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AN OVERVIEW OF THE MARINE FISHERIES RESEARCH IN THE LAKSHADWEEP

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INTRODUCTION

The Union Territory of Lakshadweep consists of 10 inhabited islands and 16 uninhabited islets. The U.T. has an area of 32 sq km and possesses 400,000 sq km of Exclusive Economic Zone. Each island except Androth has a lagoon on the western side, and the lagoon and the reef porvide an ideal coral habitat for a variety of flora and fauna. The islands and submerged reefs which possess rich fishery resources in the water areas around them are Agatti, Bangaram, Tinnakara, Parali, Perumal Par, Pitti, Suheli, Bitra, Cheriyapaniam, Baliyapaniam, Kadamat, Kavaratti, Androth, Kiltan, Kalpeni, Elikalpani and Minicoy. Of these, Minicoy, Agatti, Suheli and Bitra are important with regard to the tuna pole and line fishery. Coconuts and tuna are the mainstay of the economy of this U.T. Since the land area is limited, the scope for large scale development of land based agriculture and industries is meagre. The future programmes have to be centered on the judicious exploitation of marine living resources. In recent years, the Lakshadweep has assumed greater importance in view of the special consideration shown by the Government of India towards its alround development and welfare of the people. Marine fisheries have to play a major role in maintaining and upgrading the standard of life of the islanders. In this context the contributions by the Central Marine Fisheries Research Institute and the Department of Fisheries to the development and management of marine fishery resources are worth mentioning.

The present paper attempts to document all the available information on marine fisheries research in Lakshadweep. The paper highlights all the essential aspects concerning fisheries, marine biological and environmental research carried out on Lakshadweep. Marine biological and fisheries research on the Lakshadweep dates back to the end of the 18th century, when the surgeon naturalist A. Alcock sailed on the 17th October, 1891 by R.M.S. *Investigator* and cruised the Lakshadweep sea for two months. Apart from a graphic description of the islands, Alcock (1894) gave an account of the deep sea fishes collected from the Lakshadweep waters. The Cambridge University Expedition under the leadership of Prof. J. Stanley Gardiner was the next significant event in the marine biological and oceanographic research on Lakshadweep and the results were reported in the two volumes of *"Fauna and Geography of the Maldive and Laccadive Archipelagoes"* (J.S. Gardiner (Ed.) 1903-1906). Later, Hornell (1910) and Ayyangar (1922) described briefly the tuna fishing methods in Lakshadweep.

Realising the importance of the marine living resources particularly oceanic tuna fisheries and the need for judiciously exploiting them, the Central Marine Fisheries Research Institute (CMFRI) established a Research Centre at Minicoy in 1958, and the Department of Fisheries, Lakshadweep was established in 1959. The establishment of these two institutional systems gave fillip to the marine biological and fisheries research in the Lakshadweep sea. During the last four decades scientists of CMFRI, NIO and Fisheries Department of Lakshadweep have contributed to our knowledge on primary and secondary production, the fisheries resources, their potential, fishing methods, fishery biology of tunas and livebait fishes, corals, coral reefs, ancillary marine living resources and environmental characteristics. A historical resume of marine fisheries research on Lakshadweep has been given by James (1989).

EXPLORATORY SURVEYS

As early as 1928 the erstwhile Madras Fisheries Department conducted experimental trawling in the

seas around Lakshadweep using the steam trawler *Lady Goschen* (Sundera Raj, 1930). The material collected from *Bassas De Pedro Bank* included quality perches such as *Lethrinus* spp., *Epinephelus* spp. and *Lutjanus* spp. Jones (1959a) has given a detailed account of the co-operative oceanographic investigation carried out by R.V. *Kalava* in the Lakshadweep waters. Valuable data on the oceanographic conditions and the fishery resources of the seas around Lakshadweep was collected during the cruises of R.V. *Kalava*. The larval fishes collected from this area included those of *Xiphias gladius, Istiophorus platypterus, Katsuwonus pelamis, Euthynnus affinis and Auxis* sp. (Jones, 1958a, 1958c, 1959a, 1959b, 1959d, 1960c, 1963). The results of exploratory surveys of R.V. *Varuna* in the seas around Lakshadweep have been well documented by Silas (1968, 1969, 1972). Data on the environmental parameters, secondary production and fishery resources of the Lakshadweep sea were collected during the cruises of FORV *Sagar Sampada* and the results were published in the Proceedings of the First Workshop on Scientific Results of FORV *Sagar Sampada* (1990).

ASSESSMENT OF FISHERY POTENTIAL

There is a general consensus that the living resources in and around the islands hold great potential for exploitation to a high magnitude. But, from the resource point of view, the Lakshadweep archipelago was not surveyed seriously till recently. In this context the CMFRI had carried out a comprehensive indicative survey of the fishery potential of the islands from January to March 1987 and the results were published in CMFRI Bulletin No. 43 (1989).

Studies on the assessment of stock of tunas in the Lakshadweep waters were given priority in the research programmes of CMFRI in view of the fact that the steady increase in the landings and decrease in mean length of yellowfin tuna exploited by the Japanese tuna fishing fleet. The development of purseseine fishery in the western Indian Ocean with reference to its effect on the stocks of migratory skipjack tuna have been pointed out by Yohannan *et al.* (1993). The annual average (1990-94) production of total marine fish in Lakshadweep is 11,000 tonnes, of which tunas formed 6362 tonnes as against a potential yield of 50,000 tonnes. (George et al, 1977).

OBSERVATIONS ON CRAFT AND GEAR AND FISHING METHODS

Scientific observations on the craft and gear and fishing methods were initially carried out by the erstwhile Madras Fisheries Department. There is a well established traditional system for the capture of tunas in Minicoy, Agatti and Suheli Par, by the pole and line fishing using live-baits. Hornell (1910), Ayyangar (1922) and Ellis (1924) recorded their observations on the fishing tackles and tuna fishing industry in the islands. Hornell (1910) gives an account of the pole and line fishing methods of Minicoy. Jones and Kumaran (1959) described the fishing craft, gear and methods which existed just at the end of the premechanisation era. The mechanised pole and line fishing boat, its fishing gear and fishing methods for skipjack tuna as well as for livebait are described by Ben-Yami (1980), Silas and Pillai (1982) and Livingston (1990). James *et al.* (1989) proposed the introduction of drift gillnetting, surface trolling and longlining in the open sea for the capture of larger fishes.

STUDIES ON TUNAS AND RELATED FISHES

Studies on the fishery for the biology of tunas and tuna livebait fishes are being undertaken at the Minicoy Research Centre of CMFRI, since its establishment. Aspects such as the fishery, length frequency distribution, age and growth, length-weight relationship, maturity, spawning, food and feeding habits and other biological characteristics of the yellowfin and skipjack tunas have been studied by Raju (1961, 1963, 1964a, 1964b), Thomas (1964a, 1967), Thomas and Kumaran (1963), Appukuttan et al. (1977), Madan Mohan (1986), Madan Mohan and Kunhikoya (1986a, 1986b), Madan Mohan *et al*, (1986a) and Varghese and Shanmugham (1987). Different types of tuna shoals have been described by Silas and Pillai (1982) and Livingston (1987a, 1987b). Madan Mohan (1986) gave a brief account of tuna shoals associated with flotsam. Studies on the population dynamics of tunas have been made by Silas et al. (1986b) and James et al. (1986c). The status and the various programmes of tuna fishery development and management in Lakshadweep have been discussed by Varghese (1986, 1987a), Silas and Pillai (1986), James (1987), James and Pillai (1987) and James et al.

(1987b), James et al. (1989). Schooling behaviour of tunas in Lakshadweep waters was investigated by Livingston (1989). Future development and management of tuna fishery in the Lakshadweep have been discussed by James et al. (1989).

INVESTIGATION OF LIVEBAIT RESOURCES

The success of the pole and line fishery in Lakshadweep depends on the abundance and timely availability of suitable livebaits in required quantity. Realising their imporatnce in successful and sustained tuna fishery, Jones (1958a, 1958b, 1960a, 1961a, 1964a) carried out long term research on livebaits. During the cruises of R.V. *Kalava* the occurrence of *Spratelloides delicatulus* around many islands have been observed. Jones (1960a) points out its importance as a potential livebait. Subsequently Jones (1961a, 1961b) recorded *S. Japonicus*. Later Jones (1964a) described 45 species of livebait fishes belonging to 30 genera and 19 families based on the result of his primary survey. A detailed account on the fishing methods, storage and utilisation of the livebaits is also available (Jones, 1958b). Another noteworthy work on the livebait fishes is that of Thomas (1964b). During 1960-61 he made observations on fluctuations of live-bait fishes in Minicoy and pointed out that 11 species were being regularly exploited. Pillai and Madan Mohan (MS) paid attention to the ecology and biology of several species of reef fishes at Minicoy with special reference to livebaits during 1981-84 period. They included *S. Japonicus, S. delicatulus* (Madan Mohan and Koya, 1986c), *Chromis caeruleus* (Madan Mohan et al. 1986b) *Dascyllus aruanus, Acanthurus triostegus* and *Abudefduf glaucus* (Pillai et al, 1986.) The microhabitat and coral association of the livebait fishes of the lagoon in Minicoy has been elucidated by Pillai (1983a). He further pointed out the impact of mass mortality of corals on reef-associated fishes including livebaits. The exploitation potential and plan for development of the livebait fishes of Lakshadweep have been described by Nair (1986), Pillai et al. (1986), Pillai (1991) and James et al, (1987a). The ecological stress in Minicoy lagoon and its impact on tuna livebait have been pointed out by Pillai and Madan Mohan (1986). The population characteristics of tuna livebaits in Lakshadweep have been studied by Gopakumar and Pillai (1988). The results of the exploratory surveys for livebaits covering all the lagoons, by the scientists of CMFRI have been published in the CMFRI Bulletin No. 43 (Kumaran *et al.*, 1989a). Gopakumar (1991) described the tuna livebait scarcity problem in Lakshadweep and options for solving it.

The increase in the number of mechanised pole and line units has resulted in higher catches of tunas and hence the demand for livebait has also increased. The situation may have adverse effects on the stocks of some of the common livebaits. Jones (1964b) thought of *Tilapia mossambica* as an alternative for livebaits and introduced it into Minicoy. Now the species has established itself in all the fresh water ponds, wells and tidal pools at the southern tip of Minicoy. However, Tilapia has not been a successful alternative to the other livebaits.

STUDIES ON OTHER FINFISH RESOURCES

The productive waters around the Islands, the submerged banks and the crevices of coral boulders and reefs are ideal habitats for a large number of commercially important fishes other than tunas which offer scope for extensive fishing (Kumaran et al. 1989b). The contribution of the fishery resources other than tunas to the total fish production of the islands is around 30% to 55% in recent years, belonging to important groups such as alasmobranchs, perches, carangids, halfbeaks, belonids, red mullets and seerfishes. These resources are mainly exploited by traditional gears like hooks and line, harpooning, surface trolling drag nets and cast nets. Silas (1968) described the oceanic and demersal fishery resources of the Laccadive sea. Problems, prospects and development programmes in the fisheries sector, and the need for diversification of fishing effort for exploiting different resources have been suggested by Varghese (1974), Haneefa Koya (1982), Kumaran and Gopakumar (1986), Varghese (1986, 1987a, 1987b) and Kumaran et al. (1989b). The comprehensive survey of the fishery potential of the Islands, undertaken by the CMFRI in 1987 revealed that the species belonging to seventeen families form the major share of other finfish resources of Lakshadweep sea (Kumaran et al, 1989b). Among the other finfishes of Lakshadweep sea, those of ornamental value are very abundant. Of the 601 species of marine fishes belonging to 126 families reported from these islands, atleast 300 species be-

longing to over 40 families are ornamental fishes (Jones and Kumaran, 1980; Murthy et al., 1989). These ornamental fishes offer great scope for export (Anon, 1986; Tomey, 1985, 1986; George et al., 1986; James, 1987; James et al., 1986b, 1987b; Murthy et al., 1989 and Vijay Anand and Pillai, 1995).

ICHTHYOFAUNAL STUDIES

The earlier accounts on the ichthyofauna of Lakshadweep sea are those of Alcock (1894, 1902) and Alcock (1890, 1892, 1898, 1899, 1900). A valuable contribution towards the knowledge of the ichthyofauna is that of Balan (1958) who documented 80 species of fishes belonging to 65 genera from the islands of Agatti, Kavaratti, Amini and Kadamat. Jones and Kumaran (1959) listed 154 species of fishes from the lagoon and reef, many of which being new records. The list was further elaborated by Jones (1960a, 1960b), and Jones and Kumaran (1967a, 1967b, 1967c) and culminated in the publication of the 'Fishes of the Laccadive Archipelago' (Jones and Kumaran, 1980). They have documented 603 species of reef fishes and bathypelagic fishes. Due consideration has also been given to the systematics of commercially important tunas as well as the common livebait fishes. This publication remains to be the most comprehensive account on the fish fauna of the Lakshadweep. Pillai *et al.* (1992), studied the ichthyofauna of the intertidal reef flats of Minicoy atoll. Recently, Vijaya Anand and Pillai (1995) studied the biology and ecology of coral reef fishes of Lakshadweep with observations on other coral reef ecosystems of India. They have listed 421 species of reef fishes belonging to 26 families, including 12 new records from Lakshadweep.

MARINE INVERTEBRATE FAUNA

The marine invertebrate fauna of Lakshadweep sea are unique and diverse. The early information on the marine fauna are mostly based on the various papers published in the two volumes of 'Fauna and Geography of Maldive and Laccadive Archipelagoes' (Gardiner (Ed.) 1903-1906). Nagabhushanam and Rao (1972) made a detailed ecological survery for the marine fauna of Minicoy atoll. The marine invertebrate fauna so far studied, mostly from Minicoy, included the **foraminiferans** (Chapman, 1895); **corals** (Gardiner, 1903b, 1906a, 1906b, 1906c,; Cooper, 1906; Pillai, 1971a, 1971b, 1972, 1983a, 1983b, 1985, 1986, Pillai and Jasmine, 1989; Suresh and Mathew, 1993); **sponges** (Thomas, 1973, 1979, 1989); **coelenterates** (Borradaile, 1906d; Browne, 1906a, 1906b, Mamman, 1963), **nemertines** (Punnet, 1903a); **cephalochordates** (Cooper, 1903; Punnet, 1903b); **enteropIneustans** (Punnet, 1906), **echiuroids** (Shipley, 1903a), **sipunculoids** (Shipley, 1903b), crabs (Alcock, 1898, 1899, 1900; Borradaile, 1903a, 1903b, 1903c, 1903d, 1906a, 1906b, 1906c; Sankarankutty, 1961); **lobsters** (Meiyappan and Kathirvel, 1978; Pillai et al, 1984a), **cirripeds** (Borradaile, 1903c), **amphipods** (Walker, 1906), **alphids** (Coutiere, 1903, 1905, 1906), **molluscs** (Eliot, 1906; Hoyle, 1906; Smith, 1906; Hornell, 1910; Burton, 1940; Appukuttan, 1973; Rao *et al.*, 1974; Namboodiri and Sivadas, 1979; Nair and Dharmaraja, 1983; Panicker, 1978; Appukuttan *et al*, 1989) and **echinoderms** (seacucumbers) (Bell, 1902; Gardiner, 1903a; Burton 1940; Sivadas, 1977; Murthy *et al.*, 1979; Mukho-padhyay and Samanta, 1983, James, 1969; Naga-bhushanam and Rao, 1972; Daniel and Haldar, 1974; Rao and Misra, 1983 and James, 1989), and **seaweeds** (Kaliaperumal et al., 1989).

ANCILLARY MARINE LIVING RESOURCES

There are good number of ancillary living marine resources which include seaweeds, crustaceans, molluscans, sponges, echinoderms, turtles, birds etc. Information on these resources is based on the faunistic observations conducted now and then by different workers. An account of the ancillary living resources has been given by George *et al.* (1986).

FISHERY ENVIRONMENTAL STUDIES

The Central Marine Fisheries Research Institute was the pioneer organisation to initiate detailed oceanographic investigations on the enviornmental features of the Lakshadweep sea as early as 1959 (Jayaraman et al., 1959, 1960). During the cruises of R.V. *Kalava* and R.V. *Varuna* a good deal of information on physical, chemical and biological parameters of the marine environment and also oceanographic features such as currents, watermasses, upwelling etc. have been collected. The investigations of Ramasastry (1959) and Jayaraman et al. (1959) have revealed the existence of four distinct watermasses in the Arabian Sea. The influence of the nutrient rich Antarctic bottom water in the Lakshadweep sea area was indicated by Prasad (1951) and Jayaraman et al. (1960). Other significant contributions to our knowledge of the oceanographic

features of this area are those of Patil and Ramamirtham (1963), Rao and Jayaraman (1966, 1970), Sankaranarayanan (1973), Rao et al. (1976) and Sen Gupta et al. (1979). A brief account of the environmental features of the sea around Lakshadweep has been given by Nair et al. (1986). The early studies on the primary production of Lakshadweep waters are by Prasad and Nair (1964). The productivity of the reefs has been estimated by Nair and Pillai (1972). Qasim et al, (1972) made a comprehensive study on the primary production of the ambient waters and reefs of Kavaratti atoll. The primary production of the seagrass beds of Kavaratti atoll has been determined by Qasim and Bhattathiri (1971). Other major investigations on primary produciton of Lakshadweep sea are those of Bhattathiri and Devassy (1979) and Qasim et al. (1979). Nair et al. (1986) described the productivity of the seas around the Lakshadweep. In general, the coral lagoons and the adjacent sea are highly productive and responsible for the enrichment of various fishery resources (Madhuprathap et al. 1977; Bhattathiri & Devassy 1979; Mathew, 1982; Girijavallabhan et al., 1989).

The earliest work on zooplankton is that of Wolfendin (1906) on copepods. Jones (1959c) carried out studies on the zooplankton assemblages around some of the northern islands. Silas (1972) estimated the zooplankton biomass closer to the reefs of the islands during the cruises of R.V. *Kalava*. He has also made studies on the deep scattering layer (DSL) closer to the islands and suggested that the DSL constituted an important source of forage to pelagic fishes. A quantitative study of the zooplankton of the Kavaratti and Kalpeni atolls has been made by Tranter and Jacob (1972). Other works on the zooplankton assemblages of the Lakshadweep waters are those of Prasad and Tampi (1959), Goswamy (1973, 1979, 1983), Madhu Pratap *et al.* (1977), Nair and Rao (1973), Mathew (1982), Rengarajan (1983), and Silas and Mathew (1987).

CONSERVATION OF THE ECOSYSTEM

The seas around the Lakshadweep and the reef lagoons are of great ecological significance as they influence the fauna and flora associated with the coral reefs and the high sea resources to a great extent. A plethora of events both natural and man made have been creating havoc to the ecosystem. Indiscriminate dredging and blasting of the corals and sea erosion and the consequent siltation have resulted in the death of corals leading to imbalance in reef ecosystem. The details about the oil spill in Kiltan from the oil tanker 'Transhuron' have been described by Qasim et al. (1974). The lagoon environment of Minicoy has undergone visible changes in the last three decades due to natural causes and human interference (Pillai, 1983a, 1985, 1986). Possible threats to the marine environment of Lakshadweep have been described by Sivadas (1987). The need for preserving these delicate ecosystem has been pointed out by James (1987) and James et al. (1986b, 1987b). The declaration of a few undisturbed and undamaged areas in the region as marine parks and reserves is necessary (James, 1987; James et al., 1987b; James and Pillai, 1989). This would have the advantage of not only preserving the natural environment, but also providing excellent tourist attraction.

MARICULTURE POTENTIAL

The protected bays and lagoons of the island provide suitable sites for mariculture. Further, there are many potential candidate species (perches, baitfishes, ornamental fishes, seacucumber and seaweed) available for mariculture. Apart from the indigenous cultivable species, fry of fast growing fishes and prawns can be transported from the mainland and cultured. But so far no serious attempts have been made to utilise the mariculture potentials of the islands. Limited experiments conducted in the Bangaram lagoon for pearl oyster culture showed encouraging results. Further studies would be required to assess the technical feasibility and economic viability of pearl oyster farming and pearl production (Varghese, 1987a; James, 1987; James et al, 1986b). It may also be worthwhile to undertake investigaions on the feasibility of introducing aquaculture programmes suitable to the island conditions (James et al, 1986b). *James (1986)* has pointed out the need for undertaking the culture of baitfishes. Lal Mohan et al. (1989) suggested that more research inputs are required to develop suitable mariculture programmes for the islands. There exists a more scope for the culture of finfishes in cages, seaweed culture, creation of artificial reefs and searanching of finfishes and seacucumbers, without disturbing the vital ecological properties of the lagoons.

DEVELOPMENT OF FISHERIES AND THEIR MANAGEMENT

A wealth of information on the marine flora and fauna is now available and properly documented. Except for the continuous monitoring of some of the important resources such as tunas, livebaits, corals and seaweeds, most of these studies on the flora and fauna are based on intermittent observations at Minicoy and a few other islands by various workers from time to time. A realistic estimate of the various resources, both qualitative and quantitative, is essential for any future plans for development. The CMFRI has conducted a short and time bound indicative survey during January to March 1987. The survey remains as a benchmark for future surveys and development programmes. The survey results were aimed at assessing the various fishery resources and their potential; impact of environmental damages of the endangered ecosystems such as coral reefs; evaluating the ancillary resources such as seacucumber, sponges and ornamental fishes, identifying areas and species suitable for mariculture in the islands and suggesting various measures that would help the administration and developmental agencies in perspective planning and development of fisheries in Lakshadweep. Proper implementation of the recommendations on development of tuna fishery, baitfish fishery and other finfish resources; improvement of fishery products, export of ornamental fishes and other minor resources such as seacucumbers, crustaceans, molluscs and seaweeds given by the CMFRI (1989) could ensure sustained growth of the fisheries sector and the economy of the islanders.

These tasks call for urgent action to :

1. Introduction of larger pole and line vessels (15-20 m OAL) to extend the area of fishing operations.
2. Diversification of the fishing gears such as drift gillnetting, purseseining and longlining to catch tunas and other groups of fishes.
3. Culture of livebait fishes and improvement on the methods of storage and transportation of livebait fishes.
4. More hygienic preparation of *masmin*.
5. Creation of the required ecofriendly mariculture infrastructure initially in the government sector to demonstrate the various farming technologies in the lagoons to the island communities.
6. Undertaking systematic training in mariculture technologies at various levels targeting at the fishing communities, progressive fishermen and enterprising youth.
7. Undertaking sustained onfarm trials in the lagoons.
8. A pragmatic policy of farm site allocation in the lagoons without impairing the interests of other users like navigators and baitfishers.
9. Financial supports through soft credits and subsidies.
10. Augmentation of post-harvest infrastructure including processing, transportation and marketing.
11. Specific thrust on entrepreneurship development among the islanders.
12. Diversification of fishing activities will also generate employment opportunities to the youth of the islands.
13. The declaration of a few undisturbed and undamaged areas in the islands as marine parks and reservoirs. This would have the advantage of preserving the natural environment and providing excellent tourist attraction.

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