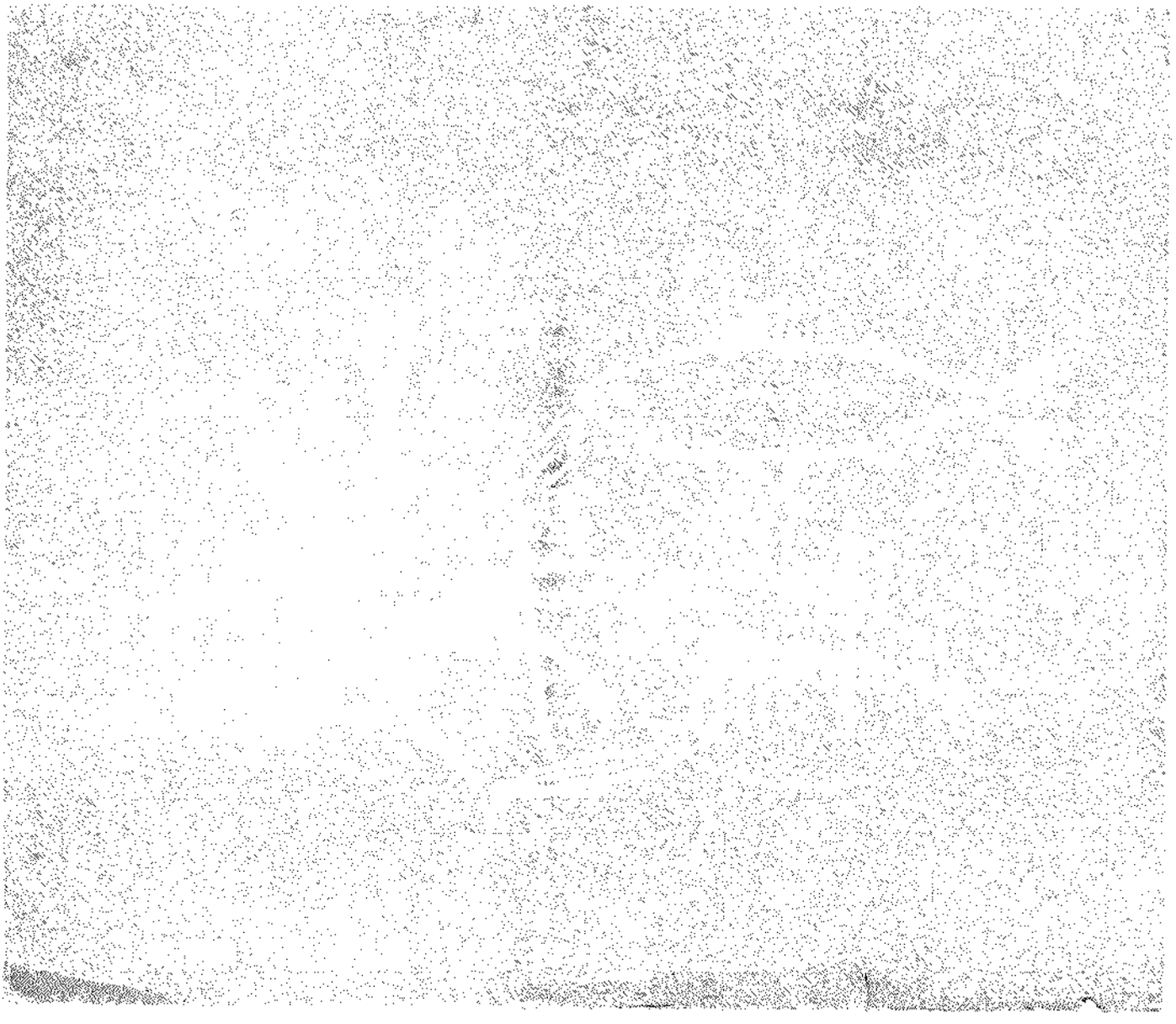
PROCEEDINGS OF THE SYMPOSIUM

ON

LIVING RESOURCES *of* THE SEAS AROUND INDIA

ICAR



PROCEEDINGS OF THE SYMPOSIUM
ON
LIVING RESOURCES OF THE SEAS AROUND INDIA

ICAR

SPECIAL PUBLICATION
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
COCHIN-11
1973

PEARL OYSTER RESOURCES OF INDIA

S. MAHADEVAN* AND K. NAGAPPAN NAYAR*

Central Marine Fisheries Research Institute, Mandapam Camp

ABSTRACT

Of the 6 distinct species of *Pinctada* Roding (Pteridae) *viz.*, *Pinctada fucata* (Gould), *P. margaritifera* (Linn.), *P. chemnitzi* (Philippi), *P. anomioides* (Reeve,) *P. sugillata* (Reeve) and *P. atropurpurea* (Dunker), the first named species is the common pearl oyster of India, occurring on the pearl banks off Tuticorin coast in the Gulf of Mannar on the rocky ridges extending all along the coast of the gulf at depths of 15 m–25 m. They are occasionally found in the Palk Bay also in shallower waters lying in loose clusters over a bottom of coarse sand grains covered with a matrix of dead shells. In the Gulf of Kutch they are found on the intertidal reefs.

The pearl fishery in the Gulf of Mannar is unpredictable and it is a question of utilizing the natural resource as and when the pearl oyster spat settle down and grow. It is difficult to have effective control over the conditions affecting the settlement and growth of the pearl oyster in the natural beds because of their occurrence in the open sea.

For the purpose of conducting an organized fishery, the population of fishable oysters should be determined with accuracy. The existing method of estimation of population, the knowledge of the grounds and the method of fishing require reorientation. To this end a thorough survey of the areas of oyster settlement was undertaken for a period of 3 years and the grounds charted for the first time by means of direct under-water observations by SCUBA. The outlook for pearl fisheries in the next few years is rather bleak at present.

The success and failure of the pearl fisheries of the past and the futile attempts made over a number of years to watch for the possible settlemenet of the pearl oyster spat show that the only alternative to put India in the map of pearl producing nations is to resort to pearl culture practices.

INTRODUCTION

SHELL fish as a source of protein food from the sea are only second in importance to the true fishes. The world production of this group stood in 1966 at about 2·9 million tons against 52 million tons of fish and 1·26 million tons of shrimps (Jones, 1968). Apart from the food value there are many molluscs which are of commercial importance otherwise. Of these the pearl oysters of the genus *Pinctada* Roding are the most thoroughly exploited, for the pearls and the mother-of-pearl shells. Table I shows the different species of *Pinctada* and their world-wide distribution. The important species forming a fishery in the different parts of the world may vary from country to country, although the one may be found in the other country also. In the case of Japan it is *P. martensii*, in Australia it is *P. maxima*, in Ceylon it is *P. fucata* (=*P. vulgaris*) and in the Persian Gulf it is *P. margaritifera* which form the commercially important species.

It may be seen that six species of *Pinctada* occur in Indian waters, *viz.*, *P. fucata*, *P. chemnitzi*, *P. margaritifera*, *P. atropurpurea*, *P. anomioides* and *P. sugillata*. But only *P. fucata* (Syn. *P. vulgaris*) occurs in large numbers forming a distinct pearl fishery. As such this species is considered as the pearl oyster of the Indian region.

* Present Address: CMFR Sub-station, 93, North Beach Road, Tuticorin-1.

Bolman (1941) stated that the most important pearl fisheries furnishing the greater part of pearls for the universal trade, 7/8 of the whole world production, are found in Persian Gulf having been known since 500 B.C. In the Red sea, though not very important, pearl oysters are found near Faron Islands lying west of Mecca, on the Arabian coast. On the African coast near the Island of Delhak and Massena pearl oysters are found. In Australia, pearl oysters exist around the peninsula of Cape-York, Thursday Islands, north and west coasts up to Sharks-Bay. Extensive pearl oyster beds are noticed on the Atlantic and Pacific Coasts of Middle America (Gulf of California, west coast of Nicaragua and Gulf of Panama), Columbia Coast and north coast of Venezuela. In addition pearl oysters also occur near Philippines, coasts of Mollucas, south coast of Celebes, Geram, south coast of New Guinea and Aru islands, Islands of Marianen (17° lat. and 145° 50' N long.), Guam, Bismarck Archipelago, Admiralty Islands, New Ireland, New Britania, Fiji, Hawai, Islands of Ulu, Manihiki Islands (10° S lat. and 161° W. long.), Tahiti, Papeete, Manihi, Polynesia and Melanesia. All the pearl fisheries from New Guinea to the last named group are in the Pacific ocean. Japan, Straits of Korea, Sakhalin Islands are the other places. On the north-west coast of Madagascar also pearl oysters are available.

In spite of the fact that there are many countries in the world where pearl fisheries exist, complete and comparative account and value of these fisheries are available only for a few countries. As such it is difficult at present to assess their relative importance. In the Indian region pearl oysters exist in the Gulf of Mannar and in the Gulf of Kutch. Apart from the outstanding publications of Hornell (1905, 1916 and 1922) on the Indian pearl fisheries in the Gulf of Mannar and Palk Bay and Herdman's monograph (1903–06) on the pearl oysters of the Gulf, no uptodate information and account of the pearl fisheries of the Indian region is available. A preliminary idea of the pearl oyster resources of the Gulf of Kutch, is also obtained from the writings of Hornell (1909). Recently, a review of the pearl fisheries of this area has been prepared by Eswaran *et al.* (under publication) which gives some details of the fisheries held from 1913–66. It is hoped that the following account will furnish the much needed information on the pearl fisheires and pearl oyster resources exploited at present in the Indian region.

Pearl Oyster Grounds in India

Gulf of Mannar

Pearl oysters find an ideal habitat in the Gulf of Mannar coast of the Madras State. The submarine plateau of the inshore areas of the Gulf is dotted with flat rocky patches lying within 10–20 metre depth at a distance of 11–16 km from the shore. Oysters settle and grow on the hard rocky substrata called ' Paars '. Starting from Pamban in the north at the head of the Gulf (78°18' E long to 9° 15' N lat.) and ending with Manapad in the south (78° 15' E long to 8° 15' N lat.) a distance of 160 km there exist more than 60 well-known paars. The names of these paars are given in detail by Hornell (1922). Sundararaj (1926) has stated that the extent of the pearl beds in Indian region come to about 770 sq.miles as compared to 572 sq.miles of the Ceylon Coast. A perusal of various published accounts and records failed to show the actual extent of the various paars, apart from stray mention of the areas of important banks like Tholayiram Paar and Kudamuttu paar. Figure 1 shows the paars, as they existed in the Gulf of Mannar some five decades ago, from north to south classified into important groups in keeping with their relative geographical position and with their identity of physical and biological characteristics. For purposes of comparison the banks known along the Ceylon coast are also shown.

Pearl fisheries of Gulf of Mannar

The record of pearl fisheries in the Gulf of Mannar of which some figures are available begins with 1,708 when 4,11,69,637 oysters were fished off Tuticorin Coast and a gross revenue of Rs. 8,30,000 was obtained by the Government. This was conducted after a disastrous 3 days fishery in 1700. No further fishery appears to have taken place between 1708 and 1740. A fishery seemed to have taken place in 1746 but no figures are available about its magnitude. In 1747 the

TABLE I

Distribution of the different world species of the genus Pinctada *Röding*

Species	Places of occurrence	Quality of pearls
1. *Pinctada margaritifera* (Linnæus)	Persian Gulf; Gulf of Oman; North Australia; South coast of Australia upto Mereton Bay; Torres Strait; Gulf of Mannar	Light Pink; Greenish yellow
2. *P. margaritifera* var. *erythraeensis* (Jameson)	Panama; Mexico; Gulf of California	Light Pink; White; Yellow
3. *P. margaritifera* var. *mazatlanica* (Hanlay)	do.	Black or greenish black
4. *P. maxima* (Jameson) ..	North, East (up to Trans Ville) and South West Australia; Sulu sea; Indian Archipelago; Pacific Ocean; Mergui Archipelago	White with soft iridescence and strong lustre
5. *P. albina carcheriaum* (Jameson) ..	West Australia; Sharks-Bay	Light yellow; Light lemon; Light green; Light Pink
6. *P. margaritifera* var. *cumingi* (Reeve)	South Pacific; Coast of Polynesia	Pink, yellow and light green
7. *P. radiata* (Leach) ..	Venezeula	Translucent Light Pink White
8. *P. martensi* (Dunker) ..	Japan	Light white; Yellow
9. *P. sugillata* (Reeve) ..	Madagascar; Australian waters; Tuticorin	do.
10. *P. chemnitzi* (Philippi) ..	China Sea; Hong Kong; Tranquebar; Tuticorin; Rameswaram; Moreton Bay (Australia); Japan; Philippines	..
11. *P. maculata* (Gould) ..	Central Pacific across to west and into Indian ocean	Deep orange; Light yellow
12. *P. albina sugillata* (Reeve) ..	East-Indies; Celebes; Australia; Torres strait; South New South Wales;	Metallic lusture
13. *P. albina* (Lamarck) ..	Australian waters	..
14. *P. fucata* (Gold) ..	Gulf of Mannar; Australian waters; Mediterranean	Light pink; Yellow Light red; Oriental lustre

In addition to the above *P. atropurpurea* (Dunker) and *P. anomioides* (Reeve) are also reported from Indian waters (Prasad and Bhaduri, 1932; Rao, 1968).

unproductive cycle was broken and pearl fisheries took place in the two next succeeding years. Between 1749–84 there is no record of a pearl fishery. A fishery in 1784 yielded Rs. 43,000 followed by another in the same area in 1787 giving a revenue of Rs. 63,000. In 1792, a fishery was conducted in the shoreward paars off Tuticorin yielding Rs. 42,000. The pearl banks came under the control of the British in 1796, from which year records of pearl fisheries were fairly well kept. During the 165 years ending 1961 a total of 27 pearl fisheries had taken place along the Indian coast, the biggest being in the series from 1955–61, for a period of 7 years. Hornell (1916) has stated that the Ceylon pearl banks were also very disappointing although their record was better than the Indian coast. In a period of 250 years from 1663–1914 there appeared to have been 61 fisheries in Ceylon coast whereas for the entire period from 1663–1961 in India only 40 fisheries had taken place. The gross revenue for the Ceylon side also seemed to be considerably greater. The up-to-date details of the various pearl fisheries conducted in Tuticorin have been furnished in Table II,

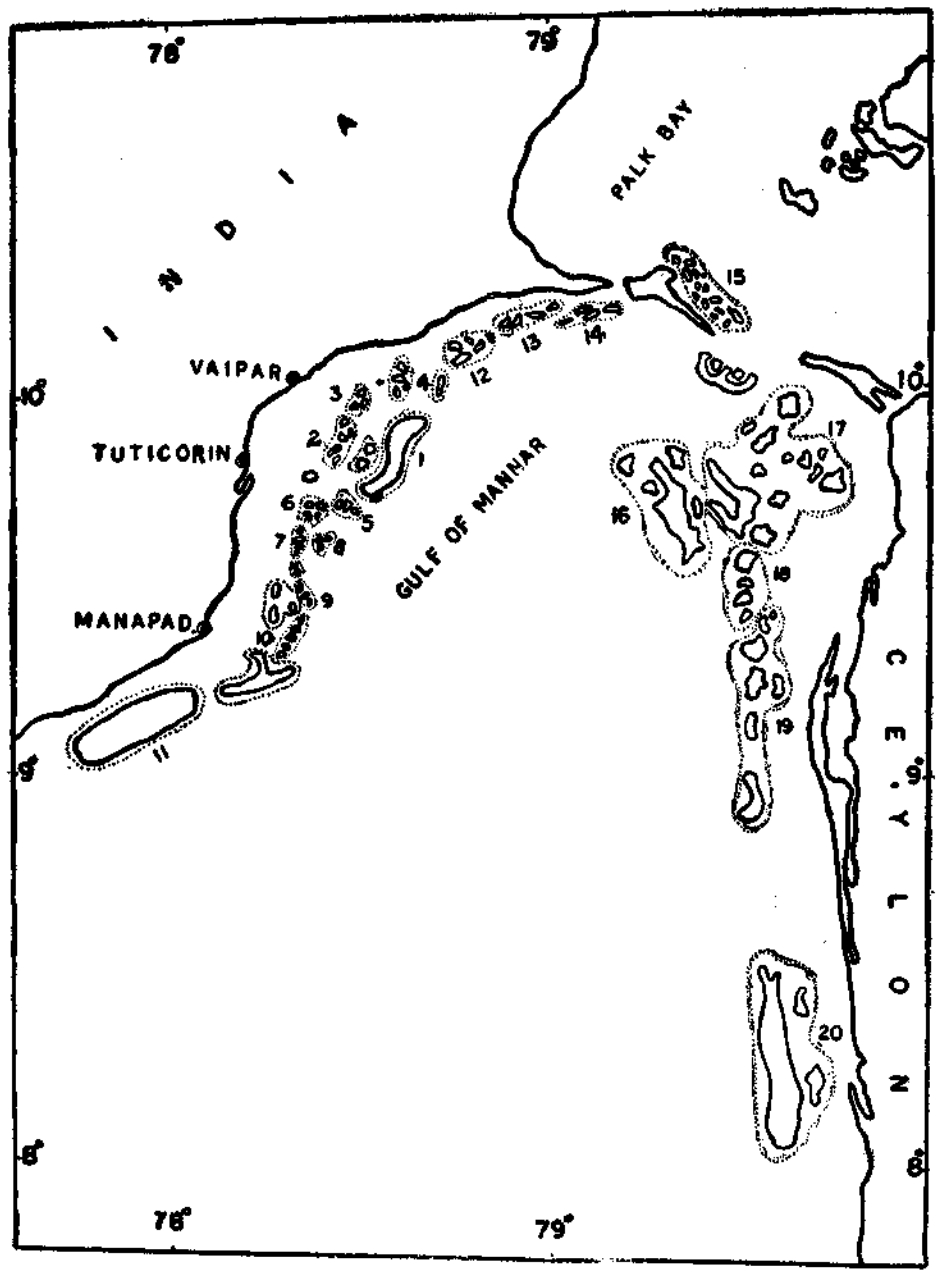


FIG. 1 Pearl Oyster Beds in the Gulf of Mannar and Palk Bay.

Indian Coast: 1–15. 1. Thollayiram paar group. 2. Uti paar group. 3. Cruxian paar group 4. Vaipar paar group. 5. Nanjurichan paar group. 6. Pulipundu paar group. 7. Inner Kudamuti paar group. 8. Outer Kudamuti paar. 9. Karuwal paar group. 10. Manapad paar group. 11. Ovari paar group. 12. Vember paar group. 13. Kilakarai paar group. 14. Pampan paar group. 15. Rameswaram pear group.

Ceylon Coast: 16–20. 16. Periya paar group. 17. Chevat paar group. 18. Modregam paar group. 19. Donnan paar group. 20. Chilaw paar group.

TABLE II

Pearl fisheries off Tuticorin from 1805 *to* 1961

Year	No. of days fished	Total No. of boats	Number of divers	Grand total fished	Gross Govt. revenue	Paar fished
1805	..	..	..	7,16,47,305	39,109	Velangu Karuwal
1807	..	..	..	7,16,47,305	2,91,539	Tholayiram
1810	..	..	..	2,20,36,658	2,38,897	,,
1815	..	..	..	..	..	..
1818	..	..	..	1,55,00,000	1,67,708	Kudamutti, Saith, Pudu
1822	..	..	..	1,44,00,000	1,55,698	Tholayiram
1828 April	..	..	..	75,41,940	70,127	Kudamuti, Saith, Kadian, Kanavai, Rajavuk Chippi Chothith
1830 March		..	..	1,28,58,993	1,01,639	Tholayiram, Kilathi, Padutha Marikan Thundu
1860	..	..	..	..	2,50,276	Cruxian, Cruxian thund Nagara, Uti, Uduruvi
1862	..	..	..	..	1,29,003	Karai Karuwal, Velangu Karuwal
1889	52	1,731	..	1,26,00,531	1,89,984	Tholayiram
1890	40	857	..	18,06,762	25,061	,,
1900	15	746	..	28,01,036	19,461	Teradipiditha
1908	20	528	..	11,01,642	10,218	Tholayiram
1914	20	562	..	5,33,416	16,542	Off Tondi Palk Bay, Cruxian, Pulipoondu
1926 February-March	33	3,428	..	1,40,96,839	2,25,498	Tholayiram
1926 November-December	23			16,08,931	31,386	,,
1927	45	1,398	..	1,03,37,061	2,54,497	..
1927	56	1,398	..	62,51,940	1,95,038	..
1928	31	1,597	..	34,54,729	2,02,575	..
1955	44	2,297	759	35,08,967	1,3 ;,526	Tholayiram, Saithambathu
1956	18	325	457	21,29,058	44,795	Tholayiram
1957	51	1,893	733	11,75,214	1,68,807	Tholayiram, Kodamuthu Karuwal, Rajavukku Chippi Choditha, Dudu
1958	..	..	805	2,14,76,514	4,51,098	Tholayiram, Kodamuthu Karuwal, Rajavukku, Chippi Choditha, Poonthottam
1959	..	..	1,896	1,64,28,298	8,00,568	Tholayiram, Kodamuthu Karuwal, Rajavukku Chippi Choditha, Poonthottam
1960	..	..	1 821	1,58,29,263	2,15,266	Tholayiram, Kari Kodamuthu, Kodamuthu
1961	..	..	1,350	1,53,96,928	2,88,860	Tholayiram, Koothadiar

from which it is seen that Tholayiram paar group has figured as the most consistent area where oysters have been fished (16 years), Kudamuttu paar group (6 years) and Karuwal paar group (5 years) coming next in importance. The shoreward paar group, north of Tuticorin, also seems to have been useful in sustaining oysters to fishable size. The other areas appar to be unproductive

or unfavourable for the growth of oysters. Pamban, Rameswaram and Kilakarai groups of paars are not ideal for oyster survival since no oyster population which had settled down there has ever reached fishable stage or size. Ovari and Manapad group also fall under this category although not much inspection appears to have been done in these far off beds from Tuticorin.

Palk Bay

In the Palk Bay area the sea bed does not appear to be conducive for the settlement of the oysters except for a small stretch of 10 km. distance from Dhanushkodi to Rameswaram where rocky patches occur at depths ranging from 7 metres to 13 metres (Fig. 1). Hornell (1922) has not mentioned this area in his account. Perhaps he considered it to be of no practical importance. For the sake of information the names of the paars known in this region are given here. Marikolundu paar, Nadu paar, Pasi paar and Thanthi kambi paar are all offshore patches off Dhanushkodi. The inshore patches between Kothandaram koil to Rameswaram are Kannagi paar, Vangusoli paar, Thakadu thatti paar, Vettura paar, Mandal challi paar, Narikuzhi paar, Kadalthamarai paar, Vaipadu and Sethu paar. The total area offered for attachment for oysters by these rocky patches is less than 2·5 sq.km. since many of them are very small.

Apart from the above, two distinct beds of pearl oysters off the west coast of Palk Bay off Tondi have been recorded by Hornell (1916) although it is open to doubt whether to consider them as potential banks or not. The sea bottom here is of muddy sand with dead shells lying loose in plenty. The depth range of these patches covering an area of 1·25 sq.km. is 10–12 metres.

Apart from a freak fishery in 1914 held at Tondi lasting for 20 days there is no record of any other fishery having been conducted in the Palk Bay. Hence the Gulf of Mannar grounds are considered to be more important and productive.

Gulf of Kutch

Pearl oysters grow attached to the reefs, about 42 in number known as *Khaddas* which are scattered along the Halar coast from Jodiya to Ajad (70° 16′ E Long to 22° 42′ N lat. to 69° 20′ E long to 22° 25′ N lat.). These reefs are separated by sandy areas and mangrove forests. Some of the best fishing grounds are situated on the tide washed reefs, a few km east of Beyt. According to Hornell (1909) pearl oysters occur in that zone which marks the low tide seaward fringe of the shore reefs of Adatra, Poshetra, Hanuman Dandi, reefs of Chindi, Borio and Mangunda. Gokhale (1960) gives the estimate of the area available for attachment of oysters as 60,000 acres. Except the above area, pearl oysters do not occur anywhere along the west coast of India up to Cape Comorin, although stray ones are noticed on the rocky ridges off Muttam and Colachel.

The pearl fishery of the Gulf of Kutch is small in magnitude when compared to Tuticorin fishery. The average number of oysters taken annually is only 30,000 or so and the maximum (76,685) was in 1916–17 (*vide* Table III). The fishery is not wholly annual in nature and after 1938 a gap of 3–5 years between each fishery is seen. Easwaran *et al.* (unpublished) attribute this to unproductiveness and thinness of oysters in the oyster beds. The beds at Pirotan, Movada, Chhao, Chicheya, Deeda and Sirival are considered to be more productive than the beds at Betwaran, Jindhada, Kalumbar, Narada and Danni. The beds here being approachable during low tide and within control by human agencies can be stocked with oysters taken from Gulf of Mannar when spat settlement is noticed or if feasible from Bahrein which is close by and the results of transplantation can be watched. Special overland transhipment of oysters can be tried and results watched. Secondly the oyster stock in deeper waters in that area should be assessed. Already a scheme has been programmed by the Gujarat Government for the exploration of the deeper beds and it is hoped that the results of the survey would throw more light on the pearl fisheries of the region.

TABLE III

Pearl fisheries of the Gulf of Kutch from 1913–14* *to* 1966–67

Year	Number of oysters harvested	Value of pearl realised in Rupees
1913–14	33,171	7,503
1914–15	39,589	15,606
1916–17	76,658	14,550
1917–18	27,685	7,995
1919–20	29,951	14,487
1920–21	52,306	10,384
1921–22	17,526	6,208
1923–24	25,434	15,739
1926–27	33,818	28,320
1928–29	14,995	15,944
1930–31	38,527	10,470
1931–32	20,829	6,958
1934–35	24,326	12,489
1935–36	9,689	2,344
1937–38	44,655	5,360
1938–39	522	135
1943–44	37,321	61,693
1946–47	31,059	23,531
1950–51	32,441	23,000
1953–54	11,519	13,530
1956–57	35,389	6,201
1960–61	3,922	6,005
1961–62	17,208	..
1964–65	1,661	..
1966–67	30,000	..

* I am very grateful to M/s. C. R. Eswaran and K. R. Narayanan, of the Gujarat State Fisheries, for kindly permitting me to make use of the data.

METHODS OF FISHING FOR THE OYSTERS

The pearl fishery in the Gulf of Kutch is conducted once in three years and has been a state monopoly. The fishery lasts for three months starting after the inset of the monsoon. This period

synchronises with the highest spring tides, exposing the reefs during the ebb tides. The fishermen walk in to the reefs and pick the oysters. They are paid at the rate of Re. 0–25 for every oyster collected, irrespective of the presence or absence of the pearls in them.

In the pearl beds of the Gulf of Mannar and the Palk Bay the methods followed by the fishermen in removing the pearl oysters and chanks are identical, *i.e.*, by skin diving and the crafts and accessories used are also the same. The fishing season depends on the locality and the clarity of water in that area. During the period extending from November to Middle of May the Palk Bay waters are turbid while Gulf of Mannar is calm and the water clear. Diving in the Gulf is best done in this period. The conditions during the south-west monsoon period commencing from June till middle of October are congenial for Palk Bay fishing.

Skin diving for pearl oysters has been in vogue for over several centuries in this area. But still this age-old method is being followed.

On an average a skin diver can make 10–15 dives an hour and in all 30–40 dives a day. But this is variable depending on many factors. A diver is credited with being able to clear at one descent an area of two and a half to three square yards (Hornell, 1922). The diving begins around 10 A.M. and stops by 1 P.M. If they reach the banks late they dive till 3 p.m. their effort becomes less and less as time advances because of physical exhaustion due to diving and due to chillness of wind and water.

The pearl fishery is a Government monopoly. Therefore the diving operations are conducted under the supervision of the Government. The catches of oysters of each canoe for the day are apportioned on a 2:1 basis, Government getting 2/3 share. Those oysters are latter auctioned in public. The divers are allowed to sell their share to the public.

Inspection of pearl beds and assessment of oyster population

Before going into the details of the assessment of the oyster population and exploitation of the available resources as practised today it is necessary to have some information of the oysters and the pearl formation in oysters.

Pearl oyster in the Gulf of Mannar is said to have two spawning periods, one in the south-west monsoon period and the other in the north-east monsoon period. Herdman (1906) has stated that Ceylon oysters breed in May–July and November–January. Malpas (1933) puts it as July–August and December–January, whereas Hornell (1916) says of Indian oysters that April–May and September–October are the periods. Whatever the period the veliger larvae after the pelagic life of about 5 days as estimated by Herdman (1906) and Hornell (1922) may settle down as 'spat' on the rocky areas and grow. This spat settlement on the banks may be either by self effort (as stated by Devanesan and Chidambaram 1956) or by surface cross drifts from Ceylon to India. Growth during the first two years of life is very quick under healthy conditions. During the third year the rate of increase is reduced and in the fourth year still less. It was noticed by Herdman (1903) that the three year old oysters average $69{\cdot}96 \times 64{\cdot}79$ mm and $3\frac{1}{2}$ year old oyster average 70×64 mm. Pearl formation is said to begin at the beginning of the third year and oysters are considered to be fishable in the third, fourth and fifth years their lives. The formation of pearls in the oysters has been dealt with by various authors in detail (Herdman and Hornell, 1906; Bolman 1941). Pearson (1933) calculated the longevity of the oyster to be five years and considered that oysters older than five years are rare, the best age for fishing being probably between $3\frac{1}{2}$ to $4\frac{1}{2}$ years. An oyster bed may contain oysters of only one age group (homogeneous) or more frequently heterogeneous because of the possibility of successive spat fall every year during the spawning season.

To find out whether there is any possibility of pearl fishery, many details will have to be ascertained by inspection of the pearl banks by employing divers.

To ascertain the presence and distribution of oysters over the whole of the effective pearl banks region an intensive examination by circle inspection was felt desirable, by Captain Donnan in 1902. This has been described in detail by Herdman and Hornell (1906) and Hornell (1922). This method will also help to chart the contour of the pearl banks. But at present this system is not followed by the Indian pearl fishery scientists due to obvious difficulties. Instead they follow the 'rectangular method' of Inspection. Here three canoes with a couple of divers in each take equidistant positions at the northern edge of the paar area to be surveyed and dives are made at random moving south. Thus three sets of parallel dives are made throughout the length of the paar. The results of each dive is noted down in a square chart showing the oysters taken. The total number of oyster taken by the divers divided by the dives made will give the average oysters taken per dive (*i.e.*, for 3 sq.yds. assuming that each diver covers only that area during a dive). The area of the bank is already known approximately. From this the approximate population of the oysters in the bank is calculated. Likewise the inspection is done for several banks and estimation of oyster population is made separately for each bank. This is the first step in the field.

Secondly these oysters are taken to the laboratory and their length frequencies are studied to find out the percentage of different size groups. Based on this the age of the oyster is ascertained. If more than 60% of the oysters in a bed is 3 years and more of age, then the bed is con idered fishable.

The third step is to put all these oyster in a pot and allow them to rot. At the end of a week's period the oysters are washed and the pearls obtained are all separated, graded, weighed and their value and quality ascertained. The number of oyster allowed to rot is known; the weight and value of pearls are also known. Hence the pearl value calculation is made for a lot of 1,000 oysters. If the value is considerable (*i.e.*, more than Rs. 30 per 1,000 oysters) then it is considered feasible to exploit the bed for oysters.

Since the fishery will be attended to by over 800 or more divers, enough oyster population should be available for the success of the fishery. Each good diver can take anything between 1,500–2,000 oysters per day and on this basis in one day a minimum of atleast 2,00,000 oysters should be available for exploitation, giving allowance for other factors. Any fishery held for less than two months is not attractive or profitable.

Inspecting the pearl banks in the entire Gulf has to be done periodically if a possible fishery is not to be missed. Even though oysters might be found in several banks in one year, that does not naturally lead to a pearl fishery subsequently since these oysters populations have to undergo many vicissitudes in nature if they are to survive and sustain a fishery. A thorough scrutiny of the pearl banks inspections since 1834 upto 1955 showed disappointing trends in the pearl oyster survival although in a few years successful pearl fisheries did occur.

The reasons put forward by various persons for the oysters not reaching the fishable stage in the natural beds may be divided into biological and physical. They are:

Biological

1. Growth of 'Suram' (*Modiolus*) population on oyster beds.
2. Abundance of sharks, skates and rays and their depradatory attacks on oyster beds; in addition to these, fisheries like *Balistes*, *Lethrinus*, *Serranus* and *Tetradon* also eat away the young oysters.
3. Menace from sea-stars crunching the young and old oysters.
4. Natural mortality.
5. Migration of oysters from place to place.!

Physical

6. Sand drift over paar engulfing the oysters.
7. Fierce underwater currents creating difficulties for oyster settlement in the spat stage.
8. Clandestine fishing of mature oysters.
9. Improper inspection of oyster beds.

If anything could be done by man to prevent these calamities overtaking the oysters in the vast sea it is only possible with reference to items (8) and (9), the others being beyond human control. The irregular cyclic nature of the pearl fisheries and the undependability of oysters reaching the fishable size made Hornell and others to conclude that the only economically sound way of making the Indian pearl fisheries permanently and regularly remunerative is to concentrate upon the inducement of the pearls by artificial means and to avoid all expensive methods of controlling the natural beds in deeper waters. However, systematic and careful watch should be maintained to observe the natural resources by means of inspection done periodically so that we may ensure that beds of oysters do not go unfished if any when they reach the fishable size. This exploitation of the available stock should be done to the maximum extent possible. It is only with this object that the detailed inspection of the pearl banks is being done at present by the Madras State Government. But there are certain drawbacks and difficulties in the system that is followed at present.

The pearl banks were first charted sometime in 1870. Their location, and approximate area of a few important beds given at that time are still being followed. It is not known how far the topography of the rocky inshore bottom has been affected over the number of years that have elapsed since then. The extent of the rocky surface available for oyster attachment is also not known. Knowledge of the area of the paar is necessary for the proper assessment of oyster population if a fishery is to be declared on a commercial basis. This necessitates recharting of the banks and finding out the extent of the banks.

So far only the rocky areas within the limit of the skin divers reach have been examined and exploited. Efforts to find out new areas of rocky patches beyond 10 fathoms have not been taken seriously nor were the known areas in deeper zones inspected because of the limitations inherent in the skin-diving practice. This means that oysters in deeper waters have been so far unfished if they had settled down and survived. Thus a potential natural resource would have gone unutilized. Modern method of Aqua-lung diving can take a person even to 30 metres safely. With this it is possible to estimate the oyster populations by direct observations in the natural beds in shallow as well as deeper areas lying beyond the skin-diver's reach. The direct study will also help to study the oyster enemies in the natural surroundings. With these objects a new orientation was given to the study of the pearl banks by training the authors and two other scientists in Aqua-lung diving method and an underwater survey of the sea beds lying between Tirchendur to Vaipar, which was considered the most useful area, was begun. Leaving out the area lying inside of 10 metres and beyond 27 metres depth it was estimated that totally 4,000 sq.km of the inshore zone of the Gulf of Mannar can be surveyed for finding out the existence, location and extent of potential oyster beds. Of this, the zone from Cape-Comorin to Manapad and the one from Vaipar to Pamban, accounting for 1,300 sq. km. each, being not so important and productive were kept out for future survey. Only the area lying between Vaipar lat 8° 55′ N to South of Tiruchendur lat. 8° 25′ N was taken up for survey. This area was divided into three zones and the system and method adopted for the survey work has been detailed by Mahadevan and Nagappan Nayar (1968). An area of 800 sq.km out of a total of 1,400 sq.km envisaged for detailed study has been so far examined by covering 2,389 stations of 600 metres interval. The nature of bottom, depth and the bearings of the stations ascertained during this phase of work paved way for detailed study of only the rocky stations during the second phase of the survey work. These rocky stations were buoyed up at intervals of 300 metres and diving was done in all stations. Any extension of paar or discontinuity thereof was ascertained by diving at shorter intervals whenever needed so that the exact contours may be

fixed. This was followed by making Aqua-plane survey over the entire rocky area. Likewise many rocky patches were mapped and their extent calculated.

It was seen that 60 sq.km of potential rocky area is available in the area so far surveyed for oyster attachment. While the remaining work is in progress it may be said that in all only 100 sq.km area of sea-floor would be of rocky nature at the most. This would mean that of the 1,400 sq.km only 7% of the sea-bed forms the oyster bed.

From the chart prepared thus a comparison was made with the ones published by Hornell (1922). Although there are areas which are in agreement with each other we are constrained to feel that silting has taken place in many places as evidenced by sand covering the pits and crevices of the rocky and even coral blocks up to a height of 20 cm, at times. The shoreward group of paars is a continuous stretch but for small strips of intervening sand unlike what he had shown. Three patches of rocky floor north of the famous Tholayiram paar appear to be new extensions which are not marked by Harnell. Two series of rocky bottom are evident from the map. An inner series within 16 metre depth and an outer series bordering 16–18 metre depth zone. The inner shoreward series is more often than not affected by sediment laden water because of the profuse silt brought down by the Tambarparni and Vaipar rivers. The outer series is free from this and considered more congenial for good oyster growth. Observations made on oyster enemies like sea-stars *Modiolus*, Octopus, Skates and rays and bottom fishes have already been detailed by Mahadevan and Nagappan Nayar (*op. cit.*).

Estimation of oyster population

The basis for calculating the pearl oyster population in the natural beds followed till now is of the assumption that a skin diver will clear oysters found in an area of 3 square yards per dive. To check up this with collections made from aqua-lung dives 1 sq.metre metal frame was thrown at random in the same area where the skin diver operated and his catches were compared with ours. This was done for the thickly populated bed, sparsely populated bed and in beds with many pits and crevices.

	Oysters in fully packed bed per dive	Average	Oysters in thin bed per dive	Average
Skin diver ..	42, 62, 100, 47, 64	71	19, 13, 17	16
Aqua lung ..	413, 317, 393, 355, 410	375	62, 39, 92	63

Comparison of averages will show how incorrect the deductions could be, if based on the above assumption. Obviously the aqua-lung diver has better clarity, time and confidence to collect all oysters in the area whereas the skin diver suffers from want of time. His performance in the bed with pits is more unsatisfactory. It is our opinion that the population of oysters calculated based on the skin divers performance will be an underestimation and this out-dated method should in future be replaced by the aqua-lung diving system of collecting oysters from known area for this purpose.

In respect of the comparative efficiency of both systems of diving also the performance of a skin diver is far inferior. A capable diver making an average of 40 dives a day would bring at the most 1,500–2,000 oysters of mature size from a good bed. This has been verified many times during the time of pearl fishery. An aqua-lung diver could send up 1,200 oysters per hour from the same bed. If he works 4 hours in a day 4,800 oysters can be lifted which is equivalent to the work of 4 naked divers. The exploitation with aqua-lung is thorough unlike in the case of skin divers who move from one spot to another where they can get more oysters per dive out of competition and desire to make more money at the time of a fishery. This will leave many small patches unexploited.

Therefore it is felt necessary that the aqua-lung diving method should be introduced on a commercial scale by a phased programme of training and providing equipments to the divers. The scheme of imparting training to the divers is easy since all of them are good swimmers and physically robust. The initial training in the use of masks and fins (which many have already begun practising) and training in the aqua-lung diving principles and practices would take 3 months to be completed. It will be possible to train 100 divers in one year provided 20 pairs of aqua-lungs and accessories are given to start with. Necessary training personnel are available. At the end of the training the divers will have to be supplied with aqua-lung at subsidised price.

Notwithstanding the above efforts to harvest the natural resources it becomes imperative on our part to resort to producing culture pearls as in Japan, so that pearl production can become a regular commercial proposition. The first attempt at culturing the oysters in captivity was made at Tuticorin as early as in 1864 by Phipps as is evident from Markham's (1866) letter written to the British Government in India. Actually the pearl oyster nursery in Tuticorin at Hare Island was commenced in November 1864 and Prof. Huxley and de Broca (a French Officer at that time) advised about the feasibility of successfully transplanting live molluscs from Bahrein to Tuticorin. After repeated trials the area chosen for culturing was found to be fouled by mud stirred up near the shore and they wanted the farm to be shifted from Tuticorin. It was kept in abeyance till Hornell acquired Krusadai Island for this purpose in 1916. The farm work started after nearly 12 years in 1933. But the experiments conducted in this line at Krusadai by several workers did not succeed in bringing out spherical pearl of value. (Devanesan and Chacko, 1958). The technique still remains to be perfected. A scheme for the culture pearl experiments is being prepared on a collaboration basis between the Madras Government and Indian Council of Agricultural Research for implementation.

Acknowledgement

Our sincere gratitude is due to Dr. S. Jones, Director, Central Marine Fisheries Research Institute, for all his encouragement, guidance, suggestions and help while carrying out the underwater survey work and in the preparation of this report. To Shri K. V. Rao, our grateful thanks are due for critically going through the paper and offering valuable suggestions. We are very thankful to Mr. A. D. Isaac Rajendran, Assistant Director, Madras Fisheries, for making available some rare records for scrutiny and to Mr. C. T. Rajan for his assistance in the preparation of charts.

References

Bolman, J. 1941. The Mystery of the Pearl. *Internationales Archiv fur Ethnographic*, Suppl. Bd. 39. E. J. Brill Leiden, 1–170.

Eswaran, C. R., K. R. Narayanan and M. S. Michael. 1950. Pearl fisheries of the Gulf of Kutch (under publication).

Devanesan, D. W. and K. Chidambaram. 1956. Results obtained at the pearl oyster farm, Krusadai Island, Gulf of Mannar and their application to problems relating to pearl fisheries in the Gulf of Mannar. *Contr. from Marine Biological Station, Krusadai*, 4.

—— and P. I. Chacko. 1958. Report on culture pearl experiments at the Marine Biological Station, Krusadai Island, Gulf of Mannar. *Contr. from Marine Biological Station, Krusadai Island No.* 5: (Madras Govt. Publication).

Gokhale, S. V. 1960. Shell fisheries of Saurashtra region, Gujarat State. (Gujarat Government Publication).

Gravely, F. H. 1929. Administrative report of the Madras Fisheries Department for the year ending 30th March 1928. Report No. 1 of 1929 *Mad. Fish. Bull.* 23: 1–86.

Herdman, W. A. 1903–06. *Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Mannar* (with supplementary reports upon the marine biology of Ceylon by naturalists). Royal Society, London-1. 1: 1–307; 2: 1–300; 3: 1–384; 4: 1–326; 5: 1–452.

HORNELL, J. 1905. *Report to the Government of Madras on the Indian Pearl Fisheries in the Gulf of Mannar* (Madras Government Publication).

———. 1909. *Report to the Government of Baroda on the Marine Zoology of Okhamandal in Kattiawar.* Part I: 1–148. William and Norgate, London.

———. 1916. Marine Fishery Investigations in Madras 1914–15. *Mad. Fish. Bull.* **8**: 11–122; 42–104.

———. 1922. The Indian pearl fisheries of the Gulf of Mannar and Palk Bay. *Ibid.*, **16**: 1–188.

JONES, S. 1968. The mussel fishery of the west coast of India. *Sea-food Exporter* **3** (1).

MAHADEVAN, S. AND K. NAGAPPAN NAYAR. 1968. Underwater ecological observations in the Gulf of Mannar off Tuticorin. VII. General topography and ecology of the rocky bottom. *J. Mar. biol. ass.*, **9** (1): 147–163.

MALPAS, A. H. 1933. Further observations on the age and growth rate of the Ceylon pearl oyster with special reference to oysters of Donnan's Muttuvarattu Paar. *Cey. Jour. Sci.* Sect. C. **5**: 21–48.

MARKHAM, C. R. 1865. Letter dated 26–11–1965 to Govt. of Madras, Revenue Dept. Lon. Proceedings No. 5 of Revenue Department Madras Govt. dated 3–12–1866.

PEARSON, J. 1933. The Maximum yield of a pearl oyster bed. *Ceylon. J. Sci.*, Sect. C, **5**: 1–20.

PRASAD, B. AND J. L. BHADURI. 1933. The pearl oysters of Indian waters. *Rec. Indian Mus.*, **35**: 167–174.

RAO, K. VIRABHADRA. 1968. Pearl oysters of the Indian region. Symposium on Mollusca, *Mar. Biol. Ass. India.* Abstract: 23.

SUNDARARAJ, B. 1926. Administrative Report of the Department of Fisheries for the year ending 30th June 1925. Rept. No. 1 of 1926. *Mad. Fish. Bull.* **20**: 1–78.

———. 1930. Administrative report of the Department of Fisheries for the year ending 30th June 1929. Rept. No. 1 of 1930. *Ibid.*, **24**: 1–103.