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40 Flatfishes, goatfishes and whitefishes

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ABSTRACT

Although in order to exploit these minor demersal resources there are no specialised fishing efforts, their contribution to demersal finfish production is substantial, mostly exploited by bootom trawling in recent years. The annual flat fish production has been amounting upto 63,344 t in 1992, that of goatfishes upto 33,300 t in 1991 and of whitefish to 25,340 t in 1985. Of late, Kerala has accounted for 47% flatfish production, followed by Karnataka-Goa 23% and Maharashtra 14%. For goatfishes, Tamilnadu-Pondicherry is responsible for 41% followed by Kerald 30% and Andhra Pradesh 13%. Gujarat has been harvesting 49% of the Whitefish yield, followed by Karnataka-Goa 18 % and Maharashtra 13%. The present paper brings together all the available data published and unpublished on the fishery and biology of various species contributing to the fisheries in different parts of the country. Based on these it is seen that the catch of the Malabar sole can be marginally increased in Calicut but not in Mangalore. In the case of the whitefish, there is an all-India decline in production in all the states due to indescriminate exploitation of juveniles by considerably small cod end mesh size of bottom trawls. The present paper draws attention to the gaps still existing in our knowledge and the future research need on the fishery and biology of the important species, stock assessment estimates,relationships between the parental stocks and the progeny; the bottom hydrological conditions and the biological characteristics of the various populations in space and time, for realising the Maximum Sustainable Yield and for implementing their management and conservation.

Introduction

The flatfishes are benthic, carnivorous, belong to the Order Pleuronectiformes have both the eyes on one side of the body and include the

flounders, halibuts, soles, plaice, dabs and turbots. The important families are : Psettodidae, having sinistral or dextral eyes and with a single genus *Psettodes;* Bothidae, having sinistral eyes with genera such as *Bothus* and *Pseudorhombus;* and pleuronectidae, having dextral eyes, with genera such as *Samaris, Synaptura, Zebrias, Solea, Paraplagusia and Cynoglossus.* Many species are greatly esteemed for their delicate and flavored meat, are cheap and within he easy reach of the low income public. In recent years, the annual total production vary from above 24, 000t in 1982 to more than 63,300 t in 1992,forming about 2.8% of the annual marine fish production.

Goatfishes or red mullets usually live in shallow waters with a sandy and /or muddy bottom, are carnivorous and belong to the family Mullidae. The important genera available in Indian region are : *Mulloides, Parupeneus* and *Upeneus.* Most of the species are well known table fishes. Some are used as live baits for tuna fishing. The recent annual production from this resource ranges from more than 28,000 t as in 1988 to more than 33,300 t as in 1991.

The whitefish or butter fish or milk trevally is *Lactarius lactarius* belonging to the family Lactaridae and occurring in shallow waters upto about 100m depth, in wide ranges of sea bottom. It is also carnivorous and much esteemed as a food fish. The recent annual production has ranged from more than 20,000 t as in 1983 to more than 25,300t as in 1985.

In view of the importance of these resources in the marine fisheries of India, investigations on their fishery, biological characteristics and /or stock assessment were undertaken in the Central Marine fisheries Research Institute for some time.

Materials and methods

Although about ninety species of flatfishes and twenty of goatfishes are reported from India, only a few contribute to fisheries of appreciable magnitude. The data on the annual catch statistics of these resources presented in the paper are collected, estimated and documented by the Central Marine Fisheries Research Insititute from time to time. The materials and methods of researches on the fisheries and biology of various species have been documented by Chidambaram (1945) , Seshappa (1964, 1973, 1975, 1976, 1978), Jones and Menon (1951) Seshappa and Bhimachar (1951,1954,

1995), George (1958), Pradhan (1959, 1960, 1965, 1969 a,b,c,), Thomas (1969), De groot (1974), Devadoss and Pillai (1974), James *et al.* (1974), Abraham and Nair (1976), Luther *et al.* (1982), Seshappa and Chakrapani (1987) Mathew *et al.* (1992) and Khan and Nandakumaran (1993). Reports on the early developmental stages of flatfishes are those of Gopinath (1946), John (1951), Nair (1952 a,b), Seshappa and Bhimachar (1955), Jones and Pantulu (1958), Kuthalingam (1957,1960), Balakrishnan and Devi (1974) and Ramanathan and Natarajan (1979); of the goat fishes are those of Gopinath (1946) Uchida *et al.* (1958) and Bensam (1984); and of the whitefish is that of Nair (1952).

The parameters of growth stock assessment, yield,biomass and related ones were estimated by Von Bertalanfy equation (Beverton and Holt, 1957) and based on the studies of Thompson and Bell (1934), Pauly (1983) and Sparre (1987).

Biology

Specieis composition :- Only a few species of marine flatfishes contribute to large catches along the Indian coast; and infact only a single species, *Cynoglossus macrostomus* (Norman) forms a fishery of importance, mostly along Kerala and Karnataka coasts. A larger growning species *C. dubius* (Day) also contributes to a minor fishery along the above coasts; and small numbers of species such as *C.lida* (Bleeker), *C. punticeps* (Richardson), *C. bilineatus* (Lacepede) *C. arel* (Scheider), *Paraplagusia* and *Pseudorhombus*; are reported to appear in small quantities in Karnataka. Species of *Solea, Synaptura* and *Pseudorhombus* are occasionally taken in small quantities from inshore catches, especially *S. ovata* ((Richardson) *P. arsius* (Hamilton) and *Psettodes erumei* Schneider, the last sometimes called the "Indian halibut" occuring in small quantities along both the coasts and recorded from deeper areas also. Along the east coast *P. erumei* and *C. arel, C. bilineatus, C.punticeps, Zebras quagga* (Kaup), *P.erumei* and *Pseudorhombus* and *Heteromyceterias* at mandapam; *P.earumei* and *P. arsius* occur throughout the year at portonovo while the other species that have occurred there seasonally are *C.arel, C. lida, Pseudorhombus malayanus* Bleeker and *Laepos nigrescens* Lloyed.

In India, the important species of goatfishes are : *U. sulphureus* (Cuvier), *U.vittatus*, (Forsskal), *U. tragula* (Richardson), *U. bensasi* (Temminck and Schlegal), *U. sundaicus* (Bleeker) *U. molluccensis* (Bleeker) and *Parupeneus Indicus* (Shaw).

There is only one species of whitefish *Lactarius lactarius*.

Food and feeding :- The Indian Psettodidae and Cynoglossidae have been classified into three feeding behavioural groups, viz., fish feeders, crustacean feeders and polychaetes-molluscs feeders. Among all flatfishes the Malabar sole *C.macrostomus* is found to be bottom feeder preferring mainly a diet of polychaetes, amphipods and small bivalves; with the polychaete worm *Prionospio pinnata* to be the dominant item in the stomach during some periods. The food consumed is generally related to the nature and amount of benthic organisms available. A comparative study on the food in relation to nature of the organisms and their colonisation in the Malabar areas has revealed three distinct food type areas, a polychaete dominant Quilandy-type, a bivalve dominant Thalassery-type and a mixed type. Among these areas, the fishery was observed to be the best in the first type area which has predominantly muddy bottom.

In the case of *P. erumei*, Pradhan (1969 a) and Abraham and Nair (1976) from the west coast have reported that this species feeds on fishes, molluscs and crustanceans, and concluded that it is a voracious carnivore, swallowing organisms as a whole. Pradhan (1969 a) has pointed out that the major componant is teleosts and cephalopods while crustaceans and bivalves are subsidiary ones; and that the juveniles did not show any specific difference on the food and feeding habits in comparison with the adults. *P.arsius* is also a carnovore feeding on fishes, molluscs and crustaceans, both pelagic and demersal as reported by pradhan (1959). Although these species are principally benthic, the occurrence of pelagic fishes such as *Thryssa* and *Stolephorus* in the stomach contents indicates their occasional migration to the water column, an actvity noted in many other flatfishes also.

The food of goatfishes consists manly of crustanceans, molluscs and polychaetes; the juveniles feeding on smaller crustacea such as *Mysis*, cumacea, zoea larvae, young ones of *Acetes*, larval molluscs, fish eggs and larvae (Kuthalingam, 1955, 1956; Rabindranath, 1966; Thomas, 1969). Kuthalingam (1955, 1956) has concluded that the juveniles of *P. indicus* may be surface feeders and the adults perform vertical migrations for feeding while *U. cinnabarinus* was found to feed on fast swimming crustaeceans such as *Squilla, Acetes* and *Matuta;* and that it is a selective feeder. Thomas (1969) has noted that *U. tragula* is also a selective feeder on prawns and crabs.

From available literature and unpublished data collected, it is found

that the whitefish also is carnivorous feeding on teleostean fishes (mostly anchovies), shrimps and other crustaceans (Chacko, 1944; Devanesan and Chacko 1944; Chidambaram and Kurian 1952; James *et al.* 1974). According to James *et al.*, (1974), the juveniles feed more on crustaceans rather than on the other items.

Age and growth :- *C. macrostomus* has been reported to grow to about 17 cm in total length; but bulk of the commercial catches in the southwest coast is made up of 10-13 cm groups although the range is from 5.5 to 15.5 cm. Seshappa and Bhimachar (1955) have reported that females tend to grow at a faster rate than males. The scales of this species have growth rings formed during the monsoon season on them which can be used in the assessment of age and growth. Usually the vast majority of the fish during September-October fishing season measuring 10-12 cm are one year old and are products from the previous spawning season. Besides, considerable quantities of the two year old fish also have been found during certain years, measuring 14-15 cm with lesser growth increment in the second year; but three year old specimens of 16-17cm are rare in the catches. According to Khan and Nandakumaran (1993), the fish grows to about 6 cm when it is about 6 months old, 10 cm at 1 year, 12 cm at 1 1/2 years, 13 cm at 2 years and 14 cm at 2 1/2 years. However, studies undertaken at Mangalore during 1992-95 suggest that the fish attains about 15 and 18 cm respectively at the end of the 1st and 2nd years.

Seshappa (1975) has observed the length range of *C.dubius* at Calicut as from 2.2to 41.2 cm in total length, the vast majority being in the range of 5 to 40 cm; and the fishery is mostly supported by 17 to 24 cm size groups. A study of growth rings on scales has revealed that the first ring, probably associated with the monsoon is formed when the fish is about 18 cm total length, perhaps indicating one year old. The data also indicate that fishes of 25 cm total length are about 2 years old and of 29-30 cm are 4 years old.

The studies of Pradhan (1969 c) at Mumbai have indicated that *P. erumei* reaches length of 22,42 and 55 cm at the end of the first three years of life and that the populations along both the east and west coasts are homogeneous.

Based on length freauency studies Thomas (1969) has concluded that *U.tragula* attains a length of 12 cm at the end of the first year and about 15-

16 cm at the end of second year. Studies undertaken on *U.sulphureus* at Madras indicate that the fish attains 12,16, and 18 cm at the end of the first three years of life.

According to Chacko (1944) and Chidambaram and Kurian (1952), the size range of commercial catches of the whitefish is 11 to 26 cm along the southeast coast. James *et al.* (1974) have reported from Mangalore that the whitefish attains a length of 15 cm at the end of the first year, 21 cm at the end of the second year and that the life span is only two years. The studies at Mangalore during 1992-95 indicate that the fish reaches about 20 and 25 cm respectively at the end of the first and second years of life.

Length-weight relationship:- The length weight relationship of *C.macrostomus* at Calicut is w(g) = 0.0000 3759 L $^{2.6128}$ (mm) Khan and Nandakumaran (1993). At Mangalore the relationship is: Log W= -5.9242 + 3.3416 * Log L; r = 0.68. Kutty and Qasim (1969) have observed that there is no marked difference in the growth rate of male and female *C. macrolepidotus* and that the length (in cm) -weight (in gm) relationship is W= 0.001107 L $^{3.4148}$.

The length- weight relationship of immature and mature *U.tragula* arrived at by Thomas (1969) is Log W = -4.8776 + 2.9638 log L for the former and Log W= -5.3756 + 3.2015 log L for the latter. In *U. bensasi* the relationship is Log W = -4.1347 + 2.6809 Log L.

At Mangalore the lenght-weigth relationship of the whitefish is Log W = -4.90655 + 3.005 * Log L ; r = 0.9

Size and age at first spawning :- *C. macrostomus* from Calicut attains sexual maturity at a length of 10-12 cm when it is less than one year old and usually the eggs are ready for release at about 12 cm length when the fish is about one year old (Seshappa and Bhimachar, 1955). In Mangalore the size at first maturity as observed during 1992-95 is 11 cm. *C.dubius* becomes sexually mature and spawns at a length of about 28 cm and that the minimum size at first maturity is 28.7cm (Seshappa, 1975). Pradhan (1965) reported that *P.erumei* females at Mumbai mature first at 41 cm.

Thomas (1969) has recorded that the size at first maturity in *U.tragula* along the southeast coast is about 12 cm when the fish is about one year old.

In the case of the whitefish the male attains sexual maturity at 16 cm and the female at 18 cm along the southeast coast according to Devanesan and Chacko (1944); but at Mangolore James *et al.* (1974) observed that the size at first maturity is 12-13 cm. when the fish is about one year old.

Spawning season:- Spawning of the Malabar sole at Calicut commences by about October and extends upto the premonsoon months of April-May (Seshappa and Bhimachar, 1955); while in Cochin it is in September as well as in April-May (Mathew *et al.* 1992). At Mangalore also the major spawning is observed to be from October through March, with the peak during November-January. In the case of *C.dubius* at Calicut, Sehsappa (1975) has observed that the spawning season commences from about October / December more or less similar to that of the Malabar sole. The spawning season of *P.erumei* at Mumbai is stated to be September- October by Pradhan (1965).

Among goat fishes, *U.tragula* was observed to spawn at Mandapam from May to November (Thomas, 1969) while at Madras *U. sulphureus* seems to have an extended breeding from September through June with two peaks during September-December and March-May.

In the case of the whitefish, the sawning season off the southeast coast is during November-February period when the fishery is at its peak (Chacko, 1944; Devanesan and Chacko, 1944). James *et al* (1974) have opined that off Mangalore it, spawns almost throughout the year with a possible peak during January - May. The multiplicity of ova diameter modes has indicated that the fish spawns in batches over a prolonged period.

Sex ratio and fecundity :- In *C. macrostomus* Seshappa and Bhimachar (1955) have found that the sexes become differentiated at about 6-7 cm and that sex ratio is variable from time to time, the average being 1 M : 1.4 F. At Mangalore it has varied from 1 M : 0.57 to 1.65 F during 1992-95 and the fecundity of the species has ranged from about 6,540 to 19,890 eggs for fishes of 13.6 and 15.7 cm TL respectively. The sex ratio of *C.dubius* at Calicut showed 3.47 M: 3.047 F (Seshappa, 1975). Pradhan (1965) has found the sex ratio of *P.erumei* at Mumbai as 1M : 3.8 F; that there is sexual segregation in certain months and that the fecundity is 31, 380 to 12,19.080.

Among goatfishes, Thomas (1969) has observed the sex-ratio of *U.tragula* at Mandapam as 1M: 1.92F and its fecundity as 19,000to 92,800. In Madras, *U.sulphureus* had a sex ratio of 1M: 1.75 F.

The sex-ratio of the whitefish at Mangalore is 1 M : 0.2 to 1.1 1F (James *et al.*1974) and the studies during 1992-1995 have indicated a similar trend. The fecundity of the species estimated by James *et al.* (1974) is 9,000-79,000 eggs in fishes of 16.3 to 21.4 cm TL, weighing 60-124gm. During 1992-95, the estimates made are about 8,950 eggs in a fish of 14.3 cm and 31,340 eggs in another of 18 cm TL.

Fishery

Flatfishes :- The total flatfish landings along the Indian coast has been estimated to fluctuate from about 2,000t as in 1951 to about 63,344 t as in 1992. The landings have recorded a distinct increasing trend with the advent of bottom trawling and registered a regular production of more than 10,000 t from 1968, crossing the 15,000 t mark in 1981, 24,00t in 1982 and attained more than 40,00t in 1984. However, there was a decline from the 1984 level in 1985 although a recovering trend was observed until 1991. The year 1992 has witnessed an all-time record of 63,344 t followed by a decline to 46,660t in 1993 and still lesser to 44,200t in 1994. The average production during the five years period of 1990 - 94 is 44, 270 t which is about 7 % of the total demersal finfish production and 2 % of the total marine fish production of India. Of the total production, about 90% is from the west coast and 10% from the east. Groupwise, the tongue soles contribute to about 93% followed by the Indian halibut (*Psettodes*) 6% and a variety of flounders 1%, consisting of *Pseudorhombus, Samarias, Bothus*, etc. The tongue soles are usually shallow water forms while the halibut is available in deeper waters.

Among all the species of flatfishes available in India, it is only the Malabar sole *C.macrostomus* which forms a regular fishery from ancient times along the south-west coast in the states of Kerala and Karnatka; and documented atleast from the beginning of this century. Rao (1967) has pointed out that the region between Mulki in Karnataka and Kollam in Kerala is the important zone for the Malabar sole. According to Seshappa (1973), in the pre-war years the annual production was about 9,400t there was an increasing production form 1944 onwards with record production in 1950-51, amounting to about 18,800t. Some regular features observed by him are: best landings during September, considerable decline during October, restricted fishery at the central sector in the following months and little catches in the premonnsoon months. During the premechnised era, the important gears used were: castnets, boatseines (*Paithu vala*) in Kerala and shore-seines (*rampani*,

kairampani) in Karnataka. Certain other gears namely *Nethel vala, Pattamkolli vala* and *Chooda vala* also were used to harvest the sole. Seshappa (1973) has reported high catches in premonsoon months, dominated by juveniles. With the introduction of mechanisation from the sixties, the fishing pattern has changed, from capturing the shoals at the surface and subsurface regions by indigenours gears to effective capture by bottom trawlers. After commencement of mechanisation and bottom trawling, the bulk of the Malabar sole caught is by this gear with a mesh size of 15 to 25 mm operated mostly from small trawlers of 14 m OAL in the depth zone of 10-50 m, although non-mechanised country crafts are also employed in certain locations.

Among various states, the West Bengal-Orissa zone has recorded the least annual production of flatfishes ranging from 6 to 810 t with abundance during 1985-87. In Andhra Pradesh, the production was not quite impressive until the eighties (56-247t). In 1981 there was a sudden spurt of 2,210 t annual yield, which was followed by higher production (850 to 1,630 t) when compared to the production until 1980. A similar trend was observed in Tamilnadu-Pondicherry with the annual catches ranging from about 120 to 1,180 t between 1956 and 1979; but crossing the 2,240 t mark in 1980. Subsequently the production ranged from 1,630 to 3,840 t with the peak in 1991, showing a higher level. In Kerala, the flatfish production has shown a steady increase, from 7,610 t in 1956, crossing the 10,000 t mark in 1958, but declined subsequently. With fluctuations in between, the production has crossed the 12,000 t level in 1974, again to record a decline until 1980. Thereafter there was a steady increase, crossing the 20, 000 t mark in 1989 although declining by about 28% in the next year. In Karnataka, the annual catches ranged from about 720 t in 1986 to 1,660 t in 1971 and crossed the 2,500 t level in 1974. Subsequently the fishery has declined to about 680 t in 1984 but showed considerable improvement in subsequent years and reaching the all-time peak of 19,080 t in 1992. In Maharashtra and Gujarat the flatfish production may be said to have stabilised only since the seventies, ranging from about 1,800t to the peak of 6,910 t in 1993 in the former and about 2,460 to 6,790 t in the latter state. During the past about ten years, Kerala has contributed to the bulk average annual production of 47% followed by Karnataka-Goa 23 % and Maharashtra 14%.

According to Mathew *et al.* (1992), the maximum production of flatfishes in the west coast is from Kerala (40%) followed by Karnataka - Goa (35%), where the Malabar sole constitutes the bulk of the yield. In the Malabar

coast of Kerala, bulk of the landings is immediately after the monsoon, within two or three months; and the fishery is characterised by wide fluctuations. In Cochin, Mathew et al. (1991) have noted a direct and positive correlation between the catch rate and the intensity of rainfall as well as the peak usually occuring in June, after the onset of the monsoon. In Karnataka - Goa the bulk of the production is during the monsoon and postmonsoon. In Maharashtra and Gujarat the bulk of the production is during premonsoon and postmonsoon months, usually higher production during the latter period in Maharashtra and *vice versa* in Gujarat. Among various species, *P.erumei* contributes up to 15% of the total faltfish production in both these states (Mathew *et al.* 1992). However, an organised fishery for this fish is not reported from any part of the country (Prabhan, 1969c). The all-India annual halibut landings which have ramained at about 1,384 t in 1982-83 have recorded a gradual increase as a result of expansion of fishing to deeper areas subsequently upto 70-100 m depth in recent times and crossing the 2,870t production in 1990. At Mumbai, prior to introduction of bottm trawling the occurrance of *P.erumei* in commercial catches was rare and seasonal (Prabhan, 1969 c), caught mostly in the stationary type of bag nets, popularly called "Dol". But since the inception of bull-trawling by new India Fisheries Ltd, there was considerable increase in the catches of this fish, mostly from Mumbai proper, Cambay,Veraval, Probunder and Dwaraka.

Goatfishes :- Prior to the advent of commercial bottom trawling the indigenous crafts and gears such as shore-seines, boat seines fish traps, etc. were responsible for the production of goat fishes. Thomas (1969) has stated that the fishery had some magnitude in the states of Andhra Pradesh and Tamilnadu in the east coast and Kerala, Karnataka and Maharashtra in the west coast. According to him, *U. sulphureus* and *U. vittatus* were the two species available in the above states except in Tamilnadu where *P.indicus* and *U. tragula* are the dominant ones. The all India production of goatfish ranged from 1,110 to 1,513 t during 1950-55 period; and in 1956 there was a sudden and transient spurt in production to more than 10,400t, which was followed by a rapid decline and fluctuation around 3,027 t as in 1964 to 1,526 t in 1956; and an all time low of 1,344 t in 1967, although recovering subsequently. After the spurt in 1956, the next peak recorded was so late as in 1974 when a production of more than 7,000 t was recorded which was again followed by a sudden decline to about 2,640 t in 1975. The 10,000 t mark was crossed for the second time only in 1987 after a lapse of more than 30 years and this

was followed by a record production of 28,463 t in 1988. Again, there was a decline in the next year and further reduction in the subsequent two years. It may be seen from the above data that the all-India goatfish producion is marked by wide fluctuations and sudden and transient spurt of increase followed by decline.

Among various states, the annual production was meagre in West Bengal-Orissa zone, usually ranging from 1 to 34 t upto 1979. The production has increased in the eighties, reaching the peak of about 420 t in 1985, followed by a gradual decline thereafter although reaching about 370 t in 1993. In Andhra Pradesh, the landings have varied from 170 to 1,220 t till the seventies after which there was a higher level of yield, reaching about 4,080 t in 1987, although declining later. A similar trend was observed in Tamilnadu-Pondicherry and Kerala with a peak of 11, 380 t in 1988 and declining thereafter in Tamilnadu-Pondicherry; with an all time peak of 18,820 t in 1990. In Kerala production was much lower, marked by wide fluctuations and there was no further recovery at all. In Gujarat the fishery has commenced only from early seventies, increased in quantum thereafter, reached an all time peak of 18,195 t in 1985; declined by 64% of the above in the next year itself; and led to a meagre of 1,327t in 1993 (93% lesser than in 1985). Among various states during the past about ten years, Gujarat is responsible for the bulk production of 49%, followed by Karnataka-Goa 18% and Maharashtra 13%.

White fish :- In south-east coast, the main fishery for the whitefish is from Novemeber to February (Chacko, 1944; Devenesan and Chacko, 1944; Chidambaram and Kurian, 1952). At Mangalore, James *et al.* (1974) have observed that the fishery is supported by 0 and 1 + year old fish and that the fairly high fecundity seems to allow for necessary recruitment. Kaikini (1975) has observed that off Mumbai-Saurashtra waters whitefish concentrated in the depth range of 20-45 m, the 30-35 m zone being the optimum one. The depth ranges were observed to change according to the season, the catch rate being the highest during April-June period. A gradual north-south migration of the species from Kutch commences in April and culminates by the following January at Cambay.

Stock assessment

Seshappa and Chakrapani (1987) have studied the extence of stocks of the Malabar sole and opined that although there is some variability in the meristic characters among different centres, the samples from Cochin perhaps belong to a stock different from those of other centres. In Calicut, Khan and Nandakumaran (1993) have studied the population dynamics of *C.macrostomus* during 1987-92. According to them the instantaneous rate of total mortality during the period was 2.5; the average annual landing was about 959; and the maximum sustainable yield (MSY) is about 1,694 t, which is much higher than the annual harvest. Based on these data and the exploitation ratio, the total standing stock was estimated as about 2,592 t there. They have also concluded that the yield can be increased by enhancing the effort up to a value of 0.96. However, since the increment in yield will not be remunerative beyond a value of 0.87, increasing it beyond 0.87 will not commensurate with increase in the effort. At Mangalore during 1992-95 the exploitation rate was estimated to be 0.727; the MSY as about 2,513t; and it is estimated that an additional of 357 t can be harvested, although the exploitation rate is above optimum.

In the case of whitefish at Mangalore, the studies have shown that the exploitation rate during 1992-95 is 0.694; that the average annual catch of 257 t is almost equal to the MSY of 268 t, although the actual catch during 1994-95 has amounted to 429 t.

Studies have not yet been undertaken on the stock assessment of goatfishes.

Conservation and manangement options

There is no specialised fishery targeted for flatfishes, goatfishes and whitefish in any part of the Indian coast, including for the Malabar sole. The bulk of the catches for these resources are bycatches in the fisheries targeted for other resources such as shrimps. According to Khan and Nandakumaran (1993) the effect of fishing on the stock of Malabar sole available at Calicut is negligible and that the present fishing effort there can be increased two-fold from the present level of harvesting 959 t to 1,646 t which can be considered as the economic yield. They have concluded that from the present effort of only 0.4, it can be increased to 0.87 for achieving such a purpose. However,

the studies undertaken at Managalore indicate that the present exploitation rate there for Malabar sole is about the optimum. Also, since about 83% of the present annual yield there is from the region up to about 30 m depth, which is overexploited for vaious resources and since a ban on bottom trawling upto 5km from the coast is at present under the active consideration of Karnataka Government, further intensificaion of exploitation in the above region shall be only counter-productive. Studies on yield -mesh curve at Mangalore also indicate that any change from the present length at first capture of 11 cm will only reduce the yield per recruit.

In the case of the white fish studied at Mangalore during 1992-95, it is seen that the present fishing effort is 5.938 and that any change from the present length at first capture of 14 cm will only reduce the yield per recruit. As the average annual MSY at Mangalore is about 268 t, as against the annual average catch of 257 t and since the actual catch is 429 t during 1994-95, it is seen that the resource is being overexploited there; and that this level has to be decreased.

The whitefish is one resource that has been showing a gradual and consistent decline on an all-India basis from an all-time annual peak production of 25,337 t in 1985 from low levels in the sixties and seveties. The decline has been so alarming that it has reached an all-time low of a mere 4,189 t in 1993, which is only about 16.5% of the production in 1985. The decline is very much marked in the states of Andhra Pradesh, Tamilnadu-Pondicherry, Kerala, Karnataka -Goa and Maharashtra; but not so much in Gujarat. In the south-west coast, in a single centre, Vizhinjam alone according to Luther *et al.* (1982), the annual production which was 62.4 t in 1970 has gone down to a meagre 0.1 t in 1979. From these facts, it can be easily stated that in order to maintain the MSY from this valuable resource, it is very much essential to reduce the intensity of its exploitation by reducing the quantum of production increasing the cod-end mesh size for rational capture and conserving the potential spawners, in order to ensure continuity of higher production in all the states

Economics and marketing

Although for large-sized flatfishes such as the halibut there is demand in the market, small sized species like the Malabar sole, fetch only Rs. 5 to 15/kg in the local markets,. Accordingly, about 90 % of the small sized soles

are sundried with other fishes such as sardines, sciaenids, silver bellies etc. and sold out during nonfishing seasons at a rate of Rs. 10 -25/ kg.

Goatfishes are esteemed as good quality fishes for food and are mostly consumed in the fresh condition at a price of Rs. 15 - 40/kg. When the catch exceeds the local demands the fishes are sundried along with other fishes. Prior to sundrying on the beach, the fish is kept in salt solution for a day. After this, the fish is packed in baskets such as of palmyrah leaves and transported to interior markets. Some species of goatfishes are used as live baits for tuna fishing in the island of Minicoy, as reported by Jones and Kumaran (1959) and Jones (1964).

The whitfish has good demand in local markets in fresh condition with a price tag of Rs. 35 - 50 / Kg. Almost the total catch is consumed in the fresh condition, although small proportions are sundried and fetch prices of Rs. 80-100/kg during nonfishing seasons.

Future research priorities and conclusion

In view of the fact that there is no special targeted fishing of these resources in any part of the Indian coast as at present, the future research priorities for these resources cannot be delinked from those of the others which are also caught by the same crafts and gears employed. Preliminary studies of Seshappa and Chakrapani (1987) have indicated that there are two major stocks of Malabar sole, viz. the Cochin stock and the general stock. In order to impliment meaningful stock assessment studies of this resource in Kerala-Karnataka region, it is essential to confirm this aspect by more exhaustive studies in space and time and also by involving modern biochemical methods of racial investigations. Also, if different stocks are present, the degree of their intermingling and the role if any of them on the variations in production will have been undertaken in one or two centres so far . such studies will have to be undertaken in the other centres also and a wholistic picture will have to be obtained. Similar studies on the important flatfishes from off Maharashtra and Gujarat also are an essential prerequisite that will have to be undertaken.

Another area which needs urgent attention is the evaluation of the relationship between the parental stocks of various species/stocks and their progeny. Although the fecundity estimates of a few species of the resources have been worked out no attempt seems to have been made to estimate the

fecundities of the total populations year after year, to correlate the fecundities with the strength of the resultant progeny/year classes as well as to develop statistical and predicatable models based on the findings.

Although research work on the fisheries and biology as well as environmental parameters of the fishing grounds in which these resources are available has been undertaken in certain localities, concerted effort on collecting data from the benethic areas where these resources occur do not seem to have been undertaken so far. In order to elucidate the relationship existing between the environmental parameters and the biological characteristics of species in space and time which result in the variations in production from year to year, it is absolutely essential to implement collections of data on the same, to analyse them, to interpret the results as well as to develop models for forecasting of prodcution in relation to environmental parameters.

In order to finalise the MSY as well as to ensure economic sutainability it is urgent to study the optimum cod-end mesh size for these resources in space and time; as well as to enforce the results and recommendations without any compromise.

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