PROCEEDINGS OF THE SYMPOSIUM

ON

LIVING RESOURCES *of* THE SEAS AROUND INDIA

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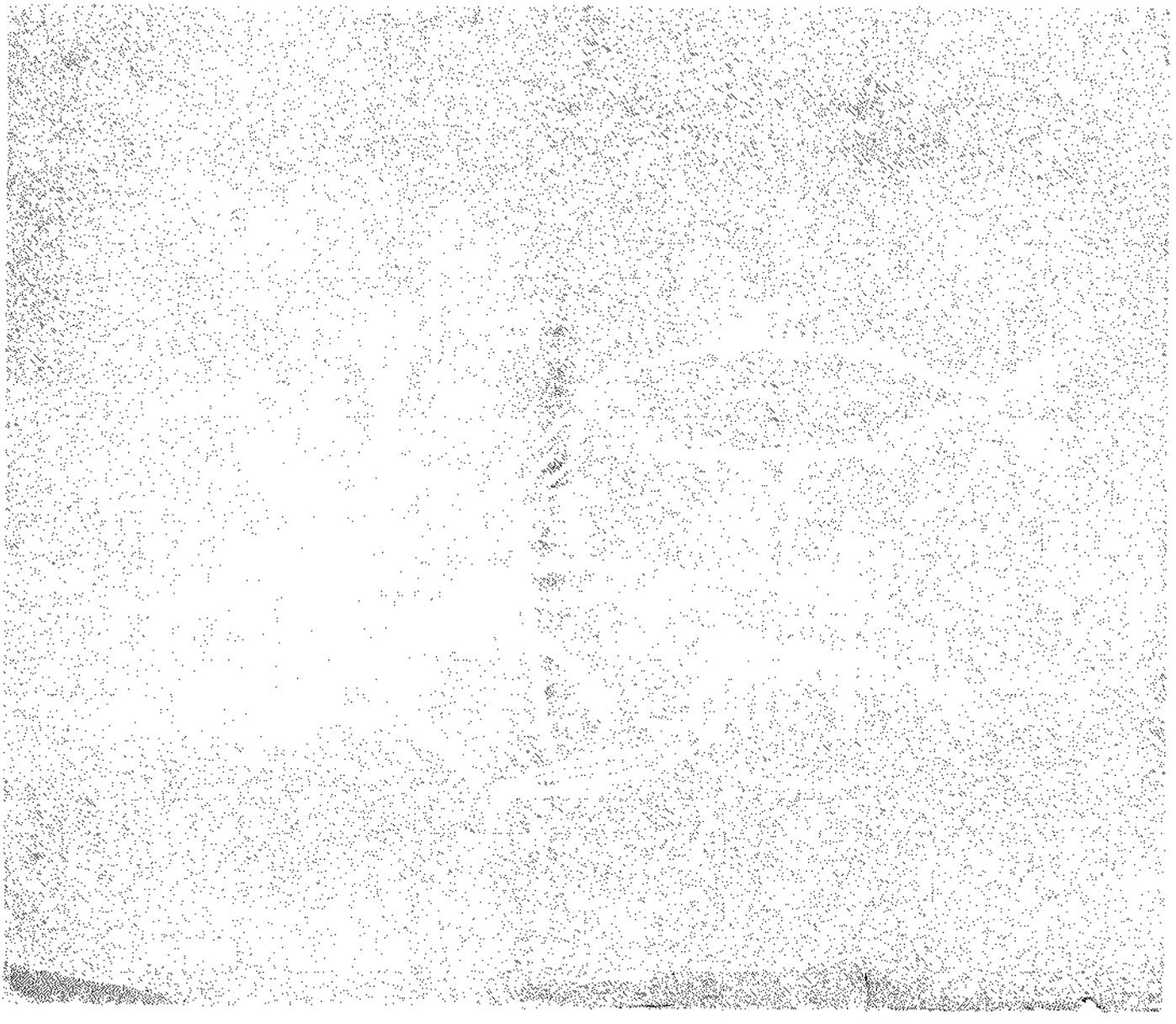

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CLAM, COCKLE AND OYSTER RESOURCES OF THE INDIAN COASTS

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ABSTRACT

India, faced with the problem of food shortage as it is, has, since two decades, been systematically investigating and harvesting the resources of the seas around her with a view to augmenting her food production. But the emphasis laid has been mostly on fishes, and the molluscan shellfish, in general, have not been given due attention. Besides forming food, the molluscs are a useful source in making lime, mortar and cement for the house building industry and as ornaments and curios. This is a source where relatively little investment can bring in high returns. Among the edible molluscs, clams and oysters abound our coasts. Though the biology of species like *Crassostrea madrasensis*, *C. gryphoides*, *Meretrix meretrix*, *M. casta*, *Katelysia opima*, *K. marmorata*, *Solen kempi*, *Donax cuneatus*, *D. faba*, *Gafrarium tumidum*, *Anadara granosa* and a few others has been studied from different areas data on the exploited and potential resources have not been adequately obtained.

In the present paper the distribution of clam, cockle and oyster resources of the Indian coasts, including the estuaries and backwaters, based on a survey conducted along the east and west coasts and the published data has been dealt with. The present level of harvesting is given and the scope for future exploitation is indicated. The need for starting systematic culture of these species as well as simple transplantation to bring new areas into production is stressed. The need for educating the public on the food value of the molluscs is also pointed out. This article cannot be said to cover all the above aspects in great detail but it attempts to highlight the importance of the edible bivalve resources in the present situation.

INTRODUCTION

THE lamellibranchs have far excelled the gastropods and cephalopods among the molluscs as a cultivable source of food. Their sedentary habits, easy accessibility, profuse proliferation and hardy nature have been taken advantage of in farming them on scientific lines. Most of them are a good source of protein, glycogen and minerals and are easily digestible and compare favourably with other animal foods conventionally eaten by man. Apart from forming food they have another significant importance as a source of lime in the shell lime industry and are extensively used in the manufacture of cement.

The world production in 1966 was 7,36,000 m. tons of oysters and 5,00,000 m. tons of clams and cockles. The major oyster producing countries are the United States of America, Japan, France and the Republic of Korea. Against this the total production of all molluscs (unclassified) in India, as given in the *F.A.O. Year Book*, has stood at 100, 100, 300, 500, 300 and 1,000 m. tons during the years 1961 through 1966. It should be pointed out that these figures indicate but a fraction of the actual landings. There is no system at present of collecting data for the molluscs, as for the fishes and crustaceans, except in the case of pearl oyster and chank and hence the lack of any figures indicating the actual magnitude of the total landings.

Scanning through the literature on the Indian molluscan resources it could be seen that the late Mr. James Hornell, more than any other individual, has contributed to our knowledge greatly.

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His works (1909 *a*, *b*; 1910 *a*, *b*, 1916 *a*, *b*, 1917, 1922 and 1949) on the Indian molluscs remain to-date the most authentic ones on many aspects of Indian shellfisheries. Rai (1932) made a survey of the coast of the then Bombay Presidency and made available valuable data on the oyster and clam industry of that area. There are several other publications that give some information on the abundance and economic importance of the clams and oysters, some of which are Comber (1905), Annandale and Kemp (1916), Rai (1928), Awati and Rai (1931), Rao, H. S. (1941), Patil (1952), Rao, K. V. (1952, 1958, 1963, 1966), Abraham (1953), Nayar (1955), Durve (1960), Rao *et al.* (1962), Joshi (1963), Ranade (1964), Kundu (1965), Alagarswami (1966), Jones (1968) and Narasimham (1968). Besides these there are several others which relate to the biological and chemical investigations on individual species. Despite the interest evinced by various workers, concerted efforts still remain to be made for the scientific exploitation of the molluscan resources.

In the present article an attempt has been made to give information on the clam, cockle and oyster resources of India based on the observations made by the authors during surveys undertaken for this purpose and the information contained in the earlier publications. The second author contributed data for the Andhra and Orissa coasts.

Species of Commercial Importance

Clams and oysters, besides mussels, are of prime importance among the edible molluscs of India. Though the true cockles of the genus *Cardium* are not abundant in our waters the cockle-like ark shell *Anadara granosa* forms extensive beds in some areas. The pearl oysters hitherto valued only for the pearls they produce are a potential source of food. The window-pane oyster, though not a relished item, could be considered for culinary purposes.

Among the clams those belonging to the family Veneridae are by far the most important in the Indian waters. The species that contribute to fisheries of commercial importance are *Meretrix meretrix* (Linnaeus), *M. casta* (Chemnitz), *Katelysia opima* (Gmelin), *K. marmorata*, *Paphia laterisulca* and other *Paphia* spp., *Villorita cyprinoides* (Gray), and *Gafrarium tumidum* (Röding). Among others *Mesodesma glabratum* (Lamarck), *Solen kempi* Preston, *Sanguinolaria diphos* (Gmelin), *Donax cuneatus* Linnaeus, *D. faba* Gmelin and *D. incarnatus* Chemnitz have limited significance. The true cockles *Cardium assimile* Reeve and *C. asiaticum* Bruguiere, though occurring at several places, are not of commercial importance. The ark shell *Anadara granosa* (Linnaeus) which is referred to as cockle in the South-East Asian region constitutes a fishery in some centres like Kakinada.

Though 11 species of edible oysters have been recorded from the Indian waters (Awati and Rai, 1931) only four of them are of importance, they being *Crassostrea gryphoides* (Schlotheim), *C. discoides* (Gould), *C. madrasensis* (Preston) and *C. cucullata* (Born). The window-pane oyster *Placenta placenta* (Linnaeus) is of local importance in some places. Six species of pearl oysters occur in India of which *Pinctada fucata* (Gould) [= *P. vulgaris* (Schumacher)] is abundant in certain years showing considerable fluctuations.

Apart from the above there are numerous others which, lacking in abundance, are not being utilised. Hornell (1917) stated '.... as far as I know, there are no poisonous species found on the Indian coasts'.

Clam and Cockle Resources

Meretrix meretrix and *M. casta*.—*Meretrix meretrix* known as the 'great clam' is the mainstay of the clam fishery along the Maharashtra, Goa and North Kanara coasts, though it occurs all along the east and west coasts. The numerous estuaries and backwaters present along the coast-

line of Maharashtra State abound in clam wealth and the main species that contribute to the fishery are *Meretrix meretrix*, *Katelysia opima* and *Paphia laterisulca*. Rai (1932) estimated the production of the first two species in the erstwhile Bombay Presidency at approximately 4 million pounds with the then value of Rs. 1,02,000. Recently Ranade (1964) who investigated the clam resources of the state in more detail estimated that out of the total number of 70 creeks along the state's coastline from Thana to Ratnagiri District 34 are productive, where about 3,600 persons are engaged in clam fishing taking about 24,03,000 pounds of clams from the creeks annually valued at Rs. 2,88,000. *M. meretrix* and *K. opima* alone contribute nearly 70% of the total production, the rest being accounted by *P. laterisulca*, *K. marmorata* and *Donax cuneatus*. The most productive areas lie in the Ratnagiri District which account for more than half the total for the state, Kalbadevi estuary and Bhatia creek alone producing about 5,00,000 pounds of clams (Ranade *op. cit.*). Tarkarli creek, south of Malwan, is another important clam producing centre where *M. meretrix* is particularly abundant.

Clam collection is done both by men and women during low tides with or without the help of canoes and rake nets, and marketing is done only by the women. Bombay, Ratnagiri and Malwan are the important marketing centres for clams, the last two centres being particularly important for *M. meretrix*. The clams are sold either in heaps as in Bombay and Ratnagiri, a heap of about 25 clams costing 50 paise in Bombay and the same quantity costing only 25 paise in Ratnagiri, or in measure as in Malwan, about a litre costing 30 to 50 paise. Dried meat of clams is also put for sale in Malwan (Pl. I—1, 2, 4; Pl. II—1, 2).

The rivers of Goa have abundant clam resources particularly *M. meretrix* and *Villorita cyprinoides*. Tiracol, Chapora, Sal, Mandovi and Zuari are the rivers that are important for clams in that order. The major fishing centres for *M. meretrix* are Siridao on the Zuari, Siolim on the Chapora and Ribander on the Mandovi. *M. meretrix* is sold in the markets near the fishing centres of which Panaji and Mapusa are important. The clams are divided into two groups according to the size, the larger ones being sold at 50 paise per hundred and the smaller ones at 25 paise per litre. The clam season is throughout the year excepting the monsoon months. In all about 400 to 500 persons are engaged in clam fishing in Goa.

In North Kanara District of Mysore State, Karwar is one of the major clam centres. The Kalinadi estuary is thickly populated with clams mainly of two species *M. meretrix* and *Paphia malabarica*. The clam fishing villages along the estuary are Kodibagh, Nandangadda, Sunkeri, Sadasivgarh and Kanasgiri. *M. meretrix* is predominant on the bank side of the estuary while *P. malabarica* is more abundant in the deeper regions. About 300 to 400 are engaged in clam fishing and about 50 canoes are put in use for the purpose. Generally two men set out in a canoe and dive in turns, the boat being kept in position with a bamboo pole. The diver goes down with the clam net and pushes the clams along with the sand into the net with his sole. On coming up the clams and dead shells are washed in water and emptied into the canoe. The net which is locally known as 'akhya' has a roughly semicircular mouth with a cane frame (length of the beam 64 cm, from centre of beam to top of arc 47 cm) and a webbing of 2 cm mesh with an overall length of about 90 cm. Ropes are tied to the two ends of the beam and the middle of the arc in the fashion of bridles and all the three ropes are knotted together to which a single thicker rope is attached (Pl. II—6). When more clams are caught than what could be marketed on the same day, part of the catch is stored near the bank for 2 to 3 days for subsequent marketing. The clam markets in and around Karwar are busy from 9 A.M. to 1 P.M. and it is a common sight to see a row of 20 to 40 women with basket loads of clams (Pl. III—1). The price that obtains here is very low, about 100 being sold at 20 paise or less.

The clam shells are used in the manufacture of shell lime at several places like Kodibagh, Sadasivgarh, Sunkeri and Nandwad. In all about 20 kilns operate around Karwar (Pl. III—2). But the kilns, locally known as 'bhati' are in production only for six months in a year, the average number of working days being about 50. At a daily average of 25 bags (each bag about 20 kg) the annual

lime production per kiln is about 25 m tons worth Rs. 1,250. The annual production of clams from Kalinadi river alone would be around 1,000 m tons. About half of this is constituted by *M. meretrix.*

South of Karwar, the Gangavali river and Tadri river have extensive clam resources and the latter is as productive as the Kalinadi river. The species are the same but the predominant one is *Paphia malabarica.* Ankola, Moorba, Wadgoni creek, Mirjan, Horwada, Mudgian, Sanikatta, Tadri and Aghanasini are the important centres for *M. meretrix* along the North Kanara coast. Clams are being fished throughout the year with a peak season about March–June. From Sanikatta truck loads of clams are sent to distant places like Panaji and Belgaum for marketing. Ankola is also an important marketing centre for clams. The Sharawathi estuary also contains extensive clam beds, the most important species being *M. meretrix.* On both sides of the estuary at Honavar and Kassarkod clams are collected regularly by about 100 persons.

Along the South Kanara coast and further south *M. casta* replaces *M. meretrix* in importance. Coondapur, Silanadi, Malpe, Mulki, Gurpur and Netravati rivers contain abundant clam resources. Two species predominate in the clam catches in these rivers, namely *M. casta* and *Villorita cyprinoides,* the former being by far more abundant. In the Mulki river canoes are employed to transport the women divers to the collection centres (Pl. III—5). These women belong to a particular community known as 'Dikkenokalu'. They dive to the river bottom and pick up the clams which they keep in their 'madi' (a piece of cloth folded like a bag) or in a bag net fastened to their waists (Pl. III—6). When they have collected the maximum they could carry they reach the shore to put the collection down and re-enter the river for further collection. The important markets for clams are Malpe, Mangalore and Mulki. *M. casta* is sold 100 for 20 and 10 paise for large and small clams respectively. Clam meat is also put for sale at 10 paise for about 200 gm. *Meretrix* is more in the markets than *Villorita.*

The shell lime industry, though functioning to full capacity only for two months in a year, is running successfully at Ullal near Mangalore (Pl. IV—1, 2). There are about 40 kilns (local name 'goodu') each with a capacity of 40 bags (each bag 50 kg) a day. Each bag of lime costs Rs. 8 at the production centre. Over 3,000 m. tons of shell lime is produced at this centre worth over Rs. 5,00,000. The lime is used in manuring coffee plantations. Out of season there is very little production. The clam shells for the kilns come mainly from Tadri river.

Along the Kerala coast *M. casta* is one of the important clams occurring in almost all the estuaries and backwaters. Kozhikode, Beypore, Vembanad lake and Quilon are some of the centres where this species is collected for local consumption. Kitchen middens of shells are sold to merchants who use them for making lime.

Along the east coast, *M. casta* occurs in the Vaigai estuary, Coovum river, Adyar estuary, Pulicat lake, Chilka lake and at several other places. The beds in Adyar river were extensive and some of the largest ones were spread over an area of 10 acres containing about 50 million clams (Abraham, 1953). But in the recent years the beds have become very much restricted. Shell-mining for subfossil deposits of *Meretrix* in Pulicat lake for the cement factories situated in Madras is an important industry. Though five species of molluscs constitute the deposits, *Meretrix* is the most important and valued best. Very nearly 40,000 tons of these shells were taken from this lake during 1914–15 (Hornell, 1916 *b*). In Kakinada Bay *M. meretrix* occurs in fair abundance and nearly 400 metric tons of clams valued at about Rs. 20,000 (value for the shells) are collected annually (Pl. IV—4).

Along the Orissa coast *Meretrix* spp. occur in Bahudi river near Sonapur. The clams occur conjointly with oysters and are particularly abundant in the upper reaches of the river. Apart from the living clams extensive shell deposits are present on either side of the river in an area of about 500 acres to a depth of about 3·5 m. The presence of shell deposits is detected by driving an iron

rod into the ground, and listening to the sound it makes on touching the shell deposits. About 500 tons of deposits are quarried annually which, when converted into shell lime, is worth about Rs. 50,000. In the Chilka lake *Meretrix* spp. occur in the channel area at Manikpatna. The shells are taken to Kaluparaghat and Chandpur for selling to the merchants who use them in shell lime production. About 400 tons of shells are collected annually which account for lime worth about Rs. 40,000.

Katelysia opima and *K. marmorata*.—These two species are of great importance in the clam fishery of Maharashtra State. They surpass the 'great clam' *M. meretrix* in production in some areas. In Mahim Bay where several species of clams are found *K. marmorata* occurs in thick beds spread over an area of 25,000 sq. metres. The density of population is high with 400-500 clams per sq. metre. *K. opima* also occurs in this bay but only in small numbers.

K. opima occupies a significant place in Ratnagiri District where almost half of the total production of clams is constituted by this species. Kalbadevi creek near Ratnagiri and Tarkarli creek near Malwan are the important areas for *K. opima*.

South of Malwan *Katelysia* spp. do not form a major constituent in the clam fishery though it occurs at several places. Along the east coast *K. opima* occurs in the Kundugal mud flats near Pamban and Adyar estuary where fishery on a small scale exists. In Kakinada Bay also this species is found.

Paphia laterisulca and other *Paphia* spp.—The species of *Paphia* are again important along the north-west coast as those of *Katelysia*. *P. laterisulca* occurs in Mahim Bay and is also found in most of the estuaries along the Maharashtra coast. In Ratnagiri District *Paphia* contributes to about 10% of the total production of clams. In Goa *Paphia* sp. occurs in Siolim, Siridao and Ribander but the fishing season is a short one from March to May. In Kalinadi river *P. malabarica* is more abundant than *M. meretrix* and is sold in all the markets in and around Karwar. The fishing methods and production have already been discussed under *M. meretrix*. In Tadri creek *P. malabarica* is the main species being collected throughout the year with peak activities during March-May. *Paphia* occurs in several places along the Malabar Coast and the east coast of India but not in any abundance.

Villorita cyprinoides.—The 'black clam' has a patchy distribution along the west coast, the northernmost region where it is represented being Goa. Here it is next only to *M. meretrix* in importance. It is fished at Siridao, Savoi, Amonen and Naibag, the last mentioned centre being more significant than the others. Panaji and Mapusa are the important markets for the species in Goa where it is sold at 30 paise per litre.

In North Kanara area this species is not respresented but appears again in the Mangalore area. But the magnitude of the resource appears much less than in Goa and is not comparable with *M. casta* which is the mainstay of the clam fishery of South Kanara coast. In Mangalore market the black clam is sold at 25 paise per hundred.

Along the Kerala coast it is available in the Cochin area and at several other places to its south. But its importance emerges from the occurrence as extensive subfossil deposits in the Vembanad lake, which are used as raw material in the cement industry. These deposits consisting essentially of *V. cyprinoides* along with a small quantity of *Placenta placenta* shells are found east of Alleppey extending over an area of about 16 km in length and 3 to 5 km in breadth. The deposits occur at a depth of 1 to 4 m from the lake bed. The shell content varies from 0 to 75% and they are imbedded in silt. The Travancore Cements Ltd., Kottayam, exploits this resource and quarries about 60,000 m. tons of shells annually by means of dredgers. The value of shells collected is about Rs. 10,80,000. About 10,000 m. tons of white cement and 40,000 m. tons of grey cement are manufactured from these shells.

Along the east coast this clam does not seem to occur in living condition but shell deposits of this species are found in South Arcot District at Merakkanam, Kuduvayur, Cuddalore, Uppanur, Killai, Pichavaram and Paravanur (Hornell, 1916).

Gafrarium tumidum.—This cockle-clam, though represented in small numbers in many parts of our coast, is particularly abundant in the Palk Bay and Gulf of Mannar. In the mud flats of Pamban extending about 1 km and of Rameswaram it is found in large numbers and is fished for the meat and shells. Hornell (1922) states that 'probably no other bivalve is so universally valued on the shores of Palk Bay as is this cockle-clam'. It forms an excellent food and the shells are sold for the lime industry at 75 paise for 20 litres. Nearly 5 tons of this clam are annually collected at Pamban and Rameswaram. Along the Coromandel coast it is only sparsely distributed.

Mesodesma glabratum.—This clean and white clam is found in coarse sandy beaches of the islands at the head of the Gulf of Mannar and is seldom collected. It is a good potential resource and a few tons of clams could be collected annually from these islands alone. Elsewhere these clams are found only in small numbers.

Solen kempi.—This species has commercial importance in Ratnagiri area and also occurs at Ennur and Chilka lake. The annual landings at Ratnagiri are over 3 m. tons valued about Rs. 2,000 (Rao *et al*., 1962). Apart from its use as food, the meat is used as bait in hook and line fishery at Ratnagiri. Another species of *Solen*, *S. truncatus*, is common in Karwar Bay.

Sanguinolaria diphos.—It is fairly common along the Coromandel coast in the backwaters of Madras, Cuddalore and Nagapattinam and in the Karwar area. On the Konkan coast *S. atrata* is commonly found. Nowhere it is of much significance in the clam fishery.

Donax spp.—Widely distributed along the sandy shores of the Indian coast, *Donax* spp. are a promising resource for exploitation. *D. incarnatus* is a common species along the Bombay coast; in Kamat's Bay, Karwar Bay and Binge Bay around Karwar. *D. cuneatus* and *D. faba* are extensively distributed along both the east and west coasts. *D. scortum* is fairly abundant along the Palk Bay and Gulf of Mannar. The density of population of *Donax* is high wherever they occur giving as many as 475 individuals of *D. cuneatus* per sq. ft. in the Palk Bay (Nayar, 1955). At very few places these are marketed and in Malwan it is sold at 12 paise per litre. However, along the entire coastline poor people collect these clams for domestic consumption. In Chilka channel area the shells are collected and sold for the lime industry.

Cardium spp.—Unlike the European cockle, the Indian species do not form a fishery anywhere along the coastline. In the Gulf of Kutch *C. assimile* occurs in fair abundance. *C. coronatum* is very common in Karwar Bay. Several species of *Cardium* occur in the Palk Bay and Gulf of Mannar but not in any appreciable numbers.

Anadara granosa.—This ribbed ark-shell is abundant only at few places in India. In the Kakinada Bay a good fishery exists for this species (Narasimham, 1968). Surrounding the bay there are many fishing villages whose fishermen engage themselves in the collection of clams, window-pane oysters, etc. The shells are all used in the manufacture of lime which is a prosperous industry around Kakinada. The villages where lime burning is done are Yerragaruvu, Yetimoga, Lakshmipathipuram, Balusutippa and Mulletimoga. *A. granosa* ranks second in importance following the window-pane oyster in this area. It is sold at Rs. 1·50 to 2 per basket of about 30 kg. The meat is rarely eaten except by pregnant women for whom it is considered of medicinal value. About 1,000 tons of ark-shells are collected annually valued at Rs. 50,000 as raw material and much more when converted into lime. In Bahudi river (Sonapur) and Pulicat lake *A. granosa* occurs in small quantities in sub-fossil deposits along with *Meretrix* spp. and it is utilised in the lime burning industry.

Ark-shells also occur in some creeks in Bombay and Alibag where they are used as food along with other clams.

Edible Oyster Resources

Crassostrea gryphoides and *C. discoides*.—These are the two important species of oysters along the west coast of India, especially in the northern parts. *C. discoides* is distributed in the muddy creeks of Kutch, the Aramra creek and off Poshetra Point, Port Okha, Dwarka and Porbunder. Along the Maharashtra coast *C. gryphoides* is the main species though the other species also occurs at a few places. Malad, Boiser and Satpuri creeks, Palghar, Kelva, Navapur, Utsali, Dahisar and Mahim creek are the important oyster fishing centres around Bombay, among which Palghar is the most important. Oyster farming is practised at Kelva, Navapur and Utsali. One year old small oysters are collected from the neighbouring rocks and placed in the farm site. These farms serve merely as the fattening grounds as no attempts are made to collect the spat and rear them. After an year in the farms the oysters are removed for marketing starting from late October. Restocking of oysters is done from March to May. The shucked oysters are brought to Bombay markets where there is a good demand (Pl. I—1, 3). A dozen oysters are sold for a rupee. The oyster season lasts from late October to May.

South of Bombay in Maharashtra State oyster fishing is practised in Alibag, Ratnagiri, Jaytapur and Malwan. In Purnagad creek near Ratnagiri the oysters are attached to the rocks at a depth of 4 to 5 fathoms and the diver uses hammer and chisel for dislodging the oysters from the rocks (Pl. I—5, 6). Each diver collects about 100 oysters a day, mostly large sized ones, and sells them for about Rs. 5 to 8 to the merchants who retail them at Rs. 1·25 to Rs. 1·50 per dozen. The oyster season is from December to May. About 15 divers do oyster fishing in this creek. Jaytapur is far more important than Purnagad in oyster trade as the oysters from here are sent to Bombay for big hotels. Though oysters are found and sometimes collected in Malwan they are not of any significance as clams are available in plenty and cheap.

Oysters are exploited in Goa at Ribander, Siolim and Curca. At Ribander about 40 men are engaged in oyster fishing in Mandovi river where collection is made in the central part of the river by diving (Pl. II—3, 4). The oyster meat is sold in the markets in earthen vessels (Pl. II—5). The shells are heaped in front of the fishermen's houses in Ribander for selling them to the merchants for the manufacture of shell lime.

Oysters are found in Karkal Island, Karwar Head and Ladies Beach near Karwar but they are being little exploited at present (Pl. III—3).

Crassostrea madrasensis.—Unlike the former two species, *C. madrasensis* enjoys a wider distribution along the south-west and east coast of India in almost all the estuaries and backwaters. It is found in Tellicherry, Elathur, Beypore, Cochin Harbour, Azhikode and Vembanad lake on the Kerala coast and Cuddalore, Covelong, Madras Harbour, Ennur, Pulicat, the deltas of Krishna and Godavari rivers, Visakhapatnam, Sonapur backwaters and Chilka lake on the east coast. From the exploitation point of view Ennur, Pulicat and Sonapur backwaters are fairly important. In the Pulicat lake oyster farming was started in the early twenties and though it helped to meet the demand from Madras during the pre-war years both demand and supply fell down considerably subsequently. Poultry feed was prepared and supplied from this farm on a small scale. Present conditions of the oyster farm at Pulicat are not encouraging. If the currently contemplated Pulicat Fisheries Development Scheme materialises the possibilities of reviving the oyster farm by suitable methods could be considered.

The Sonapur backwaters of River Bahudi hold abundant congregations of oysters and are presently being exploited for the shells utilised in the manufacture of poultry feed. About 500 tons

of feed are produced annually which is worth about Rs. 150,000. Oyster meat is consumed only by the fishermen community locally and is seldom sold in the markets. The oyster beds are auctioned every year by the Fisheries Department of Government of Orissa which fetches them a revenue of about Rs. 2,000 a year. In the Chilka channel a small oyster bed was known to exist near Manikpatna. But this bed is not exploited at present due to lack of demand.

Crassostrea cucullata.—The rock oyster has an extensive distribution both along the east and west coasts. Unlike the backwater oysters dealt with above this species thrives well only under marine conditions (Pl III—4). It occurs conjointly with mussels wherever the latter are found. Hornell (1922) stated "they are of excellent flavour, but on account of their small size, both natural and often further reduced by overcrowding, as well as the difficulty experienced in opening them by reason of their interlocking edges, they are not of economic importance". However, this is collected and utilised as food in many of the coastal villages particularly along the west coast.

Window-pane Oyster Resources

The window-pane oyster, *Placenta placenta*, known for the seed pearls it produces, has been under exploitation in the Gulf of Kutch (Balapur Harbour in Beyt island and Rann Bay) where it occurs in abundance. However, the pearls produced are of inferior quality and are used only in medicine. It occurs in the Bombay Harbour and its vicinity, Malabar coast, muddy creeks south of Tuticorin, Buckingham Canal (Madras), Pulicat lake, Kakinada Bay and Nagapattinam. Though the flesh has hitherto not been used as food in India, Rao (1963) suggests the possibility. A major aspect of its importance is its utility as a source of shell lime. The subfossil deposits of Vembanad lake contain small quantities of shells of this species. In Kakinada Bay, among the lime producing molluscs, the window-pane oyster is of great significance (Pl. IV—3). They are fished from the deeper waters of the bay at a depth of about 4 fathoms. About 150 persons are engaged in full-time shell-fishing and nearly 600 on an off-time basis (for all species of molluscs). Plank-built boats are used to reach the grounds and the fishermen from villages far off from the bay set out on a week's shell-fishing trip camping, off fishing hours, on the shore nearby. Fishing is conducted throughout the year with a peak season in summer (March–May), and a secondary peak from October to November during certain years. Each boat collects about 100 to 150 kg of window-pane oysters per trip of about 3 to 4 hours. The annual production is about 4,000 tons valued at about Rs. 100,000. Nowhere else along the Indian coast the window-pane oyster fishery is of comparable importance.

Pearl Oyster Resources

Pinctada fucata occurring in the Gulf of Mannar and Palk Bay and the allied form from the Gulf of Kutch, besides their supreme importance as pearl producing molluscs, are also edible species. Gunasekara (1962) conducted chemical analysis of the Ceylon pearl oyster meat the results of which show that it has approximately 19% protein, 74% moisture, 2% ash, 2·5% fat and 2·5% carbohydrates. The adductor muscle of the Japanese pearl oyster *Pinctada martensii* finds much favour in the 'tempura' dish of Japan (Alagarswami, 1968). Hornell (1917) observed "If ever a fish cannary be established on the shores of Gulf of Mannar, I believe that in those years when pearl oysters are poor in pearls though abundant numerically, the canning of their flesh would prove a remunerative undertaking". Alagarswami (*op. cit.*) has dealt with in detail the pearl oyster resources of India and the possibilities of pearl culture.

General Considerations

Unlike the case of fishes, the development of molluscan resources in our country involves two problems, the first being creation of demand, and the second, improved and rational exploitation of the resources. The first problem is a sociological one and will have to be attempted on a national

level. The nutritive value of the molluscan food which lies in the presence of protein, glycogen and mineral content of their tissues will have to be widely publicised and, if necessary, demonstrations should be arranged in the coastal towns and villages. Fortunately along the west coast there is already a good demand and some of the species are even intensively exploited. But on the east coast the shells are valued more than the meat of the molluscs and creation of interest in the molluscan food needs greater attention here.

The solution for the second problem of improved and rational exploitation of the resources lies in improving the existing fishing methods, imposing restrictive measures wherever necessary and resorting to culture practices. These demand a thorough knowledge of the resources and their biological and environmental aspects. A system of survey to collect the data on landings, size composition, etc., should be worked out and introduced. Introduction of licensing system, at least for the species of major importance such as oysters, *Meretrix*, *Katelysia*, *Paphia*, etc., will help in assessing the resources correctly. Power fishing would not become necessary until the molluscan resources of the deeper waters are explored by systematic surveys. Biological minimum size for exploitation for each of the commercially important species should be studied and made the minimum for commercial exploitation. Observation of closed seasons and closed areas for fishing coinciding with the peak spawning of the species will help in maintaining an optimum breeding reserve.

It is by resorting to culture practices a major break-through could be achieved. Simple methods of collecting seed clams from the natural environment and laying them in protected areas will go a long way in increasing the yield. In Japan, U.S.A., Korea and Malaysia such simple practices for clams have produced good results. Leasing of tidal lands to individuals will help in devoting greater attention to the farms. The farm could be suitably improved to stimulate natural settlement of seed clams. Giving a different location with the bottom conditions not very different from the natural beds would help in obtaining faster growth. *Anadara granosa* is extensively cultured on this principle in Japan and Malaysia (Cahn, 1951; Pathansali and Soong, 1960). *Meretrix meretrix*, *M. casta*, *Katelysia opima*, *K. marmorata*, *P. laterisulca* and *Anadara granosa* could be adopted for culture and the present yield could be increased severalfold. *Meretrix* spp. could be introduced in marine fish farms where the milk fish and mullets are grown after taking into consideration the productivity of the farms. In this connection the instance of the fish farm of the Central Marine Fisheries Research Institute at Mandapam where *M. casta* established itself successfully is worth noting. The Indian clams are fast growing and in most cases attain maturity within a few months of existence. The spawning season also extends considerably, most of them being continuous breeders. These facts offer an advantage in clam farming.

Oyster culture has made great strides in Japan, U.S.A., and more recently in Korea. Tilla few years back spat collection, transplantation into growing grounds and re-laying in fattening grounds have been the usual activities of an oyster culturist. But the recent development of raft culture added another dimension to oyster culture enabling hanging culture thereby increasing the available area into volume. Yet another development has been the artificial rearing of larvae in hatcheries as successfully done in U.S.A. and Japan. But all these developments have not made any impact on our oyster industry. The only attempts in oyster farming seem to have been made by the Bombay oystermen in Kelwa and the Madras State Fisheries Department at the Pulicat oyster farm, as discussed earlier. But the conditions have more or less remained static without making any progress in improving the methods of culture. In the Pulicat farm, thanks to the efforts of Mr. James Hornell, systematic investigations were commenced in 1910. Taking the cue from the story of the Sind oyster beds which were prosperous for about half a century from 1843 but began to be overexploited due to the demand that sprang up from the interior places and finally became exhausted by 1910, Mr. Hornell initiated scientific investigations at the Pulicat oyster farm. The natural oyster beds at Pulicat and Ennur were rich and oyster supply was effected from these beds to places as far as Calcutta. In the 1926–27 season 269,875 oysters were sold from these beds. But depletion began to appear in 1922 at Pulicat and in 1929 at Ennur.

Though efforts are made during this time to place the culture practices on scientific lines they did not yield the desired results. In the recent years the oyster resources of Pulicat and Ennur have considerably dwindled.

Unlike fishes the molluscs considered here are sedentary with restricted mobility and for this reason they are more prone to depletion than the former. But the same fact enables us to understand in advance the indication of depletion and to resort to conservation measures which could be effective if done in time. Though molluscs can at no time play a major role in fishery economics of India as fishes and prawns do now we can ill-afford to relegate any resource to the background. Being a proteinous food the molluscs can play a significant role in enriching the unbalanced diet of the coastal populations. If suitable measures are taken for clam farming it will also open up new avenues for the canning industry which can find an export market for the commodity.

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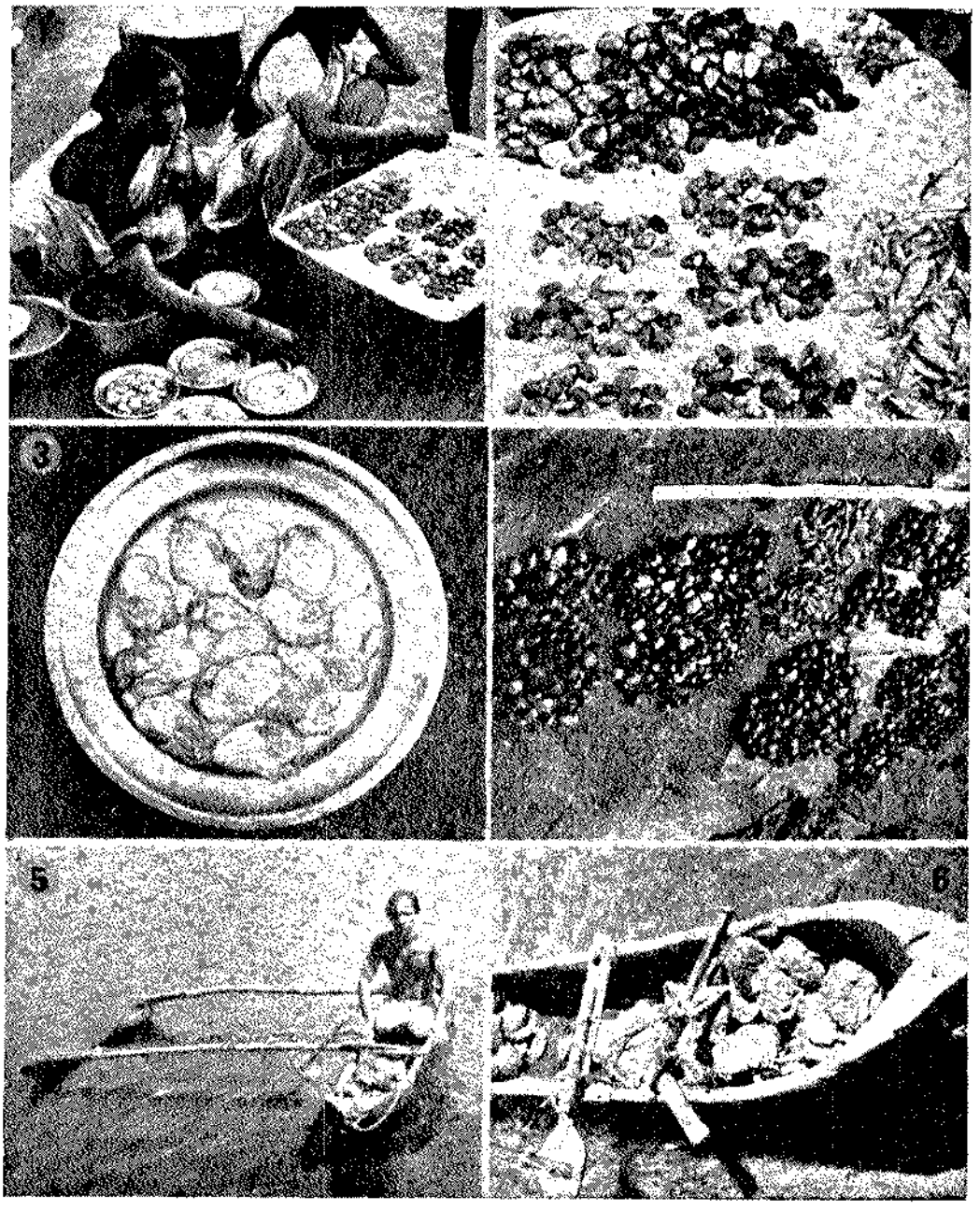
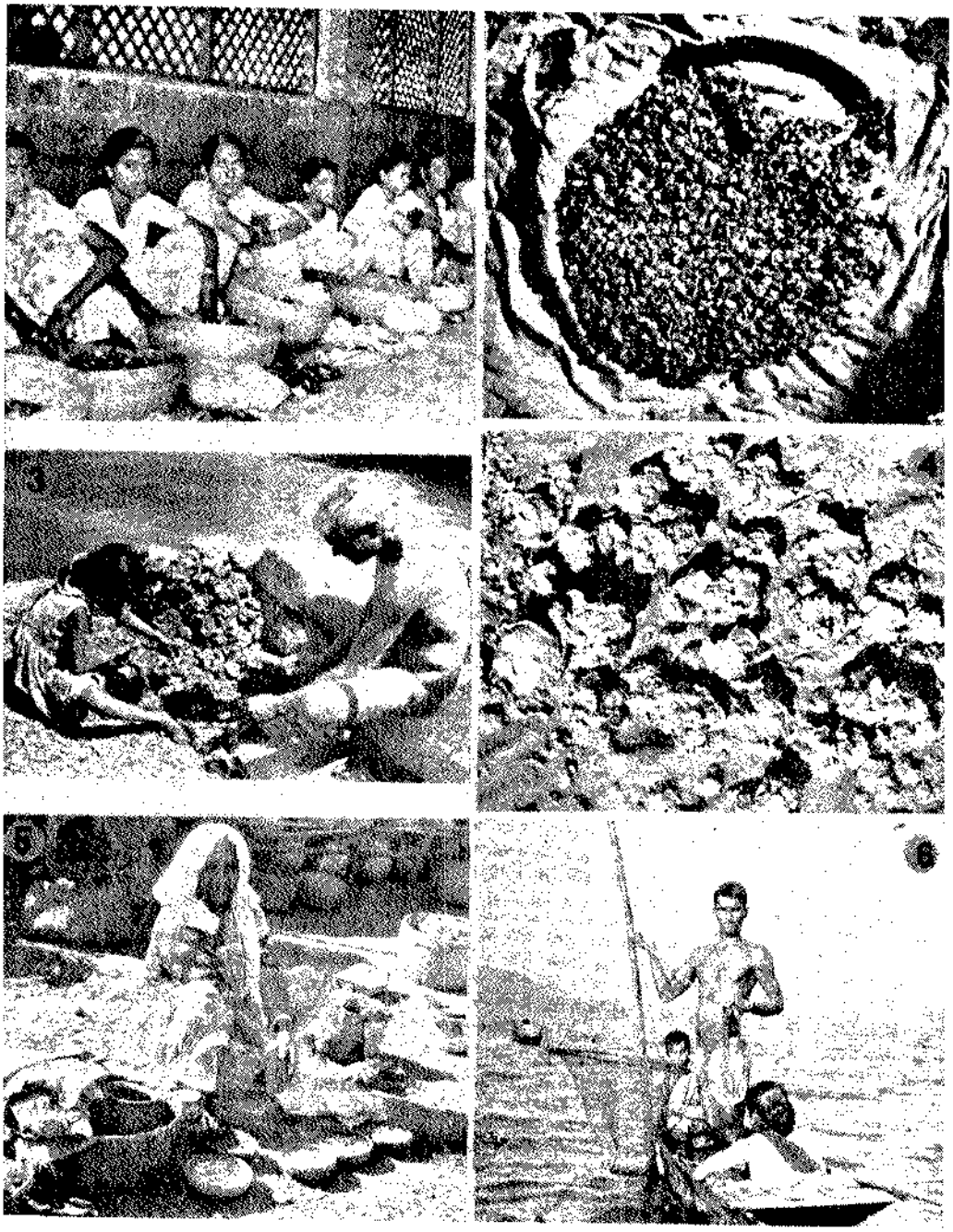


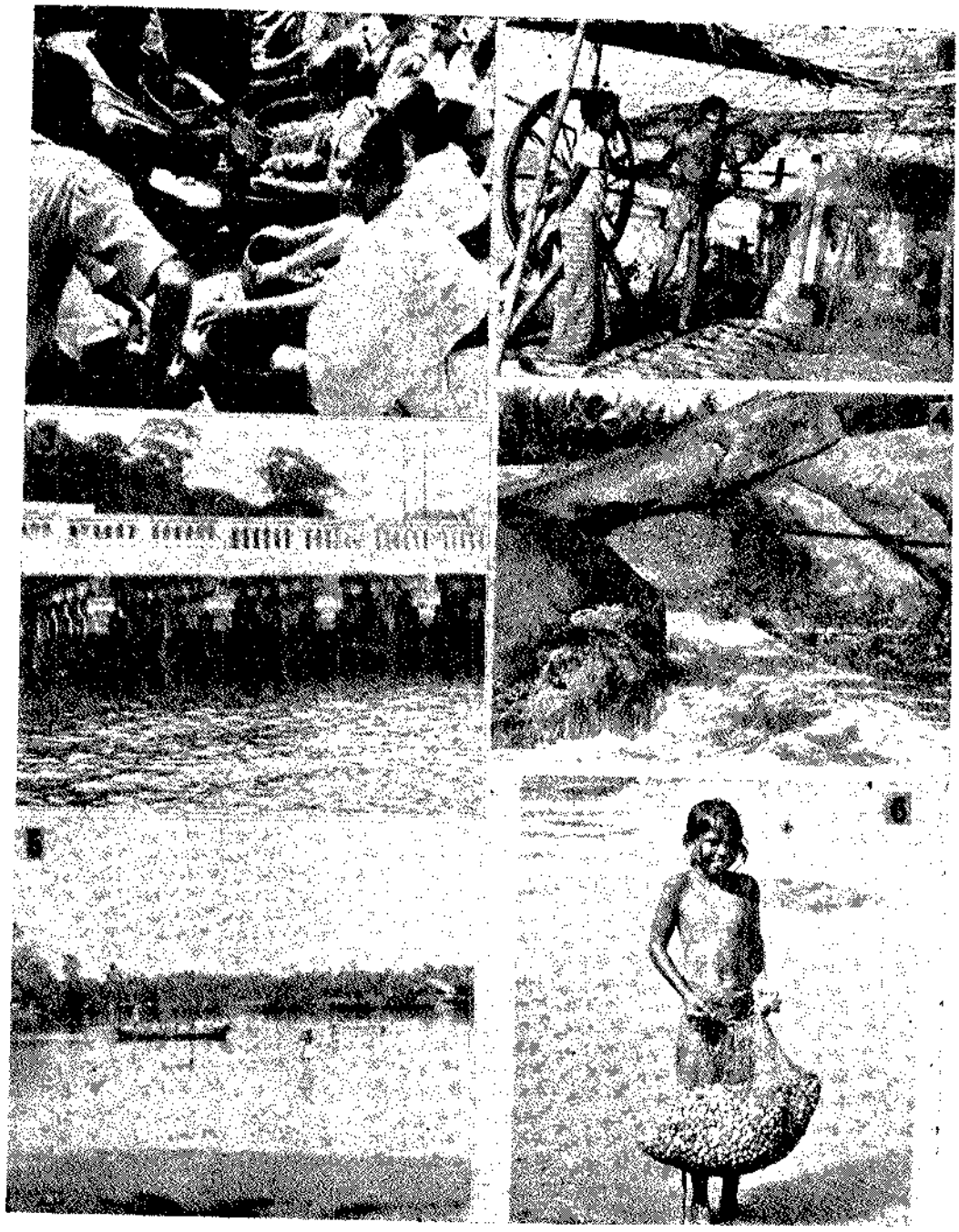
1. Shellfish section of the Bombay fish market. 2. Clams sold along with fishes. 3. Shucked oysters in the market. 4. Clam stall in Ratnagiri market. 5. Oysterman of Purnagad (Ratnagiri) and his outrigger canoe. 6. A day's oyster catch in the canoe with the tools.

(Photographs by K. Alagarswami)



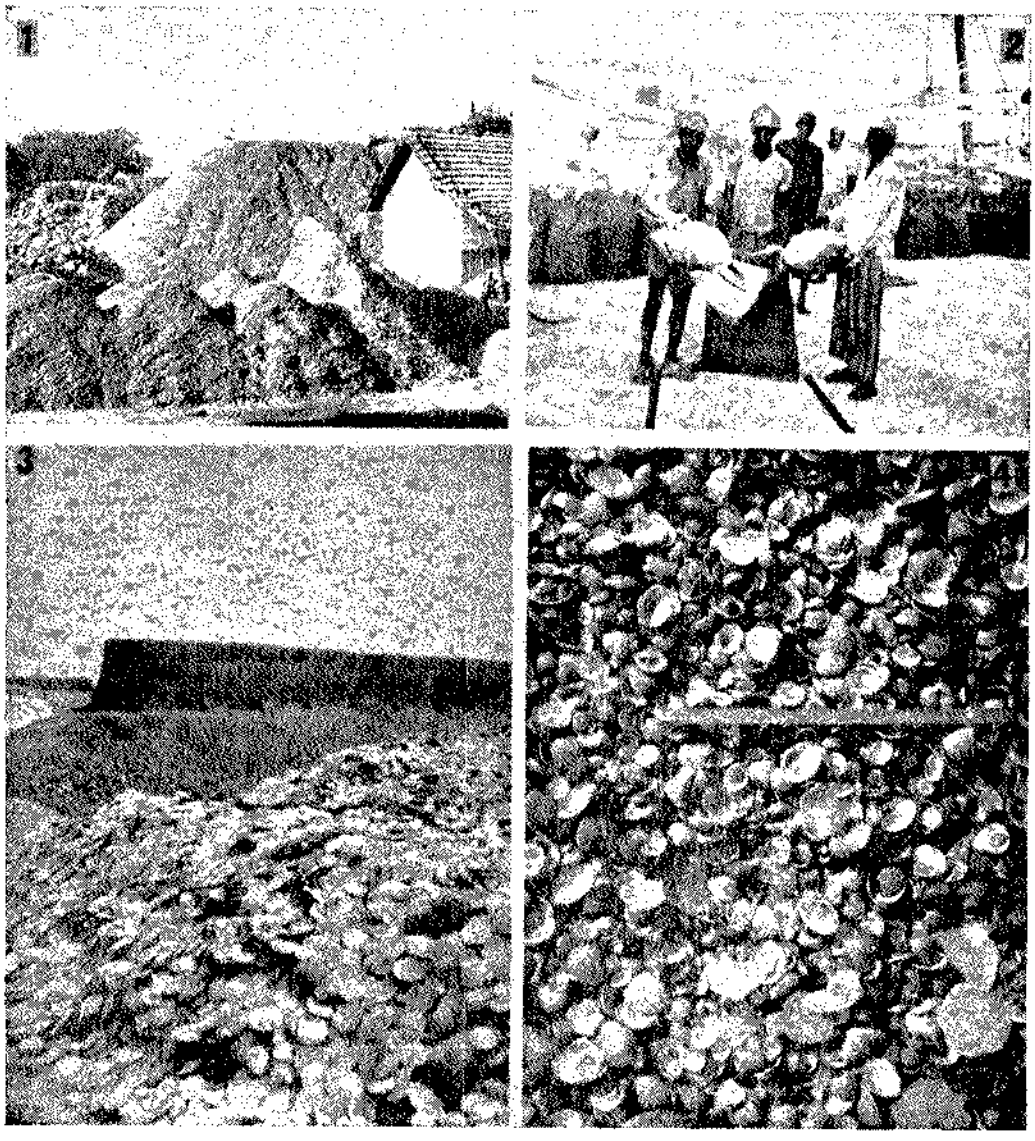
1. Clam vendors in Malwan market. 2. Dried clam meat on sale. 3. Oysterman of Ribander (Panaji, Goa) shucking the oysters. 4. Oysters on the mud flats in Siolim (Goa). 5. Women selling oysters in Panaji market. 6. Clam fishing in Kalinadi estuary (Karwar). The fisherman is holding the 'akhya' net with the catch (his wife and son also aboard).

(Photographs by K. Alagarswami)



1. Clam market in Karwar. 2. Shell lime kiln in Karwar. 3. Oyster fouling on the pillars of the jetty at Karwar. 4. Oyster spat on the rocks near Mangalore. 5. Clam fishing near Mulki by women. 6. Girl with a collection of clams in the Mulki river.

(Photographs by K. Alagarswami)



1. Shell heaps (raw material for the shell lime industry) at Ullal, near Mangalore. 2. Bagging the shell lime. 3. Shells of window-pane oyster and the kiln at Yerragaruvu village near Kakinada. 4. Clam shells (*Meretrix*, *Paphia* and *Anadara*) for the kilns at Yerragaruvu.

(*Photographs* 1 *and* 2 *by K. Alagarswami and* 3 *and* 4 *by K. A. Narasimham*)