Distribution and Fishery of *Lates calcarifer* in India

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Sea bass, *Lates calcarifer*, is widely distributed along the coasts of the Indo-Pacific Region, and in India this fish supports a commercial fishery mostly in estuaries, brackishwater lakes and lagoons. It is landed in very limited quantities from coastal waters (Raj 1916; Chacko 1956; Devasunadaram 1954; Jhingran and Natarajan 1969; Jhingran 1982).

Studies exclusively on the fishery of *Lates calcarifer* are lacking, and only a very few detailed studies have been carried out (Jones and Sujansingani 1954; Chacko et al. 1953; Jhingran and Natarajan 1966, 1969). Most of the studies relate to the biology and culture of sea bass (Ghosh 1971, 1973; Ghosh et al. 1977; Hora and Nair 1944; Kowtal 1976, 1977; Menon 1948; Mukhopadyay and Karmakar 1981). Gopalakrishnan (1972) has dealt with the taxonomy and biology of *L. calcarifer* along with other culturable tropical fishes. In this paper the distribution and fishery of *L. calcarifer* are reviewed. The future prospects for the exploitation of the resource are indicated and recommendations are made for further development of the fishery based on studies of the population dynamics of this species.

Distribution

Lates calcarifer is distributed in the northern part of the Indo-Pacific region, southward to Australia and westward to East Africa in the coastal waters (Day 1958; FAO 1974). In India this species occurs along the coastal waters in small quantities and in estuaries, lagoons, backwaters, and lower reaches of rivers adjoining estuaries in good abundance. A certain fraction of the population, especially very large, mature adults, appear to avoid lagoons and inhabit mostly the coastal inshore waters. The rest of the population, mostly young ones, occur in less saline intertidal zones, estuaries and other backwaters. The occurrence of this species in offshore waters has not been reported from India. The sea bass breeds in the sea and the fry enter the Thakuran, Matlah and lower stretches of Hoogly Estuary during May–October in West Bengal and during July–August in Chilka Lake near the lake mouth in Orissa (Jhingran and Natarajan 1969).

Stray fingerlings, measuring 50–70 mm occur in the northern sector of Pulicat Lake during May–June (Rao and Gopalakrishnan 1975). Early larvae 4–6 mm have been reported from the intertidal zone of the creeks of Kakdwip (Mukhopadhyaya and Varghese 1978). As observed from the fishery, 46.8% of the *L. calcarifer* resource is distributed in the northern sector, 45.1% in the central sector and only 8.1% in the southern sector of the Chilka Lake (Jhingran and Natarajan 1969). Young ones measuring 374 mm and below always occurred in good abundance in Chilka Lake (50% and above). However, during some years fish of the size group 375–599 mm have been abundant. The size groups larger than the latter are distributed sparsely and their percentage distribution decreases with the increase in size and age (Jhingran and Natarajan 1969). Sometimes this species occurs in rivers in fresh water (Anon 1951).

Migration

Though this species is considered to be anadromous in Thailand (Smith 1945), migration is not highly pronounced in India. Localised migration of lesser magnitude for the purpose of feeding and breeding has been reported by Chacko (1949a) in Coleroon River mouth, ascending up to the Lower Anaicut a distance of nearly 50 km. In Krishna River, sea bass ascend for a distance of 50 km (Chacko 1949b).

On the southeast coast of India, at Muthpet, Tamil Nadu, the young ones migrate into saline swamp (Chacko 1949c). In the Godavari and Krishna rivers this fish has been reported to migrate up to 130 km from the sea (Anon 1951) and all these migrations into the freshwater rivers, brackishwater lagoons, lakes and swamps are for shelter, feeding and growth. However, the breeding migration is not clear. During breeding seasons (June–July and January–March for Chilka stock and October–December for Tamil Nadu stock), the potential breeders are considered to migrate to the adjoining sea for spawning (Jhingran and Natarajan 1969; Chacko 1949c; Jones and Sujansingani 1954).

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Fishery

Fishing Grounds, Craft and Gear

The brackishwater lakes and estuaries of major rivers of India are the important fishing grounds for this species. The important lakes are Chilka Lake in Orissa, Pulicat Lake in Tamil Nadu and Vembanad Lake and its connected backwaters in Kerala. Among the estuaries, the Hoogly-Matlah estuary in West Bengal, the Mahanadi Estuary in Orissa, the Godavari and Krishna estuaries in Andhra Pradesh, the Cauvery Estuary in Tamil Nadu and the Narmada and Tapti estuaries in Gujarat support the fishery to a considerable extent.

Plank-built boats, dugout canoes and catamarans are employed in the fishing operations. Some of the craft are now mechanised. The plank-built boats are mechanised with inboard engines and the others with portable outboard engines. These fishing craft are of various types and sizes with different vernacular names. The fishing gear of Chilka and Pulicat Lakes has been described and discussed by many workers (Hornell 1924; Mitra 1946; Anon 1951; Devasundaram 1951, 1954; Jones and Sujansingani 1952, 1954; Job and Pantulu 1953; Chacko et al. 1953; Mohapatra 1955; Mitra and Mohapatra 1957; Jhingran and Natarajan 1969; Krishnamurthy and Rao 1970). There are 13 well-defined nets of three types (dragnets, gillnets and cast nets) in use in Chilka Lake. Krishnamurthy and Rao (1970) described one shore seine, 8 dragnets, 3 bagnets, 2 fixed nets, 2 stake nets, 1 cast net, long lines and hand lines which are extensively used in Pulicat Lake.

The important gear used include: *Bhekti jal*, a dragnet with bag, in Chilka Lake and *Koduva valai*, a type of gillnet, made of sun hemp twine, in Pulicat Lake. These two nets have been designed with the aim of exploiting the sea bass and are named after the sea bass. The knots of the *Koduva valai* are of reef-knot type which get loosened depending upon the girth of the fish captured. The *Bhekti jal* net catch comprises 59.3% sea bass. The net is 9 m long, 3–4.5 m in depth and provided with rectangular floats and having a knot to knot mesh size of 45–76 mm (Jones and Sujansingani 1954). The other gear used to land sea bass in Chilka Lake are *Khepa jal* (cast net, 6.1%), *Bhida jal* (drag net, with bag, 5.5%), *Noli jal* (gillnet without foot rope, 0.9%), *Patua jal* (drag net with bag, 0.7%), *Khadi jal* (drag net without bag, 0.5%), *Menjia jal* (gillnet with foot rope, 0.2%) etc. In Pulicat Lake *Badi valai* (shore seine), *Peria konda valai* (drag net), long line and hand line and *Barang jal* (gillnet) in Hoogly-Matlah Estuary also land sea bass.

Fishing Methods

Four types of fishing methods (net, impoundment, hook and line, trap) are employed in the brackishwater lakes and estuaries of India.

Net fishing is conducted throughout the year with apparently low fishing intensity during October–December, contributing 50–66% of annual production of Chilka Lake in which the sea bass constitutes 2.1% of the production. The drag nets have been reported to land the bulk of the catches. Impoundment fishing is conducted by erecting large impoundments with the help of split bamboos in shallow areas of lakes and are operated during October–February, accounting for 13–22% of the lake's annual production. Hook and line fishing is conducted using monofilament as snoods with No. 6–10 hooks in long lines. Monofilament hand lines are employed using prawns and fish as bait for *L. calcarifer*, threadfins and other perches. Trap fishing is conducted with traps mostly for prawns during March–September in Chilka Lake. Perch traps made of bamboos are extensively used in Palk Bay and Gulf of Mannar in Tamil Nadu.

Catch Statistics

Estuarine Fishery

The catch of *L. calcarifer* during 1964–76 from Hoogly-Matlah estuary varied between 21 and 283 t and the percentage composition in all fish catches between 0.15 and 3.43. On an average 78.4 t of *L. calcarifer* were landed annually which constituted 0.9% of the total average production.

Annually 179.8 and 466.5 t of fresh and dried fish from Mahanadi estuary are caught (Shetty et al. 1965). *Lates calcarifer* constituted 3.7% of the total production from the estuary. An average annual catch of all fish of 3036.1 t has been reported from Godavari estuary in which the perches formed 6% of the landings (CIFRI 1964). The percentage composition of *L. calcarifer* has not been reported. Venkatesan (1967) reported the estimated total landings of 371 t of fish from six estuaries of Tamil Nadu on the southeast coast of India in which sea bass constituted 14.5 t or 3.9% of the total catches during 1967–68. The information on the catch statistics on sea bass is not available for the other estuaries along the Indian coasts.

Lake Fishery

Several workers have studied the fishery of Chilka Lake since 1930 (Mitra 1946; Devasundaram 1954; Jones and Sunjansingani 1954; Jhingran and Natarajan 1966, 1969; Sengupta and Patro 1970). Detailed studies on the important fisheries of Chilka Lake were carried out by Jhingran and Natarajan (1969) during 1957–65. The estimated annual average fish yield was 3663 t in which sea bass constituted 5.9% of the total catches. The yield per hectare for the lake varied from 25.1 to 43 kg with an average of 35.3 kg/ha and the calculated yield of *L. calcarifer* was about 2.1 kg/ha.

The *Lates calcarifer* fishery of Chilka Lake showed extreme fluctuations and the highly successful fishery in 1964 with landings of 749 t has been ascribed to

Table 1. Estimated total fish catch and composition of *L. calcarifer* in Chilka Lake. Source Jhingran and Natarajan (1969).

Year	All fish catch (t)	*L. calcarifer* total catch (t)
1957	4,455.7	174.3
1958	3,837.9	136.2
1959	3,796.7	150.9
1960	2,603.6	102.2
1961	2,861.2	55.3
1962	3,896.9	113.0
1963	3,928.4	294.5
1964	3,214.0	748.6
1965	4,375.6	163.3

continuous lakeward ingress during the period January-June and October-December (Table 1). In impoundment catches, the size range 150–374 mm formed 65.3%, 375–599 mm 32.4% and 600–749 mm formed 2.2%.

Population Dynamics

Length-Weight Relationship

De (1971) recorded a strong positive correlation of these two parameters at early stages of life of *L. calcarifer*.

Ganguly et al. (1959) studied the length–weight relationship of *L. calcarifer* in a natural population in relation to other morphometric characters. The length–weight relationship of *L. calcarifer* is Log W = –5.0188 + 3.0342 Log L, r = 0.9988. Patnaik and Jena (1976) have worked out the length–weight relationship of the species of Chilka Lake.

Mortality Parameters

NATURAL MORTALITY COEFFICIENT (M)

The natural mortality coefficient in *L. calcarifer* estimated by the 'Independent Method' (Pauly 1980) from the formula Log M = –0.0066– 0.279 × Log L_∞ (cm) + 0.6543 Log K + 0.4634 × Log T (°C) is 0.45.

TOTAL MORTALITY COEFFICIENT (Z)

The total mortality (from fishing, natural as well as migratory loss) computed separately for year II/I and III/II age-groups and averaged for the period 1958–65 by Jhingran and Natarajan (1969) was estimated at 63%. If the annual average mortality rate A is 0.63, then the average survival rate is 0.37 (i.e. S=1–A; 1–0.63 = 0.37) and the total instantaneous mortality coefficient Z is Log_e of S i.e. –0.99. With sign changed Z is 0.99.

FISHING MORTALITY COEFFICIENT (F)

The average annual fishing mortality coefficient F is Z–M; i.e. 0.99–0.45 = 0.54.

Recruitment

Maturing and mature individuals of *L. calcarifer* have been observed during April–July in Chilka Lake. Peak period of breeding has been inferred to be June–July and spawning is believed to take place in the inshore waters (Raj 1916; Jones and Sujansingani 1954; Jhingran and Natarajan 1969; Gopalakrishnan 1972). It is very likely that another spawning in Chilka *L. calcarifer* may be around the period January–March. The recruits to Chilka fishery in July–August are traceable to this period. Recruitment to the fishery takes place at 162 mm (modal value) and again in July–August at modal sizes 112–162 mm during 1958–65 (Jhingran and Natarajan 1969). The latter recruits are especially dominant in certain years. The age at recruitment is 0.378 year and age at first capture is 0.65 year.

Yield per Recruitment

The yield per recruitment of *L. calcarifer* for different fishing mortality coefficient (F) at the age at first capture 0.65 year for three different M/K ratios i.e. 1.5, 2.0 and 3.0, is given in Fig. 1. For the prevailing M/K ratio 2.0, the fishing mortality coefficient which can bring in the highest yield of 598.4 g is 0.3 which is far below the highest average fishing mortality coefficient during 1958–65, i.e. 0.54, and this is so in the other two M/K ratios also. Jhingran and Natarajan (1969) observed that, in spite of the increase in number of fishermen over the years, the effective fishing effort has not substantially changed resulting in a stabilised yield within a certain range. The quantum

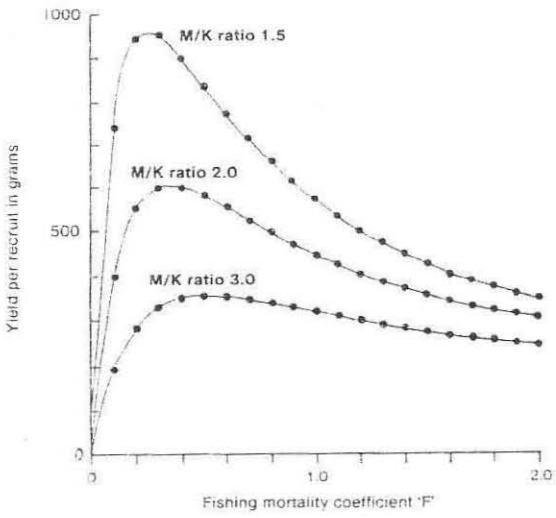

Fig. 1. Estimates of yield per recruit (in *grams*) of *Lates calcarifer* for three different M/K ratios indicated at different fishing mortality coefficients (F) and prevailing age at first capture, i.e. 0.65 year.

of fishing effort, however, far exceeds the optimum level and this is reflected in low mean age size.

The annual mean length in fishing during 1958–65 varied in the range 234–562 mm with an overall mean length for the entire period at 405 mm. The minimum size at maturity was 425 mm which is fairly close to overall mean length. As the age at first capture is anywhere below 405 mm, the prevailing fishing intensity is much higher than the required optimum level. Considering these points it was rightly suggested by Jhingran and Natarajan (1969) that any additional input of fishing effort is therefore not warranted.

Optimum Age of Exploitation And Potential Yield Per Recruit

The optimum age of exploitation (t_λ) is defined as the age when the brood attains its maximum weight, and potential yield *(Y)* is the quantity corresponding to this weight as a function of infinite fishing intensity (Beverton and Holt 1957). The optimum age of exploitation and potential yield for recruitment estimated by the method of Krishnankutty and Qasim (1968) are 3.82 years and 961 g.

Discussion

Present Status of Exploitation

The foregoing observations, namely low mean age, low age at first capture and high rate of exploitation all reflect that the Chilka Lake stock of *L. calcarifer* is subjected to high fishing pressure. Any improvement in yield could be expected only when the age at first capture is increased by manipulation of gear selectivity for which there is little scope in the tradition-oriented fishing practices in Chilka Lake. Substantial quantities of *L. calcarifer* are obtained in impoundment fishing, forming 8.3% whereas the species constituted only 2.1% in net fishing. The question of mesh size regulation under these circumstances has no relevance. However, it may be pertinent to suggest that fish smaller than 150 mm occurring in the catches must be saved and returned to the lake alive. Marketing and local consumption of these sizes must be banned as a first step in the direction of improving the stock and fishery.

However, it is encouraging to note that since this species depends on the sea for breeding, a certain fraction of the population, especially very large size groups, appear to avoid lagoons and they no longer come under the fishing pressure in lagoons. They act as reserves in providing constant recruitment to make good the depletion in the fishing area. However, in some years there has been heavy recruitment. Depletion of this stock because of overfishing in estuaries/lagoons is a remote possibility. This stock bears analogy, in some respects, to a coastal or 'fringe' fishery where part of the population is unfished and beyond the coastal gear (Jhingran and Natarajan 1969).

Prospects and Recommendations

It is well known that increase in production of *L. calcarifer* from the capture fisheries sector is very much limited as the fishery is sustained mostly by immature fish aged less than 2 years. Most of the recruits suffer fishing mortality without spawning even once in their lifetime and only a very few grow into adults and return to sea for breeding. If the fishery has to be improved the age at first capture must be sufficiently well above the minimum size at first maturity (425 mm). As this is highly unlikely, only the size regulation as suggested already may be implemented to protect the fishery from irrational exploitation. Further, to augment the sea bass natural recruitment, sea ranching of this species may be attempted by standardising a series of techniques on breeding by natural as well as induced methods under captivity through maintenance of a series of brood stocks and rearing of the larvae and young ones in well-established hatcheries to obtain high survival rates. The young ones thus reared may be released in the wild in good numbers in addition to supplying the seed regularly for commercial culture in ponds and other natural and constructed impoundments. Follow-up action may be taken to assess the impact of sea ranching of this species in the overall production. Attempts may also be made to stock this species in freshwater ponds, lakes and reservoirs. This species may not breed and get well established in fresh water as in the case of *Hilsa ilisha* and *Rhinomugil corsula*, but it has been reported to grow faster in fresh water (Alikunhi 1957; Ghosh 1971). This may be expected to form a good game fish like salmon in lakes and reservoirs.

Studies on *Lates calcarifer* are very limited in India, probably because this species does not constitute a large commercial fishery in coastal waters except in lagoons and estuaries. National support through organised research programs is limited and considering the quantum of the catch and its economy there is no government-sponsored program operated exclusively on *L. calcarifer*. However, because it is a good quality table fish, and fetches a high price, and considering the prospects for culture, it is essential that studies be initiated through well-planned research on the biology, artificial propagation and culture in fresh and salt water.

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