.00
Other cost [2a(i)]			21,450.00	21,450.00
2b(i) Total operating cost			39,450.00	39,450.00
2c) With Rf. 15 as opportunity cost[6] per unit of labor				
Labor cost (15*10*180)			27,000.00	27,000.00
Other cost [2a(i)]			21,450.00	21,450.00
2c(i) Total operating cost			48,450.00	48,450.00
3. Total cost				
3a) Total cost (with zero opportunity cost of labor) [1 + 2a(i)]			34,960.00	38,500.00
Average cost = Marginal cost		194.20	213.90	
3b) Total cost (with Rf. 10 as opportunity cost per unit of labor), [1 + 2b(i)]			52,960.00	56,500.00
Average cost = Marginal cost		294.20	313.90	
3c) Total cost (with Rf. 15 as opportunity cost per unit of labor) [1 + 2c(i)]			61,960.00	65,500.00
Average cost = Marginal cost		344.20	363.90	

[1] Based on the survey conducted by the author in Velidhoo and Holudhoo in Noonu atoll in the Maldives between November 1985 and January 1986.
[2] Source: Ministry of Fisheries, Male.
[3] Only capital cost is depreciated at 10% and 15% ARI.
[4] Error due to rounding up.
[5] See Note 1.
[6] 50% higher than the survey figure.

because it may not be effective in controlling the total level of fishing effort. In contrast, financial control by imposing a tax on fish catch has the advantage of not limiting technical progress in the future. Also it provides the opportunity to generate funds to defray the costs of management.

The author is of the view that the opportunity cost of labor per day in the Maldives is around Rf. 10 (Rf. 1,800/year), based on the casual wage rate per day in Maldivian fishing villages, which was Rf. 10 per day at the time of the survey. On this basis, the optimal level of tax should have been between 55 and 60%. The present estimate indicates that the resource rent rate is 50% which is slightly lower than that required to maximize social profit. Thus, the present pricing policy, although implemented with the objective of raising revenue to subsidize imported stable commodities to consumers mainly living in the capital Male, has helped in preventing socially wasteful employment and investment in the fisheries sector even though it has not completely eliminated it.

The methodology in this paper for determining the optimal tax could be used whenever the world price for Maldivian tuna is altered or whenever the cost of tuna fishing in the Maldives is altered. Another advantage of this system is that it is presently in operation even though its purpose is not to achieve the socially optimal level of catch.

Acknowledgement

The author wishes to thank Mr. Jameel, the Senior Under Secretary, Ministry of Fisheries, The Republic of Maldives, for assistance with data and for facilitating the author's field work in 1985/1986. Research for this paper was carried out whilst the author was working towards his Ph.D. at the University of Newscastle, N.S.W. under the supervision of Professor C.A. Tisdell.

References

Agnello, R.J. and L.B. Donnelly. 1976. Externalities and property rights in the fisheries, Land Econ. 52: 518-529.

Anderson, L.G., Editor. 1977. Economic impacts of extended fisheries jurisdiction, Ann Arbor Science, Michigan, USA.

Anderson, L.G. 1980. A comparison of limited entry fishery management schems. FAO Fish. Rep. 236: 47-74.

Anderson, R.C. and J.A. Wilson. 1977. Economic dimension of fees and access control under the fishery conservation and management act of 1976. Washington Law Rev. 52: 701-745.

Anon. 1986. Management of the east coast tuna fishery options and considerations. Fish. Pap. 86-10, Australian Fisheries Service, Canberrra.

Christy, F.T., Jr. 1976. The fishery conservation and management act of 1976: management objectives and the distribution of benefits and costs. Washington Law Rev. 42: 657-680.

Crutchfield, J.A. 1986. Fishery management: a time of change, p. 0-0. *In* T.J.A. Hundloe (ed.) Fisheries management. Griffith University Press, Australia.

Fraser, G.A. 1979. Limited entry: experience of the British Columbia salmon fishery. J. Fish. Res. Board Can. 36: 754-763.

Gulland, J.A. 1977. Goals and objectives of fishery management. IOFC/DEV/74/36, FAO, Rome.

Kailis, T.G. 1982. Limited entry - an industry view, p. 77-86. *In* N.H. Sturgess and T.F. Meany (eds.) Policy and practice in fisheries management. Australian Government Publishing Service, Canberra, Australia.

McConnell, K.E. and V.J. Norton. 1978. An evaluation of limited entry and alternative fishery management schemes, p. 188-200. *In* R.B. Rettig and J.J.C. Gintner (eds.) Limited entry as a fishery management tool. Washington Sea Grant Publication, Washington.

Ministry of Planning and Development. 1985. Republic of Maldives: National Development Plan, 1985-1987. Male, Republic of Maldives.

Pearce, P.H. and J.E. Wilen. 1979. Impact of Canada's Pacific salmon fleet control program. J. Fish. Res. Board Can. 36: 754-763.

Pearce, P.H. 1980. Regulation of fishing effort. FAO Fish. Tech. Pap. 197. 82 p.

Sathiendrakumar, R. and C.A. Tisdell. 1986. Fishery resources and policies in the Maldives: trends and issues for an island developing country. Mar. Pol. 10: 279-293.

Sathiendrakumar, R. and C.A. Tisdell. 1987. Optimal economic effort in the Maldivian tuna fishery: an appropriate model. Mar. Res. Econ. 4(1): 15-44.

Treschev, A.I. 1978. Application of the fished volume method for measuring fishing effort. Co-operative Research Report 79. International Council for the Exploration of the Sea, Copenhagen.

Manuscript received 18 July 1988 ; accepted 31 January 1989