CMFRI
bulletin 34

SEPTEMBER 1983

MARICULTURE POTENTIAL OF ANDAMAN AND NICOBAR ISLANDS—AN INDICATIVE SURVEY

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
P.B. No. 1912, Cochin 682 018, India

CMFRI
bulletin 34

SEPTEMBER 1983

MARICULTURE POTENTIAL OF ANDAMAN AND NICOBAR ISLANDS—AN INDICATIVE SURVEY

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
P.B. No. 1912, Cochin 682 018, India

Bulletins are issued periodically by Central Marine Fisheries Research Institute to interpret current knowledge in the various fields of research on marine fisheries and allied subjects in India.

Abbreviation : ***Bull. cent. mar. Fish. Res. Inst.***

©
Copyright reserved

Published by
E. G. SILAS
Director
Central Marine Fisheries Research Institute
Cochin-682 018, India

Edited by
K. ALAGARSWAMI
Senior Scientist
Central Marine Fisheries Research Institute
Cochin-682 018, India

Restricted circulation

CONTENTS

1

INTRODUCTION : AN INDICATIVE SURVEY OF THE MARICULTURE POTENTIAL OF ANDAMAN AND NICOBAR ISLANDS

E. G. SILAS[1]

The Andaman and Nicobar Islands enjoy the status of an archipelago with over 550 islands, islets and rocky outcrops in the Bay of Bengal, lying between 6°45'N and 13°41'N lat. and between 92°12'E and 93°57'E long. With a land area of only 8293 sq. km, it has a total coastline of 1962 km which is about one-fourth of the total coastline of India. Of the 2 million sq.km of the Exclusive Economic Zone of India, 0.6 million sq.km or 30% of the area lies around the Andaman and Nicobar Islands. However, the annual marine fish production in the islands is around 1500 tonnes forming about 0.1% of the total of India's 1.4 million tonnes. Being oceanic islands, the continental shelf around them is limited to about 16,000 sq.km as compared to the total shelf area of about 452,000 sq.km of the country. With practically no continental slope, the land drops steeply to great depths not far from the coastline.

The limitations of continental shelf are, to a certain degree, compensated by the presence of numerous bays, creeks and inlets on the landward side and vast expanses of productive oceanic waters of the Bay of Bengal on the west and the Andaman Sea on the east. Major developments in fisheries are possible in the oceanic waters around the islands, particularly for oceanic fishes such as tunas, tuna-like fishes, billfishes, elasmobranchs and squids. Such programmes need large capital investments, infrastructure facilities and trained manpower.

The islands did not have a traditional fishing population and the only fishing used to be done by the aborigines with bow and arrows and by the tribal Nicobarese with spears. Starting from the early 'fifties, fishermen from mainland were encouraged with incentives to settle down in the islands and carry on fishing activities. However, this has not led to any remarkable development. The remoteness of the islands from the mainland, lack of infrastructure and the absence of a fish trade between mainland and the islands are some of the factors responsible for the poor development of fisheries.

Marine capture fisheries in the Andaman and Nicobar Islands has a vast scope for increasing production several fold from the present order of 1500 tonnes/annum. This would require long-term integrated development programmes on manpower, technology, infrastructure and capital assets such as vessels and gear. While this has to be done in a phased manner, certain immediate short-term possibilities exist for fisheries development in the bays, creeks and inlets fringing the islands. These water bodies can be developed for culture of marine organisms, or mariculture, for increasing fish and shellfish production. Aquaculture is closer to agriculture than fish capture is and can be taken up with relative ease both by the fishermen and farmers and could be a part-time job while dealing with semi-culture and extensive farming. Mention may be made here of the brief experimental programme on fish culture taken up by the Department of Fisheries, A & N Islands at Chippighat. The project had to be abandoned as it was not based on the right principles of fish farming.

Although farming of marine organisms is not totally new to the country (Kerala and West Bengal have certain traditional systems practised by the rule-of-thumb), technical advances have been made in the field only during the last one decade. The Central Marine Fisheries Research Institute (CMFRI) has played a pioneering role in this and developed technologies which are low-cost in investment and easily adoptable and manageable by an average farmer or fisherman. These relate to culture of marine prawns, mussels, oysters, seaweeds and finfish. The Institute has made significant achievements in pearl culture which requires

[1] Director, Central Marine Fisheries Research Institute, P. B. No. 1912, Cochin 682 018.

a higher level of technology and investment. More recent developments have been on controlled seed production of these species, again with low-cost technologies, for reducing or removing mariculture's dependence on nature for seed supply. With this background, the CMFRI planned to explore the potential of Andaman and Nicobar Islands for development of mariculture.

An action plan for this survey was drawn up by the end of 1977. The objective as defined then was to conduct a rapid survey of the Andaman and Nicobar Islands to (1) identify and indicate the species resources suitable for mariculture, (2) collect environmental data from the bays, creeks and mangroves and indicate locations that can be considered for mariculture, and (3) assess the infrastructure facilities that are present and that would be required for taking up mariculture. Since it rains for nearly 9 months in a year in the islands due to the south-west and north-east monsoons, and a survey of this nature would not be possible during such wet conditions, January-April 1978 was chosen for carrying out the programme. The survey was done by two teams of scientists. The first team was in the islands from 31 January to 18 March and the second team from 21 March to 22 April 1978. The composition of the teams was as follows :

Team 1 : Dr. K. Alagarswami (Leader), Dr. R. S. Lal Mohan, S. Shri S. Shanmugham and K. Ramadoss (Scientists), R. Panigrahy (Research Scholar), J. Antony Pitchai and Soosai V. Rayen (Skin-divers) and P. Raghavan (Photographer). Dr. R. S. Lal Mohan officiated as team leader during part of the survey.

Team 2 : S. Shri K. Nagappan Nayar (Leader), S. Mahadevan, R. Marichamy, D. C. V. Easterson, M. Kathirvel and Dr. C. P. Gopinathan (Scientists), J. Antony Pitchai and Soosai V. Rayen (Skin-divers), and M. Rengan (Laboratory attendant). Dr. D.B. James, the then scientist-in-charge of the Port Blair Research Centre of CMFRI, gave local assistance in organising the programme and also participated in the survey, around Port Blair. Shri C. John, Fieldman at the Port Blair Centre assisted in the field work.

The survey concentrated on the resources of finfish, crustaceans, molluscs, sea cucumbers and seaweeds. Information on salt-water crocodile and marine turtle resources was also collected, as these two endangered resources are of considerable importance from the viewpoint of conservation. Experimental fishing nets were used for collection of biological samples. Facilities of the fishing boats of the Department of Fisheries at Port Blair were availed of whenever possible. SCUBA-diving equipment were used, besides skin-diving, for observations on the mollusc, seaweed and other sedentary resources and sea-bed conditions. Hydrographical data were collected and primary productivity was estimated. Plankton samples were examined from the observation centres. Topography of the areas visited was studied. Special emphasis was placed on studies of the mangrove ecosystem as potential grounds for mariculture and as a source of seed.

The places visited by the teams during the survey are given below (the base camps are given in italics). Figs. 1-8 illustrate the areas surveyed.

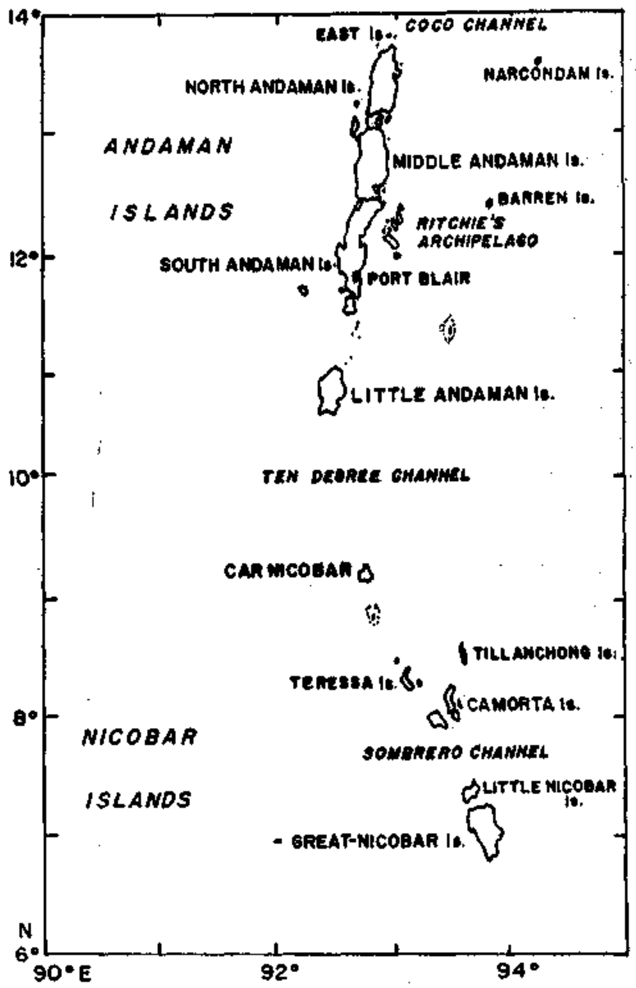


Fig. 1. Andaman and Nicobar Islands

North Andaman : Table Is., Smith Is., Turtle Is., Ross Is., Smith Bay, Blair Bay, Ariel Bay, Atalanta Bay, Lakshmipur, Kalpong creek, *Diglipur*, Durgapur Bay, Kalighat, Stewart Is., Sound Is., Oyster Point and Ray Hill.

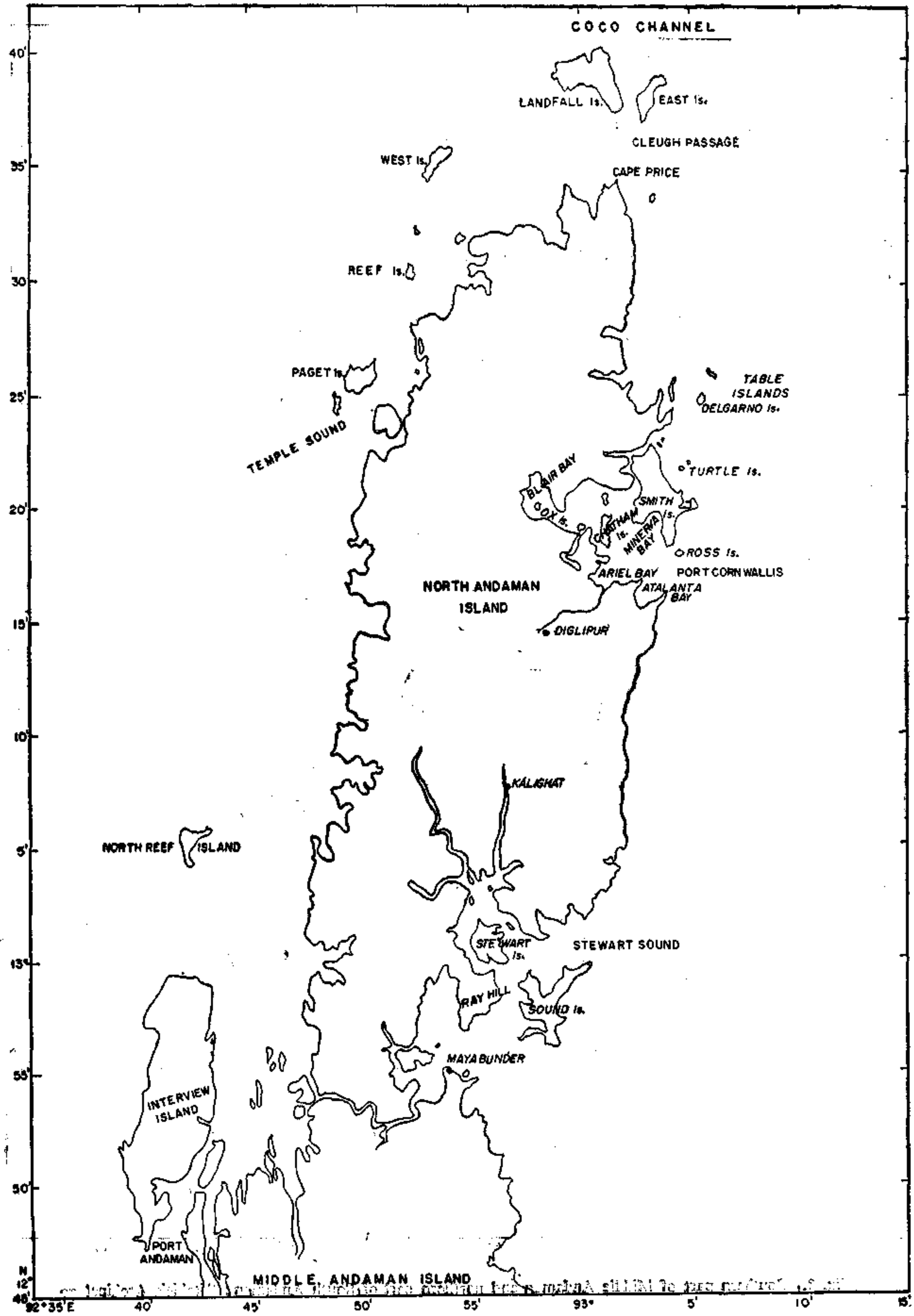


Fig. 2. North Andaman and northern part of Middle Andaman (Places surveyed are given in italics in Figs 2—8)

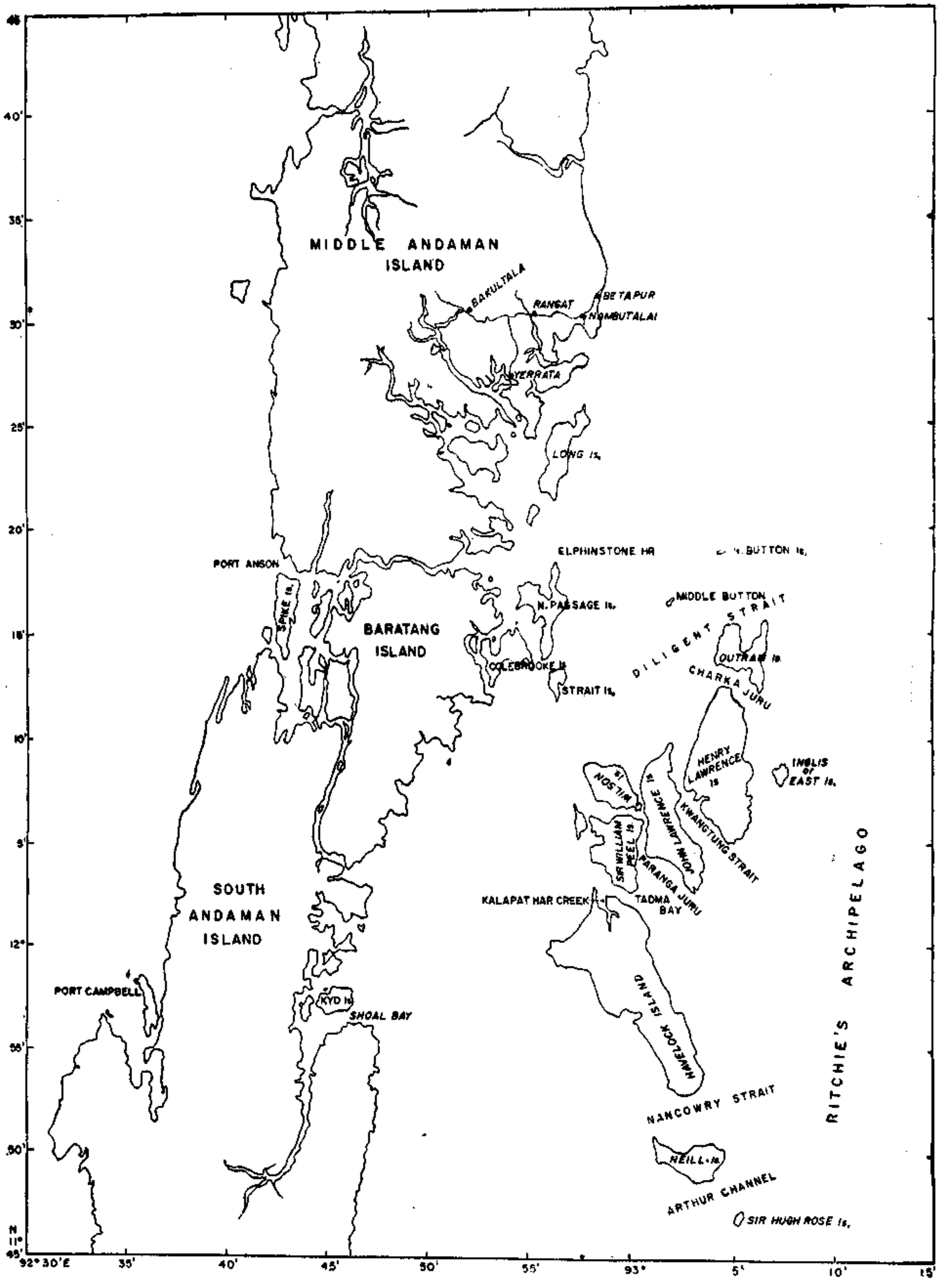


Fig. 3. Southern part of Middle Andaman and northern part of South Andaman; Ritchie's Archipelago

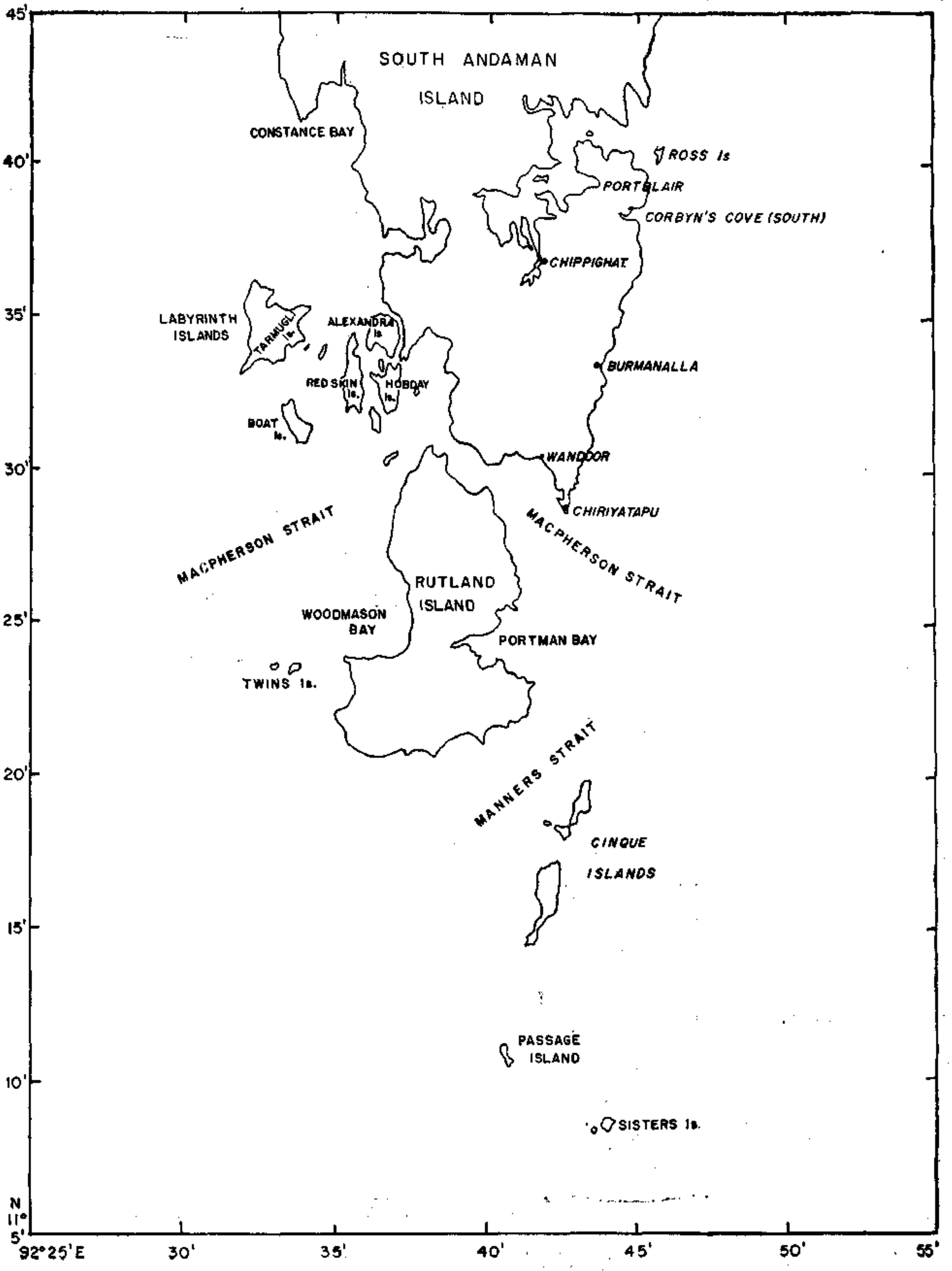


Fig. 4. Southern part of South Andaman

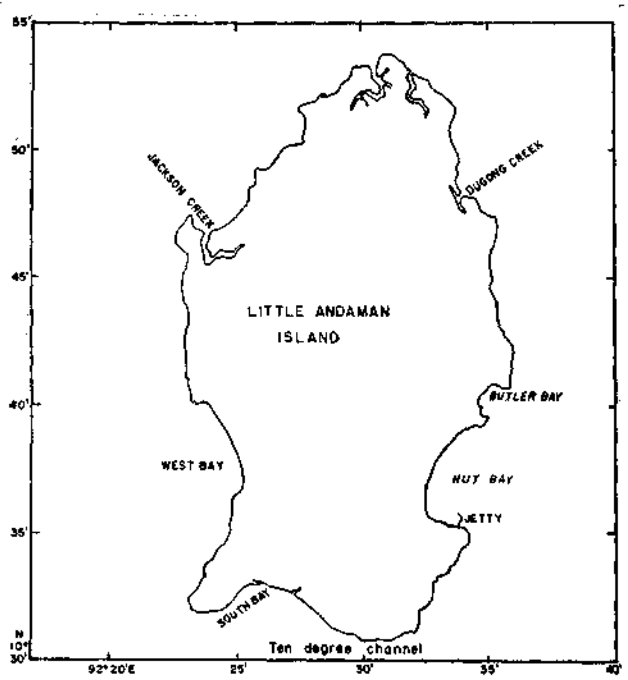


Fig. 5. Little Andaman

Middle Andaman : *Mayabunder*, Rampur, Austin creek, Bakultala creek, *Rangat*, Betapur, Yerrata creek and Long Is.

Ritchie's Archipelago : Outram Is., Henry Lawrence Is., John Lawrence Is., Inglis Is., Sir William Peel Is., Havelock Is., *Neill Is.* and Hugh Rose Is.

South Andaman : Kyd Is., James Is., Shoal Bay, North Bay, Semiramis Bay, Command Point, Bamboo flat, Dunda's Pt., Viper Is., Minnie Bay, Navy Bay, Chatham Is., *Port Blair*, Blair reef, Phoenix Bay, Atalanta Point, Aberdeen jetty, Ross Is., Sesostris Bay, South Pt., Janghlighat, Corbin's cove (south), Chippighat, Burmanalla, Wandoor, Chiriyatapu, Macpherson strait, Rutland Is. and North and South Cinque Is.

Little Andaman : Hut Bay and Butler Bay.

Car Nicobar : Hog Pt., Sawai Bay, Teetop, Passa creek, Keating Pt., *Malacca*, Kimios and Arong.

Nancowry group : Camorta Is. (Kakana, Naval Pt., Octavia Bay), *Nancowry* (Champin Bay, Spiteful Bay, Reid Pt.), Katchall Is. (Kapanga, *East Bay*, Hoinipoh, Jansing) and Trinkat Is.

Great Nicobar : Man Pt., Campbell Bay and Vijayanagar.

Thus, a very broad coverage was given but the intensity was limited, more so in the Nicobar Islands. Inter-Island transport was the major restraining factor. Diglipur, Mayabunder, Rangat, Ritchie's Archipelago, Port Blair, Car Nicobar and Nancowry received relatively better attention than the others.

The materials collected during the survey were deposited at the Tuticorin Research Centre of CMFRI. The scientists independently and collectively analysed the materials and examined the survey data at Tuticorin. In preparing the results of the survey for publication, the scientists were assigned to write on the areas of their specialisation, using all materials and data collected by both the survey teams.

Some scientists of the Central Marine Fisheries Research Institute have visited Andaman and Nicobar Islands on earlier occasions for carrying out specific studies. Those which are relevant directly or indirectly to the development of mariculture have been included in this Bulletin. A list of papers from this Institute on the Andaman and Nicobar Islands and their resources published earlier in different journals is given at the end of Bulletin. Shri R. Whitaker and Shri S. Bhaskar of the Madras Snake Park Trust who have first-hand knowledge on saltwater crocodile and marine turtle resources were requested to write on them.

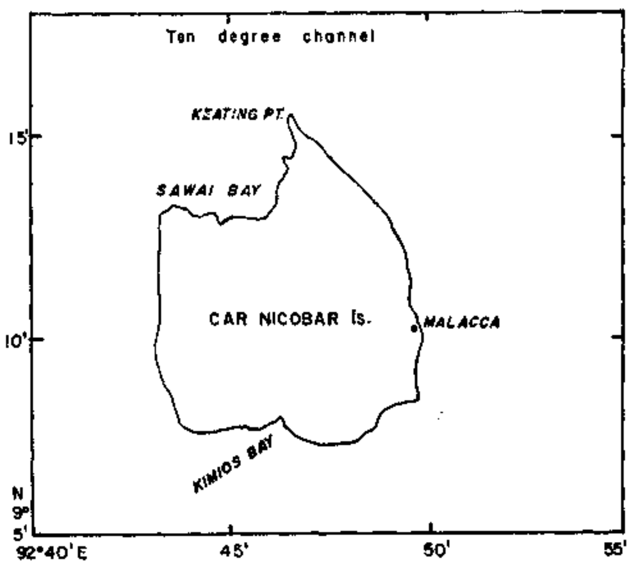


Fig. 6. Car Nicobar

In conducting the survey on the mariculture potential of the Andaman and Nicobar Islands, we have received the help and assistance of a number of officers of the A & N Administration without which it would not

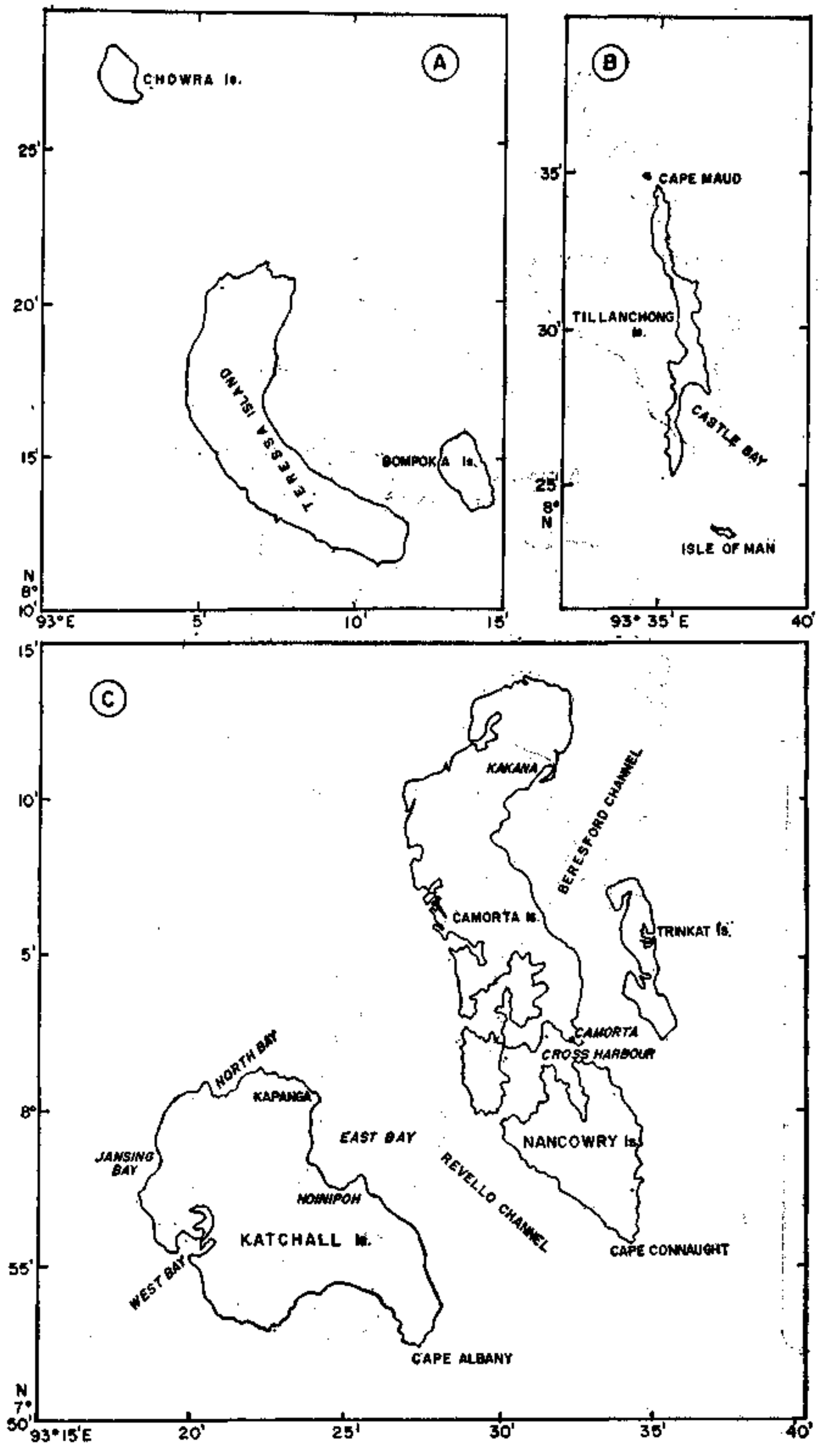


Fig. 7. A. Teressa group; B. Tillanchong group; C. Nancowry-Camorta group of Islands

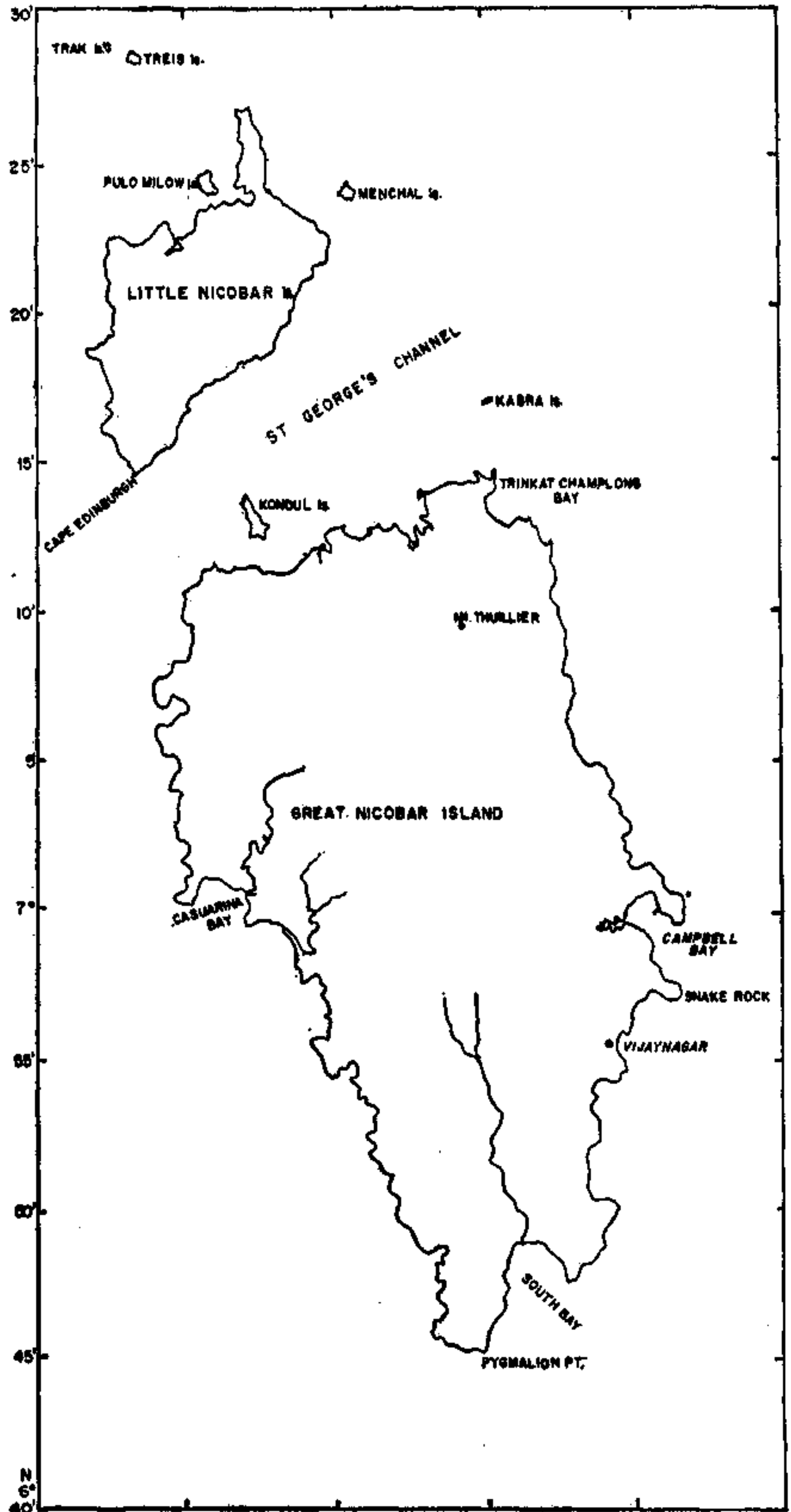


Fig. 8. Little Nicobar and Great Nicobar

have been possible to complete the work. Our grateful thanks are due to Shri S. M. Krishnatry I.A.S., the then Chief Commissioner of the A & N Islands for his keen interest in the survey and for all the help provided through the various departments of the Administration. Shri P. M. Gokulapala Menon, the then Director of Fisheries made available on occasions two departmental boats for experimental fishing and helped in planning the programmes locally. We are thankful to Shri R. Whitaker and Shri S. Bhaskar for contributing the papers on crocodile and sea turtle resources. My coll ague Dr. K. Alagarswami assisted me in planning the survey programme, coordinated the preparation of the papers and edited them for this Bulletin.

2

TOPOGRAPHICAL FEATURES OF AREAS SURVEYED

S. MAHADEVAN[1] AND D. C. V. EASTERSON[2]

INTRODUCTION

Valuable information is available through the publications of Kloss (1902) and Parkinson (1938) on the general topographical features of many of the Andaman and Nicobar Islands. Elliot (1972) had added some precise details for a selected few islands with notes on land and shoreline reliefs. Rao's (1937, 1939) accounts deal with the nature of sea bottom of shallow areas inhabited by *Trochus* and *Turbo* species. Still our knowledge and understanding of the intertidal and subtidal zones of most of the islands is very meagre. The present survey provided an opportunity to visit many islands, bays and creeks and study these features from a particular angle of finding out their potential and suitability for mariculture operations. Observations were made on the disposition of coral reefs, back reef area, reef slope and the sea bottom in its vicinity with the help of SCUBA diving wherever needed. Due to limited facilities of transport from Island to island and short duration, only a rapid survey could be undertaken.

The details given in this report are by no means exhaustive but still the document is an addition to the existing knowledge and understanding of the nearshore ecosystem and topography of these islands. It has also enabled identification of many areas in the group where potentialities for mariculture exist. The calculations of area and positions of places are approximate. Nautical charts published by the Naval Hydrographic Office, Dehra Dun have been basically used, supplemented by the observations made during the present survey, in giving the topographical features of the islands. Some of the typical features are illustrated in Plates I and II.

ANDAMAN GROUP

NORTH ANDAMAN

1. *Delgarno*

13°24′ N Lat ; 93°05′ E Long.

This is the largest of the Table Island group which is a group of two islets and shallow reefs. The island is surrounded by live reefs. The southern side was surveyed. Beach sandy and intertidal area of 50 m length is of sand stone. Water clear and current strong. Larger algae are absent. Holothurians common and corals are in rich diversity.

2. *Turtle Island*

13°21′ N Lat ; 93°04′ E Long.

This is a group of two islets. The larger and the southern islet was surveyed. Beach and intertidal zone upto 1 m depth are sandy ; beyond is of sand stones and further out rocky. Majority of corals near to shore are dead. Herein gorgonids and *Trochus* were observed.

3. *Smith Island* (Fig. 1)

13°18′-13°23′ N Lat ; 93°02′-93°50′ E Long.

Maximum elevation of island 132 m. Mangrove luxurious along Minerva Bay; intertidal flat of coral stones exposed with low tide along south and south-eastern tip. The bottom is sandy close to Ross Island.

4. *Ross Island* (Fig. 1)

13°17′-13°18′ N Lat ; 93°45′-93°49′ E Long.

Area 0.8 sq. km ; maximum elevation of the Island 90 m. From north to south-east intertidal rocky area extends outwards. In the north-west side a sandy bar, exposed with low tide connects the island with the Smith Island.

5. *Blair Bay* (Fig. 1)

13°20′-13°22′ N Lat ; 92°57′-92°59′ E Long.

Extent of bay is approximately 4 sq. km with centrally located Ox Island. Marshy shore with quicksand regions. Mangrove lines the beach.

Present address :

[1] CMFRI, Regional Centre, Mandapam Camp.

[2] CMFRI, Cochin 682 018.

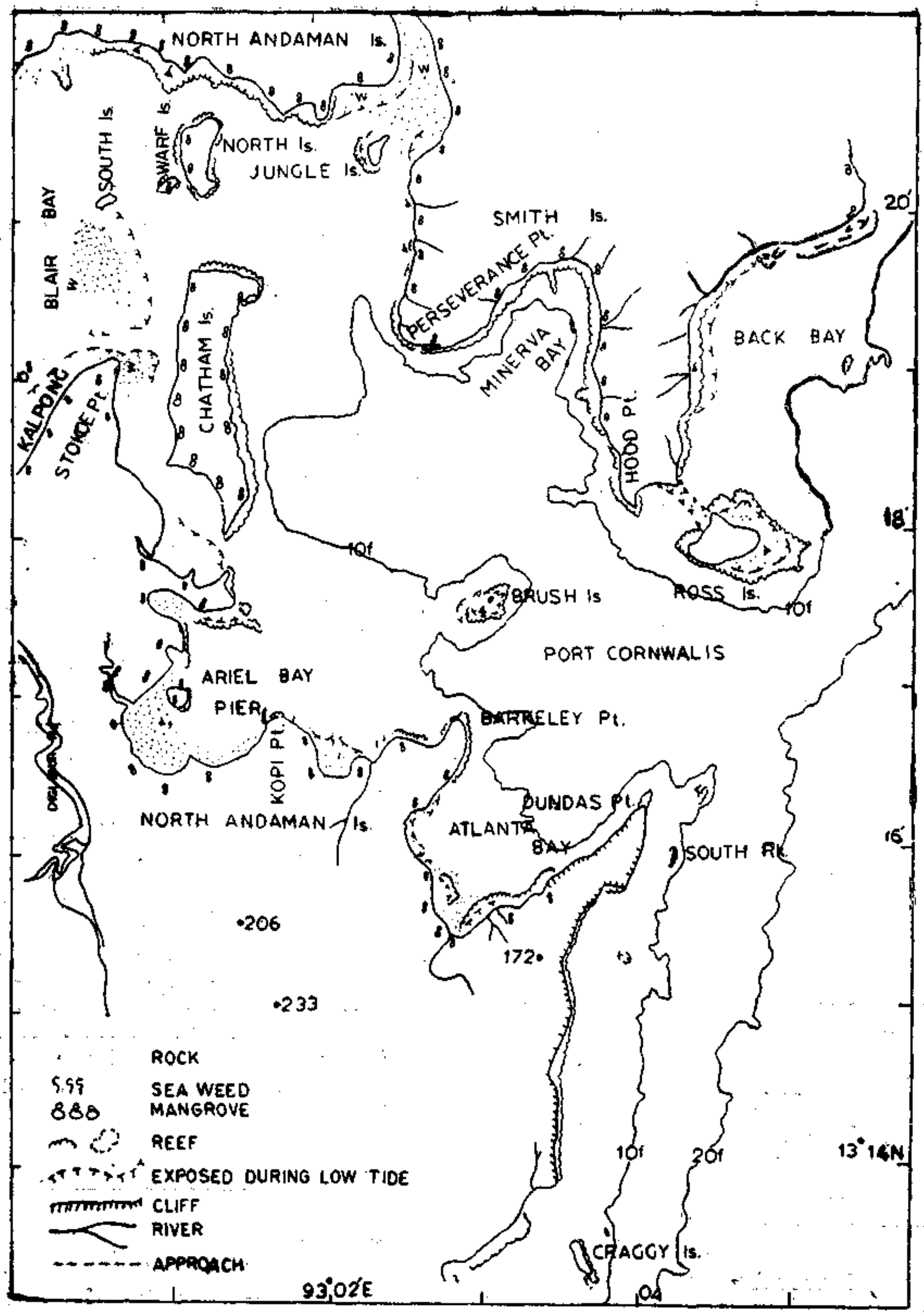


Fig. 1. Details of areas surveyed in Port Cornwalis-North Andaman Island (Note : In all figures elevation and distance are in metres. Depth is in fathoms in figures 1 and 5, while in others is in metres. In transects dominant fauna have been listed in first row and flora in the second. The sea bottom contour has been drawn as observed in the study site. Scattered and close dots stand for sand and mud respectively. f — fathom ; Hr — Harbour ; Pt — point ; Rk — rock ; W — mud).

6. *Ariel Bay* (Fig. 1)

13°16′-13°17′ N Lat ; 93°07′-93°10′ E Long.

Extent of the bay is about 1.5 sq. km. Bay area shallow (0.1-3.0 m deep). Western side lined by mangroves and muddy with coral stones. Southern stretch upto Kopi jetty is free of mangroves. Bottom of bay is of black sand and mud mingled with coral patches.

7. *Atalanta Bay* (Fig. 1)

13°15′-13°17′ N Lat ; 93°02′-93°04′ E Long. Bounded by Barkeley point in the west and in the east by Dundas point. Vast intertidal sandy flat gets exposed. Coral stone spread over the flat, especially in the eastern arm of bay. This flat area of sand and mud extends upto 2 m depth in the bay and reaches upto 13 m depth in the open sea.

8. *Durgapur*

Near shore area is sandy with sparsely scattered coral stones ; live coral reef observed beyond 8 m depth.

9. *Stewart Island*

12°59′-13°15′ N Lat ; 92°53′-92°55′ E Long.

Approximate area of island is 6 sq. km. Maximum elevation of island 76 m. Extensive live coral formation observed along shore line. Western side with patches of mangrove bushes and muddy bottom. South-eastern side of island rocky with live corals.

10. *Sound Island*

12°55′-13°00′ N Lat ; 92°58′-93°01′ E Long.

Extent of island is about 10 sq. km. Maximum elevation 114 m. Coast is much indented. Live corals abound. Reef starts from shore and extends to 3.6 m depth. The area near to shore itself is deep.

11. *Ray Hill area*

12°57′ N Lat ; 92°54′-92°55′ E Long.

Maximum height 107 m. South-eastern shore upto Brown Point is rocky and live coral near the shore. Sandy film covers the sea bottom to a short distance. Extensive live coral formation observed upto 10 m depth.

Middle Andaman

1. *Mayabunder*

12°55′ N Lat ; 92°54′ E Long.

Maximum elevation 67 m. The jetty area has a limited sandy beach. Otherwise shore muddy with luxurious mangrove vegetation. East of jetty heap of dead coral stones along the shore line extending to 50 m outwards at 1 m depth.

2. *Betapur*

12°31′ N Lat ; 92°58′ E Long.

Swamp with mangrove forest. Beach fully intersected by fallen tree trunks.

3. *Rangat Bay*

12°28′-12°29′ N Lat ; 92°56′-92°58′ E Long.

Western side beach sandy, beyond muddy with coral stones, exposed during low tide ; jetty to Coxon Point is sandy. Current swift. Live corals observed in deep water. Western side of jetty is also rocky. Sand bottomed shallow areas upto 1 m deep get exposed. The deeper areas are studded with live coral reef.

4. *Bakultala*

12°30′ N Lat ; 92°52′ E Long.

Brackish water area with hilly terrain.

5. *Yerrata*

12°27′ N Lat ; 22°54′ E Long.

Creek is meandrous, swampy and densely lined with mangrove vegetation. Water is brackish. Adjacent Yol and Boroin creeks are also similar in nature but longer and narrow.

6. *Long Island*

12°21′-12°26′ N Lat ; 92°55′-92°58′ E Long.

Area of island is 12 sq. km (approx.). Maximum elevation is about 133 m. Thickly wooded. Raman Point to Cape Smith on south side is rocky. Shallow intertidal expanse with abundant coral boulders slowly merging into deeper live coral zone on the eastern side. North-western side is free of corals and bottom muddy. There is a mud flat of vast area exposed during low tide on western side. Live coral reef observed upto 12 m depth in Lalaji Bay.

Ritchie's Archipelago

1. *Outram Island* (Fig. 2)

12°12′-12°16′ N Lat ; 93°04′-93°07′ E Long.

Area is about 10 sq. km. Maximum elevation 70 m. Limited sandy beach, otherwise mangrove. Steep rocks characterise the nearby sea bed upto about 3 m depth. Live coral reef beyond 8 m depth. Outram harbour deep, water calm.

2. *Henry Lawrence Island* (Fig. 2)

12°05′-12°12′ N Lat ; 93°03′-93°06′ E Long.

Maximum elevation 138 m. Narrow sandy beach. Expansive inter-tidal zone in the south-east (50 m broad). Live corals up to 10 m depth. Mangrove bushes here and there along shore. Steep rocks occur in intertidal zone. Water deep close to island, current swift.

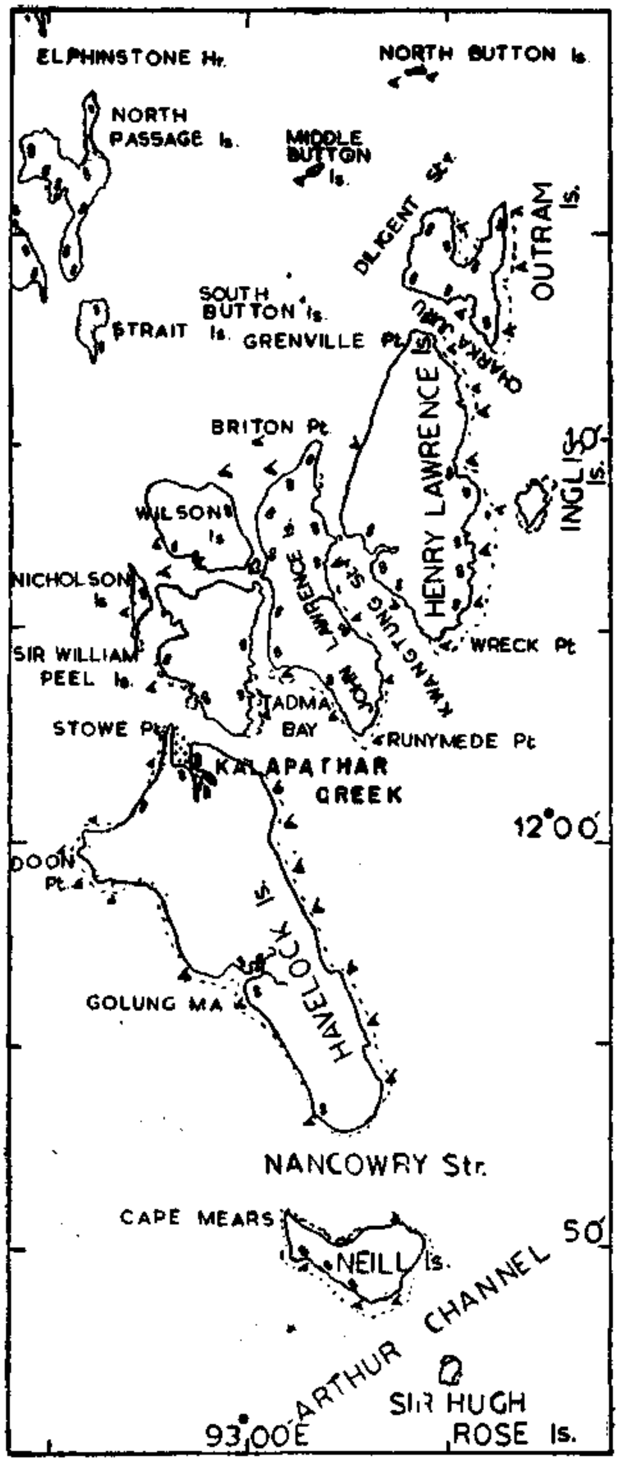


Fig. 2. Ritchie's Archipelago showing areas surveyed.

3. *Inglis Island* (Fig. 2)

12°08′-12°09′ N Lat ; 93°07′-93°08′ E Long.

Very small island of less than 1 sq. km area. Maximum elevation 31 m. Beach sandy and rocky, nearby submerged areas also sandy but with dead corals in abundance. Beyond 2 m depth live corals were noticed. Water very deep close to shore.

4. *John Lawrence Island* (Fig. 2)

12°03′-12°10′ N Lat ; 93°00′-93°01′ E Long.

Area of island is about 9 sq. km. Maximum elevation 172 m. Shore packed with coral rocks. Thin strip of sandy beach in places devoid of rocks. Live coral patches even in shallow areas. Water very deep close by. North-west swampy with mangroves and rocks.

5. *Sir William Peel Island* (Fig. 2)

12°03′-12°06′ N Lat ; 92°58′-93°00′ E Long.

Area is about 22 sq. km. Elevation 68 m. Mangrove thick, narrow sandy beach with occasional coral stones. Intertidal area restricted to few places getting exposed in patches only during extreme low tides. In eastern side of island dead coral stones abound upto a depth of 1 m ; live corals observed beyond.

6. *Havelock Island* (Fig. 2)

11°53′-12°03′ N Lat ; 92°55′-93°04′ E Long.

Large hilly island of nearly 55 sq. km area. Maximum elevation 168 m. Island has a fairly broad sandy beach except in the vicinity of Kalapathar Creek and Golung ma. In the jetty area water front is lined with scattered coral stones on sand. Large area west of jetty, about 2 sq. km, gets exposed during low tide. Coral stones and boulders common at 1-2 m depth.

Kalapathar Creek (12°02′ N Lat ; 92°58′ E Long) is muddy, mangrove lined with hilly environment. Creek mouth gets closed with sand during summer. Another backwater system in Havelock is Golung ma (11°57′ N Lat ; 93°00′ E Long) which is deep, water clear, saline to brackish, with riverine systems and bordered with extensive thick mangrove forest, mouth broad partly coralline and shore sandy.

7. *Neill Island* (Fig. 2)

11°49′-11°51′ N Lat ; 93°01′-93°04′ E Long.

Maximum elevation 102 m. Shore side mangrove covered. Live coral formation is very dense all around the island.

8. *Sir Hugh Rose Island* (Fig. 2)

11°47′ N Lat ; 93°05′ E Long.

Small island of very low elevation of 25 m. Southern shore rocky with live corals observed beyond 1.5 m depth. There is a lighthouse in this island.

9. *Kyd Island* (Fig. 3)

11°57′-11°58′ N Lat ; 92°44′-92°47′ E Long.

Area is 10 sq. km approximately. Maximum elevation 239 m. Shore line on the south rugged with coral boulders. The 1 m depth line muddy. The eastern side of island is shallow with sand and coral stones.

10. *James Island* (Fig. 3)

11°57′ N Lat ; 92°44′ E Long.

Situated closely west of Kyd Island. Difficult to approach due to thick mangroves. Mud covers the beach. The surrounding shallow areas muddy and coralline upto 2 m depth.

11. *Shoal Bay* (Fig. 3)

11°57′ N Lat ; 92°45′ E Long.

The narrow bay extends far interior with muddy bottom ; depth 8-9 m in the interior ; exterior very deep, above 30 m. Bay lined with mangrove bushes. Bottom muddy. Along with the adjacent open sea area, one of the good fishing grounds in the Island group.

SOUTH ANDAMAN

1. *North Bay* (Fig. 4)

11°42′ N Lat ; 92°46′ E Long.

Area of bay 1 sq. km approx. Bottom muddy with seaweed grown on sandy patches ; west bank coral fringed all along upto 0.5 m depth, which gets exposed during low tide ; northern region was observed to be muddy upto 0.5 m.

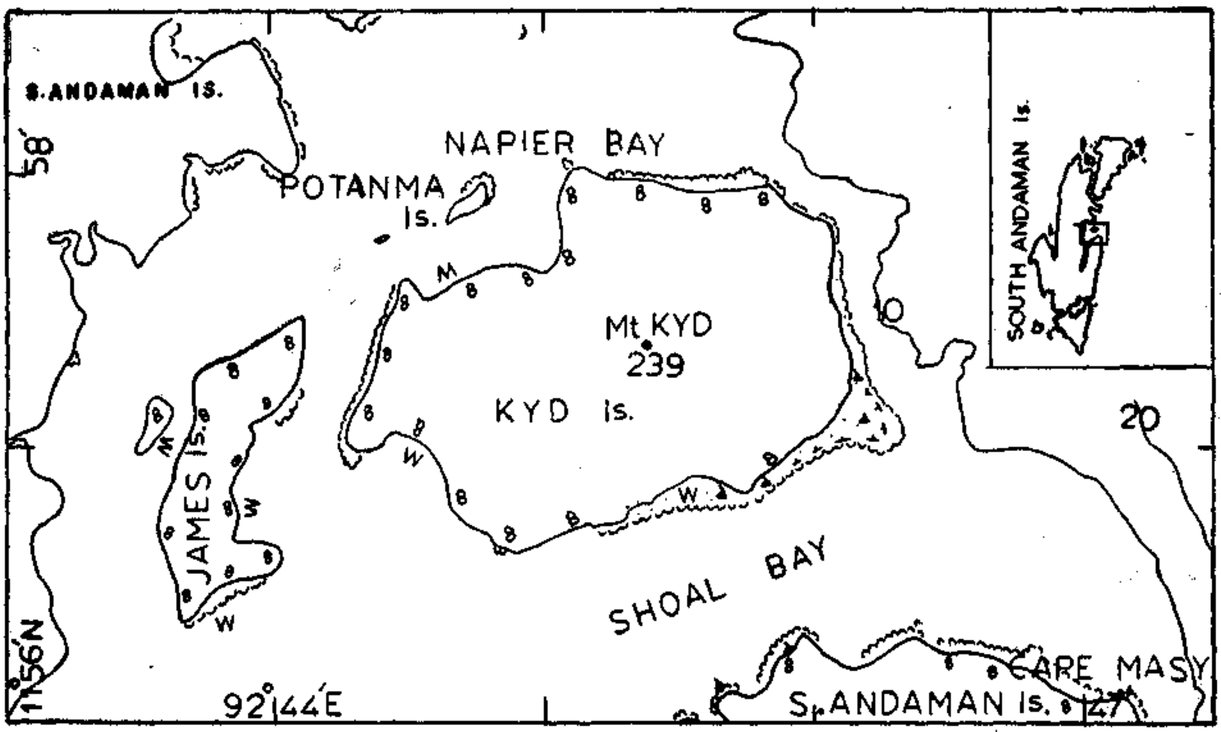


Fig. 3. Shoal Bay and the adjacent study areas—South Andaman.

2. *Command Bay* (Fig. 4)

11°41′ 70″ N Lat ; 92°43′ 60″ E Long.

Narrow bay between Semiramis Bay and Bamboo flat Bay area, bottom muddy ; live corals observed in patches upto 0.6 m depth.

3. *Bamboo Flat Bay* (Fig. 4)

11°42′ N Lat ; 92°43′ E Long.

The bay area is lined by thick mangrove bushes which extend about 10 km. Bottom is muddy and exposed with low tide. Northern side is an admixture of mud and sand, while the western side is coral fringed.

4. *Dundas Point* (Fig. 4)

11°40′ N Lat ; 92°42′ E Long.

Area characterised by black sand and mud upto 8 m depth. Shoreward area full of coral stones.

5. *Viper Island* (Fig. 4)

11°39′ N Lat ; 92°41′ E Long.

Small island of 0.5 sq. km. South, middle and south-west portions rocky up to 1.5 m; floor muddy ; north-east rocky upto 1 m depth.

6. *Minnie Bay* (Fig. 4)

11°39′ 00″ N Lat ; 92°42′ 60″ E Long.

Area 0.8 sq. km roughly. Deeply curved shallow bay of muddy bottom, maximum depth 4 m.

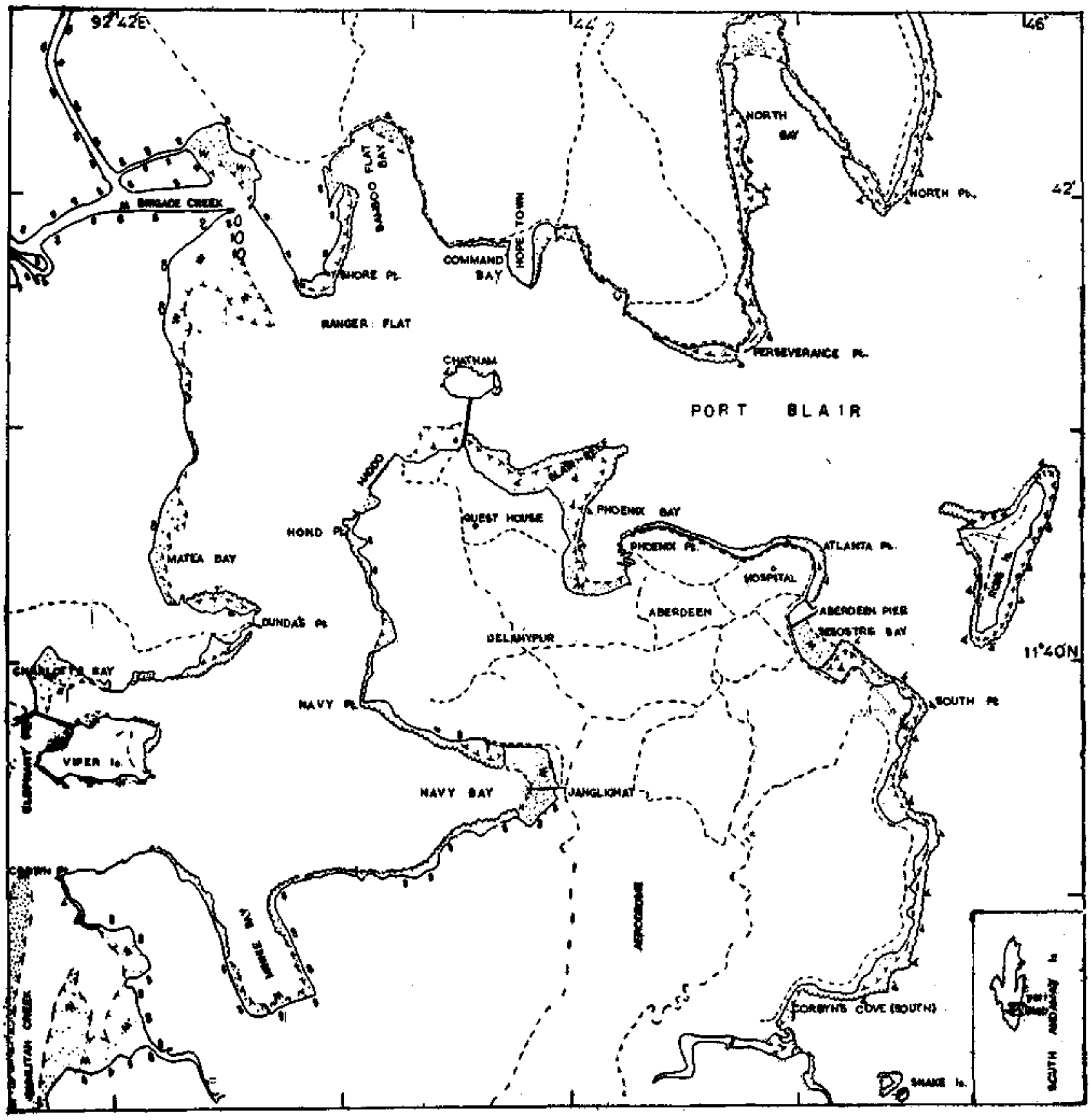


Fig. 4. Areas surveyed around Port Blair—South Andaman.

Mangrove in isolated patches; eastern entrance and western side with coral stones in shallow areas partially getting exposed with tide.

7. *Navy Bay* (Fig. 4)
   11°39′ 50″ N Lat ; 92°43′ 00″ E Long.
   Sheltered bay 6-7 m deep. Northern and southern shores characterised by mangrove dotted waterline with corals on muddy sand. Live coral patches upto 1.5 m depth. Eastern side is also muddy but devoid of corals.

8. *Chatham Island* (Fig. 4)
   11°41′ 20″ N Lat ; 92°43′ 50″ E Long.
   Small island connected to Port Blair by a bridge. North side of island deep close to shore, shore muddy all round; eastern side coral rocks upto 2-3 m depth. West of island deep with sand and mud; boulders present shoreward. Due to the timber factory located herein the coastal region is polluted with saw dust and timber waste.

9. *Semiramis Bay* (Fig. 4)
   11°41′ 70″ N Lat ; 92°44′ 00″ E Long.
   Bay is 17 m deep at maximum. Northern shore is sandy up to about 1 m depth; muddy beyond. Western side rocky. Eastern shore is strewn with boulders. Live corals were observed from 1.5 m and beyond.

10. *Blair Reef* (Fig. 4)
    11°41′ N Lat ; 92°44′ E Long.
    This is at the entrance to Phoenix Bay. Rocky and muddy flat exposed fully on western side for a distance of 0.5 km with tide; outside this area live coral formation extends to 3 m depth. Shore and upto 10 m depth, is of fine mud-like sand and beyond the bottom is muddy.

11. *Phoenix Bay* (Fig. 4)
    11°40′ 50″ N Lat ; 92°44′ 10″ E Long.
    Area 0.3 sq. km roughly. Maximum depth is about 15 m. Deeply curved bay with muddy bottom. Sand-stone formation of considerable extent is seen.

12. *Atalanta Point* (Fig. 4)
    11°40′ 40″ N Lat ; 92°45′ 10″ E Long.
    The area has an intertidal reef of about 50 m extent up to 0.6 m depth and sand-stone flat generally characterises the area. Isolated live corals were observed with sandy patches. Beyond 0.6 m depth bottom is muddy and after 9 m depth sea floor falls abruptly deeper.

13. *Ross Island* (Fig. 4)
    11°40′ N Lat ; 92°45′ E Long.
    Approximate area 7 sq. km, situated at entrance to Port Blair Harbour. Densely wooded reserve area. Heavy current close to shore. Sandy strip beach. Entire east shore is coral reef studded upto 1.5 m depth. West side free of coral blocks. In the south and southwest of island big boulders observed in deeper regions. Reported to be sinking.

14. *Burmanalla*
    A very expansive intertidal sandy flat upto 0.5 km from shore. Tidal pools and algal growth common. Boulders at 1 m continues upto 2 m depth with live and dead corals. Healthy reefs at 4 m and extends to 10 m. Bottom sandy beyond. *Tridacna* common in reef.

15. *Wandoor*
    Shore of firm mud mixed with sand. Indentations of the shore lined by mangroves. Many areas in vicinity of the shore deep upto 5 m. Living coral patches in muddy bottom.

16. *Chiriyatapu*
    11°31′ N Lat ; 92°41′ E Long.
    Area very rocky with intertidal expanse of flat coral stones with crevices and thin film of sand spread over the bottom. Coral reef formation observed upto 10 m depth.

17. *Macpherson Strait*
    11°30′ N Lat ; 92°40′ E Long.
    Strong current, sandy bottom with occasional live corals at 3 m depth and more so at 8 m. Bottom sandy beyond in the channel which is 20 m deep out in the middle. A good population of chank *Xancus pyrum* was observed.

18. *North Cinque Island*
    11°19′ N Lat ; 92°43′ E Long.
    Area opposite the lighthouse possesses a fine sandy beach, opposite to it a distance of 50 m exposed during low tide with sand and stony bottom; similar bottom continues upto 8 m depth after which starts a live coral reef belt which becomes dense at 10 m depth. South shore of North Cinque is a sandy flat which at low tide gets exposed and bridges South and North Cinque Islands.

Little Andaman

10°13′-10°25′ N Lat ; 92°50′ E Long.

Maximum elevation 210 m. Inhabited, local tribe Onges.

Hut Bay—The jetty area was investigated. Tall trees with thick growth of vegetation line the beach. The sea shore is narrow, about 3 m with many fallen trees. The intertidal region extends for about 50 m which is sandy with plenty of shingle. Herein holothurians are common. Then comes the narrow shallow area which is about 30 m wide and 3-5 m deep. Thereafter the sea is very deep. In the shallows corals are common. With low tide, water is seen steadily percolating from the land into the sea.

Butler Bay—Here the beach is sandy while the bottom of the bay muddy.

NICOBAR GROUP

Car Nicobar Island (Fig. 5)

09°08′-09°15′ N Lat ; 93°43′-93°50′ E Long.

Area 128 sq. km. Maximum elevation 72 m. Terrain not hilly ; dense mixed jungle in the centre ; coconut palms and *Pandanus* bushes abound. Good motorable road round about. Air strip, Keating Point lighthouse are the important landmarks. Nicobarese fish with traps, spear, bow and arrows and handpick molluscs. Torch fishing is also practised. Therefore the intertidal areas are almost devoid of shellfishes.

1. *Sawai Bay* (Fig. 5)

09°13′ N Lat ; 92°45′ E Long.

Located in the north-west direction between Hog Point in the west and Keating Point in the north.

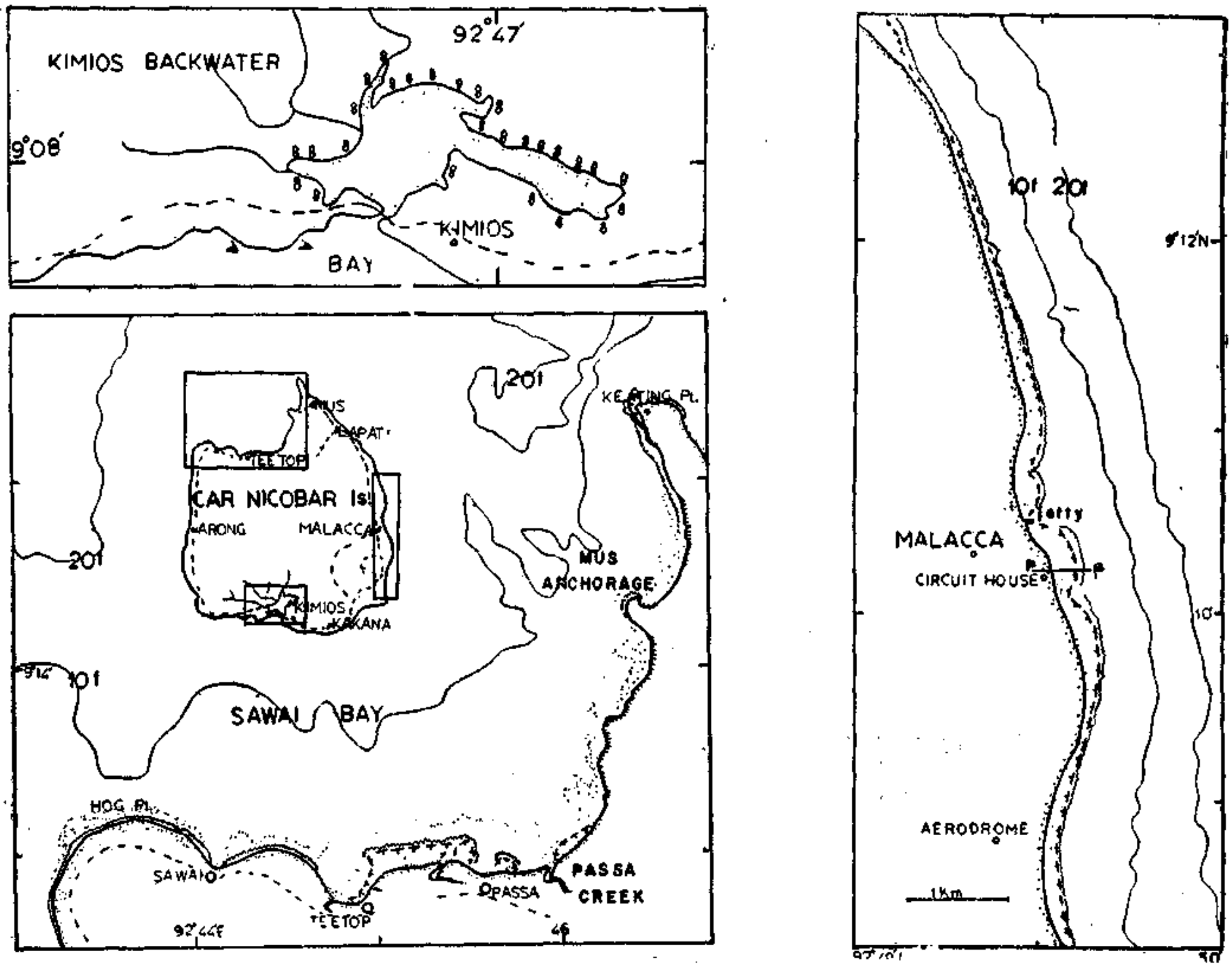


Fig. 5. Car Nicobar Island showing the areas surveyed in Sawai and Kimios Bays and Malacca.

Prominent fringing reef close to shore on the rocks at Hog Point, Sawai, Mus and Keating Point. At Teetop and Passa dead reef exposed to about 50-250 m from shore at low tide. Herein molluscs are rare due to overfishing. Live corals below low tide. Eastern sector with cliffs 20-40 m high. Beach sandy. Near shore sandy and shingle. No mangrove ; coconut palms extensive. Bay calm during summer.

2. *Malacca* (Figs. 5 and 6)

09°10′ N Lat ; 92°49′ E Long.

In the east coast between Keating Point to Lapati the beach is sandy and rocky with corals. Very deep with currents very close. Intertidal flat devoid of shellfishes due to overfishing; torch-fishing is practised in pools at low tide during early nights. Honey-comb like *Tubipora musica* was observed on the walls of tidal creeks, wherein wave driven currents are moderately strong. Coconut palms, *Pandanus* and mixed jungle on beach ; no mangrove. Malacca anchorage used during south-west monsoon. Details of fauna and flora by traverse study conducted opposite to the guest house given in Fig. 6 (β-β in Fig. 5).

South and west coasts from north of Kakana to Hog Point is rocky with strong waves and breakers ; very deep close to shore with currents making

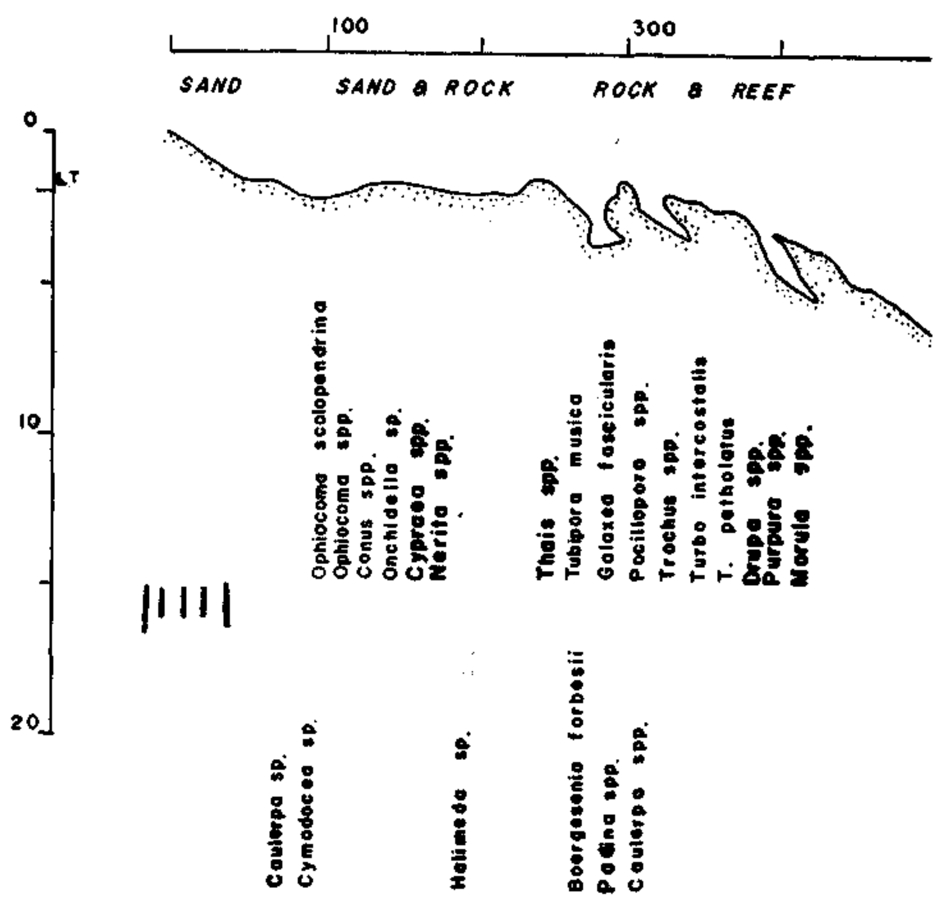


Fig. 6. Distribution pattern of fauna and flora observed by traverse studies made in Malacca (LT—Low tide level).

deep within few metres with swift current. From Lapati towards the southern end of east coast upto a kilometre north of Kakana, beach is sandy. An expanse of 150-300 m rocky flat intertidal area with sandy bottomed pools exposed during low tide. Strong waves with heavy breakers on flat rocks at low tide high, from thereon sea abruptly observation difficult. No mangroves ; dense jungle with *Pandanus* bushes throughout with coconut plantations around tribal dwellings.

3. *Kimios backwater* (Fig. 5)

09°08′ N Lat ; 92°46′ E Long.

An ideal backwater expanse of good tidal amplitude, lined by mixed jungle, mangrove and coconut palms. Bottom muddy, with coarse sand, shore sandy with rotting palm leaves. There is a permanent narrow opening with sea; water clear, brackish to saline. Tribal village closeby. Has bright culture possibilities. Fishing by trap, harpoon, cast net and hand picking practised.

CAMORTA ISLAND (Fig. 7)

08°00'-08°14' N Lat ; 93°27'-93°33' E Long.

Area about 408 sq. km. Maximum elevation 210 m. Inhabited by local Nicobarese tribes.

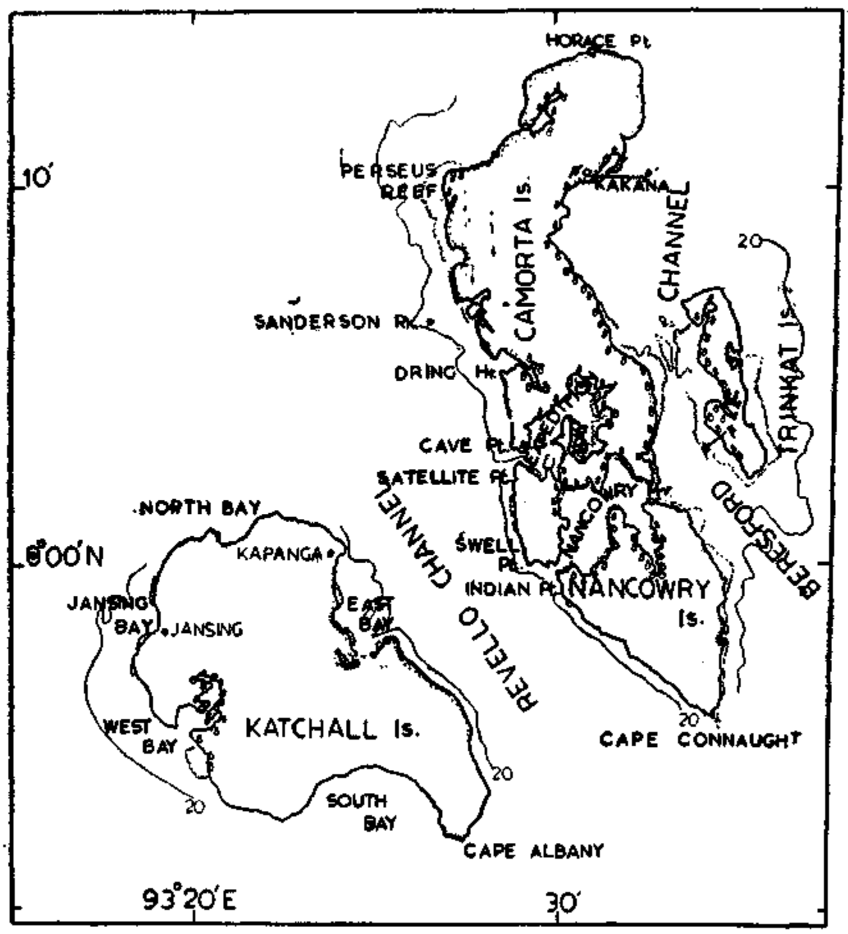


Fig. 7. Katchall—Camorta—Nancowry—Trinkat group of Islands.

1. *Cross Harbour* (Fig. 8)

08°02' N Lat ; 93°31' E Long.

Shore line with thick mangrove vegetation leaving no beach formation as the raised land mass slopes and abruptly drops into the sea. From jetty to Alfred Point, the nearshore is shallow with a depth of 1 m for a distance of 20-30 m with growth of *Fungia* and *Tridacna*. Beyond, the depth increases to 3 m for a stretch of 50 m from shore and then falls sharply to 15 m with yellow muddy bottom. This ledge is very rich in animal community and fishes. Details of distribution pattern of fauna and flora are given in Fig. 9 (α-α' in Fig. 8)

2. *Kakana* (In Camorta) (Fig. 7)

08°11' N Lat ; 93°31' E Long.

Kakana is in north-east coast of Camorta. Extensive sandy beach of 3 m width interrupted in places by mangroves and coconut palms. Nearshore shallow for about 1 km. The 1 m depth zone is of white sandy floor. Herein *Pterois* and *Trochus* young ones common ; corals not common. At 2 m depth corals abundant, increasing in extent and density up to 15 m, a distance of nearly 2 km from shore. Deeper areas are characterised by coral boulders and *Tridacna* beds and occasionally sandbanks are met with. Traverse study is given in Fig. 10 (β'-β' in Fig. 7).

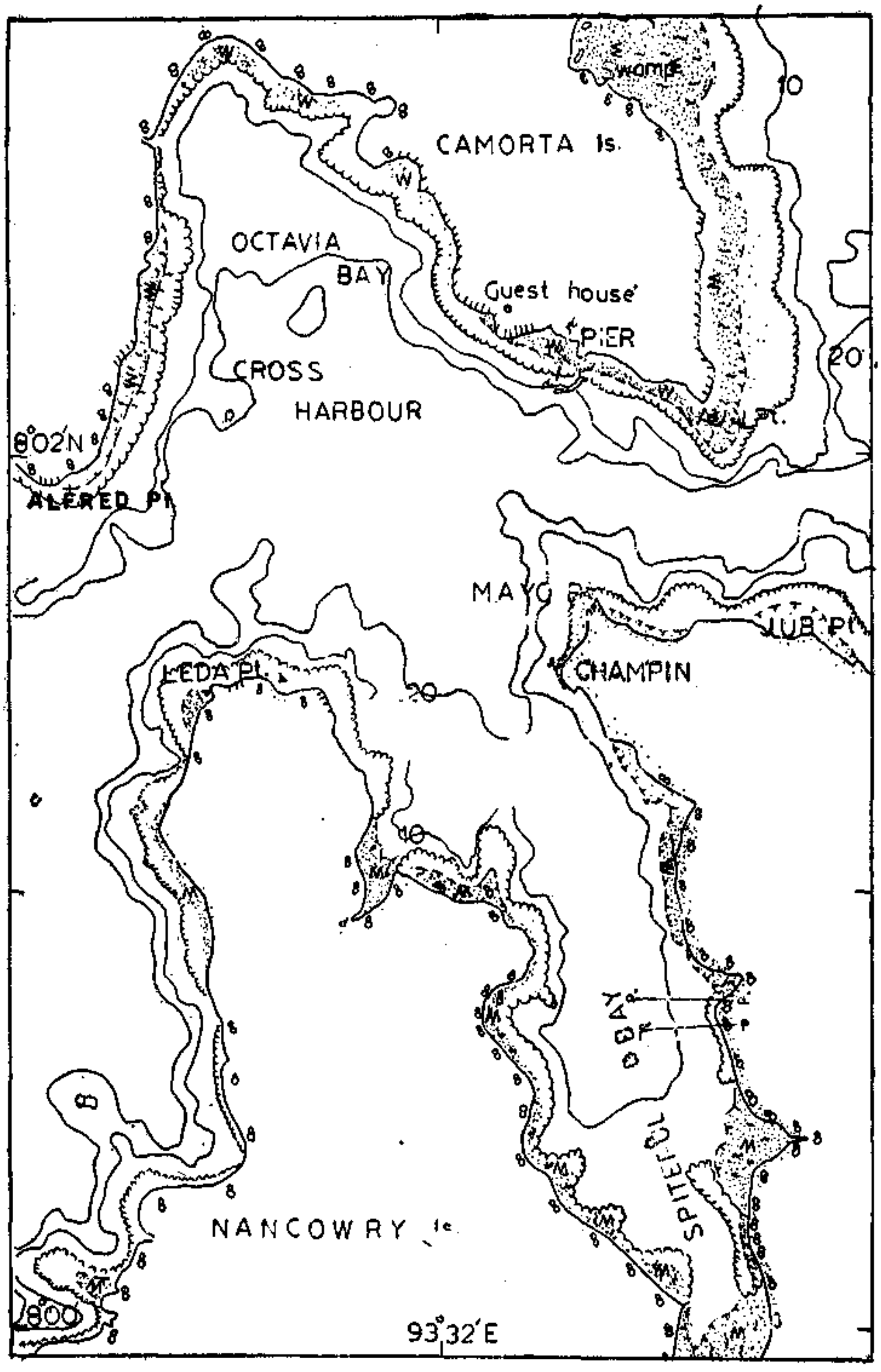


Fig. 8. Areas studied in Nancowry—Camorta Islands complex, showing the locations of Octavia Bay, Spiteful Bay and Cross Harbour (Nancowry Harbour).

PLATE I. A. Gorgonids from Mayabunder, Middle Andaman. B—D. 5—15m depth showing alcyonarian dominated niche, Hoinipoh, Katchall Island. E. Mangrove bordered creek, Kalighat, North Andaman. F. Rock oysters in the intertidal flat, Burmanalla, South Andaman. G. Sea eroded beach, Hut Bay, Little Andaman. H. Uprooted trees and rocky shore, Vijaynagar, Great Nicobar.

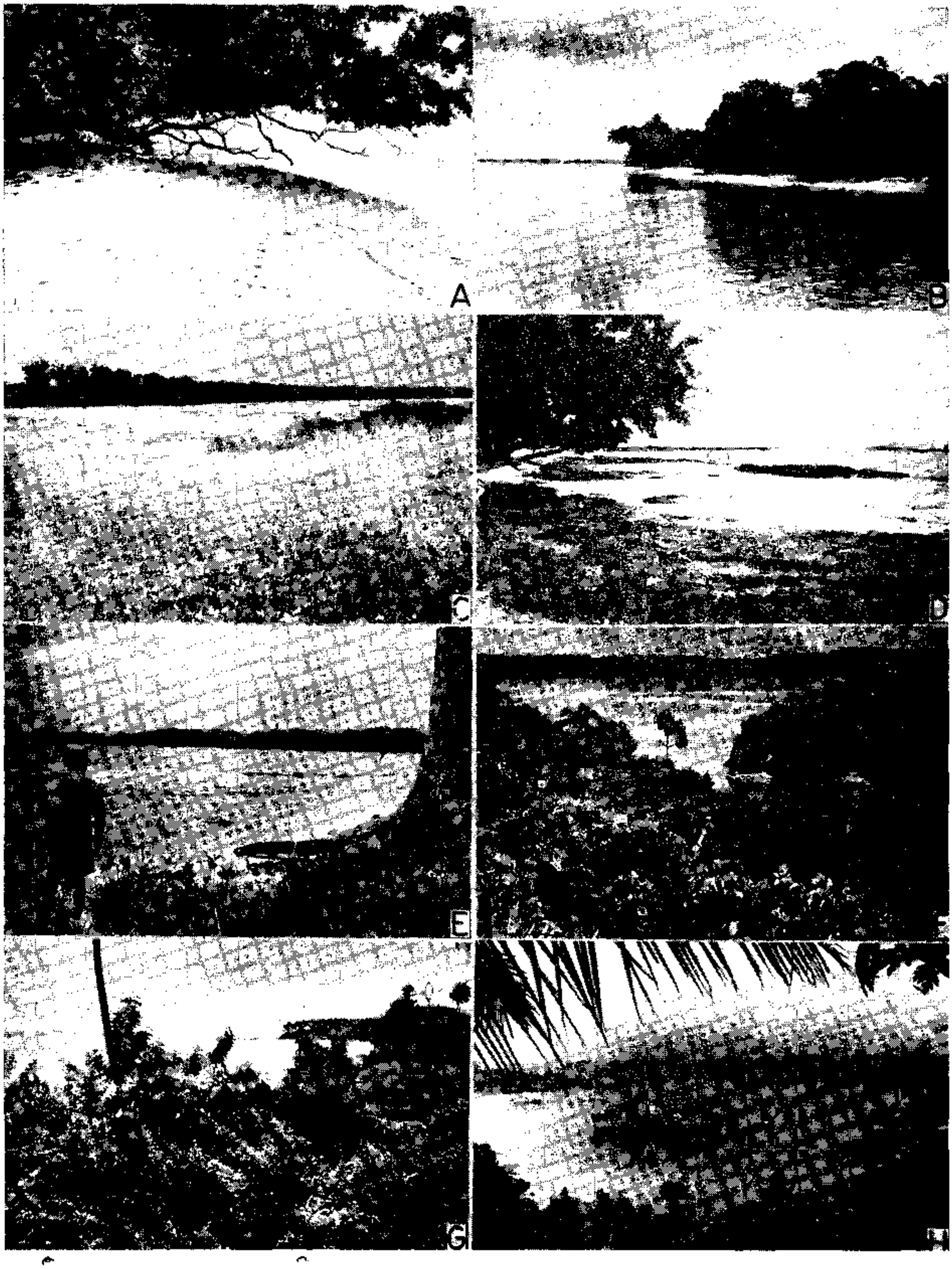


Plate II. A. Sandy mangrove lined beach, East Bay, Katchall Island. B. Sawai Bay, Car Nicobar Island. C. Weed infested marshy area in the foreground, Butler Bay, Little Andaman. D. Pitted rocky bottomed shallow area and the wave beaten stony ledge, North of East Bay, Katchall Island. E. Mayo point, Nancowry Island. F. A typical topography of Andaman and Nicobar group of islands, Octavia Bay, Camorta Island. G. South point, Port Blair, South Andaman. H. Nancowry harbour, Camorta Island.

NANCOWRY ISLAND (Fig. 7)

1. *Spiteful Bay* (Fig. 8)
   08°01′ N Lat ; 93°32′ E Long.
   Lies between Leda and Mayo Points in Nancowry Island ; elongate and extensive in area but narrow. The shore is lined with mangroves which grow thickly along water front. All along eastern side the bay is shallow and muddy of yellow colour. Sunken vessel remains were observed at the eastern entrance. At 1.5 m depth a coral girdle is seen becoming more dense in middle at 2 m depth. This belt becomes broader approaching Leda Point. Bay 13-18 m deep, of mud and shingle bottom. Transition from live coralline area to deep area is sudden as in Octavia Bay. Details of observations made in traverse are given in Fig. 11.

2. *Mayo Point to Reid Point* (Fig. 8)
   08°01′ N Lat ; 93°33′ E Long.
   Shore line on northern extremity of Nancowry consists of sand with a narrow beach progressively becoming more steep towards Reid Point. Near shore water is full with submerged coral stones and live branching corals upto 3 m depth. A similar feature seen on opposite side of Camorta jetty to Naval Point towards east.

KATCHALL ISLAND (Figs. 7 and 12)

07°52′-08°02′ N Lat ; 93°19′-92°28′ E Long.

Maximum elevation 228 m. East, North and West Bays were visited. *East Bay :* The beach and the near shore areas were sandy and intersected by creeks. The creek mouths were slushy with rich organic detritus. The sea bottom is sandy upto a depth of 15 m from the jetty. The intertidal region is very narrow and is limited to 1-2 m. At a distance of about 500 m from shore the sea bed becomes precipitous. In 10 m depth massive boulder-like live coral colonies and large alcyonarians are common. Branching corals are present but not extensive.

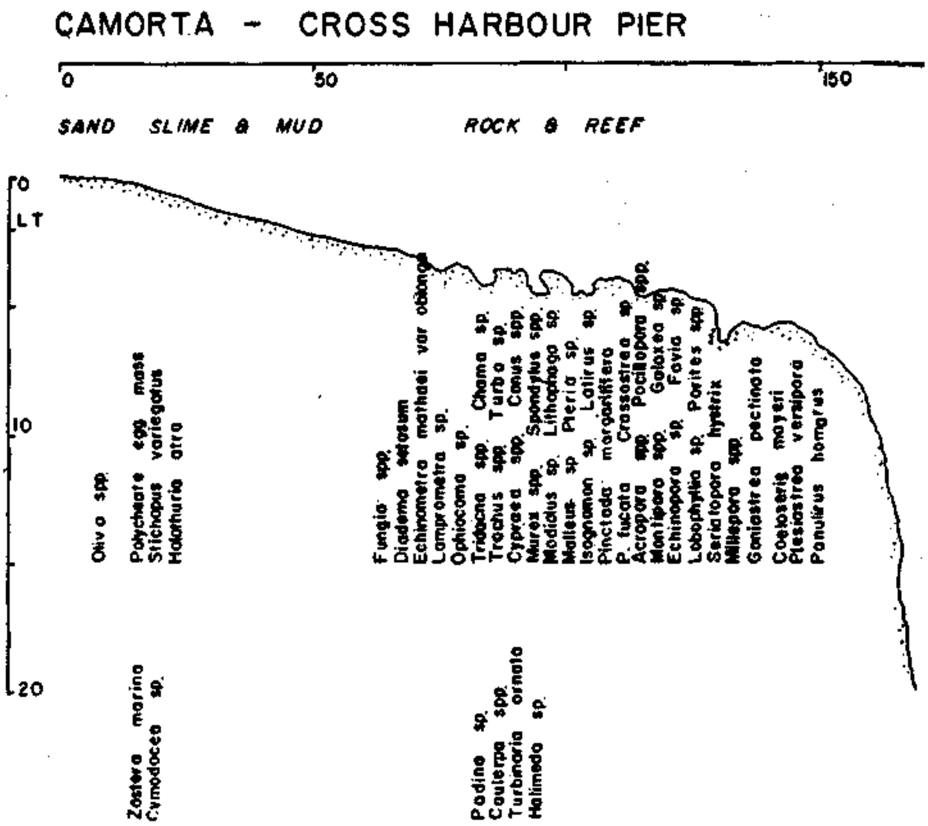


Fig. 9. Cross Harbour, Camorta Island showing a rich assemblage of communities.

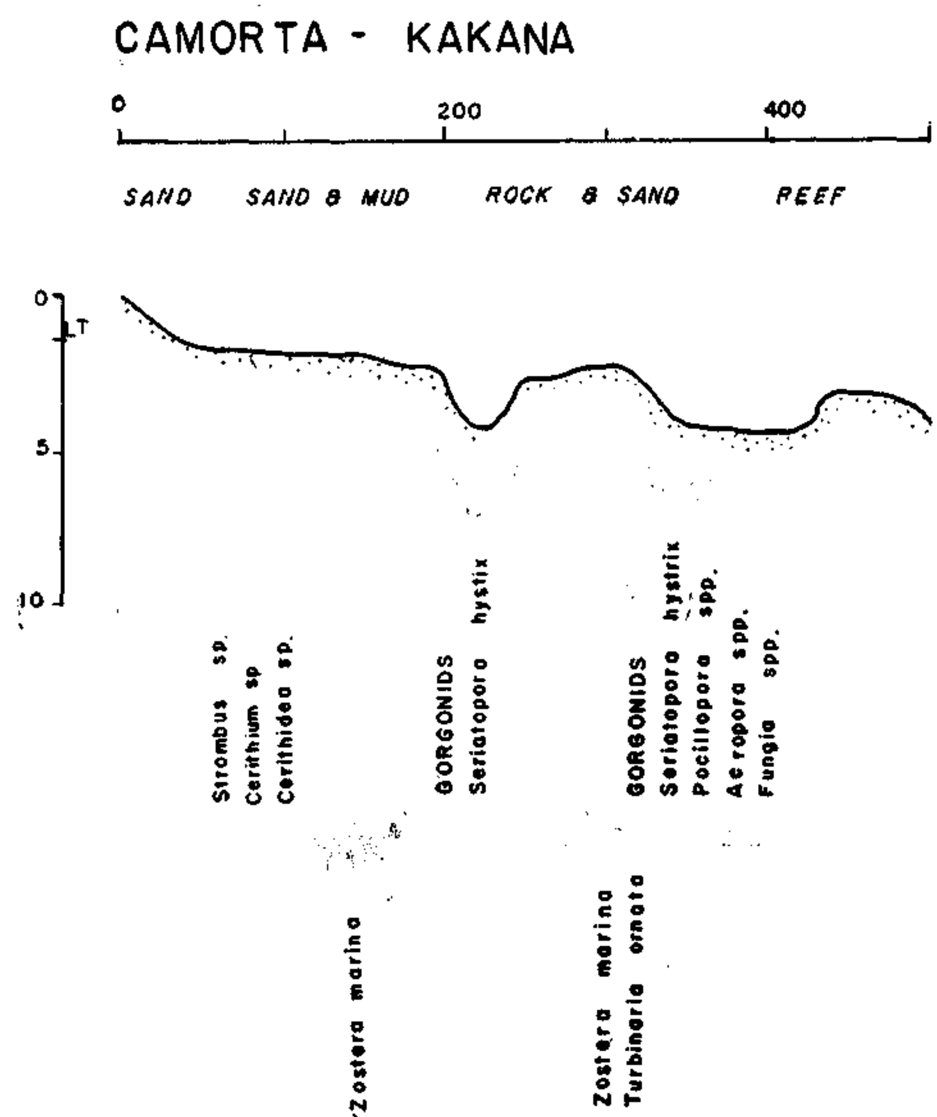


Fig. 10. Traverse study at Kakana, Camorta Island.

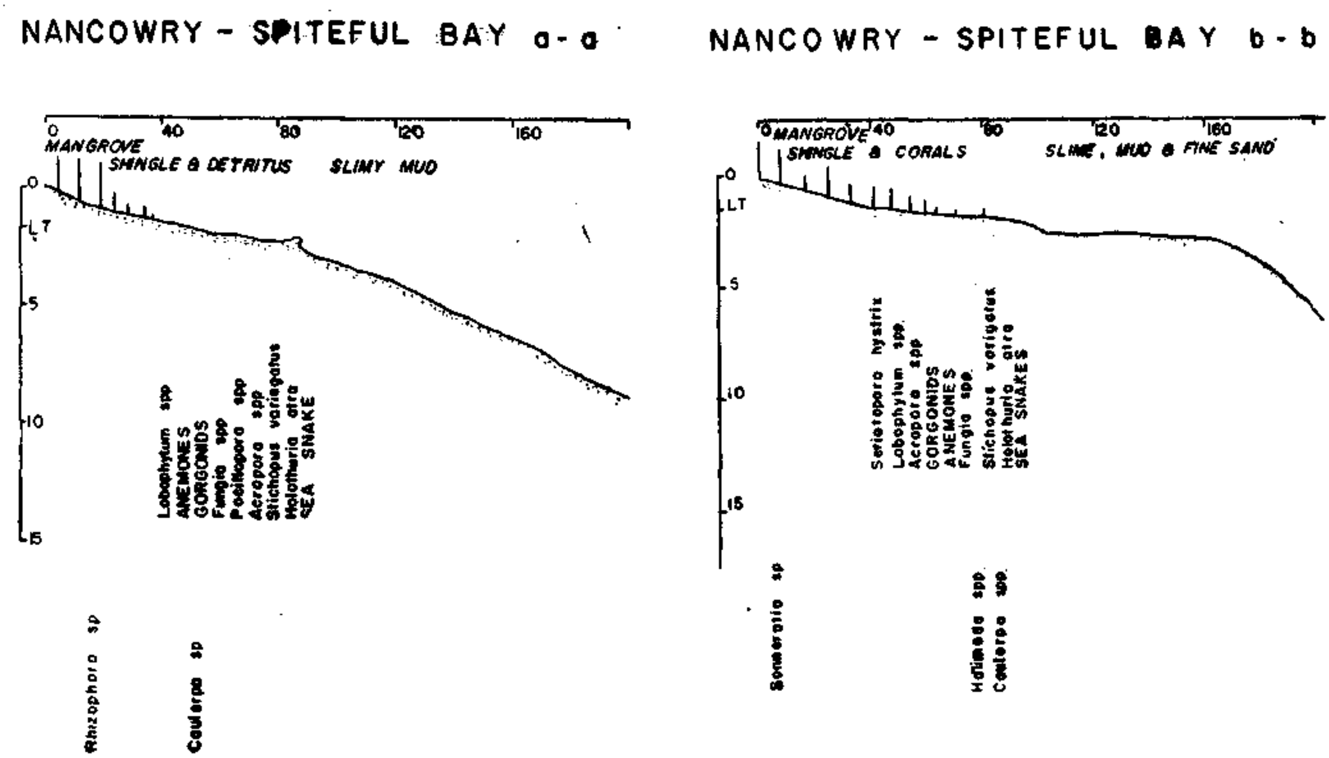


Fig. 11. Faunistic and algal distribution in Spiteful Bay, Nancowry Island.

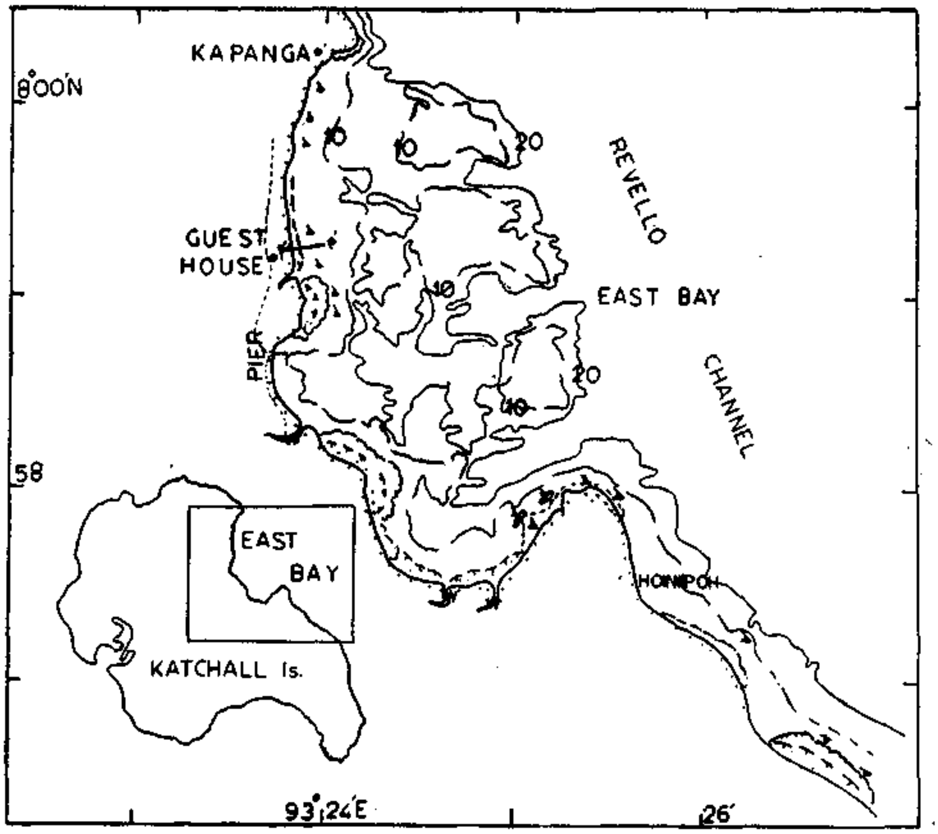


Fig. 12. Features of East Bay, Katchall Island.

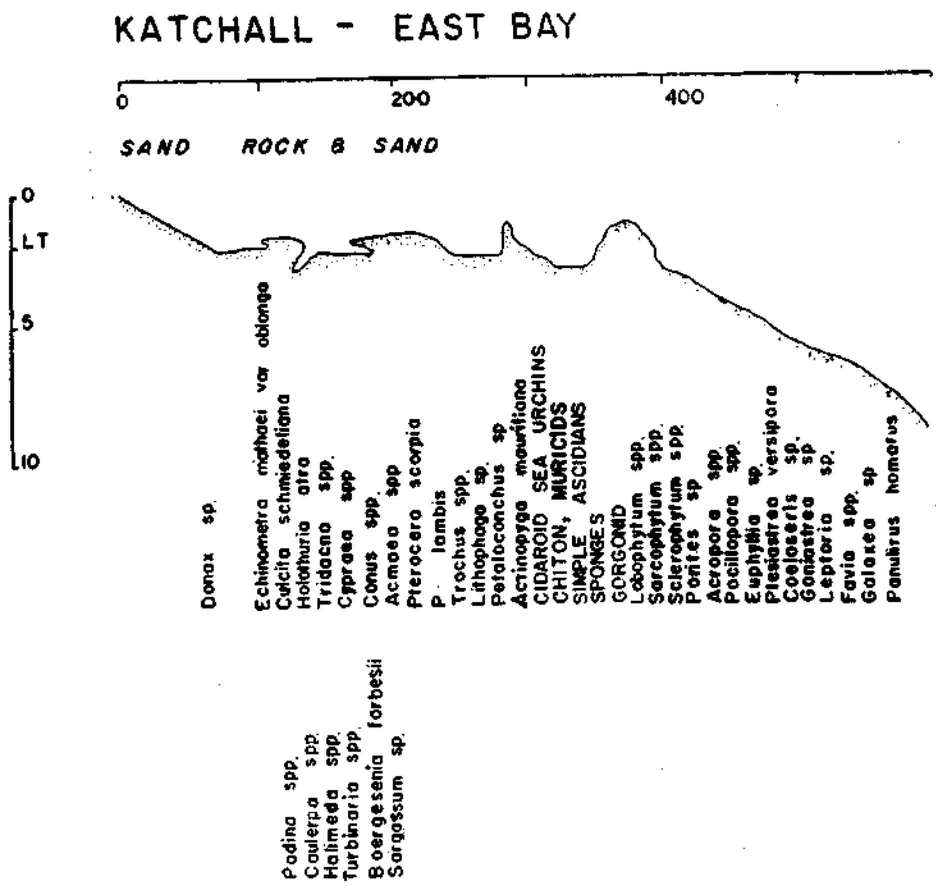


Fig. 13. Distribution pattern of near shore fauna and flora studied in the East Bay, Katchall Island.

Large sponges are observed. Coral grazing fishes, holothurians, echinoids and starfishes are common. A few rock lobsters are also observed. The results of the traverse study undertaken at a site close to the guest house, marked β-β′ in Fig. 12 are given in Fig. 13. A notable shore feature is the occurrence of thick bushes of cycads in the East Bay area and the terrain was rocky, a feature distinct from that of nearby Camorta and Nancowry. *North Bay :* The area between Jhula and Jansing is unapproachable due to heavy breakers pounding the stony ledge about 100 m away from high tide mark. The area towards the shore is stony, flat and gets exposed with low tide. *West Bay :* It is calm, shallow and slushy. Thick mangroves were observed along the shore line. Inhabited by Nicobarese and settlers from mainland.

TRINKAT ISLAND (Fig. 7)

08°02′-08°07′ N Lat ; 93°33′-93°36′ E Long. Maximum elevation 30 m. Southwestern shore of the island was studied (β-β′ in Fig. 7). Beresford Channel is deep, water clear and current very fast. The beach is lined by coconut palms, bushes and mangrove vegetation. The shore is of shingle and sand. The intertidal area extending about 100 m is of shingles with algal growth, slippery and free from major biota. An area of roughly 650-700 m wide is within 3 m depth from low tide mark ; beyond, the land falls sharply. Study was conducted within this 3 m depth zone. The site is rich in variety of species. Corals are much diversified. *Fungia, Cypraea, Conus, Tridacna,* muricids and echinoids were abundant. Major sea weeds were limited to calcareous forms and *Turbinaria.* Tidal current is fast and water clear. At places are crevices of over 5 m deep with rich fauna and the darker areas have a rich assemblage of coloured sponges. Details of observation made in a traverse are given in Fig. 14.

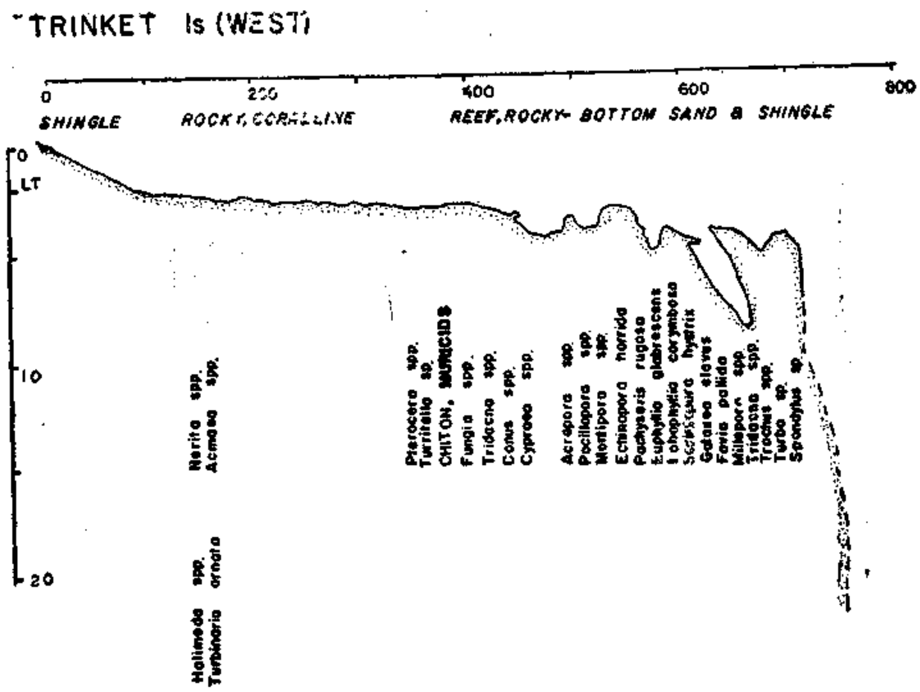


Fig. 14. Distribution pattern of fauna and flora in the West coast of Trinket Island.

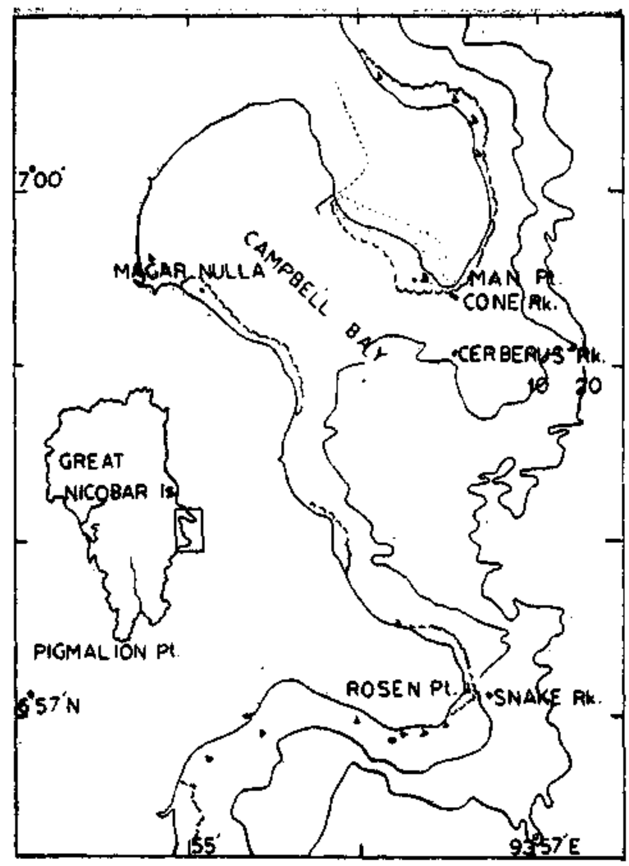


Fig. 15. Campbell Bay area in Great Nicobar Island.

Great Nicobar Island (Fig. 15)

06°45'-07°15' N Lat ; 93°39'-93°58' E Long.

Maximum elevation 568 m (Mt. Thuillier). The rivers Galathea (Dak Kea), Dagmar and Alexandra are navigable. Inhabited by local tribe Shompen and settlers from mainland.

Campbell Bay : 07°00' N Lat ; 93°55' E Long.

The Campbell bay is 1.5 km wide and 2 km long. Entrance of bay is 7 m deep. Interior is 4 m deep with muddy bottom and sand. Beach wavy from Snake Point to 20th km. Coarse sand of 4 m breadth cut up by small creeks here and there. Shore lined by forest vegetation and mangroves, encroaching into the water front in many places. Large tree trunks fallen across the beach indicating tidal erosion. Near shore sea bottom is of sand and pebbles ; calcretes, small and large, found here. Huge boulders at 1.5 m depth. This feature becomes more pronounced southwards and extends upto 3 m depth zone; beyond the depth drops to 9 m and more. Live coral formation rare shorewards, occurring in patches.

References

Elliot, Hugh F. L. 1972. Island ecosystem and conservation with particular reference to the biological significance of islands of the Indian Ocean and consequential research and conservative study. *J. mar. biol. Ass. India*, 14 (2) : 578-608.

Kloss, C. Boden 1902. *Andamans and Nicobars :* the narrative of a cruise in the schooner '*Terrapin*', with notes of the islands, their fauna, ethnology, etc. Vivek Pub. House, Delhi. Reprint 1971, xiii+373 pp.

Parkinson, C. E. 1938. *A Forest Flora of the Andaman and Nicobar Islands :* An account of the trees, shrubs and principal climbers of the islands. Mahendra Pal Singh Publishers, Dehradun, Reprint 1972, xxxvi+325 pp.

Rao, H. S. 1937. On the habitat and habits of *Trochus niloticus* Linn. in the Andaman Sea. *Rec. Ind. Mus.*, 39 : 47-82.

Rao, H. S. 1939. *Consolidated report on the shell fisheries in the Andaman during the years* 1930-1935. Zool. Surv. India, Calcutta, 130 pp.

3

HYDROLOGY OF INSHORE WATERS

R. MARICHAMY[1]

INTRODUCTION

Data collected by the earlier cruises of *Dana* Expedition, RV *Vityaz*, International Indian Ocean Expedition, INS *Krishna* and others on various hydrological parameters pertained to the deeper waters off the Andaman and Nicobar Islands. Further, the observations were mostly restricted to pre-monsoon season. Literature on hydrology of the coastal waters of Andaman and Nicobar Islands is very meagre. Sewell (1928, 1929) observed the pattern of temperature and salinity of the coastal waters of the Andaman Sea. Rangarajan and Marichamy (1972), based on their study during 1964-70 at Port Blair, correlated the seasonal changes of the marine environment with local meteorological conditions. Garg *et al.* (1968) reported that the concentration of oxygen-poor layer was greater in the Andaman Sea than in the Bay of Bengal suggesting a northerly flow at these depths. Kabanova (1964), during the 33rd cruise of *Vityaz*, concluded that the low values of primary production were due to the deficiency of nutrient salts. Reddy *et al.* (1968) observed an incidence of very high concentration of phosphates exceeding 12 μg at/l during the IIOE cruises of INS *Krishna* in 1963 in all the stations around Andaman Islands. Rao and Rao (1968) found the seasonal variations of the total phosphorus in the Bay of Bengal and Andaman Sea. Zernova and Ivanov (1964) compared the hydrological conditions on the distribution of phytoplankton in Andaman Sea. While assessing the productivity of Andaman coastal waters, certain hydrological aspects were studied by Nair and Pillai (1972). More recently, Sudarsan (1978) noticed a direct relationship between the trawl catches and salinity, temperature as well as standing crop of plankton and an inverse relationship between the rainfall and trawl catches.

MATERIAL AND METHODS

Hydrographic observations include air and surface water temperature, salinity, dissolved oxygen content and pH. Observations were generally made around 0800 hrs. Maximum number of samples were collected from creeks, mangrove swamps, mud flats, lagoons and intertidal coastal zones in the areas surveyed. The data were pooled and the average values have been shown against important centres as given in Table 1.

TABLE 1. *Hydrological observations of Andaman and Nicobar Islands during February-April* 1978

Places	No. of stations	Temperature °C			Salinity (ppt)		Oxygen ml/l		pH	
		Air	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Diglipur ..	5	27.8	28.3	—	24.76	—	4.9	—	7.93	—
Mayabunder ..	10	28.4	27.8	27.0	33.99	34.31	4.1	4.3	8.16	8.50
Rangat ..	3	30.7	29.0	28.0	31.91	32.00	5.3	5.1	8.03	8.20
Havelock Is. ..	5	29.9	28.2	28.5	31.49	31.24	5.1	4.8	8.02	8.15
Shoal Bay ..	3	30.2	29.0	29.0	30.95	30.95	4.7	4.6	7.70	7.95
Neill Is. ..	3	29.7	28.7	28.0	32.13	32.09	5.3	5.0	8.10	8.08
Port Blair ..	18	30.1	29.7	28.9	32.29	31.85	4.9	4.9	7.97	7.59
Little Andaman ..	5	30.5	29.3	29.0	32.08	31.83	5.4	5.1	7.64	8.00
Car Nicobar ..	6	30.2	30.1	29.8	32.38	32.51	6.5	6.0	8.50	8.37
Katchall ..	3	29.3	29.2	29.4	32.66	33.19	4.1	4.1	8.48	8.45
Kakana ..	2	31.4	30.6	29.0	32.72	32.72	3.8	3.7	8.40	8.40
Nancowri ..	4	30.8	30.2	28.8	33.43	33.10	4.3	4.5	8.50	8.00
Trinkat ..	1	32.0	32.0	31.7	34.00	34.15	6.2	5.9	7.50	7.80
Great Nicobar ..	2	28.1	29.8	29.3	33.40	33.70	4.8	4.3	7.82	8.40

Present address :
[1] CMFRI, Research Centre, Tuticorin 628 001.

Altogether 70 observation centres were covered and these have been represented by 14 prominent bases. Meteorological data on rainfall, temperature and humidity were collected from the Statistical Bureau, Andaman Administration and Meteorological Department, Pune.

RESULTS

The distribution pattern of atmospheric temperature, humidity and rainfall in Andaman and Nicobar Islands during the period 1972-78 (Fig. 1) revealed a more or less uniform trend in the entire territory. Temperature reaches the maximum in April and subsides at the onset of monsoon from May onwards. During January-April, the humidity fluctuates in a low range, 71-77%, in Andaman Islands and slightly higher in Nicobar Islands because of higher rainfall in the southern group. The islands are influenced by both the south-west and north-east monsoons. A long and continuous rainy season extends from May to November, with peak rainfall in June and September.

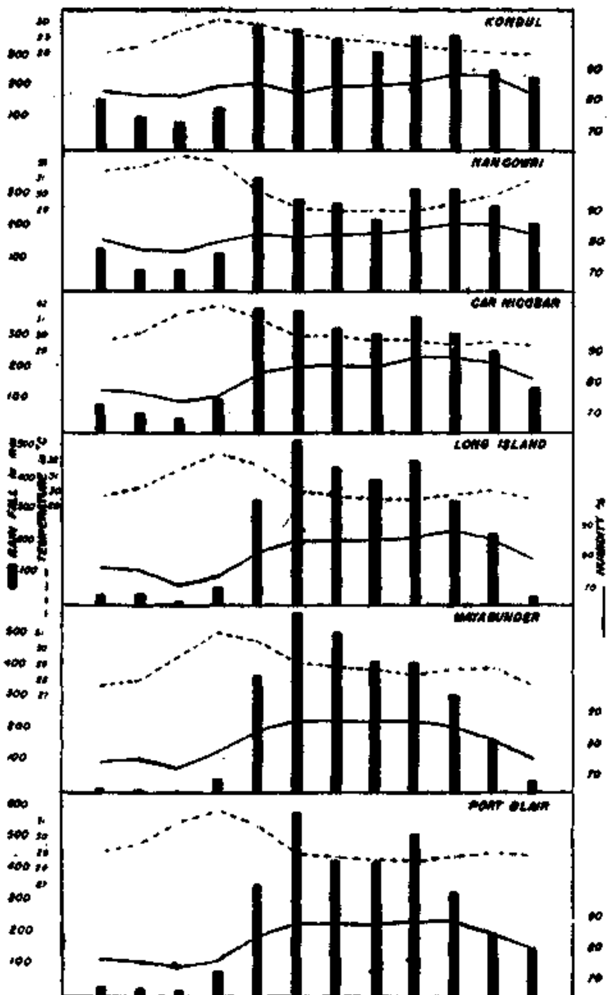


Fig. 1. Rainfall, temperature and humidity data for some centres in the Andaman and Nicobar Islands (data are averages for 1972-1978).

The results of hydrographical studies are presented in Table 1. The temperature of surface water closely followed the trend of atmospheric temperature at different centres. The range of surface temperature during February-April 1978 was 27.8-32.0°C. At the approach of summer an increasing trend in the temperature was noticed from February to April. The surface salinity was in the range 24.76-34.00 ppt. In Diglipur, observations were made only in creeks and the salinity was in the range 9.98-33.66 ppt with the average at 24.76 ppt. Also in Shoal Bay, salinity was comparatively low due to the influx of fresh water through a number of creeks. The dissolved oxygen content of the surface water was in the range 3.8-6.5 ml/l. The oxygen content was low (3.8-4.1 ml/l) in the coastal waters of Katchall and Kakana. In Trinkat and Car Nicobar, a high value of oxygen (6.2-6.5 ml/l) was noticed. The pH of the surface samples was in the range 7.50-8.50.

REMARKS

Wide fluctuations in the surface salinity may be expected throughout the islands during the months of May to September corresponding to the periods of heavy rainfall as noticed by Rangarajan and Marichamy (1972) in their observations at Port Blair. Based on the trend of salinity, they classified the seasonal changes into (1) a period of high salinity with very little fluctuation during February to April, the pre-southwest monsoon period, (2) a fairly long period of comparatively low salinity with greater fluctuations during May to November, the period of the two monsoons and (3) a period of recovery during December and January, the post-northeast monsoon period. This could be applicable for the entire territory as in the case of meteorological data.

Industrial development is advancing around Chatham Island. The saw mill and power house at Chatham and match works and the timber industry in the Bamboo Flat are dumping the wastes into the sea. The problem of pollution is restricted to the above areas at present. The pH of the bottom water samples here was considerably low probably due to the sedimentation of suspended organic matter.

REFERENCES

GARG, J. N., C. B. MURTY AND R. JAYARAMAN. 1968. Vertical distribution of oxygen in the Bay of Bengal and Andaman Sea during February-March 1963. *Bull. nat. Inst. Sci. India*, **38**, pt. 1: 40-48.

KABANOVA, Y. G. 1964. Primary production and nutrient salt contents in the Indian Ocean waters in October-April 1960-61. *Trud. Inst. Okeanol. Akad. Nauk. SSSR*, **64** : 85-93.

NAIR, P. V. R. AND C. S. G. PILLAI. 1972. Primary production of some coral reefs in the Indian Seas. *Proc. Symp. Corals and Coral Reefs*, pp. 33-42. Mar. biol. Ass. India.

RAO, V. C. AND T. S. S. RAO. 1968. Distribution of total phosphorus in the Bay of Bengal. *Bull. nat. Inst. Sci. India*, **38**, pt. 1: 93-102.

RANGARAJAN, K. AND R. MARICHAMY. 1972. Seasonal changes in the temperature, salinity and plankton volume at Port Blair, Andamans. *Indian J. Fish.*, **19** : 60-69.

REDDY, C. V. G., P. S. N. MURTY AND V. N. SANKARANARAYANAN. 1968. An incidence of very high phosphate concentration in the waters around Andaman Islands. *Curr. Sci.*, **37** (1) : 17-19.

SEWELL, R. B. S. 1928. Geographic and oceanographic research in Indian waters. iv. The temperature and salinity of the coastal waters of the Andaman Sea. *Mem. Asiat. Soc. Beng.*, **9** : 133-205.

SEWELL, R. B. S. 1929. Geographic and oceanographic research in Indian waters. v. The temperature and salinity of the surface waters of the Bay of Bengal and Andaman Sea with reference to the Laccadive Sea. *Mem. Asiat. Soc. Beng.*, **9** : 207-355.

SUDARSAN, D. 1978. Fish trawl catches of Shoal Bay, Port Blair (Andamans) in relation to hydrology and plankton. *Matsya*, **3** : 83-86.

ZERNOVA, V. V. AND J. V. IVANOV. 1964. On the distribution of phytoplankton as depending from hydrological condition in the northern part of the Indian Ocean. *Trud. Inst. Okeanol. Akad. Nauk. SSSR*, **64** : 257-264.

4

PRIMARY PRODUCTION IN COASTAL WATERS

P. V. RAMACHANDRAN NAIR[1] AND C. P. GOPINATHAN[2]

INTRODUCTION

The data on primary production from the Bay of Bengal and the Andaman Sea are very meagre. The Danish Galathea Expedition during her round-the-world cruise, made some measurements across the Indian Ocean through the equatorial current system and in the Bay of Bengal, of which two stations were from the Andaman Sea. It was observed that in the eastern part of Bay of Bengal, the lower bound ry of the photosynthetic layer was between 84-99 m and the stations located on the shelf were characterised by a high rate of production. In the Galathea report (Steemann Nielsen and Jensen, 1957), it was concluded that the monsoon shift has some influence on the rate of production in the Bay of Bengal and that extensive investigations during the different seasons are necessary in order to get a true picture of the production of organic matter.

Galathea was followed by R.V. *Vityaz* in 1956-60 and a few measurements were taken during her 31st-33rd cruises in the Bay of Bengal and Andaman Sea. Immediately following *Vityaz*, the International Indian Ocean Expedition (IIOE) started its programme and collected extensive data relating to various biological and hydrological parameters with a few observations on phytoplankton productivity. Other measurements of primary production were those of Nair *et al.* (1968) and Nair and Pillai (1972) which also do not cover the different seasons but the pre-monsoon season only.

In view of the vast potential for mariculture activities in the coastal areas of Andaman-Nicobar Islands, it was decided to cover the entire stretch of islands from Diglipur (North Andaman) to Campbell Bay (Great Nicobar). This account embodies the results of productivity measurements made during the pre-monsoon period of 1978.

BRIEF REVIEW OF EARLIER WORKS

The major factor limiting the production is the depth of the euphotic zone which has been found by Galathea to be rather low in the northern regions, presumably due to the organic and inorganic material conveyed by the Ganges, Brahmaputra and other river systems. Around the Andamans, on the other hand, there is an increase in the depth of the euphotic zone which is between 65-75 m during the pre-monsoon period and 75-90 m during the monsoon period. Further, in the offshore regions it exceeds 90 m indicating clear oceanic condi ions, while for the major part of the Bay of Bengal, towards the coast, it is less than 50 m. The other important factor governing the production is the depth of the mixed layer which is around 60 m during most part of the year, while in the central part of the bay it exceeds 80 m.

The Galathea measurements showed that the vicinity of the western side of Andamans had a rate of production of 0.31 gC/m^2/day (Steem nn Nielsen and Jensen 1957). Nair (1970) calculated the production rate for the offshore waters of the Bay of Bengal as 0.19 gC/m^2/day. Radhakrishna's (1978) recent measurements also give a comparable average of 0.16 gC/m^2/day. Nair and Pillai (1972) observed that the annual production of the reef area in the Andaman Sea was 1200 gC/m^2, which is of a lesser order than that of similar reef areas. Kabanova (1964) during the 33rd cruise of *Vityaz* found that the primary production in the central part of the Andaman Sea was 114-176 mgC/m^2/day and that the area was characterised by greater concentration of nitrates than the other regions. According to this author, in the Bay of Bengal and in the Andaman Sea, phosphates were almost exhausted by the production of phytoplankton. The surface production of the Bay of Bengal is less when compared to the Arabian Sea. This can be attributed to the greater cloud cover over the Bay of Bengal, as compared to Arabian Sea, which reduces the incident radiation and inhibits primary production at the surface and also due to the heavy

Present address :
[1] CMFRI, Cochin 682 018
[2] CMFRI, Research Centre, Tuticorin 628 001.

load of nitrogen and phosphorus brought about by rain runoff (Qasim, 1977).

The primary production value for the Andaman Sea during the monsoon period averaged for 0-50 m depth is over 50 $mgC/m^3/hr$ which would amount to nearly 2 $gC/m^2/day$. This is comparable to the high production in some of the regions of the Arabian Sea. So it can be reasonably inferred that the production rate of Andaman Sea in the upper 50 m is of a higher order equal to the northern regions of the Bay of Bengal Rest of the Bay especially the western half during the corresponding period exhibits a low rate of production (2 $mgC/m^3/hr$ (Krey and Babenard, 1976).

Results and Discussion

The temperature of the coastal waters during the period of observations ranged from 27-32°C and salinity 27-33‰. The pH ranged from 7-8.5, especially in the mangrove areas investigated and the dissolved oxygen content was 4.0-5.5 ml/l. Due to lack of facilities, the nutrient analysis of the water could not be carried out.

Phytoplankton

During the present investigation, the phytoplankton samples were collected by means of a ½ metre bolting nylon net (mesh size-0.069 mm) by surface haul of 10 minutes duration. Altogether 39 samples were collected from the Andaman-Nicobar Islands. Since the samples were obtained by means of a net, the quantitative estimation of the organisms could not be made. The qualitative studies reveal that 56 species of phytoplankters occur: 22 species of Diatomaceae, 33 species of Dinophyceae and one species of Myxophyceae (blue-green algae). The inshore samples were dominated by Dinophyceae especially species of *Ceratium*, *Peridinium*, *Ornithocercus*, *Dinophysis*, *Phalacroma*, *Pyrocystis* and *Pyrofacus* and the near shore samples predominantly contained Diatomaceae such as *Rhizosolenia* spp., *Guinardia flaccida*, *Biddulphia sinensis*, *Streptotheca indica* and *Chaetoceros* spp. The blue-green alga *Trichodesmium thiebautii* was present in all the inshore samples collected from the Nicobar group of islands. The Silicoflagellates and Coccolithophores were totally absent in these samples.

During the 31st cruise of *Vityaz*, Sukhanova (1962) found that in the Indian Ocean region near Nicobar Islands, the phytoplankton component was dominated by dinoflagellates. This feature reveals a ' basic Indo-Oceanic complex ' as suggested by Sukhanova. During the 33rd cruise of *Vityaz*, Zernova (1962) made a study of the quantitative distribution of the phytoplankton of the Bay of Bengal and Andaman Sea and she found that the total quantity of phytoplanton was high (6100 $cells/m^3$) in the Andaman Sea compared to the low values (1200 $cells/m^3$) of Arabian Sea. However, Zernova and Ivanov (1964) found that in the Bay of Bengal phytoplankton number did not exceed 500 $cells/m^3$. According to them, a higher phytoplankton number (> 5000 $cells/m^3$) was found to the south-west of the Nicobar islands and in the Andaman Sea.

Chlorophyll

The chlorophyll values also indicate a high seasonal variability in the Andaman Sea. The values as reported in the IIOE Atlas (Krey and Babenard, 1976) are considerably higher during the November-April period. A zone of higher phytoplankton production near the Nicobar islands is evident reaching upto 300-500 $\mu g/m^3$. Values ranging between 200-300 $\mu g/m^3$ have also been observed near Car Nicobar, Little Andaman and part of South Andaman. This high density of chlorophyll is observed in the Andaman Sea even upto 75 m depth in certain regions. But in May-October period, the values are considerably less. This is in contrast to a higher concentration of chlorophyll observed during May-October period in the Arabian Sea.

Primary production

The primary production measurements by ^{14}C technique were carried out at 42 stations in the Andaman-Nicobar islands. Of these 26 stations are from typical coastal waters and 16 stations from the mouth of the mangrove areas. The results of the present investigations are given in Table 1. The results indicate that there is considerable variation in unit volume production ($mgC/m^3/day$) as well as the production per unit area ($gC/m^2/day$). The mangrove areas, in general, contrast with the mangrove swamps of the mainland, being less productive. The reason for this low production may perhaps be due to the less light penetration and greater quantity of detritus reducing the oxygen content. The phytoplankton is predominantly of Dinophyceae and quantitatively of much less magnitude. The Diatomaceae in general was found to be very poor. The production rate ranges from 0.07 to 3.6 $gC/m^2/day$. The main centres where production rate exceeds 0.5-1 $gC/m^2/day$ are Mayabunder, Rangat, Chiriyatapu, Havelock, Corbyn's Cove, Navy Bay, Phoenix Bay and Shoal Bay regions of Andamans, Hut Bay of Little Andaman, Kimios and Sawai Bay of Car Nicobar, East Bay of Katchall and Spiteful Bay of Nancowry. The depth of the euphotic zone ranges 30-50 m depending on the depth of the area. This is in contrast to the open ocean area of Andaman Sea where the euphotic zone extends from 75-90 m.

It has been generally observed that as the continental shelf margins of the oceans are approached, the standing crop will increase. The same increase is presumed to exist with nearness to island shores. This hypothesis has been tested by Doty and Oguri (1956) in the Hawaiian waters which has been termed as 'Island Mass Effect'. This phenomenon could be applicable in the case of Andaman Sea as well. These authors noted a consistent increase in carbon fixation as shore is approached. The values obtained by Galathea, IIOE and other expeditions show that the deeper water stations between 1000-3000 m have on the whole a production rate of 0.1 to 0.2 $gC/m^2/day$ whereas the shallow water stations, both in the continental shelf and near island masses, have a production rate exceeding 0.5 $gC/m^2/day$. Doty and Oguri (1956) have attributed this increase in production due to runoff from high islands and percolation

TABLE 1. *Primary production values of Andaman-Nicobar coastal waters*

		$mgC/m^2/day$	$gC/m^2/day$	Nature of ecosystem
Andaman Islands				
1. Table Islands			0.86	Rocky shore
2. Diglipur (surface)		169		Creek muddy
3. Mayabunder :	North		2.7	Rocky and sandy
	Middle Channel		2.3	Sandy and marshy
	Oyster point		0.57	Rocky
	Mayabunder jetty		2.16	Boulders with sandy
4. Rangat (surface)		923		Mangrove fringed shallow
	Mangrove area		0.32	Marshy bottom
	Jetty		0.61	Marshy and sandy
5. Shoal Bay			0.57	Muddy exterior deep
6. Havelock Island			1.47	Rocky intertidal
7. North Bay (Port Blair)			0.18	Reef
8. Navy Bay (Port Blair)			2.09	Muddy shallow
9. Phoenix Bay (Port Blair)			2.09	Slushy mangrove shore
10. Sesostris Bay (Port Blair)			1.7	Mangrove fringed sandy
11. Ross Island (Port Blair)			0.23	Fouled reef
12. South Point (Port Blair)		1040		Rocky reef
13. Corbyn's Cove South			3.6	Muddy flat with creeks
14. Burmanalla		375		Sand stone flat
15. Wandoor		470		Slushy mangrove
16. Chiriyatapu			0.57	Sandy reef
17. Macpherson strait			0.85	Deep water
18. Rutland Island			0.14	Rocky area deep water
19. North Cinque			1.07	Sandy shore
20. Little Andaman :	Hut Bay		0.54	Sandy
	Butler Bay		0.48	Rocky intertidal sandy
Nicobar Islands				
1. Car Nicobar :	(i) Hog point		1.63	Sandy
	(ii) Sawai		1.02	Sandy and rocky
	(iii) Tee-Top jetty	140		Sandy and rocky
	(iv) Passa	1370		Sandy
	(v) Malacca	230		Reef
	(vi) Kimios Backwater		0.51	Marshy mangrove
	(vii) Arong	1010		Rocky rough
2. Katchall :	East Bay		2.35	Sandy reef
	West Bay	340		Rocky rough
3. Camorta :	Jetty (Cross Harbour)		0.22	Marshy reef
	Kakana		0.27	Sandy reef
	Beresford Channel	280		Deepwater
4. Nancowry :	Champin jetty		0.39	Sandy calm
	Spiteful Bay		0.56	Calm mangrove fringed
	Mangrove area	280		Marshy
5. Trinkat Island (west side)		230		Thick reef
6. Great Nicobar :	Campbell Bay		0.17	Sandy area with dead corals
	Vijaynagar	980		Sandy reef

from low islands. It is also postulated (Doty, 1954) that the benthic algae as well as endozoic species and those found in the reef regions accumulate inorganic nutrients from the passing waters which are relatively poor in nutrients which will in turn be leached out making it available to planktonic algae. Thus there is overwhelming evidence to conclude that as island masses are approached, productivity increases. The higher values noted on the eastern side of the Andaman Islands by Nair *et al.* (1968), as compared to the values observed offshore, could be due to this process of local enrichment.

According to Nair and Pillai (1972), the Andaman reef areas have an annual production of 1200 gC/m² and the respiratory requirements of the organisms in the reefs far exceed production and hence the reef in the South Andaman at least is non-autrotrophic. The efficiency of gross production is also low here because of the relative sparseness of phytoplankton and paucity of benthic algae. Further they stated that the reefs of the Andaman Sea especially of the Nicobar islands may be having a different level of total community metabolism. Though the organic production of the waters of Nicobar islands is comparatively high due to luxuriant growth of corals, it lends support to the contention raised by Gorden and Kelly (1962) that there is considerable variability between different coral reefs at the level of total community metabolism.

For determining the potential for mariculture activities, it may be more advantageous to assess the potential productivity of the surface waters for the different seasons. It would appear that the potential productivity of the surface waters is distinctly higher during the May-October period and the integrated values of daily production of the euphotic layer is also higher during the same period. However, all data indicate that though the waters of the Nicobar islands seem to be highly productive, larger part of the production is consumed by the reef fauna leaving very little surplus for the ecosystem. Therefore, in certain regions of Andamans, it is likely that the potential productivity of the ambient waters may not be available to the ecosystem as a whole.

References

Doty, M. S. 1954. Floristic and ecological notes on Raroia. *Atoll. Res. Bull.*, 33 : 1-41.

Doty, M. S. and M. Oguri. 1956. Island Mass Effect. *J. cons. Int. Explor. Mer.*, 22 : 33-37.

Gorden, M. S. and H. M. Kelly. 1962. Primary production of an Hawaiian coral reef. A critique of flow respirometry in turbulent waters. *Ecology*, 43 : 474-480.

Krey, J. and B. Babenard. 1976. Phytoplankton production. Atlas of the International Indian Ocean Expedition. *Inst. Meer. Kiel Univ.*, 1-70.

Kabanova, Ju. G. 1964. Primary production and nutrient salts content in the Indian Ocean waters in October-April 1960-61. *Trud. Inst. Okeanol.*, 44 : 85-93.

Nair, P. V. R. 1970. Primary productivity of the Indian Seas. *Bull.* 22, CMFRI, 1-56.

Nair, P. V. R. and C. S. G. Pillai. 1972. Primary production of some coral reefs in the Indian Seas. *Proc. Symp. corals and coral reefs*, 33-42. Mar. biol. Ass. India.

Nair, P. V. R., Sydney Samuel, K. J. Joseph and V. K. Balachandran. 1968. Primary production and potential fishery resources in the seas around India. *Proc. Symp. Living Res. Seas around India*, Cochin, 184-198.

Qasim, S. Z. 1977. Biological productivity of the Indian Ocean. *Indian J. Mar. Sci.*, 6 (2) : 122-137.

Radhakrishna, K. 1978. Primary productivity of the Bay of Bengal during March-April 1975. *Indian J. Mar. Sci.*, 7 (1) : 58-60.

Steemann Nielsen, E. and E. A. Jensen. 1957. Primary oceanic production. *Galathea Rept.*, Copenhagen, 1 : 49-136.

Sukhanova, I. N. 1962. On the specific composition and distribution of the phytoplankton in the northern Indian Ocean. *Trud. Inst. Okeanol.*, 48 : 27-39.

Zernova, V. U. 1962. Quantitative distribution of the phytoplankton in the Northern Indian Ocean. *Trud. Inst. Okeanol.*, 48 : 45-53.

Zernova, V. U. and Ju. A. Ivanov. 1964. On the distribution of phytoplankton as depending from hydrological conditions in the northern part of the Indian Ocean. *Trud. Inst. Okeanol.*, 44 : 257-264.

5

ZOOPLANKTON PRODUCTION IN COASTAL WATERS

R. MARICHAMY[1]

INTRODUCTION

A review of the earlier works on zooplankton of Andaman and Nicobar waters indicates paucity of information. Tsuruta (1963) discussed the representative composition and the distribution of plankton of the fish grounds for tuna in the Bay of Bengal based on samples collected in the deeper waters off these islands. Chiba (1956) and Jones (1966) have given accounts on systematic studies of copepods. Pillai (1970) and Roy (1977) described the occurrence of new species of calanoid copepods in the coastal waters of Andaman Sea. Rangarajan and Marichamy (1972) made a brief mention on the seasonal fluctuations in the biomass of plankton. Recently, Paulinose and George (1976) have recorded the occurrence of larvae of penaeid prawns in large numbers in the waters around Andaman and Nicobar Islands. No published account is available on the seasonal distribution of zooplankton from the coastal regions of these islands. The present account is an effort to provide preliminary information on zooplankton and a general treatment of the distribution of planktonic larvae along the coast.

MATERIAL AND METHODS

Thirty-six zooplankton samples were collected from the surface waters of different areas of survey. The data were pooled for each prominent centre. In Mayabunder, Middle channel, North Point and Kalighat were covered. Since there was no significant differences in the composition and distribution of zooplankton from the samples collected around Sir William Peel, John Lawrence, Outram, Henry Lawrence, and Havelock islands the data were pooled and represented from station Havelock. In Little Andaman, samples were collected from two centres, namely Hut Bay and Butler Bay. At Port Blair, the centres of observation included Ross Island, North Bay, Chiriyatapu, Navy Bay, Corbyn's Cove and Janglighat. In Nicobar group, only nine samples were taken from different islands. All the samples were collected around 0800 hours using a standard net of 0.5 m diameter and 0.4 mm mesh size, from the surface water and preserved in 5% formalin. The speed of the vessel was maintained at 1 knot during the five minutes collection time. The plankton biomass was determined by displacement method.

RESULTS

Zooplankton biomass

The displacement volume of the plankton varied between 1.4 ml and 40 ml per sample (Fig. 1). The

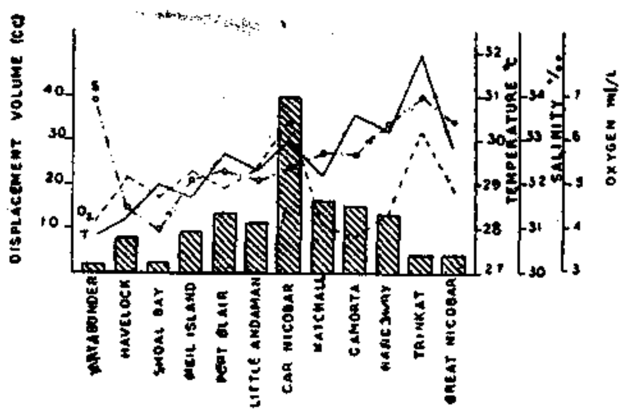


Fig. 1. Zooplankton displacement volume in relation to environmental parameters at the major centres of observation.

lowest volume was recorded from Mayabunder. Since the period of observation was very limited the influence of seasonal changes in temperature, salinity or oxygen on the biomass cannot be established. It has generally been noticed that the volume of plankton was low in places where the salinity values were relatively high and the temperature was very high or very low (Fig. 1).

Faunistic composition

The relative abundance of zooplankters is depicted in Fig. 2 for each island covered. The prominent groups in the area of study were copepods molluscan larvae, chaetognaths, decapod larvae, lucifer and

Present address:
[1] CMFRI, Research Centre, Tuticorin 628 001.

appendicularians. The faunistic composition was different from place to place. Appendicularians were rich (31.8%) in the collections made at Mayabunder, but occurred in negligible proportions in other centres. Salps, included under ' others ' in the figure, appeared

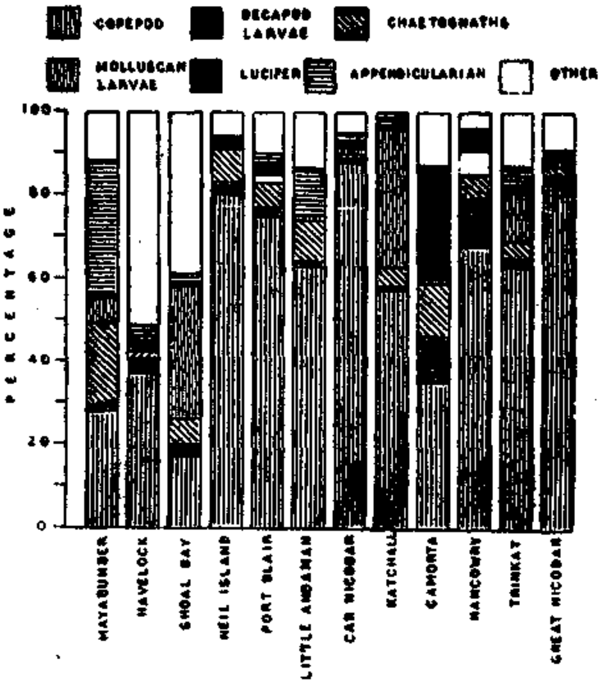


Fig. 2. Percentage of important zooplankton groups in Andaman and Nicobar Islands during February-April 1978.

equal to copepods from Havelock area, but were altogether absent in other collections. Pteropods (also included under ' others ') were fairly common in Shoal Bay (19.4%) but rare from other areas. Similarly, lucifers were predominant (52.8%) from the collections of Camorta, but formed only 4.10% in other nearby islands of Nancowry and Katchall, and were absent in other localities. Gastropod larvae were significantly rich in Nicobar Islands.

Copepods were the most important constituent of the zooplankton community. They were exclusively rich (80-87%) in Neill Island, Car Nicobar and Great Nicobar. Chaetognaths were next in importance and better noticed from Mayabunder, Port Blair and Camorta. The other constituents include siphonophores, amphipods, *Doliolum*, polychaete larvae and foraminifers and they were noticed from all collections but in negligible ratios.

Distribution of eggs and larvae

A wide variety of larvae in varying intensities was seen from many centres of the coastal waters of these islands. Fish eggs were present in the collections made at all centres. They accounted for 6.6% in total collections in Havelock area, 3.5% from Port Blair and 3.7% in Car Nicobar. Fish larvae occurred in good numbers (5.5%) around Havelock. Molluscan larvae, chiefly of gastropods, occurred in high percentage from Katchall Island and Shoal bay, but was relatively scanty in the rest of the places. The percentage of lamellibranch larvae varied from 0.1 to 2.9%. The decapod larvae constituted a maximum of 12% from Nancowry samples and varied considerably in other centres.

The data on eggs and larvae from all observation centres were pooled and the percentage composition of the groups was worked out. The gastropod larvae ranked first (74.8%) among the larval forms. Lamellibranch larvae were less (2.3%) and polychaete larvae formed 1.4%. The decapod larvae accounted for 12.6% including a variety of forms and developmental stages. Larvae of penaeids appeared to be more common. Zoea were next to them. Phyllosoma larvae were 12 to 16 number in each sample collected during first week of April 1978 from Great Nicobar and Nancowry. Fish eggs (7.9%) and larvae (1.0%) were present in moderate numbers and constituted nearly 9% of the total larval forms. The total larval forms were generally high in the Nicobar group of Islands.

Remarks

Prasad (1966) observed a moderately high plankton production in Andaman Sea. Rangarajan and Marichamy (1972) stated that the plankton production at Port Blair was high during the colder months and low during the period of high temperature and high salinity. Tsuruta (1963) remarked that waters west of Nicobar Islands were the richest in quantity of plankton, but the waters west of the Andaman Islands were the poorest in quantity during December 1957 to January 1958 in the layer at depth of 100 m. In the present study it is seen that copepods were the most abundant group. The percentage composition of the planktonic larval populations has shown that gastropods and decapods constitute the most important groups. Gastropods account for nearly 75% of all larvae. The breeding season of this group should be the summer. Menon *et al.* (1967) and Paulinose and George (1976) observed high concentration of decapod larvae nearer the shore. The decapod larvae were prominent in the coastal waters around Nicobar Islands and these may be considered as areas of higher concentrations of spawning stock and their larval forms. The availability of fish and shellfish larvae may be taken as an indication of the presence of cultivable stock. From this aspect, the Spiteful Bay of Nancowry, Hog Point of Car Nicobar, coastal areas in Katchall, Port Blair and Shoal Bay stand as potential areas for the development of mari-culture.

References

Chiba, T. 1956. Studies on the development and the systematics of copepods. *J. Shimonoseki Coll. Fish.*, 6 (1) : 1-90.

Jones, E. C. 1966. The general distribution of the species of the calanoid copepod family Candaciidae in the Indian Ocean with new records. *Proc. Symp. Crustacea*, 1 : 349-405. Mar. biol. Ass. India.

Menon, M. K., P. Gopala Menon and V. T. Paulinose. 1967. Preliminary notes on the decapod larvae of the Arabian Sea. *Proc. Symp. on Indian Ocean. Bull.* NISI, 38 : 753-757.

Paulinose, V. T. and M. J. George. 1976. Abundance and distribution of penaeid larvae as an index of penaeid prawn resources of the Indian Ocean. *Indian J. Fish.*, 23 : 127-133.

Pillai, P. Parameswaran. 1970. *Pseudodiaptomus jonesi*, a new calanoid copepod from Indian waters. *Curr. Sci.*, 39 : 78-80.

Prasad, R. R. 1966. Recent advances in the study of production in the Indian Ocean. *Second Int. Oceanogr. Cong.*, Moscow, 1966. Abst. pp. 89-90.

Rangarajan, K. and R. Marichamy. 1972. Seasonal changes in the temperature, salinity and plankton volume at Port Blair, Andamans. *Indian J. Fish.*, 19 : 60-69.

Roy, Tusharendu. 1977. Description of a new calanoid copepod, *Pseudodiaptomus nancowriensis* sp. nov. from Nicobar Islands, India. *Proc. Symp. Warmwater Zooplankton*, NIO, Goa, 100-104.

Tsuruta, Arao. 1963. Distribution of plankton and the characteristics in the oceanic fishing grounds, with special reference to their relation to fishery. *J. Shimonoseki. Univ. Fish.*, 12 (1) : 13-214.

6

CORAL REEFS AND THEIR ENVIRONS

C. S. GOPINADHA PILLAI[1]

INTRODUCTION

The coral formations of Andaman and Nicobar Islands extend from 92°30′ to 94°E Long. and 7° to 14° N Lat. flanking several large and small continental islands. This Indo-Pacific reef province, which is separated from the Sri Lanka and Southeast Indian coral formation by nearly one thousand km—a significant gap in the coral growth of the Indo-Pacific, is more or less contiguous with that of Strait of Malacca, Arakan coast and the East Indies. The absence of reef development and growth of hermatypes in the vast stretches of Bay of Bengal is probably due to the great influx of rain water through the large rivers of the Indian subcontinent, that causes deposition of large quantities of terrigenous mud as well as a lowering of salinity, particularly in the upper reaches of the bay during rainy seasons. The waters of Ganges-Brahmaputra river system are reported to be acidic in monsoon that may impose restrictions on skeletogenis of scleractinia (Sewell, 1935). Coral planulae will not settle and grow on muddy, soft bottoms with heavy silting and this may be the primary physical parameter that does not favour colonisation of corals in several areas of the Bay of Bengal.

During the present survey many stations in both Andaman and Nicobar Islands were studied in shallow nearshore waters with the aid of SCUBA, resulting in some information on the community structure of the reefs. The results are mainly based on field notes of the survey teams supplemented by discussion and examination of specimens collected at different stations. Most of the available information on the reef ecology and the various habitats, with their dominant marine fauna is summarised.

The author is obliged to Shri S. Mahadevan, scientist, for his valuable help in shaping the text by providing many details based on his experience during the survey.

Present address :
[1] CMFRI, Research Centre, Minicoy, Lakshadweep.

RESUME OF EARLIER WORKS

As early as 1847, Rink gave a short account of the Nicobar Islands. He also found evidences of a Recent geological disturbance in this area in elevated limestone deposits along the shores. A relative change in the levels of land and sea to a tune of 6-8 feet has taken place here in the Recent time. In 1858, the Austrian frigate *Novara* surveyed the area and charted the islands but no major biological study was carried out. Alcock (1893) with IMS *Investigator* visited Port Blair during 1888 and gave a very short description of the reef, also pointing out the adverse effect of silting in the inshore waters on coral growth. Sewell (1922), on board *Investigator*, described the morphology, community ecology and formation of the reefs of Nicobar in some detail. Exactly a century after the visit of *Novara*, another Austrian ship *Xarifa*, with a team of German scientists, laid anchor in Great Nicobar with a view to investigating the reefs and the reef corals. Many stations in Great Nicobar and Tillanchong (Scheer, 1971) were studied and a fairly good collection of corals was made. This still remains to be the only documented coral collection from the Nicobar waters (Scheer and Pillai, 1974). Based on collections in the Indian Museum, Calcutta, Matthai (1924) gave an account of some families of corals from Andaman Islands (only one species *Hydnophora exesa* from Nicobar). The deep-sea corals are mainly known from the *Investigator* collections (Alcock, 1893). During the last decade, several small but valuable collections from Andamans made by the scientists of CMFR Institute have furthered our knowledge of the coral fauna of Andaman Islands and these were reported by Pillai (1969, 1972).

PHYSICAL CONDITIONS

Temperature and salinity

Published data on regular monitoring of temperature and salinity year round of this area is scanty. According to Sewell (1925 *a*), the surface temperature of the waters of the Andaman Sea ranged from 27.1° to 28.1°C during October to March. Daily variation in salinity was minimum ; only a range of 0.46 to 1.21 ‰. The mean monthly value of salinity was about 33 ‰.

Sedimentation

The inshore waters of Andaman and Nicobar Islands, particularly along the unprotected shores are often turbid due to the presence of terrigenous mud and sand. During rainy season large quantities of fine silt from the mangrove soil seems to be washed into the sea by rain water. The wind generated waves, especially during the monsoon seasons, stir up shore sand and get them suspended and later deposited at the nearshore areas. The nearshore areas of most of the islands are with a sandy or muddy bottom sometimes with a cover of sea-grass. To a depth of 1 m or so and upto a distance of nearly 100 m from the shore, coral growth, in general, is scarce and whatever corals are found in this situation are those capable of combating the effect of silting (Pillai, 1971). Away from the shore the effect of silting is less felt and, hence, corals start growing in profusion intermittent with sandy areas. In protected bays and shores the effect of silting is comparatively less. The major limiting factor to coral growth and many filter feeders in the shallow nearshore areas here seems to be the deleterious effect of silting.

Surface radiation and relative brightness of waters

Studies on radiation conditions and relative brightness of water at different depths in Great Nicobar (Ganges harbour) by Scheer during 1958 (Scheer, 1966; Scheer and Pillai, 1974) showed that nearly 40% of the surface brightness on a clear day was cut in the first metre of the water column both during fore and afternoons. Only 13.8% of the surface brightness was found to reach a depth of 10 m. This observation is in agreement with that made at Addu Atoll in Maldives during forenoon (Fransisket, in Scheer, 1966) with clear atoll waters and luxuriant growth of corals. It seems that, though turbidity is of a higher magnitude nearshore, in deeper waters it is less and primary production is not much affected due to turbid conditions that cut radiant light.

Productivity and nutrient supply

Generally speaking, coral growing areas are centres of high primary production (1500 to 3000 gC/m²/yr) mainly due to the concentration of *Zooxanthellae* in the polyps of hermatypes, alcyonarians and giant clams in the form of imprisoned algae. Free living algae and phytoplankters in the ambient waters also contribute their share. Determination of primary production on an inshore reef near Port Blair by flow respirometry (Nair and Pillai, 1972) has shown a total annual production of only 1200 gC/m², which is of a lower order compared to other reef regions such as Gulf of Mannar (2500 gC/m²/yr) and Minicoy (3000 gC/m²/yr) (Nair and Pillai, 1972). These authors pointed out that the reef of Andaman studied is non-autotrophic in the sense that the respiratory requirements of the organisms on the reef far exceed the total production. Gordon and Kelley (1962) reported a similar situation from a Hawaiian reef and Stoddart (1969) felt that such non-autotrophic conditions of reefs along large masses of land may simply reflect the basic difference in metabolism of reefs near large land masses and oceanic atolls. However, this remains to be further tested and proved. The possibility of the Nicobar reefs being more productive than those of the Andaman was suggested by Nair and Pillai (1972).

Though the major part of the oxygen production measured on reefs is from the imprisoned algae and the resulting carbon being deposited on skeleton-building reef organisms, in many parts of the Indo-Pacific large concentrations of zooplankton were observed on reef areas. The role of particulate carbon as a source of nutrient energy to plankton and its role in the bottom level of food chains in the reef ecosystem is now being better understood (Qasim and Sankaranarayanan, 1970). The mucus secreted by corals as a reaction to wave action and grazing of coral-eating animals like reef fishes, is believed to aid in the production of particulate carbon which may be available to plankters. Laboratory experiments with the nauplii of *Artemia* reared with coral mucus have shown that these nauplii grow faster and live longer than the control ones (Johannes, 1967). This suggests that coral mucus certainly aids as a source of food to small plankters. Another source of nutrient enrichment in reef sites is *Tridacna*. The faeces of *Tridacna* was found to enhance the protein contents of the surrounding waters. A medium sized *T. maxima* releases 17.3 to 26.1g of protein per year in French Polynesia, according to Richard and Salvat (1977). Further, the faeces contain large quantities of symbiotic algae that are released into the water, enriching the chlorophyll content. Since *Tridacna* is very common, and at some sites abundant, in Andaman-Nicobar area, they certainly should contribute significantly to the reef productivity. Studies on the planktological aspects of this area are of limited nature. Sewell (1925) stated that during southwest monsoon there is a heavy flow of oceanic waters from the open Bay of Bengal to the west coast of Andamans which brings a rich supply of plankton and nutrients that helps a better growth of corals on the west coast of Andaman-Nicobar Islands than on the east coast.

Morphology of Reefs

The reefs of Andaman and Nicobar Islands, in general, are of fringing type with a series of patch reefs along the shores, particularly in embayments. Along the west coast of Andamans, there is a chain of interrupted banks that might be homologous with a barrier reef (Alcock, 1902). Between these banks and the shore, the sea (lagoon) is nearly 40 fm deep and the outer edges of these banks steep suddenly to a depth of 250 to 300 fm. In essence we have here a barrier reef to a length of nearly 320 km (Sewell, 1925). The following details on the reefs are based on the present survey.

Reefs of Nancowry area

Fringing the west coast of Nancowry Island in Spiteful Bay from Mayo Point to the extreme south there are coral patches. Corals grow in isolated colonies or in dense assemblages, intermittent with sandy areas. In certain places there was a profuse growth of ramose corals of *Acropora formosa* and *A. nobilis* but the area was found with a recent deposit of mud that has killed many colonies. Some of the specimens were found lying loose and only their top branches living (Pl. I, A). At a depth of 2 m and below the growth of corals becomes very profuse. Large colonies of faviids and *Porites* thrive here in luxuriant condition mixed with ramose corals of *Acropora* and *Pocillopora*. Alcyonarians are also found in good numbers. There is a concentration of *Fungia* (*F. echinata* and *F. fungites*) at certain sites on hard and sandy surfaces. On the sandy bottom *Holothuria* and *Stichopus* are the most dominant animals.

The shores of the north and northeastern sides of the Octavia Bay have mangroves chiefly of *Sonnertia* and *Rhizophora*. Corals are found from 50 m from the shore but significant growth occurs only at a depth of 1.5 m and below, about 100 m from the shore line. Massive colonies include those of *Favia*, *Favites*, *Platygyra* and *Porites*. *Acropora* and *Pocillopora* also occur but they dominate in deeper waters at the outer side of the reef. There is a heavy concentration of the blue coral *Heliopora coerulia* (Pl. I, B). The soft corals include many alcyonarians along with *Isis hippuris*. The area was found to be a very rich ground for reef associated fishes such as carangids, lethrinids, lutjanids, pomacentrids and pomadasyds.

In the East Bay in Katchall Island there is a well developed reef with an elevated flat almost continuous with the shore. The reef is mostly consolidated, level and is approximately 500 m wide. The exposed part of the flat at the higher zones is generally devoid of corals. But many crinoids were observed.

At the southern east coast of the Katchall Island (at Hoinipoh) there is a well developed patch reef. The bottom is with fine sand where corals grow in fair numbers. Both massive and ramose corals are found on the inner side. This zone is followed by a zone of alcyonarians which covers most of the available bottom. On the outer side, beyond the zone of soft corals, again scleractinians dominate. *Acropora hyacinthus*, *A. millepora* and *A. humilis* along with *Pocillopora damicornis* constitute the dominant ramose forms. *Porites lutea*, *Goniastrea retiformis* and *Platygyra lamellina* are the major massive forms. Reef fishes are very rich. Found among the corals are very many gastropods. Sea cucumbers form the dominant epifauna of the bottom sand.

The information given below on the Tillanchong Island is mainly based on Scheer (1971) and Scheer and Pillai (1974). The Castle Bay on the south has a rich growth of coral, the reef starting from the nearshore line. The bottom is sandy with a seagrass bed that harbours holothurians in large numbers. The reef flat is fissured and the first corals to appear on the flat are *Pocillopora damicornis* and *Acropora* spp. Large sized colonies of *A. palifera* are found in deep waters. Beyond the reef front the bay bottom is covered with a fine ooze supporting large number of solitary corals *Heterocyathus* and *Heteropsammia* along with free lying colonies of *Goniopora stokesi*.

The reefs of Andamans

This area has been poorly covered for reef studies. At Rangat the reef is thickly populated by massive corals, mainly *Porites lutea*. In sandy bottom *Pocillopora* spp. and *Acropora* spp. are found. *Montipora foliosa* and *Echinopora horrida* are found to cut foliaceous coralla. There is an accumulation of coral shingle over which several specimens of *Crassostrea cucullata* are seen at the littoral zone. Below the zone of *Crassostrea*, *Tridacna* were common along with gastropods. In Havelock Island the major reef builders are *Porites* spp. and among them *Tridacna* is found in abundance. In Long Island also dominant corals comprise massive types and the bottom coverage by live corals is about 75%. In Hut Bay large number of recently dead coral colonies were observed over which calcareous algae started growing. The area is muddy and the death of corals may be due to silt.

In general, the protected bays of these islands have a better coral growth along the nearshore areas than the open coasts. This might be due to less interference from silt by wave action. Between the Andamans and the Nicobars the latter have a comparatively richer growth of corals.

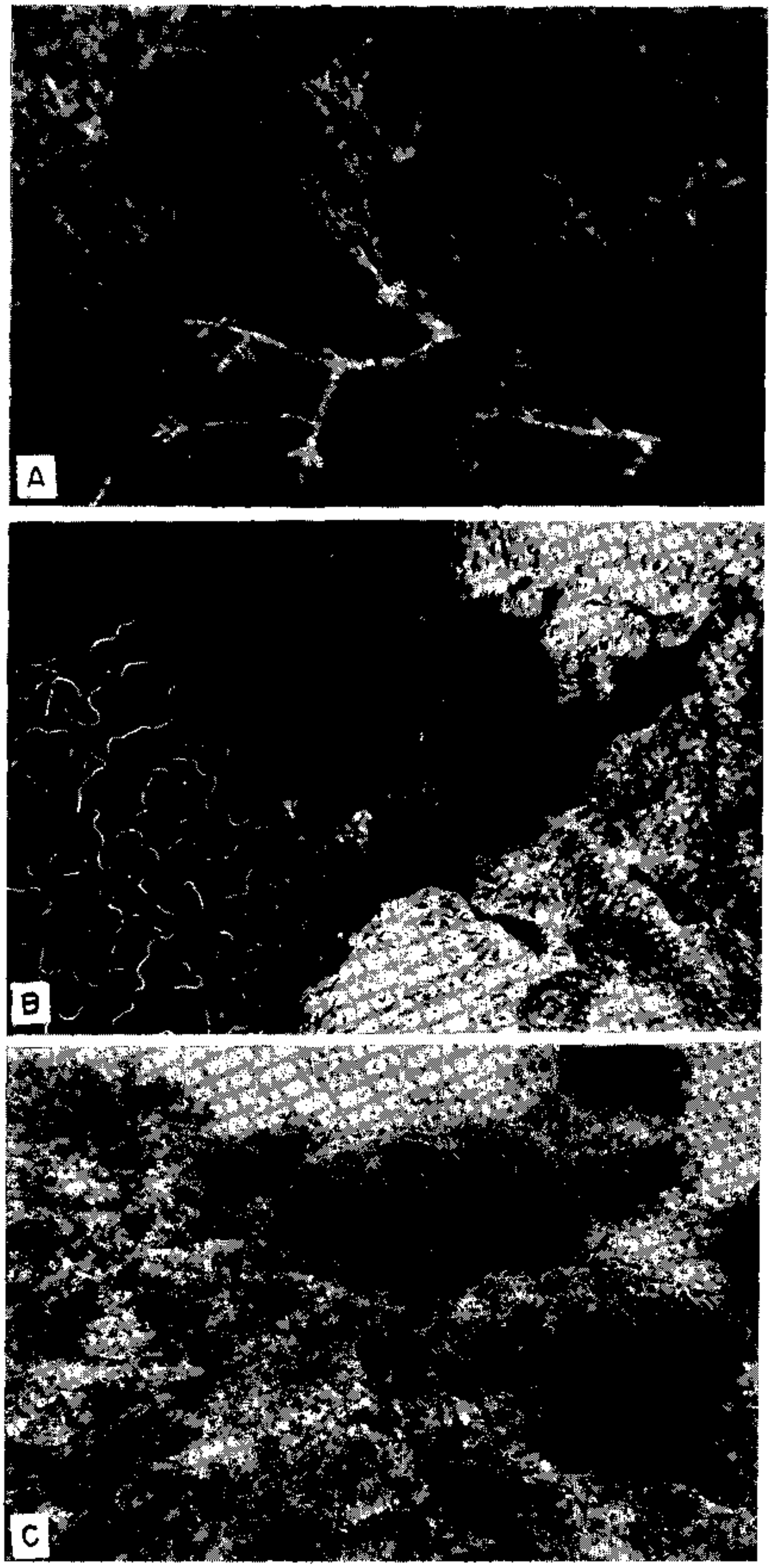


PLATE I. A—*Acropora* thicket at Wandoor, South Andaman Is. The lower parts of many specimens (*A. nobilis*) are dead. B—Reef area in Trinkat Is. Bottom right *Heliopora coerulia;* Centre top *Goniastrea pectinata;* Centre *Tridacna maxima*; Left half *Montipora*. C—Ramose corals in south-east Katchall with a concentration of *Heliopora coerulia, Acropora, Seriatopora hystrix* (top left) and alcyonarians. (Photographs by Shri K. Nagappan Nayar).

Andaman and Nicobar Reefs as Biotope

The zonation of hermatypes in this area, if any, has not been studied in detail. However, two major patterns can be derived *viz.* the massive forms and the ramose forms, each with a set of reef-building and reef-swelling species. The massive corals of this area, just like any other major Indo-Pacific coral provinces, include *Favia*, *Favites*, *Platygyra*, *Symphyllia*, *Goniastrea*, *Diploastrea* and *Porites*. The branching forms are represented by *Pocillopora*, *Stylophora*, *Seriatopora*, *Acropora* and *Montipora* spp. (Pl. I, C). A third assemblage is locally made of foliaceous forms like *Montipora foliosa*, *Echinopora lamellosa* or *E. horrida* and *Pavona* spp. The non-scleractinian corals are abundant in Andaman and Car Nicobar islands at certain localities and these are chiefly *Heliopora coerulia*. *Millepora platyphyllia* is often found. *Tubipora musica* is in great profusion in shallow waters in Car Nicobar.

The coral fauna of this area has been listed by Pillai (1972) from Andamans and Scheer and Pillai (1974) from Nicobars. Since then a few more species were obtained from this area and, to-date, a total of 135 species divided among 59 genera is known for both Andaman and Nicobar together, of which 110 species of 45 genera are hermatypes and 25 species of 14 genera are ahermatypes. A checklist of corals from Andaman and Nicobar Islands is given in the Annexure. *Madracis* sp., *Stylophora pistillata*, *Echinopora horrida* and *Physophyllia lichstensteini* were reported from Andaman and Nicobars for the first time though all are widely spread Indo-Pacific species.

Major Reef Habitats with Notes on Dominant Fauna

The sand and shingles of the upper eulittoral

This habitat is present along several shores. The beach sand in this zone is ideal habitat for burrowing clams like *Donax* spp. and *Actactodea*. A few crustaceans like *Hippa* are seen at the lowest water mark. The dead coral shingle harbours *Crassostrea cucullata* at higher levels at many sites in Car Nicobar and lower down gastropods like *Nerita*, *Thais*, *Drupa*, *Trochus* and *Cerithium* grow. In certain places *Tridacna* was noticed at the lowest level where the exposure time is minimum.

Sea-grass beds, subtidal lagoon and inshore sand

Cymodocea and *Thalassia* often cover considerable areas of the bottom in the nearshore waters. The sandy areas and the sea-grass beds are ideal habitats for sea-cucumbers such as *Holothuria atra*, *H. scabra* and *Stichopus* sp. Though the inshore area is with a high degree of sediments, the washout into the sea, particularly from the mangrove soil, during the rains brings lot of organic rich silt that provide food to these detrital feeders.

Subtidal dead shingle

The subtidal, loose or intact dead corals are very suitable dwelling places for many bivalves such as *Arca*, *Tridacna* and pearl oysters. Since this is a more stable habitat than the littoral shingle, species diversity is high here, though the population within a species is of a lesser magnitude than the eulittoral shingle. In Andaman-Nicobar Islands *Tridacna* is very common in this situation. Work elsewhere (Jaubert, 1977, p. 490) has shown that this genus has a tendency to live on the surface and sides (not underneath) of boulders and corals and it flourishes within a depth of 1 to 5 m. Beyond 15 m it does not thrive well since the radiant light is not sufficient for the symbiotic algae to photosynthesise.

The reef flats and subtidal reefs

The elevated parts of the reef flats are subject to much exposure and give extreme conditions for many animals. Only a few animals such as *Crassostrea*, mytilids, *Trochus* and other gastropods that are capable of surviving prolonged exposure and temperature fluctuations can thrive here.

The dead and living corals in the subtidal zones are excellent living situations for many molluscs, crustaceans, sponges and many worms. Among the gastropods *Drupa*, *Pyrene* and *Cerithium* are found to concentrate among the branches of ramose corals. Pearl oysters live attached to the top and sides of ramose and massive corals. Many bivalves like *Arca* and borers like *Lithophaga* are in plenty on dead and living corals.

References

Alcock, A. 1893. On some newly recorded corals from the Indian Seas. *J. Asiat. Soc. Beng.*, **62** (2) : 138-149.

Alcock, A. 1902. A naturalist in Indian Seas. Or *Five years with the Royal Indian Marine Survey Ship Investigator.* John Murray, London 328 pp.

Gordon, M. S. and A. M. Kelley. 1962. Primary production of an Hawaiian coral reef. A critique of flow respirometry in turbulent waters. *Ecology*, **43** : 473-480.

Jaubert, Jean. 1977. Light metabolism and distribution of *Tridacna maxima* in a South Pacific Atoll : Tokapoto (French Polynesia). *Proc. IIIrd Internat. Symp. on Coral Reefs*, Vol. I, 490-494, Univ. Miami.

Johannes, R. E. 1967. Ecology of organic aggregates in the vicinity of a coral reef. *Limnol. Oceanogr.*, **12** : 189-195.

Matthai, G. 1924. Report on the Madreporarian corals in the collection of the Indian Museum Pt. 1. *Mem. Indian Mus.*, **8** : 1-59. Calcutta.

Nair, P. V. R. and C. S. G. Pillai. 1972. Primary productivity of some coral reefs in the Indian Seas. *Proc. Symp. Corals and Corals Reefs, Mar. biol. Ass. India*, 33-42.

Pillai, C. S. G. 1969. Studies on Indian corals-5. Preliminary records of bermatypic corals of the suborder Astrocoeniina. *J. mar. biol. Ass. India*, **9** : 412-422.

Pillai, C. S. G. 1971. Distribution of corals on a reef at Mandapam, Palk Bay, South India. *J. mar. biol. Ass. India*, **11** (1 and 2) : 62-72.

Pillai, C. S. G. 1972. Stony coral of the seas around India. *Proc. Symp. Corals and Coral Reefs, Mar. biol. Ass. India*, 191-216.

Qasim, S. Z. and V. N. Sankaranarayanan. 1970. Production of particulate organic matter by the reef on Kavaratti Atoll (Laccadives). *Limnol. Oceanogr.*, **15** (4) : 574-578.

Richard, M. and B. Salvat. 1977. Faeces of *Tridacna maxima* (Mollusca, Bivalvia) composition and coral reef importance. *Proc. IIIrd Internat. Symp. Coral Reefs*, Vol. 1 : 495-501. Univ. Miami.

Rink, P. K. 1847. *Die Nikobaren Insel.* Kobenhagen. (Cited after Sewell, 1925).

Scheer, G. 1966. Remarks on radiation conditions and brightness measurements in water. part. 2. *Jena Review, 11th year* Nos. 4 and 5 : 263-267.

Scheer, G. 1971. Coral reefs and coral genera in the Red Sea and the Indian Ocean. In : *Regional variation in Indian Ocean Coral reefs. Symp. zool. Soc. Lond.*, **28** : 329-367.

Scheer, G. and C. S. G. Pillai. 1974. Report on the scleractinia from the Nicobar Islands. *Zoologica Stutt.*, **122** : 1-75, pls. 1-33.

Sewell, R.B.S. 1922. A survey season in Nicobar Islands on the RIMS 'Investigator', October 1921 to March, 1922. *J. Bombay Nat. Hist. Soc.*, **28** : 970-989.

Sewell, R. B. S. 1925. The geography of the Andaman Sea Basin. *Mem. Asiat. Soc. Beng.*, 9 (1) : 1-26.

Sewell, R. B. S. 1925 *a*. Temperature and salinity of the coastal waters of the Andaman Sea. *Mem. Asiat. Soc. Bengal*, 9 (1) : 133-198.

Sewell, R. B. S. 1935. Studies on corals and coral formations in Indian waters. *Mem. Asiat. Soc. Bengal*, 9 (2) : 461-540.

Stoddart, D. R. 1969. Ecology and morphology of recent coral reefs. *Biol. Rev.*, **44** : 433-498.

ANNEXURE

Checklist of Scleractinian Corals from Andaman and Nicobar Islands

The various species under different genera are listed according to their taxonic affinities.

Class ANTHOZOA
Order Scleractinia

Family **Thamnasteriidae**

PSAMMOCORA Dana, 1846.

P. contigua (Esper), 1797.
P. profundacella Gardiner, 1898.

Family **Pocilloporidae**

STYLOPHORA Schweigger, 1819.

S. pistillata (Esper) 1797.

SERIATOPORA Lamarck, 1816

S. hystrix (Dana), 1846
S. crassa Quelch, 1886
S. stellata Quelch, 1886

POCILLOPORA Lamarck, 1816

P. damicornis (Linnaeus), 1758
P. brevicornis Lamarck, 1816
P. verrucosa (Ellis and Solander), 1786
P. meandrina var. *nobilis* Verrill, 1864
P. ankeli Scheer and Pillai, 1974
P. eydouxi Milne Edwards and Haime, 1860

MADRACIS Milne Edwards and Haime, 1849
Madracis sp.

Family **Acroporidae**

ACROPORA Oken, 1815

A. formosa (Dana), 1846
A. virgata (Dana), 1846
A. gravida (Dana), 1846
A. efflorescens (Dana), 1846
A. conigera (Dana), 1846
A. secale (Studer), 1878
A. hyacinthus (Dana), 1846
A. millepora (Ehrenberg), 1834
A. pinguis Wells, 1950.
A. palifera (Lamarck), 1816.
A. nobilis (Dana), 1846.
A. plantaginea (Lamarck), 1816. (= *A. humilis* (Dana)
A. diversa (Brook), 1893.
A. variabilis (Klunzinger), 1879.
A. rambleri (B. Smith), 1880.
A. dumosa (Brook), 1893.
A. multiacuta Nemenzo, 1967.

MONTIPORA Quoy and Gaimard, 1830

M. tortuosa (Dana), 1846.
M. digitata (Dana), 1846.
M. cocosensis Vaughan, 1918.
M. turgescens (Dana), 1846
M. peltiformis Bernard, 1896
M. foliosa (Pallas), 1766.
M. composita Crossland, 1952.

ASTREOPORA de Blainville, 1830

A. listeri Bernard, 1896.

Family **Agariciidae**

PAVONA Lamarck, 1801

P. explanulata (Lamarck), 1816.
P. xarifae Scheer and Pillai, 1974.
P. varians Verrill, 1864.
P. decussata (Dana), 1846.
P. praetorta (Dana), 1846.
P. clavus (Dana), 1846.
P. duerdeni Vaughan, 1907.

PACHYSERIS Milne Edwards and Haime, 1849

P. rugosa (Lamarck), 1801.
P. speciosa (Dana), 1846.

LEPTOSERIS Milne Edwards and Haime, 1849

L. papyracea (Dana), 1846.
L. fragilis Milne Edwards and Haime, 1849.

COELOSERIS Vaughan, 1918

C. mayeri Vaughan, 1918.

Family **Siderasteridae**

PSEUDOSIDERASTREA Yabe and Sugiyama, 1935

P. tayami Yabe and Sugiyama, 1935.

Family **Fungiidae**

CYCLOSERIS Milne Edwards and Haime, 1849

C. cyclolites (Lamarck), 1816.
C. sinensis Milne Edwards and Haime, 1860.
C. distorta (Michelin), 1843.
C. hexagonalis Milne Edwards and Haime, 1849.
C. costulata (Ortmann), 1889.

FUNGIA Lamarck, 1801

F. scutaria Lamarck, 1801.
F. paumotensis Stutchberry, 1833.
F. somereville Gardiner, 1909.
F. echinata (Pallas), 1766.
F. repanda Dana, 1846.
F. danai Milne Edwards and Haime, 1851.
F. fungites (Linnaeus), 1758.
F. horrida Dana, 1846.

FUNGIACYATHUS Sars, 1872

F. symmetrica (Pourtales), 1879.

HERPOLITHA Eschscholtz, 1826

H. limax (Esper), 1797

HERPITOGLOSSA Wells, 1966

H. simplex (Gardiner), 1909.

POLYPHYLLIA Quoy and Gaimard, 1833

P. talpina (Lamarck), 1909.

Family **Poritidae**

GONIOPORA de Blainville, 1830

G. stokesi Milne Edwards and Haime, 1851
G. tenuidens (Quelch), 1886.
G. planulata (Ehrenberg), 1834.

PORITES Link, 1807

P. solida (Forskal), 1775.
P. lobata Dana, 1846.
P. lutea Milne Edwards and Haime, 1851.
P. eridani Umbgrove, 1941.

ALVEOPORA de Blainville, 1830

A. daedalea (Forskal), 1775.

Family **Faviidae**

PLESIASTREA Milne Edwards and Haime, 1848

P. versipora (Lamarck), 1816.

FAVIA Oken, 1815

F. stelligera (Dana), 1846.
F. pallida (Dana), 1846.
F. speciosa (Dana), 1846.
F. favus (Forskal), 1775.
F. rotumana Gardiner, 1898.
F. valenciennesi (Milne Edwards and Haime), 1848.

FAVITES Link 1807

F. abdita (Ellis and Solander), 1786.
F. complanata (Ehrenberg), 1834.
F. flexuosa (Dana) 1846.

GONIASTREA Milne Edwards and Haime, 1848

G. retiformis (Lamarck), 1816.
G. pectinata (Ehrenberg), 1834.

PLATYGYRA Ehrenberg, 1834

P. lamellina (Ehrenberg), 1834.

LEPTORIA Milne Edwards and Haime, 1848

L. phrygia (Ellis and Solander), 1786.

OULOPHYLLIA Milne Edwards and Haime, 1848

O. aspera (Quelch), 1886.

HYDNOPHORA Fischer de Waldheim, 1807

H. exesa (Pallas), 1776.
H. microconos Lamarck, 1816.
H. laxa (Dana), 1846.

DIPLOASTREA Matthai, 1914

D. heliopora (Lamarck), 1816.

OULASTREA Milne Edwards and Haime, 1848

O. crispata (Lamarck), 1816.

LEPTASTREA Milne Edwards and Haime, 1848

L. purpurea (Dana, 1846.

CYPHASTREA Milne Edwards and Haime, 1848

C. microphthalma (Lamarck), 1816.

ECHINOPORA Lamarck, 1816

E. lamellosa (Esper), 1797.
E. horrida (Dana), 1846.

TRACHYPHYLLIA Milne Edwards and Haime, 1848

T. geoffroyi (Audouin), 1826.

Family **Rhizangiidae**

CULICIA Dana, 1846

C. rubeola (Quoy and Gaimard), 1833.

Family **Oculinidae**

GALAXEA Oken, 1805

G. fascicularis (Linnaeus), 1758.
G. clavus (Dana), 1846.

Family **Merulinidae**

MERULINA Ehrenberg, 1834

M. ampliata (Ellis and Solander), 1786.

SCAPOPHYLLIA Milne Edwards and Haime, 1848

S. cylindrica (Milne Edwards and Haime, 1848.

Family **Mussidae**

LOBOPHYLLIA de Blainville, 1830

L. corymbosa (Forskol), 1775.

SYMPHYLLIA Milne Edwards and Haime, 1848

S. nobilis (Dana), 1846.
S. radians Milne Edwards and Haime, 1849.

Family **Pectinidae**

MYCEDIUM Oken, 1815

M. elephantotus (Pallas), 1766.

PECTINIA Oken, 1815

P. lactuca (Pallas), 1766.

Family **Caryophylliidae**

CARYOPHYLLIA Lamarck, 1801

C. arcuata Milne Edwards and Haime, 1848.
C. clavus Scacchi, 1835.
C. (Acanthocyathus) grayi Milne Edwards and Haime, 1848.

DELTOCYATHUS Milne Edwards and Haime 1848

D. andamanicus Alcock, 1898.

PARACYATHUS Milne Edwards and Haime, 1848

P. indicus Duncan, 1889.

POLYCYATHUS Duncan, 1876

P. verrilli Duncan, 1889.
P. andamanensis Alcock, 1893.

HETEROCYATHUS Milne Edwards and Haime, 1848

H. aequicostatus Milne Edwards and Haime, 1848.

EUPHYLLIA Dana, 1846

E. glabrescens (Chamisso and Esynhardt), 1821.

PLEROGYRA Milne Edwards and Haime, 1848

P. sinuosa (Dana), 1846.

PHYSOGYRA Quelch, 1884

P. lichtensteini (Milne Edwards and Haime), 1851.

Family **Flabellidae**

PLACOTROCHUS Milne Edwards and Haime, 1848

P. laevis Milne Edwards and Haime, 1848.

Family **Dendrophylliidae**

BALANOPHYLLIA Wood, 1844

B. affinis (Semper), 1872.
B. scabra Alcock, 1893.

HETEROPSAMMIA Milne Edwards and Haime, 1848

H. michelini Milne Edwards and Haime, 1848.

TUBASTREA Lesson, 1834

T. coccinea (Ehrenberg), 1834.

DENDROPHYLLIA de Blainville, 1830

D. arbuscula Horst, 1922.
D. minuscula Bourne, 1905.
D. micranthus (Ehrenberg), 1834.

ENALLOPSAMMIA Micheloti, 1871

E. amphelioides (Alcock), 1902.
E. marenzelleri Zibrowius, 1973.

TURBINARIA Oken, 1818

T. crater (Pallas), 1766.
T. peltata (Esper), 1797.
T. veluta Bernard, 1896.

7

MANGROVE RESOURCES

C. P. GOPINATHAN[1] AND M. S. RAJAGOPALAN[2]

INTRODUCTION

There has been an increasing awareness among the scientific community that the mangroves are an important component of the tropical marine ecosystem and apart from the economic uses of their vegetation, the mangrove areas are potential grounds for coastal aquaculture. It is generally recognised that mangrove areas form the feeding and nursery grounds for the juvenile stages of many commercially important species of prawns and fishes. The high productivity resulting from mangrove leaf fall supports a host of detritus feeding animals such as amphipods, mysids, harpacticoids, molluscs, crustacean larvae, prawns and fishes. The mangrove vegetation acts as a buffer against tidal currents, floods, storms and cyclones and the network of creeks and channels provide shelter to aquatic life especially in the critical stages of their life history. The vegetation also helps in preventing soil erosion in the coastal zone.

Blasco (1975) has made a comprehensive study of the mangroves of India. It is estimated that the mangrove areas in India spread to about 0.7 million ha and in the Andaman-Nicobar Islands alone it occupies 115, 200 ha. Thottathri (1960, 1962) gives a detailed account of the mangrove vegetation of Andaman-Nicobar islands. The Union Territory of Andaman-Nicobar Islands consists of several islands extending to about 800 km between lat. 6°40′ N and 13°41′ N. These islands have a long coastline where mangrove vegetation thrives under typical tropical conditions. The mangroves in general are a complex ecosystem which is influenced by tropical rains, tidal interaction, winds, cyclone and habitats such as rocky substratum and coral reefs. Because of the sparse human population and browsing cattle, the mangroves of these islands are well preserved by nature as compared to those of the Gulf of Kutch and Sunderbans which are being continually exploited for fodder and firewood. The mangroves have good seed resources of prawns and fishes.

Present address :

[1] CMFRI, Research Centre, Tuticorin 628 001.

[2] CMFRI, Cochin 682 018.

ECOLOGICAL CHARACTERISTICS

Vegetation

There are 55 mangrove species in the world, of which 27 have been recorded from India including the Andaman-Nicobar islands (Banerji, 1958 ; Navalkar, 1973). Broadly, there are three habitats of mangroves, namely the coastal mangroves, mangroves along the creeks and back mangroves which are not influenced by tidal effects. The physico-chemical condi ions of the water in the swamp area, the soil and substratum supporting the vegetation and the faunal association exhibit variations in these three habitats. These ecological conditions give rise to changing pattern of vegetation as well as succession in the mangrove species (Macnae, 1968 ; Walsh, 1974). The important mangrove trees identified in these areas were : *Avicennia marina, Sonneratia caseolaris, S. alba, Rhizophora mucronata, R. apiculata, Excoecaria agallocha, Bruguiera gymnorhiza, B. parviflora, Aegiceras corniculatum, Nypa fruiticans* and *Barringtonia racemosa.* In addi ion to typical mangrove vegetation, terrestrial forms consisting of *Pandanus* sp., *Calophyllum inophyllum, Hibiscus tiliaceous* and *Thespesia populnea* colonise the upper zone and exhibit a kind of association.

Depending upon the nature of the substratum, different associations could be seen in the mangrove areas investigated. These are :

1. *Avicennia—Sonneratia—Rhizophora* association
2. *Bruguiera—Excoecaria—Barringtonia* association
3. *Pandanus—Thespesia—Hibiscus* association

The mangrove swamps of the islands protect an abundance of microscopic and macroscopic algae. The higher algal forms such as *Padina gymnospora*

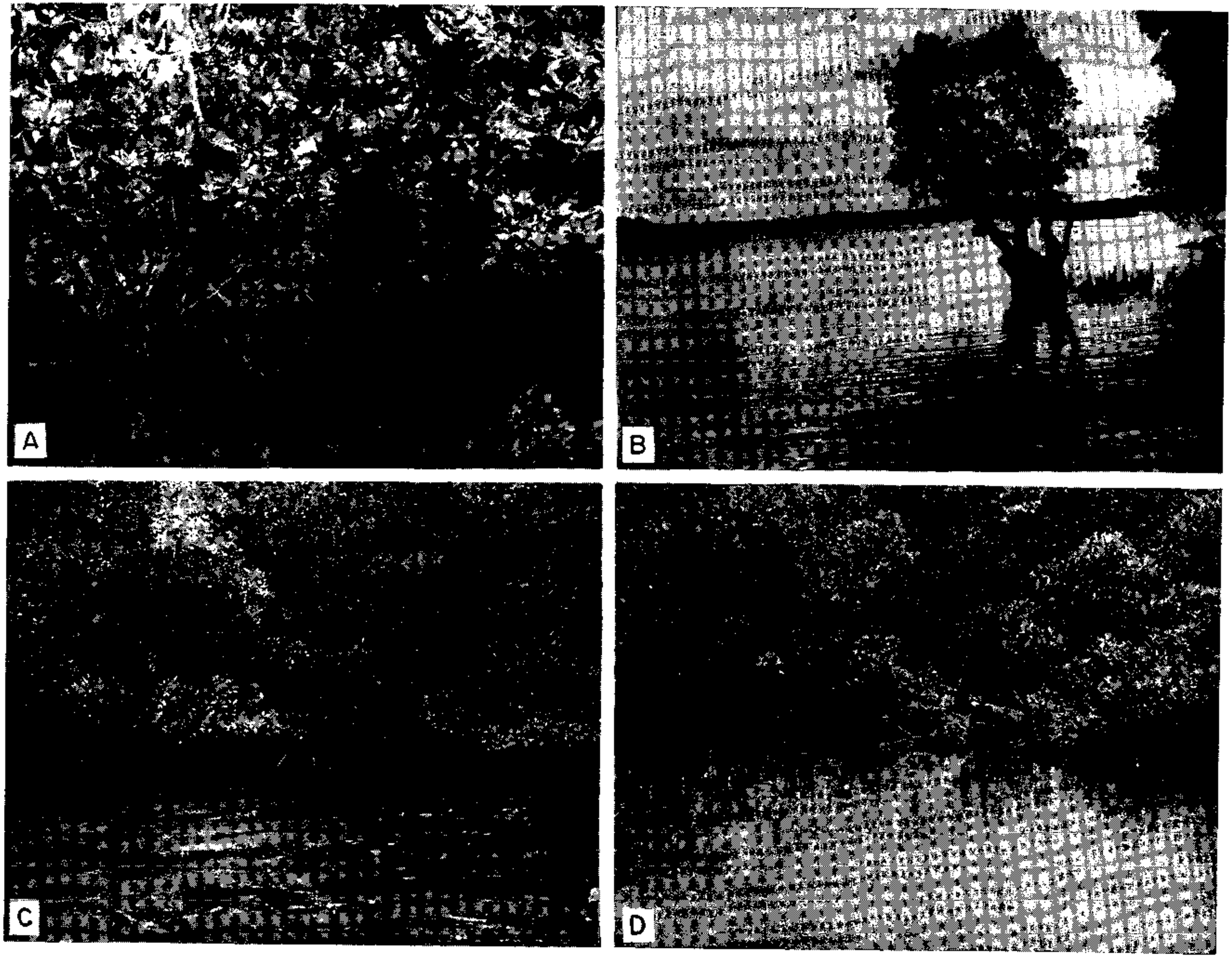


PLATE I. A. Diglipur; thick vegetation of *R. mucronata* in the mangrove; B-D. Mangroves of Spiteful Bay, Nancowry Island; B—*Avicennia marina* with submerged 'pneumatophores' in the marsh, C—*Rhizophora mucronata* and seagrass *Cymodocea* in shallow swamp, D—*A. marina* and *R. mucronata* dominating floral association.

Laurencia papillosa, *Dictyota dichotoma* and *Ulva lactuca* could be seen in most of the mangroves investigated. Besides, the micro-algal forms such as species of *Enteromorpha*, *Chaetomorpha*, *Cladophora* and *Ectocarpus* were also present.

An association dominated by the seagrasses *Zostera*, *Thalassia* and *Cymodocea* could be seen in the Spiteful Bay of Nancowry and Kakana region of Camorta Island. Strictly *Rhizophora mucronata* forests could be seen in the mangrove areas of Lakshmipur (Diglipur), Mayo, Wandoor, Chiriyatapu and Kimios (Car Nicobar). In the Corbyn's Cove near Port Blair and Katchall East Bay *Avicennia marina* is dominant.

Salient features of important mangroves

Diglipur (Pl. I, A): In the Ariel Bay region, the Lakshmipur mangrove shows thick growth of *Rhizophora mucronata* and *R. apiculata*. The alginophytic seaweeds *Padina* and *Dictyota* were found to grow well in this mangrove. The rate of production of the water column is of a lesser order (< 0.2 $gC/m^2/day$) due to the lack of sufficient illumination. Rock oysters and few fish fry were collected from the swamp.

Mayabunder: On the southern side of the jetty and in the Seaward Bay, luxuriant growth of *Rhizophora mucronata* and *Sonneratia caseolaris* was observed. The alginophytes *Sargassum* spp. and *Padina gymnospora* grow in the intertidal area. Production rate of the water column was high (> 0.5 $gC/m^2/day$).

Rangat: The mangrove is dominated by species of *Rhizophora*, *Avicennia* and *Excoecaria*. Comparatively moderate rate of production was noticed in this region (0.2-0.5 $gC/m^2/day$). The faunistic composition of this area shows an abundance of oyster spat, young ones of *Trochus*, *Turbo* and other gastropods such as *Cerithedium* and *Telescopium*.

Henry Lawrence: Western side of this island has a good mangrove swamp with species of *Rhizophora* and *Sonneratia*. Seaweeds such as *Padina*, *Sargassum* and *Turbinaria*, edible oysters and crabs were abundant. The rate of primary production is less than 0.5 $gC/m^2/day$.

Neill: *Rhizophora* and *Excoecaria* thrive on the northern and southern side of this island. The rate of production of the water is moderate (0.3-0.5 $gC/m^2/day$). The faunistic composition consists of young ones of edible oysters, few fish fry and crabs.

Chiriyatapu and Wandoor: The mangrove areas of this part of southern Andamans have a luxuriant growth of *Rhizophora mucronata* alone. Primary production (> 0.5 $gC/m^2/day$) is high and the faunistic composition proved to be good. Large quantities of fish fry (*Harengula ovalis*) and ocypod, graphid and xanthid crabs were collected.

Corbyn's Cove (Port Blair): *Avicennia marina* is dominant. The bay as well as the mangrove swamp water has a high rate of primary production (> 1 $gC/m^2/day$). The fauna consists of ocypod crabs, mud skipper *Periophthalmus* sp., fry of *Ambassis* sp. and *Therapon* sp. Seaweeds were not common in the swamp region.

Janglighat (Navy Bay, Port Blair): Navy Bay mangrove has a domination of *Avicennia marina*. The swamp in the jetty region is naturally protected and the depth is less than 4 m. This area was observed to have plenty of prawn seed, especially of *Penaeus merguiensis* and *Metapenaeus ensis* and crabs such as *Portunus pelagicus* and *Scylla serrata*.

Car Nicobar: The Kimios Bay encloses a thick mangrove vegetation dominated by *Rhizophora mucronata*. The production rate of the water was very high (> 1 $gC/m^2/day$). Seedlings of mullets and prawns, particularly *Macrobrachium equidens* were found in large quantities. Crabs *Portunus pelagicus*, *Thalamita crenata*, *Calappa hepatica* and *Metapograpsus messor* were present.

Katchall: In the east bay, the mangrove protects a good vegetation consisting of *Avicennia marina* and *Rhizophora mucronata* in the inner zone and *Pandanus* sp., *Bruguiera gymnorhiza* and *Barringtonia racemosa* in the upper zone. However, colonisation of *Hibiscus tiliaceous* and *Thespesia populnea* is also seen in the upper regions. Fry of mullets, *Ambassis* and *Therapon* were collected from here.

Nancowry (Pl. I, B-D): The Spiteful Bay is surrounded by *Rhizophora mucronata*, *R. apiculata*, *A. marina* and *Sonneratia caseolaris*. Primary production rate was more than 1 $gC/m^2/day$. Seagrasses such as *Thalassia* and *Cymodocea* were abundant in the shore region besides the domination of alginophytic seaweeds. The fauna consists of several species of crabs, fry of *Harengula ovalis*, mullets, mussels and edible oysters.

REMARKS

The practice of fish culture in brackishwater ponds (tambaks) cleared out of mangrove areas has been in vogue for many years in Indonesia. These ponds which are 0.5-2.0 ha in area are used to produce marketable crop of milkfish *Chanos chanos*. Several mangrove sites which are potential aquaculture farms have been surveyed in the Andaman and Nicobar Islands. Of these, the mangrove areas of Mayabunder, Rangat, Henry Lawrence, Neill, Chiriyatapu and Wandoor regions, Corbyn's Cove and Janglighat regions of Port Blair, Kimios Bay of Car Nicobar and Spiteful Bay of Nancowry appear suitable for developing mariculture. Chiriyatapu, Wandoor, Janglighat, Neill Islands and Kimios Bay appear good for developing 'tambak' system of coastal aquaculture.

References

BANERJI, J. 1958. The mangrove forests of the Andamans. Wld. For. Congr., 1954, 3, 1956 (1958), 425-430.

BLASCO, F. 1975. Mangroves of India. Inst. Francaise. Pondich., *Trav. Sec. Sci. tech.*, **14** (1) : 154-156.

MACNAE, WILLIAM. 1968. A general account of the fauna and flora of mangrove swamps and forests in the Indo-Pacific regions. *Adv. Mar. Biol.*, 6 : 73-270.

NAVALKAR, B. S. 1973. Ecology of mangroves. In : *Progress of plant ecology in India.* vol. 1. Today and Tomorrow Print. and Publ., New Delhi.

THOTTATHRI, K. 1960. Studies on the flora of Andaman Islands. *Bull. Bot. Surv. India*, **2** : 341-346.

THOTTATHRI, K. 1962. Contribution to the flora of Andaman-Nicobar Islands. *Bull. Bot. Surv. India*, **4** : 281-286.

WALSH, G. E. 1974. Mangrove : a review. In : *Ecology of halophytes.* Acad. Press. Inc., New York.

8

SEAWEED RESOURCES

C. P. GOPINATHAN[1] AND R. PANIGRAHY[2]

INTRODUCTION

The macroscopic algae comprising the three major classes Chlorophyceae (green algae), Phaeophyceae (brown algae) and Rhodophyceae (red algae), found mostly in the inter-tidal zone on the rocky coasts, are commonly referred as seaweeds. Recently their use as an industrial raw material in the production of agar and algin has created a great demand and attempts are under way to augment the resources by aquaculture practices. The Central Marine Fisheries Research Institute is playing a leading role in developing the techniques of seaweed culture in the Gulf of Mannar and Palk Bay. A gross picture of the seaweed resources along the coasts of mainland of India is available (Thivy, 1958; Rao, 1967, 1970).

Detailed surveys of seaweed resources have been carried out in different regions of the mainland : Mitra (1946) in Chilka Lake ; Koshy and John (1948) along Travancore coast ; Chacko and Pillai (1958) along Tamil Nadu coast ; Rao *et al.* (1964), Chauhan and Krishnamurty (1968) and Gopalakrishnan (1969) along Gujarat coast. More recently a collaborative survey was conducted by Central Marine Fisheries Research Institute, Central Salt and Marine Chemicals Research Institute and State Fisheries Department of Tamil Nadu, along the Tamil Nadu coast. To study the potential resources of seaweeds in the Andaman-Nicobar Islands, a preliminary investigation was conducted during January-April 1978 and the results are reported here.

MATERIAL AND METHODS

In the present investigation, 42 stations were covered from Diglipur in the north to Campbell Bay in the south. Seaweeds in the intertidal zone were collected in fresh condition from 1 sq. m area of the sampling sites for the determination of the biomass. Complete plants with holdfast representing different genera and species were detached carefully and preserved for detailed examination in the laboratory. Samples from deeper zones were collected by diving. But in such cases, quantitative sampling could not be done. Taxonomic determination was made using the morphological characters and also the nature of the fruiting bodies.

RESULTS

Altogether 55 species of seaweeds were collected from the Andaman-Nicobar Islands, of which 16 species belong to Chlorophyceae, 17 species to Phaeophyceae and 22 species to Rhodophyceae. The occurrence and distribution of these seaweeds are listed in the Annexure. Some of the species collected have been shown in Pl. I and II.

Diglipur : Harvestable quantities of alginophytes such as species of *Turbinaria* and *Sargassum* were noticed in the western side of Diglipur jetty, coastal areas of Table Island and the Ariel Bay as a whole. The agarophytes and other algal groups were poorly represented.

Mayabunder : In the Middle Andaman, Aves, Sound, Ray Hill and Stewart Islands were surveyed besides the coastal areas of Mayabunder. Most of the areas surveyed showed luxuriant growth of alginophytes such as *Padina, Turbinaria, Sargassum, Dictyota* and *Hormophysa*, especially at Oyster Point and German Jetty region of Mayabunder, western side of Ray Hill and Stewart Island. The harvestable quantity of agarophytes was found to be very poor.

Rangat : The seaweed vegetation was seen on the southern side of the Rangat jetty upto Nambuthalai at depths 1-3 m with the domination of alginophytes which were in harvestable quantities.

Havelock : In this section, Outram, Inglis, Sir William Peel, John Lawrence, Henry Lawrence and

Present address :

[1] CMFRI, Research Centre, Tuticorin-628 001.

[2] Marine Science Department, Berhampur University, Berhampur-760 007.

Kyd islands were surveyed in addition to the coast of Havelock. Seaweed vegetation with harvestable quantities of alginophytes was found in the rocky intertidal area of Havelock and the lagoons of John Lawrence. The agarophytes were poorly represented.

Neill : The coastal areas of Neill and Sir Hugh Rose islands were surveyed. The rocky coasts have seaweeds with the domination of alginophytes, but were not in harvestable quantity.

Chiriyatapu : Seaweed vegetation was noticed in the coastal region of Macpherson strait towards Chiriyatapu point. *Padina* spp. were dominant but did not occur in harvestable quantity.

Port Blair region : The coastal areas of Corbyn's Cove, Sesostris Bay, Navy Bay, Phoenix Bay, North Bay, Shoal Bay, Viper Island, Ross Island, Bamboo-flat and Chatham Island were investigated. The shores of Corbyn's Cove and Phoenix Bay are rocky and have good algal vegetation. Harvestable quantity of alginophytes was noticed in Phoenix Bay. No good algal vegetation was found in the rest of the areas except Sesostris Bay and North Bay where *Ulva* spp. occur as drift weeds. The results of survey conducted in the Port Blair areas showed that generally the algae were not abundant and most of them were not in harvestable size.

Little Andaman : The Hut Bay and Butler Bay were surveyed. The algal zone is very much reduced due to the sandy nature of the shore. An approximate area of 15 ha was surveyed and estimate showed a potential of about 120 tonnes of fresh alginophytes from this area. Agarophytes such as *Laurencia papillosa, Gracilaria crassa, G. corticata* and *Halimeda peltata* were also seen as drift weeds in small quantities.

Car Nicobar : Almost the entire coast of this island was surveyed and algal vegetation was found to be poor. In the Sawai Bay, alginophytes such as *Padina, Dictyota, Turbinaria* and *Hormophysa* and agarophytes such as *Gracilaria* and *Laurencia* were found in the sandy beaches as drift weeds.

Katchall : The east and west bays of this island were surveyed and negligible quantities of seaweeds were seen on the sandy beaches as drift weeds. Here also the algal zone is very limited. In the West Bay, the high wave action on the coralline rocky shore prevents the seaweeds from thriving, whereas in the East Bay, near Kapanga jetty, small areas have a good algal vegetation comprising the species of *Amphiroa, Galaxuara, Turbinaria* and *Sargassum.*

Camorta : The Cross harbour and the Kakana regions were surveyed. Species of *Ulva, Halimeda, Laurencia* and *Gracilaria* were attached on the fringing corals and also found as drift weeds in the shore region. The algal zone is very limited due to the steep increase of depth and luxuriant growth of corals around the island.

Nancowry : In the Champin and Spiteful Bay regions, a few alginophytes such as *Sargassum, Turbinaria* and *Padina* were observed. The agarophytes were represented by few numbers and *Ulva* spp. occurred in patches.

Trinkat : Since the whole coastal area of this island has a luxuriant growth of fringing corals, the algal vegetation is very poor. On these coral reefs some of the attached forms such as *Gracilaria corticata, G. millardtii* and *Turbinaria conoides* could be seen, but not in harvestable quantity.

Great Nicobar : In the Campbell Bay region of Great Nicobar, in the vicinity of the jetty, Vijayanagar, Dilla-nalla and the coastal waters, *Turbinaria* spp. *Gracilaria* spp. and *Ulva lactuca* were noticed as drift weeds. They were not in harvestable quantity.

REMARKS

During the present investigation, it was noticed that the Andaman and Nicobar Islands have a domination of alginophytes such as species of *Turbinaria, Sargassum* and *Padina* and the economically important agarophytes such as *Gracilaria* spp., *Gelidiella acerosa* and *Gelidium* spp. were poorly represented. Further, the alginophytes except *Padina,* were all in young stages during January-April and, therefore, this period is not suitable for harvest. There appears to be only a limited scope for the exploitation and utilisation of the naturally available seaweed resources in the islands. However, attempts can be made for culture of alginophytes since the seeding material of this group of algae is available in plenty, especially in the Andaman group of islands. In this latter area, the lagoons of John Lawrence island near Havelock, Corbyn's Cove and Navy Bay regions of Port Blair and Macpherson strait at Chiriyatapu with sandy substratum offer excellent grounds for culture practices of seaweeds. In the Nicobar group, Sawai Bay of Car Nicobar, East Bay of Katchall and Spiteful Bay of Nancowry are the suitable places for seaweed culture.

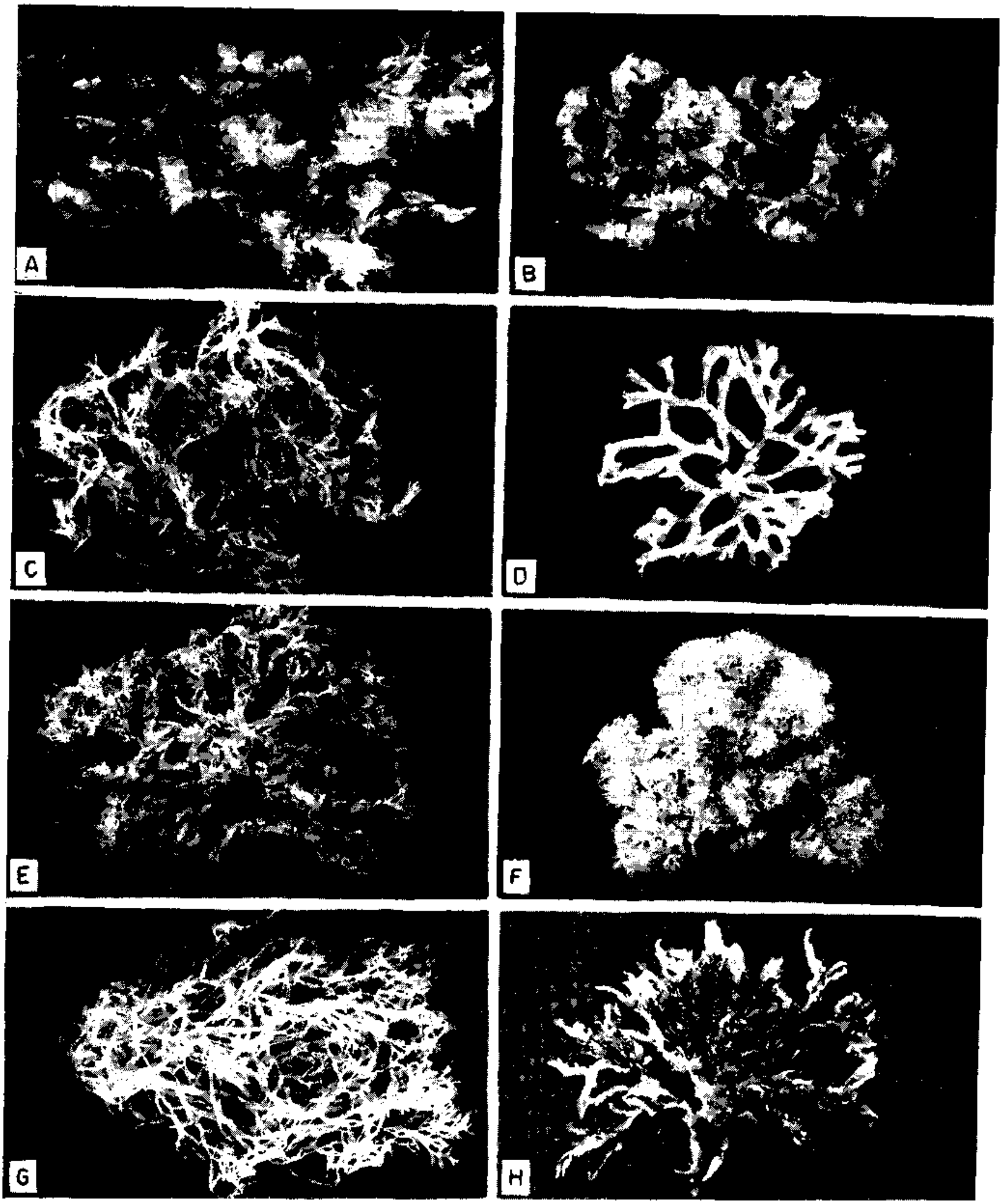


PLATE I. A. *Sargassum whitii.* B. *Turbinaria conoides*, both are algin yielding brown seaweeds. C. *Gracilaria edulis.* D. *Gracilaria crassa.* E. *Gracilaria foliifera.* F. *Gracilaria corticata* var. *cylindrica.* G. *Gracilaria corticata* var. *typica.* H. *Gracilaria millardetii.* C-H are agar yielding red seaweeds.

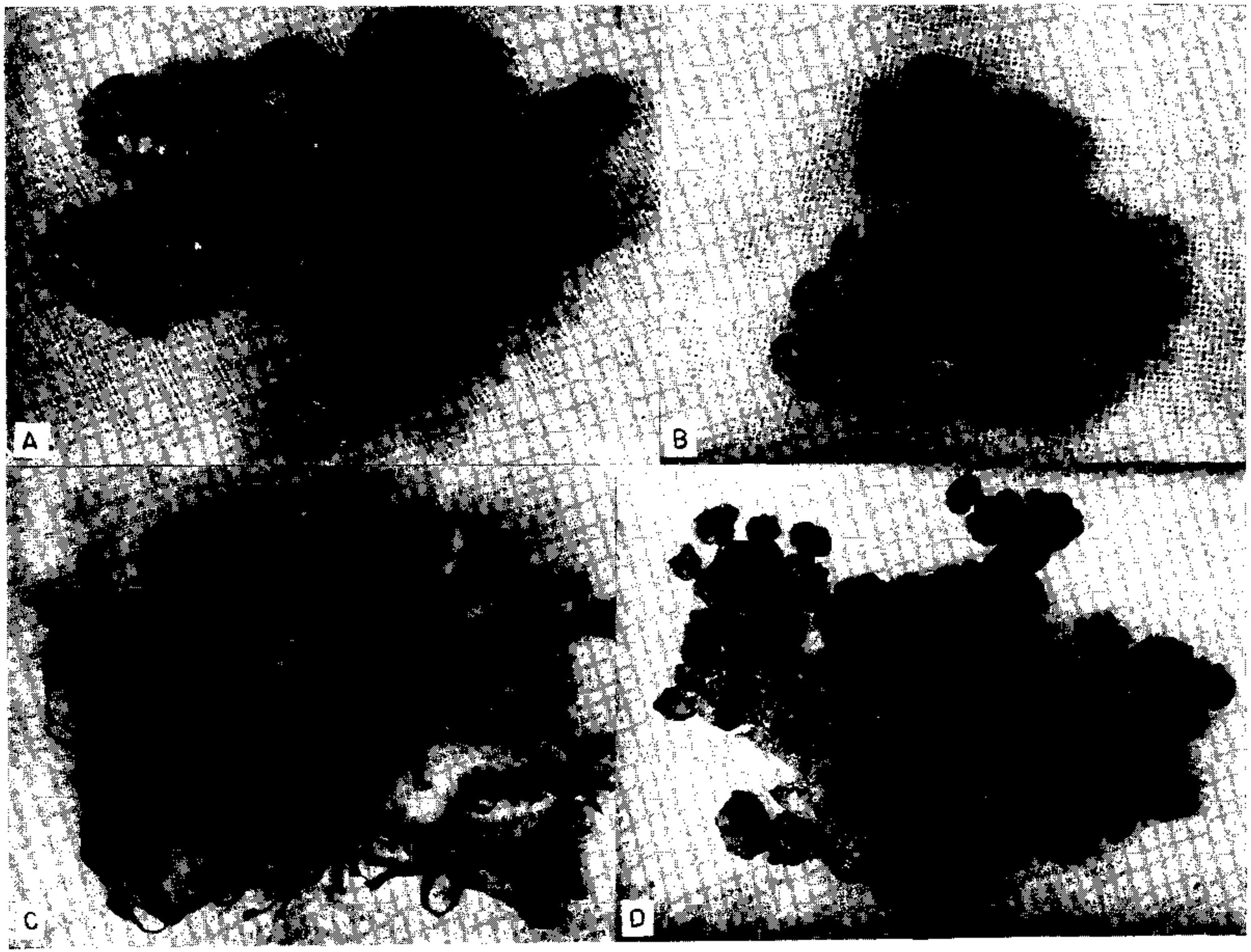


PLATE II. A. *Turbinaria ornata*. B. *Turbinaria dentata*. C. *Dictyota dichotoma*. D. *Halimeda peltata*.

REFERENCES

CHACKO, P. I. AND M. MALU PILLAI. 1958. Studies on utilisation of the seaweed resources of Madras State. *Contr. Mar. biol. St. Krusadai Island*, 6 : 1-12.

CHAUHAN, V. D. AND V. KRISHNAMURTHY. 1968. An estimate of algin bearing seaweeds in the Gulf of Kutch. *Curr. Sci.*, 37 : 648.

GOPALAKRISHNAN, P. 1969. Some marine algae from the Gulf of Kutch. *Phykos*, 8 : 61-67.

KOSHY, T. K. AND C. C. JOHN. 1948. Survey of *Gracilaria* resources of Travancore. *Dept. Res. Univ. Travancore, Rept. for Sept*, 53-55.

MITRA, G. 1946. *Development of Chilka Lake.* Cuttack.

RAO, P. S., E. R. R. IYENGAR AND F. THIVY. 1964. Survey of algin bearing seaweeds at Adatra reef, Okha. *Curr. Sci.*, 33: 464-465.

RAO, U. M. 1967. Seaweed resources of India. *Souvenir, CMFRI*, 125-129.

RAO, U. M. 1970. The economic seaweeds of India. *Bull. CMFRI*, 20 : 1-68.

THIVY, F. 1958. Economic seaweeds. In : *Fisheries of west coast of India.* Central Marine Fisheries Reasearch Institute.

ANNEXURE

LIST OF SEAWEEDS COLLECTED FROM ANDAMAN-NICOBAR ISLANDS

Class : CHLOROPHYCEAE (Green Algae)

Order : ULOTRICHALES

Family : Ulotrichaceae

1. *Schizomeris leibleinii*

   Occurrence : Car Nicobar (Malacca) and Campbell Bay

Family : Ulvaceae

2. *Enteromorpha compressa* Greville

   Occurrence : Rangat, Mayabunder, Diglipur, Havelock, Neill, Hut Bay of Little Andaman, Port Blair and Car Nicobar

3. *Ulva lactuca* Linnaeus

   Occurrence : Neill, Havelock, Hut Bay, Port Blair, Car Nicobar, Camorta and Nancowry

4. *Ulva reticulata* Forskal

   Occurrence : Port Blair

Order : CLADOPHORALES

Family : Cladophoraceae

5. *Cladophora marina*

   Occurrence : Campbell Bay

6. *Chaetomorpha antennina* Kuetzing

   Occurrence : Port Blair, Neill, John Lawrence, Car Nicobar

Order : SIPHONALES

Family : Caulerpaceae

7. *Caulerpa cupressoides* Weber-Van Basse

   Occurrence : Havelock, Little Andaman

8. *Caulerpa peltata* (Turner) Lamouroux

   Occurrence : Port Blair, Neill

9. *Caulerpa racemosa* (Forskal) J. Agardh

   Occurrence : Port Blair, John Lawrence, Neill, Little Andaman, Nancowry and Car Nicobar

10. *Caulerpa taxifolia* (Vohl) C. Agardh

    Occurrence : Mayabunder, Havelock, Neill, Port Blair

11. *Caulerpa sertularioides* (Gmelin) Howe

    Occurrence : Neill

12. *Caulerpa serrulata* (Weber-Van Bosse) Tseng

    Occurrence : Havelock, Rangat

Family : Codiaceae

13. *Codium tomentosum* (Hudson) Stackhouse

    Occurrence : Neill, Little Andaman, Port Blair

14. *Halimeda incrassata*

    Occurrence : Port Blair, Car Nicobar, Katchall and Camorta

15. *Halimeda peltata*

    Occurrence : Car Nicobar, Katchall and Camorta

16. *Halimeda discoideae*

    Occurrence : Camorta

Class : PHAEOPHYCEAE (Brown algae)

Order : DICTYOTALES

Family : Dictyotaceae

17. *Dictyota dichotoma* (Hudson) Lamouroux
Occurrence : John Lawrence, Neill, Port Blair, Car Nicobar and Camorta

18. *Dictyota bartyressiana* Lamouroux
Occurrence : John Lawrence, Neill

19. *Dictyota indica* Sonder
Occurrence : John Lawrence

20. *Padina gymnospora* (Kuetzing) Vickers
Occurrence : Rangat, Mayabunder, Stewart, Ray Hill, Diglipur, Havelock, Neill, Port Blair, Chiriyatapu, Burmanalla, Car Nicobar, Camorta and Campbell Bay

21. *Padina tetrasporomatica* Hauck
Occurrence : Rangat, Mayabunder, Stewart, Ray Hill, Diglipur, Havelock, Neill, Port Blair, Chiriyatapu and Katchall

Order : PUNCTARIALES

Family : Punctariaceae

22. *Hydroclathrus clathratus* (Bory) Howe
Occurrence : Neill, Port Blair

Order : FUCALES

Family : Sargassaceae

23. *Hormophysa triquetra* (Linnaeus) Kuetzing
Occurrence : Rangat, Mayabunder and Nancowry

24. *Sargassum wightii* (Greville) J. Agardh
Occurrence : Rangat, Port Blair, Stewart island, Katchall and Nancowry.

25. *Sargassum myriocystum* J. Agardh
Occurrence : Stewart island, Port Blair, Diglipur and Katchall

26. *Sargassum tennerium* J. Agardh
Occurrence : Stewart island

27. *Sargassum illicifolium* (Turner) J. Agardh
Occurrence : Rangat, Stewart island, Diglipur and Port Blair

28. *Sargassum duplicatum* J. Agardh
Occurrence : Rangat, Port Blair and Little Andaman

29. *Turbinaria ornata* (Turner) J. Agardh
Occurrence : Rangat, Diglipur, Mayabunder, Port Blair, Car Nicobar and Campbell Bay

30. *Turbinaria conoides* (J. Agardh) Kuetzing
Occurrence : Neill and Havelock

31. *Turbinaria decurrence* Borry
Occurrence : Neill and Havelock

32. *Turbinaria turbinata* (Linnaeus) Kuetzing
Occurrence : Havelock

33. *Turbinaria dentata*
Occurrence : Katchall (E. bay)

Class : RHODOPHYCEAE (Red algae)

Order : GELIDIELES

Family : Gelidiaceae

34. *Gelidiella acerosa* (Forskal) Feldman and Hamel
Occurrence : Port Blair, Car Nicobar and Katchall

35. *Gelidium heteroplatos* Boergesen
Occurrence : Port Blair and Mayabunder

36. *Gelidium pusillum* (Stockhouse) Le Jollis
Occurrence : Mayabunder, Port Blair, Little Andaman, Katchall, Camorta and Trinkat

Order : GIGARTINALES

Family : Gracilariaceae

37. *Gracilaria edulis* (Gmel) Silva
Occurrence : Neill, Car Nicobar, Trinkat, Camorta, Nancowry and Campbell Bay

38. *Gracilaria crassa* (Harvey) J. Agardh
Occurrence : Rangat, Mayabunder, Neill, Havelock, Little Andaman, Port Blair and Car Nicobar

39. *Gracilaria folilifera* (Forskal) Boergesen
Occurrence : Neill, Mayabunder, Port Blair, Car Nicobar and Campbell Bay

40. *Gracilaria corticata* J. Agardh
Occurrence : Mayabunder, Neill and Port Blair

41. *Gracilaria corticata* var. *cylindrica* Rao
Occurrence : Car Nicobar and Katchall

42. *Gracilaria corticata* var. *typica* Rao
Occurrence : Car Nicobar and Katchall

43. *Gracilaria verrucosa* (Hudson) Papenfus
Occurrence : Little Andaman

44. *Gracilaria indica* Rao
Occurrence : Car Nicobar

45. *Gracilaria millarditii* Rao
Occurrence : Port Blair (Aberdeen)

Family : Hypneaceae

46. *Hypnea musciformis* J. Agardh
Occurrence : Katchall (W. Bay)

Family : Gigartinaceae

47. *Chondrus crispus*
Occurrence : Car Nicobar

Order : NEMALIONALES
Family : Helminthocladiaceae

48. *Liagora ceranoides*
Occurrence : Car Nicobar

Order : CRYPTONEMIALES
Family : Corallinaceae

49. *Amphiroa fragillissima*
Occurrence : Port Blair

50. *Amphiroa rigida*
Occurrence : Katchall (East and West Bay)

51. *Galaxaura oblongata*
Occurrence : Port Blair, Car Nicobar and Katchall

Order : CERAMILES
Family : Ceramiaceae

52. *Centroceros clavulatum*
Occurrence : Port Blair

53. *Ceramium avalona*
Occurrence : Nancowry and Katchall

54. *Laurencia papillosa* (Forskal) Greville
Occurrence : Neill, Car Nicobar, Katchall, Camorta, Nancowry and Campbell Bay

55. *Laurencia obtusa* (Hudson) Lamouroux
Occurrence : Little Andaman, Chiriyatapu and Neill.

9

CULTIVABLE FINFISH RESOURCES

R. S. LAL MOHAN[1]

INTRODUCTION

Andaman and Nicobar Islands offer some of the best sites for finfish culture with their extensive mangrove swamps, numerours creeks and protected bays. During the survey of the islands undertaken by the Central Marine Fisheries Research Institute from January to April 1978, an attempt was made to identify the cultivable finfish resources and to find out the availability of their seeds. Fish landing centres and fish markets were also visited. Fishing operations were conducted with the help of two boats provided by the Department of Fisheries of the Andaman Administration. Fish seeds were collected using a hand operated dragnet and a scoop net.

CULTIVABLE SPECIES

The fish fauna of the Andaman and Nicobar Islands has been surveyed earlier by many workers (Day, 1870; Koumans, 1940; Herre, 1941). During the present survey many cultivable fishes were collected along with other fishes from various islands. They were *Mugil cephalus*, *M. dussumieri*, *Liza macrolepis*, *Chanos chanos*, *Lates calcarifer*, *Sillago sihama*, *Siganus canaliculatus*, *S. reticulatus*, *Serranus* spp. and *Lutianus* spp.

Mugil cephalus was collected from Diglipur, Mayabunder, Havelock Island, Port Blair and Chiriyatapu. *Sillago sihoma* was a common species observed in the catches from Shoal Bay, off Port Blair, Chiriyatapu, Kimios Bay and Campbell Bay. *Siganus* spp. were collected from Diglipur, Rangat Bay, Shoal Bay, off Port Blair, Chiriyatapu and Kimios Bay. Apart from these fishes which can be used for fish culture in ponds, a few species suitable for cage culture were also collected. *Lutianus* spp. were observed in the catches from off Port Blair, Chiriyatapu, Sawai Bay, Kimios Bay and Campbell Bay. *Serranus* spp. were collected from Diglipur, Port Blair and Chiriyatapu. *Lates calcarifer* was found in the catches from Port Blair and Chiriyatapu (Table 1).

TABLE 1. *Availability of cultivable fishes in Andaman and Nicobar Islands*

Place	*Chanos chanos*	*Mugil cephalus*	*M. dussumieri*	*Mugil tade*	*Sillago sihama*	*Siganus* spp.	*Lutianus* spp.	*Serranus* spp.	*Lates calcarifer*
Diglipur	+	+	+	+	–	+	–	+	–
Mayabunder	–	+	+	+	–	–	–	–	–
Rangat	–	–	+	–	–	+	–	–	–
Shoal Bay	–	–	+	–	+	+	–	–	–
Havelock Is.	–	+	+	+	–	–	–	–	–
Port Blair	+	+	+	+	+	+	+	+	+
Chiriyatapu	+	+	+	+	+	+	+	+	+
Hut Bay	–	–	+	–	–	–	–	–	–
Sawai Bay	–	–	+	+	–	–	+	–	–
Kimios Bay	–	–	+	+	+	+	+	–	–
Campbell Bay	–	–	+	+	+	–	+	–	–

+ indicates species collected during the survey

Present address :
[1] CMFRI, Regional Centre, Mandapam Camp.

Fish Seed Resources

Tampi (1973) studied the availability of cultivable fish seed occurring along the coasts of the mainland of India. James *et al.* (1980) and Silas *et al.* (1980) studied the seasonal variation, distribution and the occurrence of finfish seed. However, there is no information on the availability of the finfish seed of Andaman and Nicobar Islands.

Table 2. *Availability of fish seed in Andaman and Nicobar Islands*

Place	*Mugil* spp.	*Sillago* sp.	*Siganus canaliculatus*
Blair Bay	+	–	+
Diglipur	–	–	–
Lakshmipur	+	–	–
Mayabunder	+	–	–
Rangat	+	–	–
Neill Is.	+	–	–
Corbyn's cove south	+	+	–
Havelock (Kalapathar)	+	–	–
Burmanalla	+	–	–
Chiriyatapu	+	–	–
Hut Bay	+	–	–
Sawai Bay	+	–	–
Kimios Bay	+	–	–
Spiteful Bay	+	–	–
Campbell Bay	+	–	–

The fish seed were collected with the aid of a velon screen net with 1 mm mesh, measuring 5 m long and 3 m wide. The net was dragged along the shallow backwaters, inundated areas, saltwater creeks and mangrove swamps.

Fry of *Mugil* spp. of 15-25 mm length were collected from the mangroves near Diglipur and Lakshmipur. They were also obtained from Rangat Bay and Neill Island. The fry of *Sillago sihama* measuring 20-25 mm were collected from Corbyn's cove south. The fry of *Siganus canaliculatus* measuring 25-35 mm were collected from Port Blair (Table 2). However, no attempt was made to assess the quantitative abundance of the seeds of different species.

Potential Fish Farming Areas

It has been estimated that about 37,916 ha of marshy low-lying areas and mangrove swamps are found in Andaman and Nicobar Islands (Anon., 1975). These extensive mangrove swamps and marshy areas under tidal influence can offer suitable sites for large scale fish culture operations. Such areas are found in Diglipur, Mayabunder, Rangat Bay and Campbell Bay. Further there are many creeks along Blair Bay, Ariel Bay, Galathea river and Alexandria river. The low-lying areas adjacent to the numerous creeks in the islands offer very good sites for pen culture operations. The shallow protected bays such as Ariel Bay, Blair Bay, Sawai Bay, Hut Bay and Campbell Bay are some of the areas where cage culture of fishes can be tried.

References

Anon. 1975. *Basic statistics of Andaman and Nicobar Islands.* Statistical Bureau of Andaman and Nicobar Administration, Port Blair.

Day, F. 1870. On the fishes of the Andaman Islands. *Proc. Zool. Soc. London*, pp. 677-705.

Herre, A. W. C. T. 1941. A list of fishes known from the Andaman Islands. *Mem. Indian Mus.*, **15** : 331-403.

James, P. S. B. R., V. S. Rangaswamy, A. Raju and G. Mohanraj. 1980. Studies on diurnal variations in the occurrence of grey mullet seed at Mandapam. *Symp. Coastal Aquaculture*, Abstract 43, Mar. biol. Ass. India.

Koumans, F. P. 1940. On a collection of gobioid fishes from Andamans. *Rec. Indian Mus.*, **42** : 15-18.

Silas, E. G., G. Mohanraj, V. Gandhi and A. R. Thirunavukkarasu. 1980. Spawning grounds of the milkfish and seasonal abundance of the fry along the east and southwest coast of India. *Symp. Coastal Aquaculture*, Abstract 40, Mar. biol. Ass. India.

Tampi, P. R. S. 1973. Culturable marine fish resources from brackish water environment. *Proc. Symp. Living Resources of the Seas around India*, Special Publication, Central Marine Fisheries Research Institute, pp. 390-394.

10

PENAEID PRAWN RESOURCES AND POTENTIAL FOR PRAWN CULTURE

E. G. SILAS[1], M. S. MUTHU[1] AND M. KATHIRVEL[2]

INTRODUCTION

Our knowledge of the penaeid prawns of Andaman and Nicobar Islands is based on the pioneering works of Wood-Mason (1891, 1893), de Man (1892, 1911), Alcock and Anderson (1899), Alcock (1901, 1905, 1906) and Balss (1925), who reported about i20 species, most of them deep water forms. Recently, Silas and Muthu (1976 *a*, *b*) and Thomas (1977) recorded 12 littoral species for the first time from this region, of which one is new to science. Though data on the landings of penaeid prawns from these islands are available from 1965 onwards, no information is available on the biology of the exploited stock. Basic information on the biology of important prawns n Andaman and Nicobar Islands collected during the survey, along with the data collected earlier are presented here. The potential for prawn culture is indicated.

MATERIAL EXAMINED

Date of collection	*Locality*	*Gear*
10.5.'76	Wright Mayo	Bag nets (stake net)
12.7.'76	Wright Mayo	Boat seine (shallow waters)
20.7.'76	Chauldari	do.
19.12.'76	Diglipur	Drag net (near shore)
3.2.'78	Rangat	Cast net (creeks)
8.2.'78	Mayabunder	Trawl net (40 m depth)
12.2.'78	do.	Bag net (shallow creeks)
14 2.'78	Tennyson Creek in Mayabunder	Cast net
16.3.'78	Bamboo Flat-Port Blair	Bag net
1.4.'78	Campbell Bay	Boat seine
18.4.'78	Janglighat-Port Blair	Bottom- set gillnet

Present address :

[1] CMFRI, Cochin 682 018.

[2] CMFRI, Research Centre, Madras 600 105.

The prawn samples were analysed in detail for species composition, size distribution, sex-ratio and maturity. The samples of prawn seed were obtained by operating a velon screen net measuring 3 m in length and 1 m in breadth in shallow intertidal areas along the sandy beach in the following localities :

Date	*Locality*
10.2.'78 to 18.2.'78	Tennyson creek
17.2.'78	Lakshmipuranalla in Diglipur
24.2.'78	Havelock Island
1.3.'78	Chiriyatapu
2.3.'78	Corbyn's Cove
10.3.'78 to 18.4.'78	Chippighat—Port Blair
18.4.'78	Janglighat—Port Blair
26.3.'78	Wandoor and Burmanalla—Port Blair
29.3.'78	Hut Bay
30.3.'78	Tee Top—Car Nicobar
12.4.'78	Kimios backwater, Passa Bridge, Sawai and Malacca in Car Nicobar
5.4.'78	East Bay, Katchall
4.4.'78	Kakana and jetty—Camorta
3.4.'78	Champin jetty—Nancowry
1.4.'78	Campbell Bay—Great Nicobar

PRESENT STATUS OF EXPLOITATION

Production

Data on penaeid prawn landings in the Andaman and Nicobar Islands for the years 1965-1981 are presented in Fig. 1. (Source : Annual Reports of CMFRI, Anon, 1982). The catch has registered a gradual increase from a minimum of 4 t in 1965 to a maximum of 64 t in 1979, which may be due to the increased effort by both indigenous and mechanised fishing crafts. The average annual landings during this period is 23.4 t, which formed 2.4 % of average total fish catch from these islands. The monthly landings in 1978 (Anon, 1979) indicate that more than 50 % of the catch

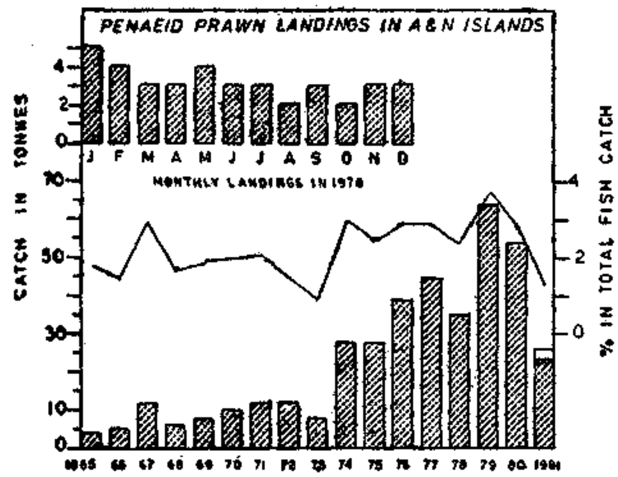


Fig. 1. Annual penaeid prawn landings from Andaman and Nicobar Islands during 1965-1981.

is landed in the first half of the year. The less catch in the second half may be due to the rough seas prevailing during the south-west monsoon, followed by north-east monsoon.

The Exploratory Fisheries Project of the Govt. of India conducted exploratory fishing operations in the Andaman waters during 1971 to 1976 (Sudarsan, 1978). But since the vessels were using only fish trawls which are not suitable for catching prawns, the crustaceans do not figure in their data. Sudarsan (1978) stated that specimens of prawns had often appeared in the trawl catches and as such a special survey for prawn resources will have to be undertaken.

Gear employed

In the early years of settlement of fishermen from the mainland, mostly indigenous gears such as bag net, boat seine, drag net and cast net were employed in fishing for prawns and fishes. In recent years, medium and large mechanised vessels belonging to the local Fisheries Department and Exploratory Fisheries Project of the Govt. of India started operating trawl nets. The indigenous gears were mainly operated by the settled fishermen at Diglipur, Mayabunder, Rangat, places in and around Port Blair, Little Andaman, Car Nicobar, Camorta and Great Nicobar. The penaeid prawns formed a portion of the total catch landed at places mentioned above, except at Little Andaman, Car Nicobar and Camorta, where fishes alone are caught by operating gill net, hook and line and boat seine.

Species composition

Totally 19 species of penaeid prawns belonging to 6 genera were encounered and they are listed below.

1. *Solenocera crassicornis* (H. Milne Edwards 1837)
2. *Penaeus merguiensis* de Man 1888
3. *P. monodon* Fabricius 1798
4. *P. semisulcatus* de Haan 1850
5. *P. canaliculatus* (Olivier 1811)
6. *Metapenaeus dobsoni* (Miers 1878)
7. *M. ensis* (de Haan 1850)
8. *M. affinis* (H. Milne Edwards 1837)
9. *M. moyebi* (Kishinouye, 1896)
10. *M. brevicornis* (H. Milne Edwards 1837)
11. *M. lysianassa* (de Man 1888)
12. *M. elegans* (de Man 1907)
13. *M. krishnatrii* Silas and Muthu 1976
14. *Parapenaeopsis stylifera* (H. Milne Edwards 1837)
15. *P. tenella* (Kishinouye 1900)
16. *Trachypenaeus curvirostris* (Stimpson 1860)
17. *Metapenaeopsis stridulans* (Alcock 1905)
18. *M. hilarula* (de Man 1911)
19. *M. palmensis* (Haswell 1882)

The percentage by number in different gears as well as all gears combined is depicted in Fig. 2. In the overall species composition, *Penaeus merguiensis* is the dominant species accounting for 49 % followed by *M. dobsoni* (42 %), *M. ensis* (2.5 %), *P. monodon* (0.6 %) and *P. semisulcatus* (0.5 %) and the rest of the species (1.9 %). Though *P. merguiensis* dominated in the samples drawn from bag net, boat seine and trawl net, it ranked second in the drag net collections. However, the gill net collection was exclusively constituted by *P. merguiensis*.

Size distribution (Figs. 3, 4)

P. merguiensis : The overall size range for the species varied from 66 to 175 mm in total length (from tip of rostrum to tip of telson). Individuals in the size groups from 71-75 mm to 136-140 mm constituted the bulk of the samples from bag net, boat seine and drag net, while prawns above 100 mm formed the major portion in cast net and trawl net samples. Since the samples were collected in different months in different years, no statement could be made on growth pattern for this species, as well as for other species studied.

M. dobsoni : The total length ranged from 51 mm to 100 mm. Two size groups, *viz.* 66-70 mm and 71-75 mm were dominant in the bag net, drag net and boat seine

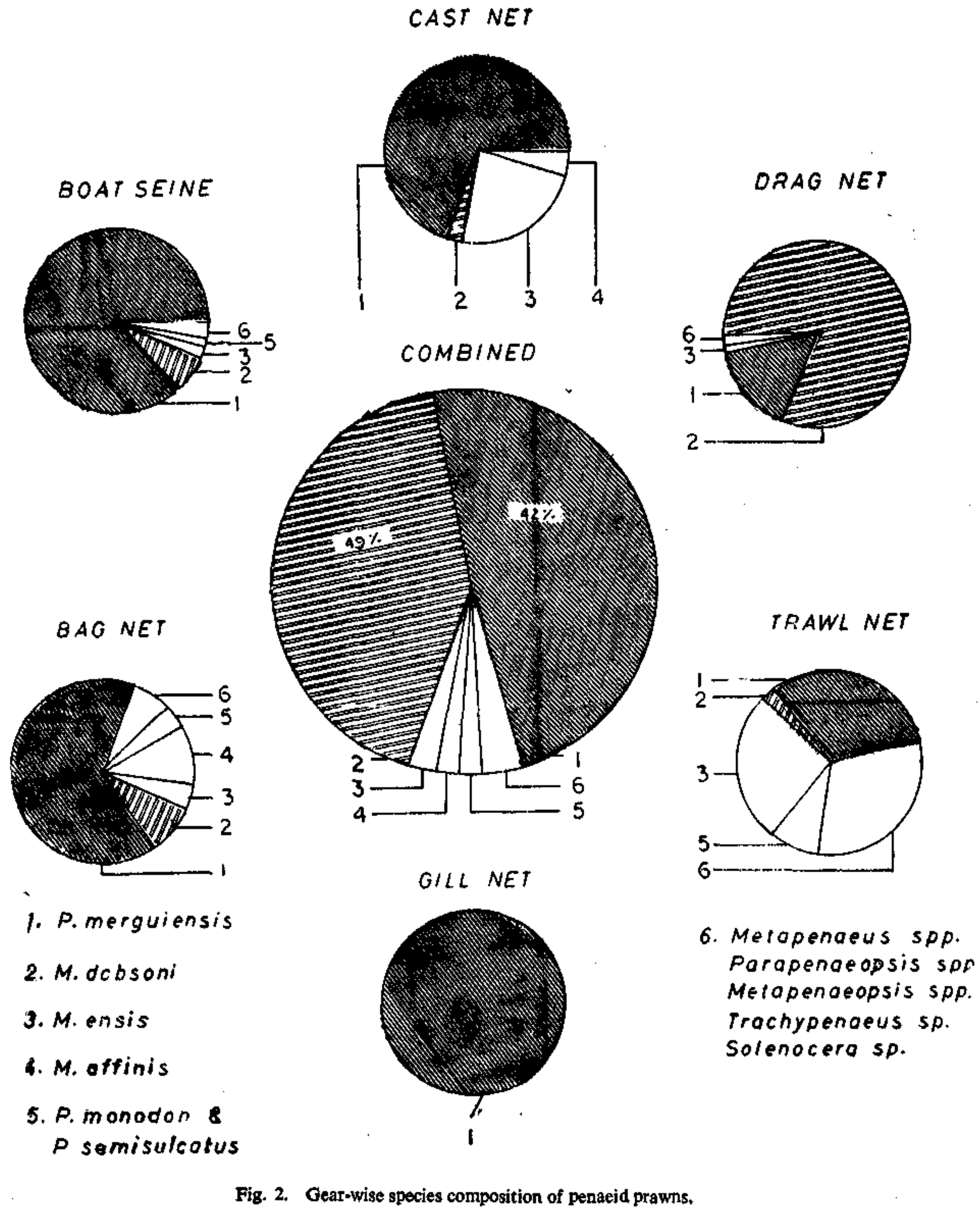


Fig. 2. Gear-wise species composition of penaeid prawns.

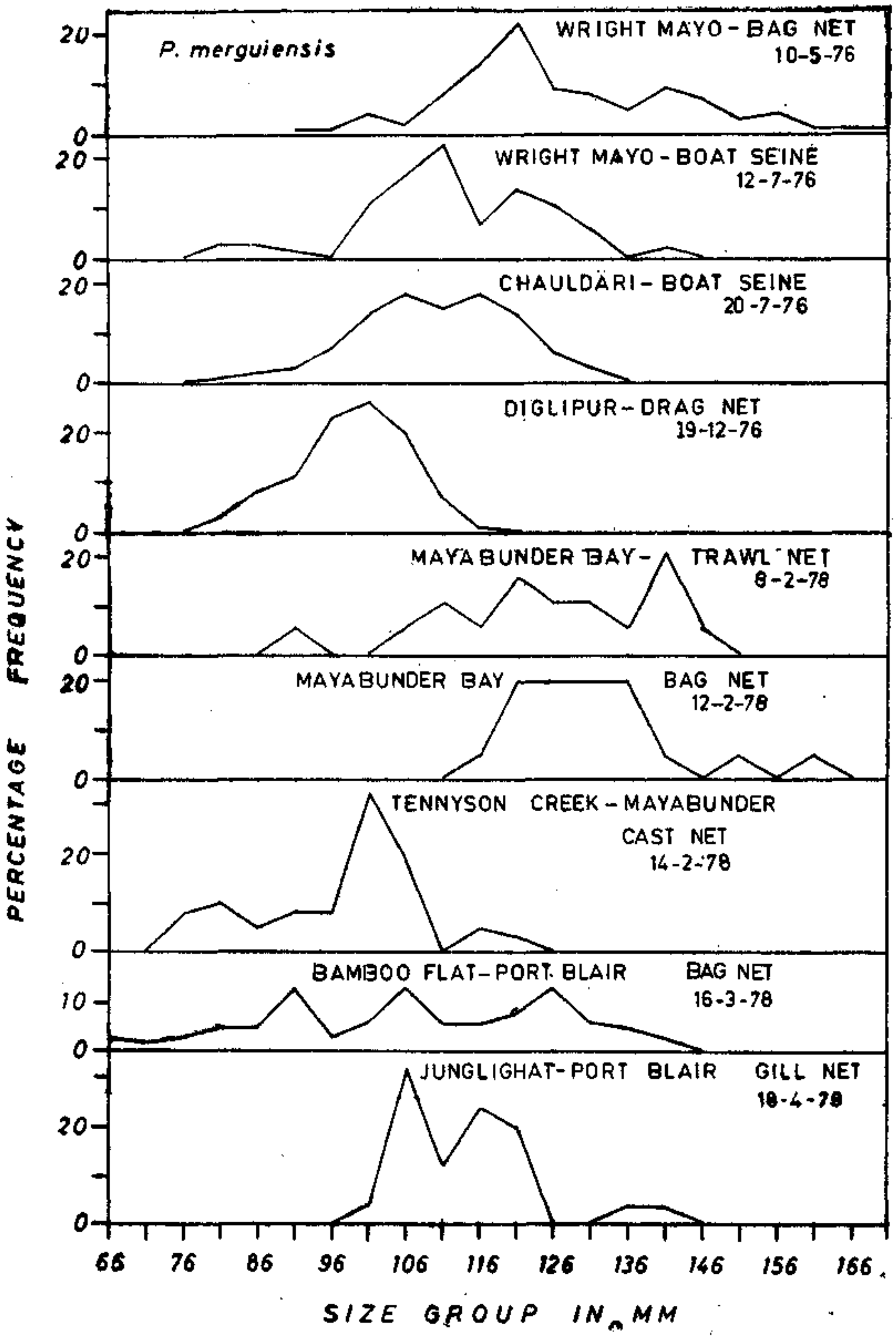


Fig. 3. Size distribution of *P. merguiensis* in different gears.

samples. In the drag net collection, prawns below 60 mm were also caught.

M. ensis : Total length varied from 46 mm to 130 mm. The dominant size group found in the cast net samples was 56-60 mm, while a larger size group (71-75 mm) formed the major portion in the bag net collections. In the trawler catches, sizes above 100 mm were encountered in lesser numbers.

M. affinis : The minimum and maximum size recorded was 66 mm and 116 mm respectively. The dominant size group in the bag net samples was 96-100 mm.

Other species : Since only a few specimens of the following species were available their size ranges recorded in samples from different gears are given below:

Species	*Gear*	*Size range (mm)*
P. semisulcatus	Bag net	62-80
	Boat seine	66-83
	Trawl	150-206
P. monodon	Bag net	90-172
M. brevicornis	Boat seine	65-94
	Drag net	56-83
M. lysianassa	Bag net	37-48
	Trawl	42-55
M. moeybi	Boat seine	50-65
	Trawl	58-73

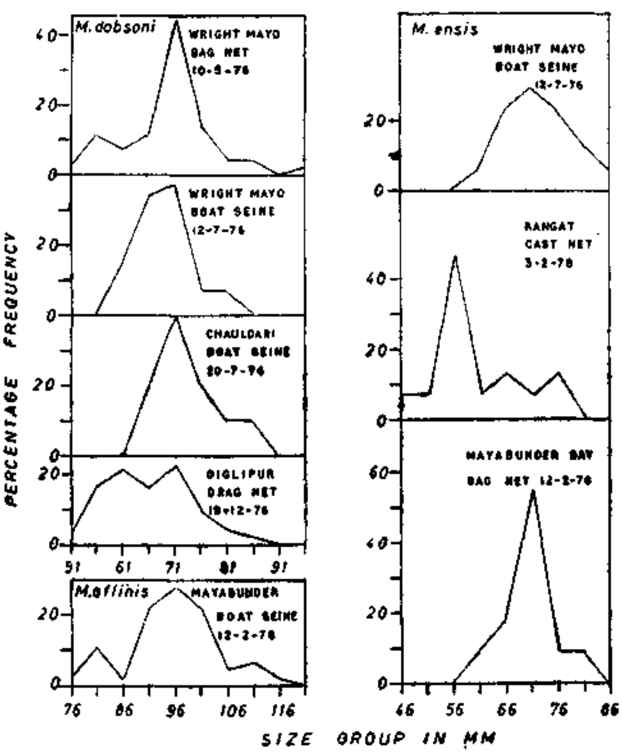


Fig. 4. Size distribution of *M. dobsoni*, *M. affinis* and *M. ensis* in the indigenous gears.

Sex ratio

		Male : Female
P. merguiensis	..	64 : 36
P. monodon	..	71 : 29
P. semisulcatus	..	50 : 50
M. dobsoni	..	40 : 60
M. ensis	..	46 : 54
M. brevicornis	..	20 : 80
M. affinis	..	53 : 47

Maturity

In *P. merguiensis*, stages I and II in ovary development were more common in May and July 1976 samples, while stage I was dominant in December samples of the same year. In 1978 samples, stages I and II were more prevalent. In *M. dobsoni*, stages I and II formed 20 to 100%, while stages III and IV were below 20% in the samples in 1976.

Abundance and Distribution of Prawn Seed

During the visit in 1978, survey on the abundance and distribution of penaeid prawn seed was conducted and the number of seed obtained in each haul from

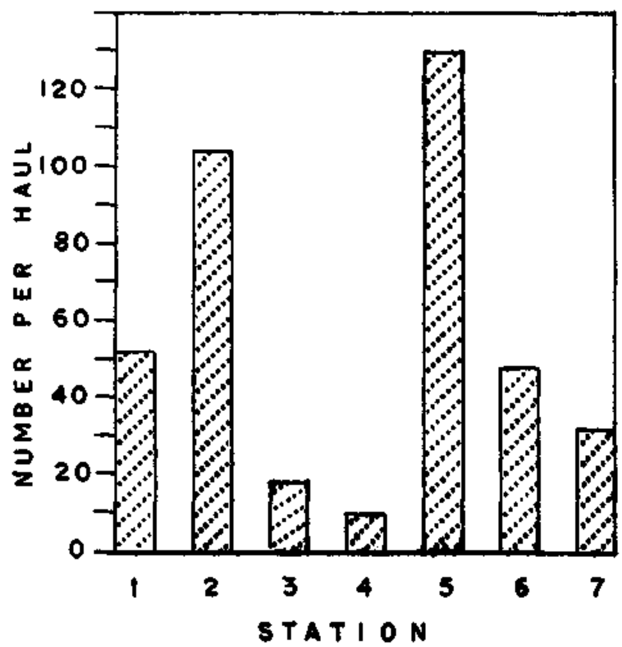


Fig. 5. Haul-wise number of prawn seed obtained from different observation centres. 1. Diglipur ; 2. Mayabunder ; 3. Havelock Island ; 4. Chiriyatapu; 5. Chippighat ; 6. Janglighat ; 7. Corbyn's cove.

Diglipur, Mayabunder, Havelock Island, Chiriyatapu, Chippighat, Janglighat and Corbyn's cove are shown in Fig. 5 and the percentage species composition indicated in Fig. 6. Among the penaeid prawn seed collected from different centres, *P. merguiensis* formed 43%, followed by *M. ensis* (30%), *M. dobsoni* (26%) and *M. brevicornis* (1%). Though *P. merguiensis* occurred in good numbers in Havelock Island and Chippighat, *M. ensis* dominated in the rest of the areas where seed was collected. Seed of *M. dobsoni* was caught in

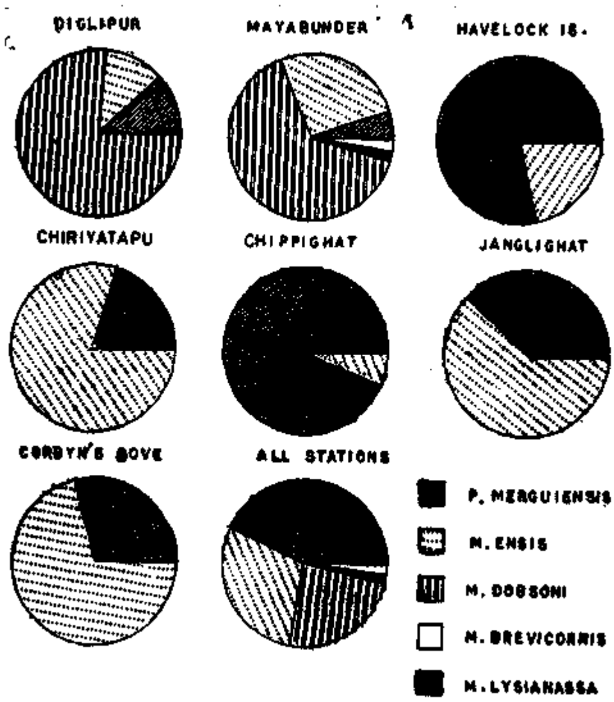


Fig. 6. Composition by number of principal species in the prawn seed collections at different centres.

considerable numbers at the northern centres namely Diglipur and Mayabunder and that of *M. brevicornis* at Mayabunder. The size range of the prawn seed is given below species-wise.

Species		*Size range in mm*
P. merguiensis	..	11-41
M. ensis	..	14-38
M. dobsoni	..	17-30
M. brevicornis	..	21-33

No penaeid prawn seed could be collected from the following centres: Wandoor and Burmanalla near Port Blair in South Andaman, Hut Bay in Little Andaman, Arang, Kimios backwater, Sawaii, Passa Bridge and Malacca in Car Nicobar, South Bay in Katchall, Kakana in Camorta, Champin Jetty in Nancowry and Campbell Bay in Great Nicobar. This may perhaps be due to dense growth of live coral and rocky bottom prevailing in the above mentioned stations, which are normally not preferred by the young prawns. Only in Kimios backwater and Passa Bridge in Car Nicobar, plenty of early juveniles of the fresh water caridean prawn, *Macrobrachium equidens* Dana were collected (size range 20-30 mm).

General Remarks on the Exploited Prawn Fishery

Like many other areas along the mainland coast, the prawn fishery of Andaman and Nicobar Islands is supported by more than a dozen species. However, *P. merguiensis* and *M. ensis* emerge as the major contributors to the penaeid prawn catch landed from these Islands. Strangely, *P. indicus* and *M. monoceros* which are important commercial species on the mainland are conspicuous by their absence in the Andamans. The prawn fishery is not well developed in the islands and there is scope for increasing the fishing effort by indigenous gear as well as by trawling. It is also necessary to conduct intensive exploratory trawling on the continental shelf. Based on a study of the relative abundance of penaeid larvae, Paulinose and George (1976) remarked that the areas around Andaman and Nicobar Islands appear to have one of the highly potential fishing grounds for penaeid prawns in the Indian Ocean.

Potential for Prawn Culture

The presence of a number of creeks and protected bays bordered by mangrove swamps, the high tidal amplitude and the ready availability of seed of commercially important penaeid prawns such as *P. merguiensis*, *M. ensis* and *M. dobsoni* in many places in the Andamans augurs well for the establishment of extensive prawn farms similar to the Singapore prawn ponds described by Hall (1962) and Tham Ah Kow (1968). Suitably located creeks and small embayments can be converted into prawn ponds by constructing bunds across the narrowest part of the mouth and fixing appropriate sluices which can be used for stocking the ponds with the naturally occurring prawn seeds during high tides and for periodic harvesting of the grown prawns during the full moon and new moon phases as practised in Singapore. Semi-intensive culture of prawns by selective stocking of the seed of fast growing species such as *P. merguiensis*, in smaller conventional coastal ponds built in suitable areas can also be taken up in the Andamans. The low-lying marshy areas on the way to Wandoor from Port Blair can be developed into prawn farms. While considering the mangrove areas for prawn culture operations care should be taken to see that the mangrove ecosystem is managed judiciously without destroying it. In Indonesia the mangroves have been used with advantage in the construction of the 'tambaks'. Mangrove vegetation on the seaward side of the ponds serve as wind breakers and the roots of mangroves growing on the bunds bind the soil and prevent their erosion. A more detailed survey should be undertaken to select sites suitable for extensive and semi-intensive culture of penaeid prawns.

Apart from collecting prawn seed from the wild, hatcheries for large scale production of the seed of *P. merguiensis* can be started at Port Blair and other places in the vicinity of the proposed prawn farms, as excellent seawater eminently suited for rearing of prawn larvae is available all along the Andaman coast. The CMFRI has already developed low-cost technology for breeding penaeid prawns in captivity and for hatchery production of prawn seed. Hence, there will be no difficulty in starting such a programme in the Andamans to supply the necessary seed to stock the ponds that are likely to come up. The prospects for starting integrated prawn farms in the Andamans are, indeed, very encouraging.

References

ALCOCK, A. 1901. A descriptive catalogue of the Indian deep sea crustacea, decapoda, macrura and anomola in the Indian Museum being a revised account of the deep sea species obtained by the Royal Survey Ship 'INVESTIGATOR', Calcutta, 286 pp.

ALCOCK, A. 1905. A revision of the genus *Penaeus*, with the diagonsis of some new species and variations. *Ann. Mag. Nat. Hist.*, **16** (7) : 508-532.

ALCOCK, A. 1906. Prawns of the *Penaeus* group. In : Catalogue of the Indian decapod crustacea in the collection of the Indian Museum, Part 3, Macrura, Fasc. I, Calcutta, 55 pp.

ALCOCK, A. AND A. R. S. ANDERSON. 1899. Natural history notes from H.M. Royal Indian Marine Survey Ship 'Investigator'. Series 3 No. 2. An account of the deep sea Crustacea dredged during the survey seasons 1897-98. *Ann. Mag. Nat. Hist.*, **7** (3) : 1-27, 278-292.

ANON. 1979. Synopsis of marine prawn fishery of India-1978. *Mar. Fish. Infor. Serv. T and E ser.* No. 10 : 1-7.

ANON. 1982. Trends in marine fish production in India-1981. *Mar. Fish. Infor. Serv. T and E Ser.*, No. 41 : 1-33.

BALSS, H. 1925. Macrure d. Deutschen Tiefse—Exp. 2, Naturtia Tel A. *Wiss. Ergeb. Deutsch. Tiefsee Exp. ' VALDIVIA '*, **20** (5) : 221-315.

DE MAN, J. G. 1892. Decapoden des Indische Archipela. In: Weber, M. (ed) *Zoologische Ergebnisse siner Reise in Neiderlandisch Ost. Indian*, **2** : 265-527, Leiden.

DE MAN, J. G. 1911. The decapoda of the Siboga Expedition. Part I. Family Penaeidae. *Siboga Exped. Monogr.*, **39** a : 1-31.

HALL, D. N. F. 1962. Observations on the taxonomy and biology of some Indo-West Pacific Penaeidae (Crustacea, Decapoda). *Fishery Publication Colonial Office* (17) : 229 pp.

PAULINOSE, V. T. AND M. J. GEORGE. 1976. Abundance and distribution of penaeid larvae as an index of penaeid prawn resources of the Indian Ocean. *Indian J. Fish.*, **23** : 127-133.

SILAS, E. G. AND M. S. MUTHU. 1976 *a*. On a new species of penaeid prawn of the genus *Metapenaeus* Wood Mason and Alcock from the Andamans. *J. mar. biol. Ass. India*, **16** : 645-648.

SILAS, E. G. AND M. S. MUTHU. 1976 *b*. Notes on a collection of penaeid prawns from the Andamans. *J. mar. biol. Ass. India*, **18** : 78-90.

SUDARSAN, D. 1978. Results of exploratory survey around the Andaman Islands. *Bull. Expl. Fish. Proj.*, No. 7 : 1-43.

THAM AH KOW. 1968. Prawn culture in Singapore. *FAO Fish. Rep.* No. 57, Vol. 2:85-93.

THOMAS, M. M. 1977. Decapod crustaceans new to Andaman and Nicobar Islands. *Indian J. Fish.*, **24** : 56-61.

WOOD-MASON, J. 1891. Natural history notes from H.M. Marine Surveying steamer ' Investigator'. *Ann. Mag. nat. Hist.* February 1891 : 187-199 ; October 1891 : 269-286 ; November 1891 : 355-362.

WOOD-MASON, J. 1893. Natural history notes from H. M. Marine surveying steamer 'Investigator'. Ser II. On the results of deep sea dredging during the season 1890-91. (Contd.). *Ann. Mag. nat. Hist.* (6) II : 161-172.

11

LOBSTER RESOURCES AND CULTURE POTENTIAL

S. SHANMUGHAM[1] AND M. KATHIRVEL[2]

INTRODUCTION

In India, the average annual lobster landings during 1975-1981 were 1,620 t forming 0.8% in the total crustacean landings. The average foreign exchange earned by exporting the frozen lobster tails (av. 584 t) during that period is Rs. 54 million. The major species contributing to the exploited fishery are the shallow water spiny lobsters *Panulirus homarus* (Linnaeus), *P. polyphagus* (Herbst) and *P. ornatus* (Fabricius). Prasad and Tampi (1968) reported 18 palinurid and 20 scyllarid lobsters in the Indian Ocean, out of which 8 species of palinurids *Panulirus homarus, P. ornatus, P. polyphagus, P. versicolor, P. penicillatus, P. longipes, Puerulus sewelli* and *Palinustus mossambicus* and 5 species of scyllarids *Thenus orientalis, Scyllarus batei, S. rugosus, S. rubens* and *S. sordidus* are known to occur along the Indian coast. The lobsters reported from the Andaman and Nicobar Islands include 3 species belonging to the family Nephropsidae and 7 species of Eryonidae (Alcock, 1901) and 2 species of Palinuridae (Balss, 1925; Chekunova, 1971). During the present survey conducted in January-April 1978, data were collected on the occurrence and exploitation of lobsters which are presented here. The potential for lobster culture is indicated.

SPECIES RESOURCES

1. Panulirus homarus (Linnaeus, 1793)

Locality: East Bay in Katchall; complete exuvia of a male specimen washed ashore; 244 mm TL (total length); 83 mm CL (carapace length).

Remarks: This species is considered to be a continental species, growing to maximum size of 320 mm in TL and it forms a seasonal lucrative fishery along the Kanyakumari District coast, Tamilnadu on the mainland. The habitat of the species is the sand-stone reefs with moderate turbid conditions. Though it enjoys a wide distribution in the Indo-West Pacific, it has not been reported from the present study area. This is the first record of the species from Andaman and Nicobar Islands.

2. Panulirus ornatus (Fabricius, 1798) (Pl. I, B)

Locality: (i) Janglighat in Port Blair; 2 females from the bottom set gill net collections; 163 & 189 mm TL; 58 & 67 mm CL. (ii) East Bay in Katchall; complete exuvia of one male; 182 mm TL; 66 mm CL. (iii) Spiteful Bay in Camorta; 1 female from the bottom set gill net collections; 162 mm TL; 58 mm CL. (iv) Kakana in Camorta; complete exuvia of one female; 178 mm TL; 64 mm CL.

Remarks: This continental species attains a maximum size of 460 mm TL and forms a major portion of the lobster landings at Mandapam in the Gulf of Mannar area. The preferred habitat of the species is a substratum of living corals with moderate turbid water conditions. Menon (1976) has mentioned availability of the species, along with *P. polyphagus*, from Andaman and Nicobar Islands.

3. Panulirus penicillatus (Olivier, 1791)

Locality: (i) South Point in Port Blair; 1 male from rocky crevices; 305 mm TL; 110 mm CL. (ii) Malacca and Sawai in Car Nicobar; partial exuviae of 1 female and 3 males (carapace portion only) washed ashore; 90 mm CL for female; 35, 72 and 83 mm CL for males. (iii) Campbell Bay in Great Nicobar; partial exuvia carapace portion only washed ashore; 90 mm in CL.

Remarks: This species is considered to be an oceanic species, commonly found in the oceanic islands and grows to a maximum size of 450 mm TL.

4. Panulirus versicolor (Latreille, 1804) (Pl. I, A)

Locality: (i) South Point in Port Blair; 1 male from rocky crevices; 257 mm TL; 95 mm CL. (ii)

Present address:

[1] CMFRI Research Centre, Tuticorin 628 001.

[2] CMFRI Research Centre, Madras 600 105.

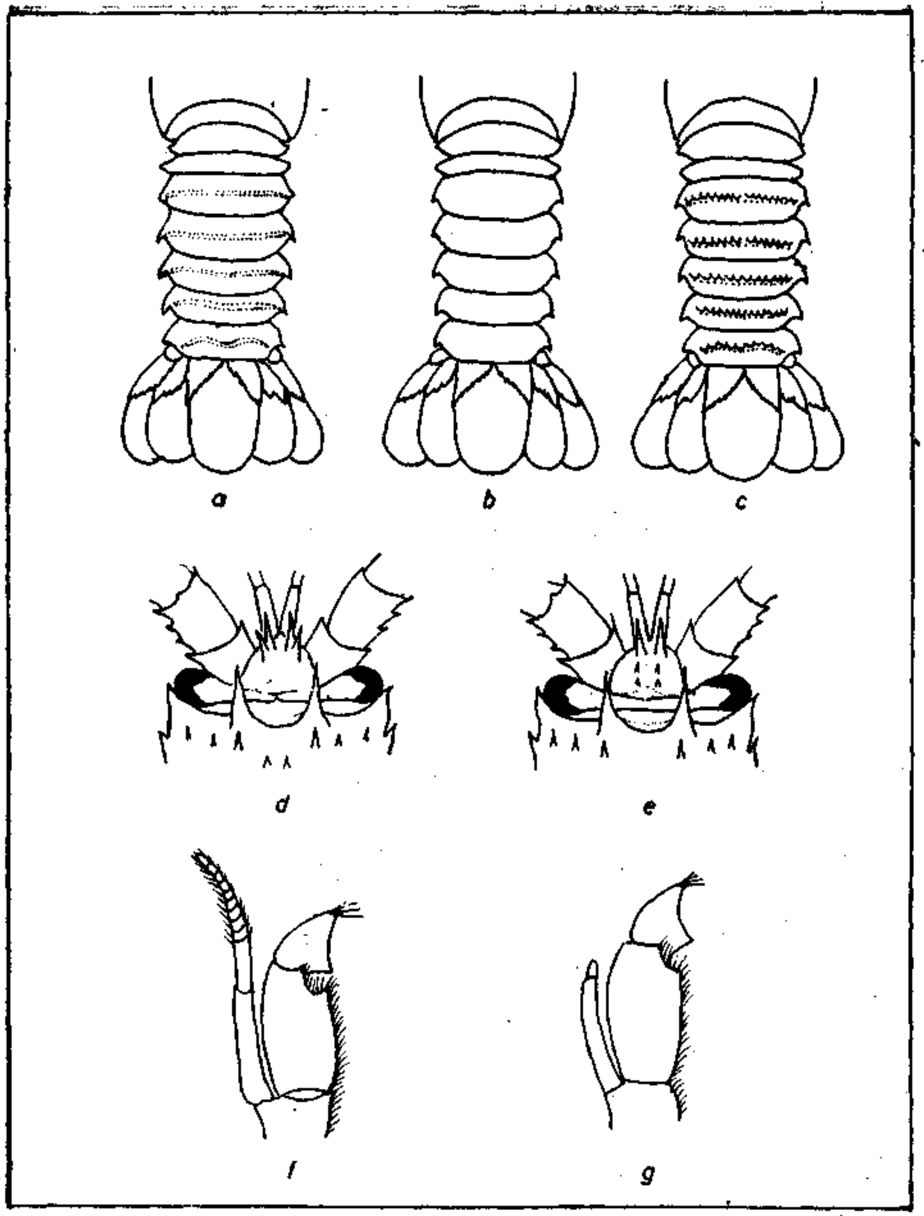


Fig. 1. A diagrammatic illustration for the identification of adults of *Panulirus* spp. occurring in Andaman and Nicobar Islands. (Explanations given in Appendix 1).

Sawai in Car Nicobar ; partial exuviae washed ashore ; 57 & 58 mm CL.

Remarks : This species is known for colonising among the live corals and also feeding on them. It attains a size similar to that of *P. ornatus*. It enjoys a wide distribution in the Indo-West Pacific. This is the first record of the species from Andaman and Nicobar Islands.

5. **Thenus orientalis** (Lund, 1793)

Locality : Shoal Bay in South Andaman ; 1 female trawled from a depth of 45 m ; 127 mm TL ; 54 mm CL.

Remarks : This species is known as the sand lobster inhabiting sandy bottom and attains a size of 270 mm TL. It is distributed in the Indo-Pacific region. Now it is reported for the first time from Andaman and Nicobar Islands.

Apart from the five species of lobsters mentioned above, moults of *Panulirus polyphagus* (Herbst, 1793) and *Panulirus longipes longipes* (A. Milne Edwards, 1868) (Pl. I, C) were seen at Port Blair. To facilitate the identification of the six species of *Panulirus* a key on morphological characters is given in Appendix 1. Based on the published accounts, a key for the identi-

PLATE I. Some species of lobsters from Andaman and Nicobar Islands : A. *P. versicolor* ; B. *P. ornatus* ; C. *P. longipes*.

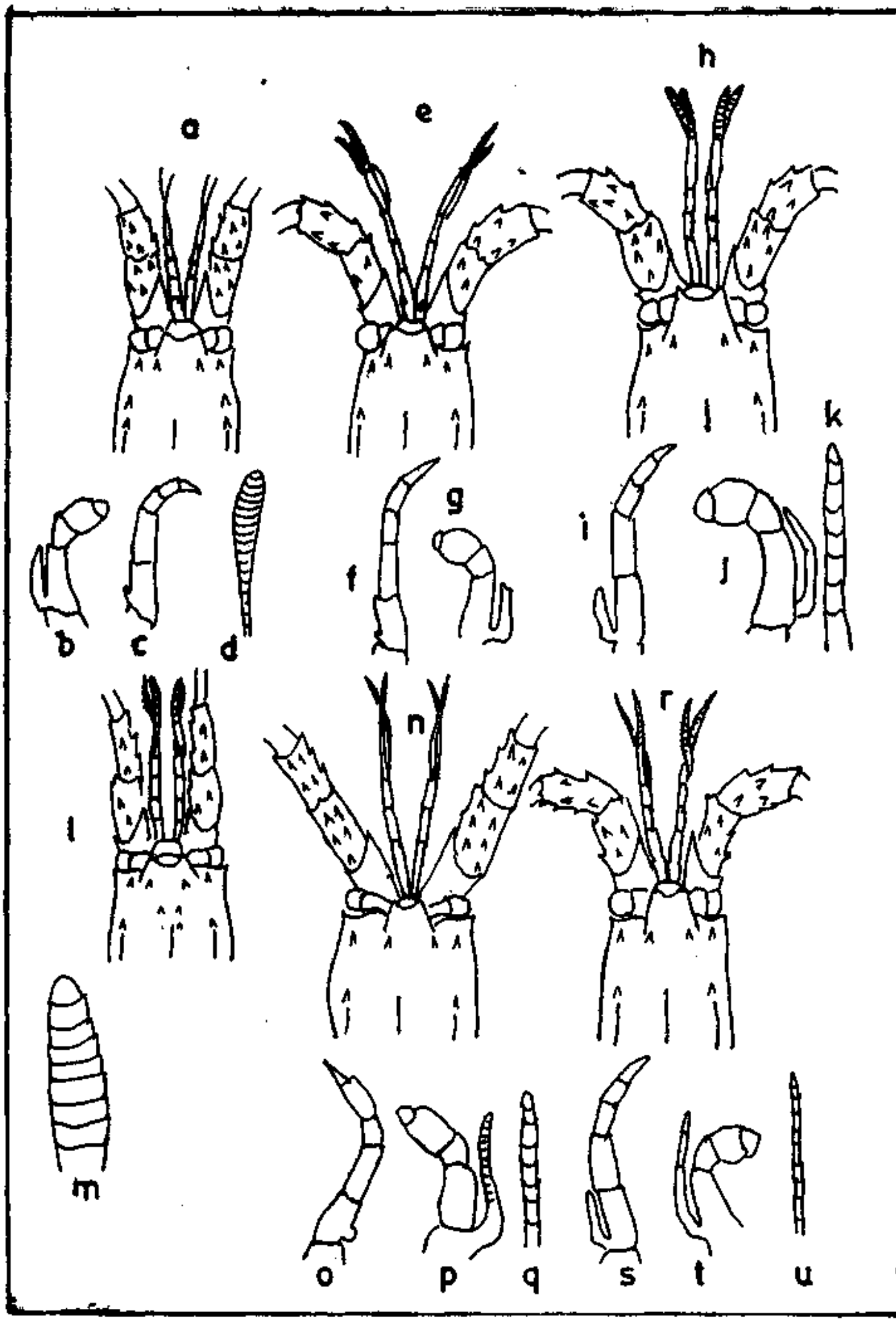


Fig. 2. Illustrations of puerulus stage (carapace portion alone) of *Panulirus* spp. *P. homarus* (a to d) : a—Anterior portion of carapace, b—Second maxilliped, c—Third maxilliped, d—Tip of antennal flagellum ; *P. versicolor* (e to g) : e—Anterior portion of carapace, f—Third maxilliped, g—Second maxilliped ; *P. penicillatus* (h to k) : h—Anterior portion of carapace, i—Third maxilliped, j—Second maxilliped, k—Tip of antennal flagellum ; *P. ornatus* (l to m) : l—Anterior portion of carapace, m—Tip of antennal flagellum ; *P. polyphagus* (n to q) : n—Anterior portion of carapace, o—Third maxilliped, p—Second maxilliped, q—Tip of antennal flagellum ; *P. longipes* (r to u) ; r—Anterior portion of carapace, s—Third maxilliped, t—Second maxilliped, u—tip of antennal flagellum.

fication of puerulus of *Panulirus* spp. is provided in Appendix 2.

Present Status of Exploitation

At present, there is no organised fishing for lobsters in these islands. Stray numbers of *P. homarus*, *P. ornatus* and *P. penicillatus* are caught along with the fishes and prawns in the bottom set gill nets operated by the fishermen at Port Blair in South Andaman and Camorta Island in the Nicobar group. The number of units operated at these two centres are 4 in Camorta and 10 in Port Blair. The lobsters caught are disposed off locally by selling mostly to the passenger ships visiting Port Blair. The only record of fishing for lobsters is by the aborigines, who caught them using bow and arrows or by shooting a small net or wading through the reef areas (Radcliffe-Brown, 1922).

The production of lobsters could be improved by increasing the number of gill net units. Simultaneously, experimental trials of fishing by lobster trap could be taken up first in Port Blair and later in Camorta and Great Nicobar Islands.

Potential for Lobster Culture

Culture of the palinurid and scyllarid lobsters is done generally by rearing postlarval (puerulus or post-puerulus stage) and juvenile lobsters to marketable size (Kensler, 1967; Chittleborough, 1974; Serfling and Ford, 1975; Philips *et al.*, 1977; Radhakrishnan and Devarajan, 1980) or by spawning, hatching and rearing of phyllosoma larvae under controlled conditions (Saisho, 1966; Ong, 1967; Robertson, 1968; Provenzano, 1968; Dexter, 1972; Inoue, 1978; E.V. Radhakrishnan, per. com.).

In the case of the Australian lobster, *P. cygnus*, it took 5 years for pueruli to attain matured stage in captivity (Chittleborough, 1974). It was possible to rear the first phyllosoma larvae of *P. interruptus* upto sixth stage in 114 days (Dexter, 1972), *P. japonicus* upto last phyllosoma stage in 253 days (Inoue, 1978), *Scyllarus americanus* upto juvenile stage in 32-40 days (Robertson, 1968) and *P. homarus* upto sixth stage in 60 days (E.V. Radhakrishnan, per. com.). The food offered to the reared phyllosoma larvae was the freshly hatched out nauplii of the brine shrimp, *Artemia*, which were more readily accepted by the earlier phyllosoma stages than later stages, perhaps because of the small size of the *Artemia* nauplii. For larger phyllosoma larvae, larger prey such as fish larvae, hydromedusae and ctenophores were offered as food, which met with considerable success. For holding and rearing pueruli or early juveniles, trash fish, clam and mussel meat were used.

The recent major breakthrough in the spiny lobster culture in India is the enhancement of growth by ablating both eyes of the lobster, which accelerates the growth in a shorter period as reported by Silas (1982) and Radhakrishnan and Vijayakumaran (1982). According to them, ablated *P. homarus* moults frequently, since the Moult Inhibiting Hormone present in the eye is removed completely after ablation. The ablated lobsters have shown an increase of 340% in weight in 88 days of rearing, whereas the control lobsters registered an increase of only 136% in the same period. By this technology developed in India, it will be possible to cultivate puerulus or early juvenile stage lobsters to marketable size of 200 grams in 5-6 months.

There is a good potential for lobster culture in Andaman and Nicobar Islands. The technology to be involved is the holding and rearing of early juvenile and puerulus stage of lobsters of the genus *Panulirus* and applying eye ablation techniques for acceleration of growth. The main source of food for reared lobsters will be the trash fish available locally. Different types of collectors such as tiles, coir and hemp fibres may be suspended from floating rafts for collection of pueruli. The key at Appendix 2 would help in the identification of pueruli of different species.

References

Alcock, A. 1901. *A descriptive catalogue of the Indian deep-sea Crustacea, Decapoda, Macrura and Anomola in the Indian Museum, being a revised account of the deep-sea species collected by the Royal Marine Ship 'Investigator'*, Calcutta, pp. 286.

Balss, H. 1925. Macrura d. Deutschen Tiefsee-Exp. 2. Naturtha Tel A. *Wiss. Ergeb. Deutsch. Tiefsee*—Exp. 'Valdivia', Vol. **20** (5): 221-315.

Chekunova, V. I. 1971. Distribution of commercial invertebrates on the shelf of India, the northeastern part of Bay of Bengal and the Andaman Sea. In: *Soviet Fisheries Investigations in the Indian Ocean.* Ed. by A. S. Bogdanov. Israel Programme for Scientific Translations, Jerusalem, pp 68-83.

Deshmukh, S. 1966. The puerulus of the spiny lobster *Panulirus polyphagus* (Herbst) and its metamorphosis into post-puerulus. *Crustaceana*, **10**: 137-150.

Chittleborough, R. G. 1974. Western rock lobster reared to maturity. *Aust. J. Mar. Freshw. Res.*, **25**: 221-225.

Dexter, D. M. 1972. Moulting and growth in laboratory reared phyllosomes of the California spiny lobster, *Panulirus interruptus. Calif. Fish. Game*, **58**: 107-115.

Gordon, I. 1950. On the puerulus stage of some spiny lobsters (Palinuridae). *Bull. Brit. Mus. nat. Hist.* (Zool.), **2**: 17-42.

Inoue, M. 1978. Studies on the cultured larvae of the Japanese spiny lobster, *Panulirus japonicus*—1. Morphology of the phyllosoma. *Bull. Jap. Soc. Sci. Fish.*, **44** (5) : 457-475.

KENSLER, C. B. 1967. Notes on laboratory rearing of juvenile spiny lobsters, *Jasus edwardsii* (Hutton) (Crustacea : Decapoda : Palinuridae). *N. Z. J. Mar. Freshw. Res.*, **1** : 71-75.

MENON, P. M. G. 1976. Fisheries in the Andamans. *Yojana*, **20** (13) : 63-68.

MICHELL, A. 1971. Note sur les puerulus de Palinuridae et les larvae phyllosomes de *Panulirus homarus* (L.) *Cah. O. R. S. T. O. M. Ser. Oceanogr.*, **9** : 459-473.

ONO, K. S. 1967. A preliminary study of the early larval development of the spiny lobster *Panulirus polyphagus* (Herbst). *Malay. Agri. J.*, **46** (2) : 183-190.

PHILLIPS, B. F., N. A. CAMPBELL AND W. A. REA. 1977. Laboratory growth of early juveniles of the western rock lobster *Panulirus longipes cygnus*. *Mar. Biol.*, **39** : 31-39.

PRASAD, R. R. AND P. R. S. TAMPI. 1968. Distribution of palinurid and scyllarid lobsters in the Indian Ocean. *J. mar. biol. Ass. India*, **10** (1) : 78-87.

PROVENZANO, A. J. 1968. Recent experiments on laboratory rearing of tropical lobster larvae. *Gulf. Caribb. Fish. Inst. Univ. Miami Proc.*, **21** : 152-157.

RADCLIFFE-BROWN. 1922. The Andaman Islanders. The Free Press, New York, pp. 1-510.

RADHAKRISHNAN, E. V. AND K. DEVARAJAN. 1980. Growth of the spiny lobster, *Panulirus polyphagus* (Herbst) in the laboratory. *Symposium on Coastal Aquaculture*, Abstract No. **157**, Mar. biol. Ass. India.

RADHAKRISHNAN, E. V. AND M. VIJAYAKUMARAN. 1982. Unprecedented growth induced in spiny lobsters. *Mar. Fish. Infor. Serv. T & E. Ser.*, No. **43** : 6-8.

ROBERTSON, P. B. 1968. The complete larval development of the sand lobster, *Scyllarus americanus* (Smith) (Decapoda, Scyllaridae) in the laboratory with notes on larvae from the plankton. *Bull. Mar. Sci.*, **18** (2) : 294-342.

SERFLING, S. A. AND R. F. FORD. 1975. Laboratory culture of juvenile stages of the California spiny lobster, *Panulirus interruptus* (Randall), at elevated temperatures. *Aquaculture*, **6** : 377-387.

SAISHO, T. 1966. Studies on the phyllosoma larvae with reference to the oceanographical conditions. *Mem. Fac. Fish. Kagoshima Univ.*, **15** : 177-239.

SILAS, E. G. 1982. Major breakthrough in spiny lobster culture *Mar. Fish. Infor. Serv. T & E. Ser.*, No. **43** : 1-5.

APPENDIX 1

A KEY TO THE IDENTIFICATION OF *PANULIRUS* SPP. OCCURRING IN ANDAMAN AND NICOBAR ISLANDS

1.	Each abdominal segment with a transverse groove (Fig. 1 a)	2
	Abdominal segment without a transverse groove (Fig. 1 b)	4
2.	Anterior margin of abdominal grooves scalloped (Fig. 1 c)	*P. homarus*
	Anterior margin of abdominal grooves not scalloped (Fig. 1 a)	3
3.	Antennular plate with 4 equal principal spines fused at base (Fig. 1 d)	*P. penicillatus*
	Antennular plate with 2 principal spines and some smaller spines behind (Fig. 1 e)	*P. longipes*
4.	Flagellum of exopod of second maxilliped well developed, multiarticulate (Fig. 1 f)	*P. polyphagus*
	Flagellum of exopod of second maxilliped small or absent (Fig. 1 g)	5
5.	Conspicuous transverse white band posteriorly on each abdominal segment ; Legs with longitudinal white lines (Pl. I, A)	*P. versicolor*
	No transverse white band on abdominal segments but a conspicuous white spot on lateral portion ; Legs with alternative yellow and black mottlings (Pl. I, B)	*P. ornatus*

APPENDIX 2

A KEY FOR THE IDENTIFICATION OF PUERULUS STAGE OF *PANULIRUS* SPP.

Modified from the earlier key given by Gordon (1950) and Deshmukh (1966) and illustrations adopted from Michell (1971)

1.	Exopodite of third maxilliped bud-like vestige	2
	Expodite of third maxilliped finger-like stump	5
2.	Two spines at the anterior end of each lateral carina on carapace ; exopodite of second maxilliped about the length of merus of endopodite ; antennae about twice the body length and with a spatulate apex	*P. homarus*
	Only one spine at anterior end of each lateral carina on carapace	3
3.	Exopodite of second maxilliped extends a little beyond the carpus of endopodite ; antennae about four times body length and without a spatulate apex	*P. polyphagus*
	Exopodite of second maxilliped reaching three-fourths the merus of endopodite	4
4.	Antennae about twice the body length and with spatulate apex	*P. ornatus*
	Antennae about thrice the body length and without spatulate apex	*P. versicolor*
5.	Exopodite of second maxilliped as long as the endopodite and that of third maxilliped surpasses the ischium of endopodite	*P. longipes*
	Exopodite of second maxilliped reaching the middle of carpus of endopodite and that of third maxilliped falls short of the ischium of endopodite	*P. penicillatus*

12

CRAB RESOURCES AND PROSPECTS FOR CRAB CULTURE

M. KATHIRVEL[1]

INTRODUCTION

The average annual crab landings during 1975-1981 from the Indian coast are 21,310 tonnes, forming 10.4% of the total crustacean landings. Rao *et al.* (1973) have estimated the total crab resources of the Indian seas at 43,000 tonnes, and nearly half of the estimated resources are at present being exploited. Out of 8 species of edible crabs listed by Rao *et al.* (1973), *Scylla serrata* (Forsskal), *Portunus pelagicus* (Linnaeus) and *P. sanguinolentus* (Herbst) have been the principal species in the exploited fishery along the coasts of the country. Except for the faunistic records of these edible crabs from Andaman and Nicobar Islands by Alcock (1899), Chopra (1935), Sankarankutty (1961) and Premkumar and Daniel (1971), no information is available on the abundance and exploitation of commercially important species from these Islands.

OBSERVATIONS

Data on the type of gear employed, species of crabs exploited, estimated catch on the day of observation and catch trend in earlier period were collected during the present survey carried out in January-April 1978. Fig. 1 gives the characters for identification of the local species of crabs. A key for field identification of the species is given in the Appendix.

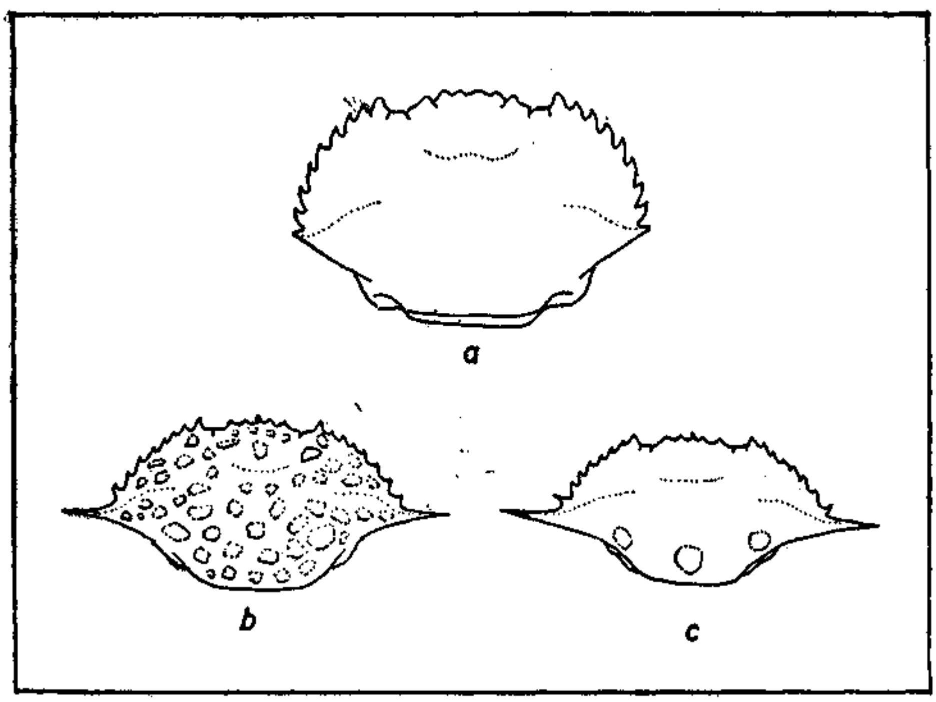


Fig. 1. The shape of anterolateral teeth of carapace and colour pattern of (a) *S. serrata*, (b) *P. pelagicus* and (c) *P. sanguinolentus*.

[1] *Present address:* CMFRI Research Centre, Madras-600 105.

Diglipur : On the eastern side of Diglipur, trawling was conducted by the mechanised boat at a depth range of 40-45 m on sandy bottom. A single specimen of the sand crab, *Portunus pelagicus* measuring 128 mm in carapace width (CW) (130 grams in weight) was obtained.

Havelock Island : On the western side of the island, crabs were obtained by hand-picking from the rocky area in the intertidal region. Two males of *Scylla serrata* measuring 114 mm and 126 mm CW and 230 grams and 295 grams in weight were collected. It was learnt on enquiry that this species was usually caught during post-monsoon months.

Port Blair : Four units of bottom set gill-net were operated at 10 m depth off Hado wharf. Bottom below was sandy. A total of 4 kg of *Portunus pelagicus* in the size range of 98 to 146 mm CW were obtained. The modal size was found at 126-130 mm.

Six units of bottom set gill-nets were operated off Janglighat at 10 m depth. Along with penaeid prawns and fishes, 3 kg of *S. serrata* and 5 kg of *P. pelagicus* were landed. The overall size range for *S. serrata* and *P. pelagicus* was 98-110 mm and 83-151 mm respectively. On enquiry, it was learnt that the maximum crab landings are during December-April.

Camorta Island : Bottom set gill-nets were operated in the Beresford channel between Camorta and Trinkat Islands on a bottom of live corals. One specimen of *S. serrata* (150 mm CW, 535 g), one *Portunus sanguinolentus* (110 mm CW, 67 g) and 2 males of *P. pelagicus* (151 & 153 mm CW, 400 g total weight) were caught.

Katchall Island : One female specimen of *P. sanguinolentus* (79 mm CW) was collected by hand-picking.

Present Status of Exploitation

In the Andaman and Nicobar Islands, fishing operations are carried out by gill-nets, boat seines, shore seines and cast nets. Altogether there are about 100 units of the gears of different types operating at present in these islands. If a day's catch from these units is taken at 80-100 kg, at least 2-3 tonnes can be expected to land in a month. No data on crab catch are available at present, as it forms a very minor component in the fishery.

Crab Culture Potential

Among the edible crabs of the Indo-Pacific region, the portunid crabs *S. serrata* and *P. pelagicus* are considered for cultivation in India (Marichamy *et al.*, 1980), Indonesia (Schuster, 1952), Philippines (Escritor, 1973), Sri Lanka (Raphael, 1973) and Taiwan (Chen, 1976). According to Ling (1973), *S. serrata* is reared in earthern ponds on a small scale in Singapore and Hong Kong and on experimental basis in Thailand. In the case of *P. pelagicus*, the development of culture is in the status of pilot scale operation in Japan. Except in Japan, in all other countries mentioned above, the young *S. serrata* measuring 30 to 70 mm in CW are collected from the natural environments such as backwaters, estuaries and salt water lakes and stocked in earthern ponds either alone or with the milk fish (*Chanos chanos*) at a stocking density varying from 5,000 to 8,000 per 0.5 ha. The duration of culture period is 6 to 10 months by which time the reared crabs attain the marketable size of 120 to 150 mm CW and weigh 400 to 500 g. The survival rate varies from 60 to 80% with a production rate of 500 to 700 kg per ha per year, when it is cultivated alone. Since *S. serrata* is adaptable to a wide range of environmental conditions and fetches a high price for its size and delicacy, preference can be given to its culture in Andaman and Nicobar Islands.

References

Alcock, A. 1899. Materials for a Carcinological Fauna of India. No. IV. The Brachyura-Cyclometopa. Part II. A revision of the Cyclometopa with an account of the families Portunidae, Cancridae and Corystidae. *J. Asiat. Soc. Bengal*, 68, Part 2 : 1-104.

Chen, T. P. 1976. *Aquaculture practices in Taiwan.* Fishing News (Books) Ltd., England, pp. 162.

Chopra, B. N. 1935. Further notes on Decapoda Crustacea in the Indian Museum. On the Decapoda Crustacea collected by the Bengal Pilot Service off the mouth of the river Hooghly. Brachygnatha (Oxyrhyncha and Brachyrhyncha). *Rec. Indian Mus.*, 37 : 463-514.

Escritor, G. L. 1973. Observations on the culture of the mud crab, *Scylla serrata.* In : *Coastal Aquaculture in the Indo-Pacific region.* Ed. T.V.R. Pillay, Fishing News (Books) Ltd., London, pp. 355-361.

Ling, S. W. 1973. A review of the status and problems of coastal aquaculture in the Indo-Pacific region. In : *Coastal Aqaculture in the Indo-Pacific region.* Ed. T.V.R. Pillay, Fishing News (Books) Ltd., London, pp. 2-25.

Marichamy, R., M. Manickaraja and S. Rajapackiam. 1980. Culture of the mud crab, *Scylla serrata* (Forsskal) in Tuticorin Bay. *Symposium on Coastal Aquaculture*, Abstract No. 159, Mar. biol. Ass. India.

Premkumar, V. K. and A. Daniel. 1971. Crustaceans of economic value of Great Nicobar Island 2. Decapoda : Brachyura : Portunidae. *J. Zool. Soc. India*, 23 (2) : 109-112.

Rao, P. Vedavyasa, M. M. Thomas and G. Sudhakara Rao. 1973. The crab fishery resources of India. *Proc. Symposium on Living Resources of the seas around India*, CMFRI, Special publication, pp. 581-591.

Raphael, Y. I. 1973. A preliminary report on the brackish-water pond culture of *Scylla serrata* (Forskal) in Ceylon. In : *Coastal Aquaculture in the Indo-Pacific region.* Ed. by T.V.R. Pillay, Fishing News (Books) Ltd., London, p. 395.

Sankarankutty, C. 1961. On Decapoda Brachyura from Andaman and Nicobar Islands. I. Families Portunidae, Ocypodidae, Grapsidae and Mictryidae. *J. mar. biol. Ass. India*, 3 : 101-119.

Schuster, W. H. 1952. Fish culture in brackish-water ponds of Java. Indo-Pacific Fisheries Council, Special publication, No. 1, 140 pp.

APPENDIX

A KEY FOR FIELD IDENTIFICATION OF EDIBLE CRABS OF ANDAMAN AND NICOBAR ISLANDS

Last pair of legs paddle-shaped; surface of carapace ill-defined; hands of cheliped inflated and smooth ; teeth on anterolateral border of carapace equal in size (Fig. 1 a) .... *Scylla serrata*

Last pair of legs paddle-shaped ; surface of carapace well defined ; hands of cheliped prismatic and costate ; last tooth on anterolateral border of carapace produced into a long spine (Fig. 1 b) .... *Portunus*

Carapace covered with mesh work pattern of irregular shaped spots (Fig. 1 b) ; a spine at the end of posterior border of the arm of cheliped .... *P. pelagicus*

Carapace with three dark red spots at the posterior border (Fig. 1 c) ; no spine at the end of posterior border of the arm of cheliped .... *P. sanguinolentus*

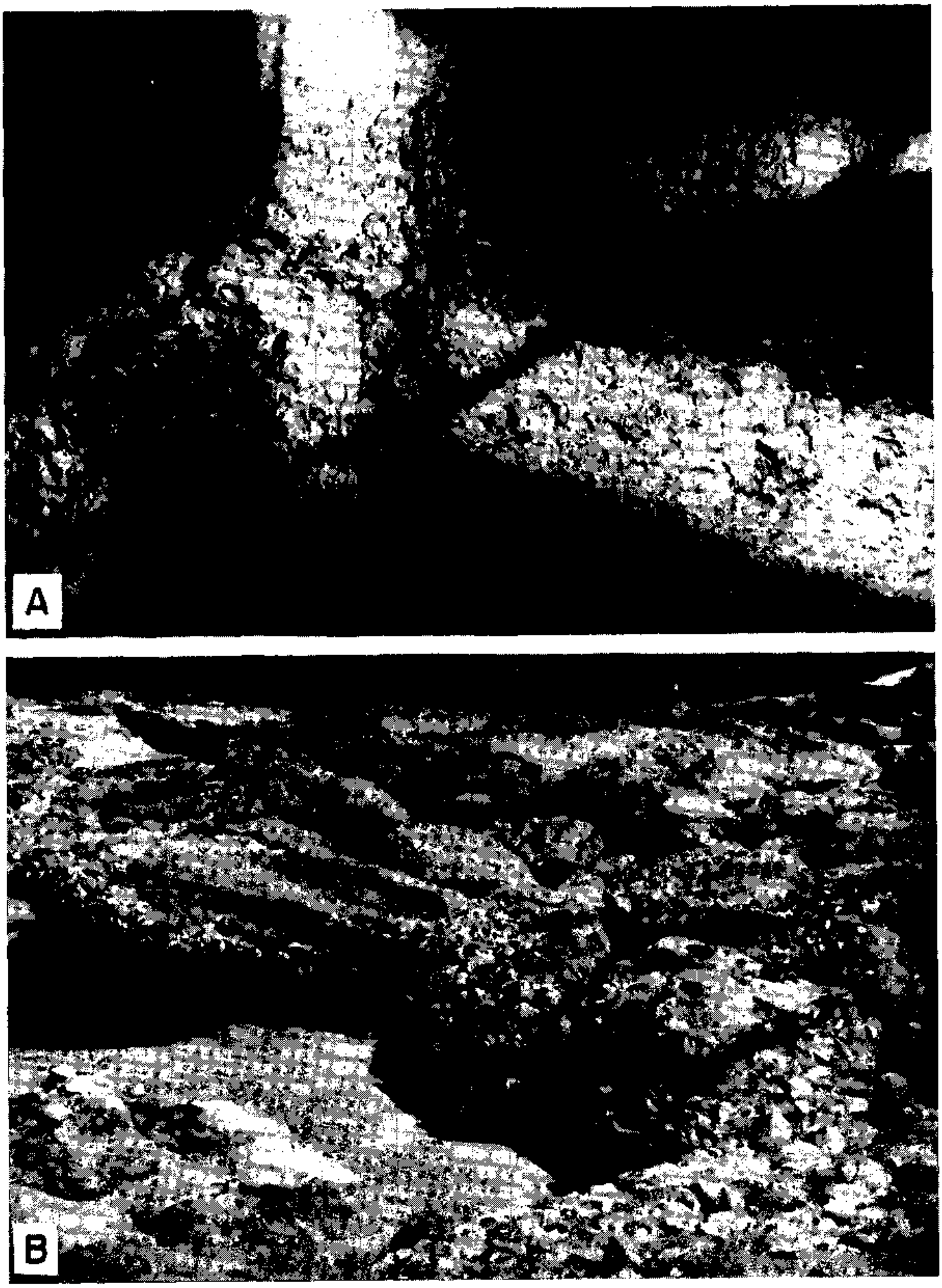


PLATE I. A—*Crassostrea madrasensis* on the R.C.C. jetty in Mayabunder. B—*Saccostrea cucullata* on the intertidal rocks in Havelock Island,

13

EDIBLE OYSTER RESOURCES AND CULTURE POTENTIAL

K. RAMADOSS[1]

INTRODUCTION

Awati and Rai (1931) recognised four commercially important species of edible oysters occurring along the Indian coasts, namely *Crassostrea madrasensis*, *C. gryphoides*, *C. discoidea* and *Saccostrea cucullata*. These species are important from the point of view of oyster culture. Already efforts are under way to farm one or more of the above species in India (Mahadevan *et al.* 1981). Hitherto not much was known about the oyster resources of the Andaman and Nicobar Islands. The survey of January-April 1978 carried out by the Central Marine Fisheries Research Institute showed that both *C. madrasensis* and *S. cucullata* are represented in these islands.

DISTRIBUTION OF EDIBLE OYSTERS

Table 1 gives the density of population of *C. madrasensis* and *S. cucullata* at the different centres surveyed.

TABLE 1. *Distribution of oysters in intertidal and subtidal areas*

Area		*S. cucullata* Nos/sq. m. Intertidal	Subtidal	*C. madrasensis* Nos/sq. m. Intertidal	Subtidal
Diglipur	..	65	5	15	2
Mayabunder	..	70	2	30	5
Havelock Island	..	65	1	35	3
Neill Island	..	30	..	10	2
Rangat bay	..	25	..	8	0.5
Long Island	..	50	2	5	2
Port Blair	..	70	5	35	0.5
Ross Island	..	15	5	5	2
Chiryatapu area		15	5	25	1
Little Andaman	..	10	2	5	..
Car Nicobar	..	..	..	..	..
Katchall	..	10	..	8	..
Nancowry	..	10	..	5	..
Camorta	..	15	..	8	..
Campbell Bay	..	30	..	5	..

Present address :

[1] CMFRI, Regional Centre, Mandapam Camp.

In Long Island *S. cucullata* was found attached on floating wood. In Mayabunder and Havelock jetties, R.C.C. pillars were found covered with *C. madrasensis* at low water mark level (Pl. I, A). The oyster population was observed to be less in Nicobar Islands as compared to Andaman Islands. The percentage of *S. cucullata* (Pl. I, B) is greater than that of *C. madrasensis* at all the centres of observation.

CULTURE POTENTIAL

Considering the topographical features of the seaward side of the east coast of Andamans, it would be safe to take up experimental oyster culture in the sheltered bays of the various islands. There are many such suitable areas such as Ariel Bay, Oyster point at Mayabunder, sheltered bays at Port Blair, Hut Bay in Little Andaman and Kimios Bay in Car Nicobar.

The salinity at most of the centres was in the range 31-33‰ similar to that of the open coast. Andaman receives a heavy rainfall of 290-325 cm per annum spread over a period of 9 months and the effect of dilution on oyster culture should be studied. The bays are comparatively shallow with soft bottom and either the rack system of culture or the line culture method may be tried. To begin with it may be feasible to attempt oyster farming in one of the bays near Port Blair, preferably the Navy Bay or the Minnie Bay.

In Andaman group of islands people, except the 'Karens', rarely consume oysters. In Little Andaman oyster meat is popular among the Bengali settlers. The Nicobar fishermen relish all kinds of shellfish and exploit them from the intertidal areas heavily, seldom allowing the molluscs to grow to large size. Considering the species resources, presence of suitable sites for farming and the local demand for oyster as food, there is a bright prospect for oyster culture in the Andaman and Nicobar Islands.

REFERENCES

AWATI, P. R. AND H. S. RAI. 1931. *Ostrea cucullata. Indian Zool. Mem.*, 3 : 1-107.

MAHADEVAN, S., K. N. NAYAR AND P. MUTHIAH. 1981. Oyster farming. *Mar. Fish. Infor. Serv. T and E Ser.*, 26 : 1-3.

14

ON THE POSSIBILITY OF MUSSEL CULTURE

S. MAHADEVAN[1]

Mussel Resource at Chippighat

Of all the areas visited in the Andaman and Nicobar Islands, only Chippighat, a narrow tidal creek near Port Blair (Fig. 1), was found to have a sizable population of green mussel, *Perna viridis*. Bumiltan creek, as it is known, meanders to the interior from Flat Bay to Chippighat.

Ecology of the area

There is a standing column of 1-2 m of water in the creek always, all along its length and breadth. Salinity of the water in the creek on the day of observation was 32.29‰ the same as that of Flat Bay. It is quite possible that during the rainy months run off water from the surrounding elevated ground would find its way into the creek at many points. But the tidal amplitude reaching the Chippighat area is so pronounced as to neutralise to a very great extent the effect of the fresh water influx and dilution. A good percentage of the stock might perish during this period, especially those which are near the banks where the rivulets join the creek.

The bottom of the creek is mostly slushy, firm in certain areas and loose elsewhere. The rocks lying scattered here and there in the creek offers a good substratum for the mussel settlement (Fig. 2). Majority of mussels thriving in the area were found attached to these submerged stones, particularly to those lying scattered among the roots of mangrove trees lining the creek at 0.5 m depth. Skin-diving was resorted to for collecting the mussels from the middle of the creek.

On an average 14 specimens were collected from 1 sq. m. area in clusters of 5 or 6 growing on stones. A total of 102 live specimens was taken ranging in size from 60 mm to 130 mm. It is estimated that at present there is a population of about 12,000 mussels in the area surveyed. Appukuttan (1977) has recorded this species as *Perna viridis*. Due to paucity of time, the

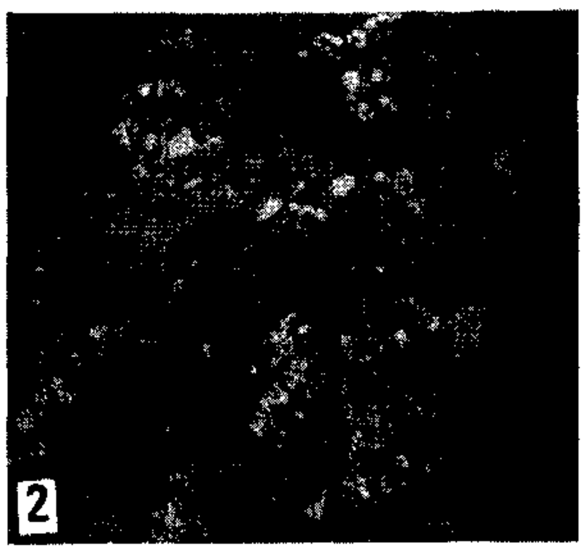


Fig. 1. The area at Chippighat where green mussel *Perna viridis* population occurs.

Fig. 2. Mussels found attached to rocks in the creek.

Present address :

[1] CMFRI, Regional Centre, Mandapam Camp.

survey could not be extended beyond to cover wider areas in the creek.

Culture possibilities

The area appears to be good for attempting mussel culture. The creek is easily accessible by road, and is sheltered from storms and surf action. Because of the shallow nature of the creek and the generally loose bottom it looks advisable to try erecting platforms on wooden poles, driven down the bottom. Mussels can be kept on trays positioned well below the water surface and grown to form the breeding stock. An alternate method would be to put them in nylon twine meshed bags suspended from the poles, keeping the mussel stock off bottom. During the spawning period, which is to be studied here, spat collection may be attempted by suspending loosely woven coir or nylon ropes of 10 mm diameter and 1 metre length. If spat collection is successful, these ropes can be spirally wound round 15-20 cm diameter 4 m long poles which can be driven for half their length into the sediment in the creek. These poles can be erected in rows perpendicular to the bank at sufficient intervals and an area of 1 ha can be initially cultivated. Based on the success of the experiments more areas can be covered in this creek and in the adjacent areas of Minnie Bay and Navy Bay also.

REMARKS

It appears difficult to attempt mussel farming in the open sea coast areas of the eastern aspect of the island because of tidal and current force. However, Ariel Bay and Blair Bay of North Andaman and Bacon Bay in Mayabunder area of Middle Andaman are places where trials can be made. Although there are sheltered areas like Octavia Bay and Spiteful Bay in Camorta and Nancowry islands, the absence of natural mussel population and remoteness of these areas are factors against any effort to be made there at present.

It is well known that South Andaman receives copious amount of rain during May to December every year (280 cm). The seasonal streams emptying the rainwater into the tidal creek at Chippighat at various points have not completely destroyed the mussel population by the dilution of saline water. This shows encouraging signs and scope for starting culture work in this area. Once the attempts are successful in Chippighat, activities can be expanded to other areas with required local modifications in the growing technique.

REFERENCE

APPUKUTTAN, K. K. 1977. On the occurrence of the green mussel *Perna viridis* (Linnaeus) in Andaman Island. *Indian J. Fish.*, 24 : 244-247.

15

THE BLACK-LIP PEARL OYSTER RESOURCE AND PEARL CULTURE POTENTIAL

K. ALAGARSWAMI[1]

Introduction

The survey of the Andaman and Nicobar Islands had, as one of its objectives, an investigation on the potential of the region for pearl culture. The Indo-Australian Archipelago is an important region in the world distribution of pearl oysters. The Mergui Archipelago, which is on the eastern bounds of the Andaman Sea is the area of Burmese pearl culture with the most valued species *Pinctada maxima* (Jameson). Although pearl oysters have been recorded from the Andamans (Prashad and Bhaduri, 1933 ; Rao, 1970) there is no information on their distribution and abundance as an exploitable resource. On the mainland of India the major pearl oyster resource is *Pinctada fucata* (Gould) and technology for pearl culture in this species has been developed earlier (Alagarswami, 1974 ; Alagarswami and Qasim, 1973). Ideal sites for pearl culture, as found in Japan (Alagarswami, 1970) or Australia (Hancock, 1973), are rare along the mainland coast. The marine ecosystem of the Andaman and Nicobar Islands with numerous bays has been considered potential grounds for pearl culture. The survey carried out during January-April 1978 provided some information on the pearl oyster resources and their ecological conditions and helped in a preliminary appraisal of the islands' pearl culture potential.

Dr. K. Alagaraja and Shri M. Srinath helped in deriving the equations for the relationships of shell dimensions and weights presented in the paper.

Material and Methods

The survey was carried out by examining the intertidal beds trekking on foot and by skin-diving and SCUBA-diving, generally up to a depth of 10 m. No diving was undertaken in deeper waters due to lack of knowledge of the environment, swift currents, sudden increase in depth profile close to reefs and shark infestation of the areas. Being a rapid preliminary survey, beset with problems of transport between and within islands, very few areas, mostly on the eastern front of the islands, could be covered. Pearl oysters collected were preserved in 5% formalin. On completion of survey, the materials were transported to the Tuticorin Research Centre of the Institute. Measurements, total weight and shell weight of the preserved material were taken and the gonads were examined for sex of the animal and stage of maturity.

Observations

Species resource

The main species of pearl oyster collected at several centres during the survey was the black-lip *Pinctada margaritifera* (Linnaeus) (Pl. I). This species is rare along the mainland coast of India. The background colour of *P. margaritifera* shells in the collections is dark green, bronze, brown or black. The shells show variation in form and outline as reported by Prashad and Bhaduri (1933) (Pl. II A, B, C). *P. fucata* (Gould) which is the commercial pearl oyster of India, known for the production of orient pearls, was represented only by two specimens in the collection, coming from Camorta in the Nicobar group. The 'flat' oysters, represented by *P. sugillata* (Reeve) (Pl. II, E) and *P. anomioides* (Reeve), were dominant in Hut Bay in Little Andaman, and one or two specimens came from Smith Is., Neill Is., Havelock Is. and Camorta. The wing shell *Pteria penguin* (Röding) was collected from Mayabunder, Havelock Is. and Camorta. *Pinctada maxima* (Jameson) was not available in the areas and depth zones surveyed.

Ecology of pearl oyster beds

Pinctada margaritifera generally occupies the intertidal reef flat and was observed up to a depth of about 10 m. The reef flat is coralline and is interspersed with

[1] *Present address :* CMFRI, Cochin 682 018.

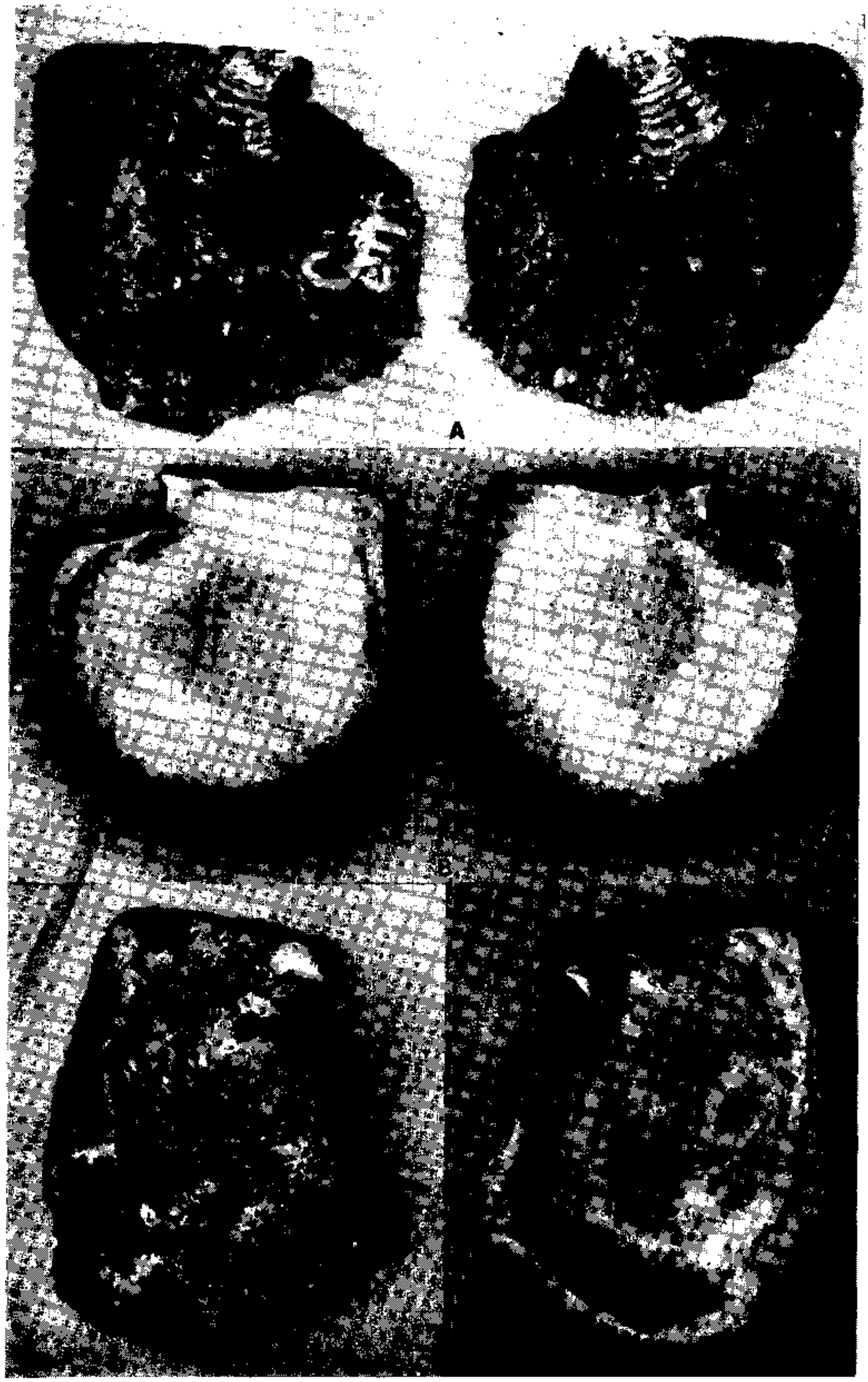


Plate I. A to D. *Pinctada margaritifera* : A—External characteristics of shell. DVM 70 mm, Hut Bay ; B—Internal features of shell, DVM 90 mm, Neill Island ; C and D—External and internal features of a distorted shell taken from a crevice of boulder, DVM 103 mm, Ross Island off Port Blair.

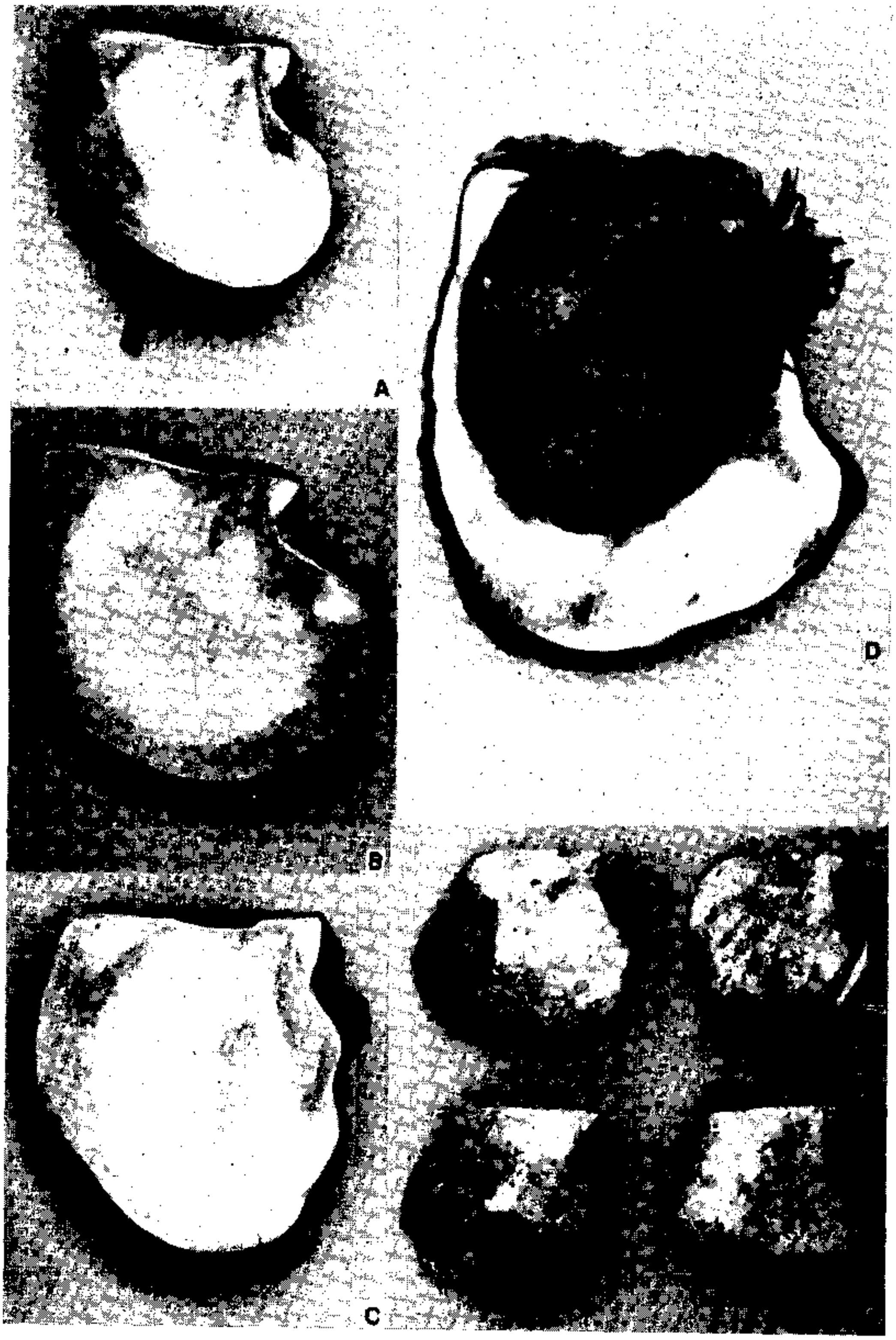


PLATE II. A to D. *Pinctada margaritifera* : A to C—Variations in nacreous border of shells DVM respectively of 45 mm, 70 mm and 69 mm ; D—Rich byssal threads and soft parts of animal ; E—*Pinctada sugillata* from Hut Bay, Little Andaman.

hard sandy bottom, covered with algal growth. Pearl oysters are found attached with strong byssal threads (Pl. II D) to live or dead corals, block corals and large boulders. While they are commonly found on the exposed sides of corals, rocks etc., are occasionally seen in crevices and such shells have slightly distorted shape (Pl. I, C, D). They are also found on the pillars of piers and jetties as in Mayabunder, Havelock Is. and Camorta.

Some of the organisms commonly found on the beds where pearl oysters have been collected are *Tridacna* spp., *Crassostrea* spp., *Trochus niloticus*, holothurians, brittlestars and ascidians. *P. margaritifera* appears to follow closely the distribution of *Tridacna* species in the islands. On the piers, the associated organisms are *Crassostrea* spp. and *Pteria penguin* as found in Mayabunder and Havelock Is.

While the pearl oysters on the reef flat are invariably covered with a thin sand encrustation, those on the pillars are relatively clean. Biofouling is light and the organisms generally noticed on the shells are algae, hydrozoans, ascidians, sponges, tubicolous polychaetes, young corals, bryozoans, oyster spat and small barnacles. Boring by sponge was occasionally noticed and on one shell, *Lithophaga* sp. was present. Going by the very little damage caused to the shells by the fouling and boring organisms, these do not appear to be of any consequence. Evidence of predation was not available, except on a few specimens from Chiriyatapu whose shell margins appeared to have been crushed by fishes.

Pearl oyster population

Among the areas visited from Diglipur base (North Andaman), *P. margaritifera* was collected only from Smith Is. The extreme south-western coast of the island had an approximate population density of 0.25 oyster/m². The 16 oysters examined were in the size range (dorsoventral measurement, DVM) 34.0-92.3 mm and weight range 7.0-152.5 g.

In Mayabunder, the northernmost part of the Middle Andaman, *P. margaritifera* was collected on the reef flat from Takla Oyster Point to old jetty and also in the new jetty area. In the latter place the density on the pillars was *ca.* 10 oysters/m², between the high water and low water marks. *Pteria penguin* and *Crassostrea* spp. formed an assemblage with the pearl oyster. The density of *P. penguin* was *ca.* 3/m². A total of 13 pearl oysters examined was in the size range 43.5-106.0 mm and weight range 13.0-184.0 g.

In Long Is., surveyed from Rangat base, only one pearl oyster and two shells were collected in the reef flat north of Lalaji Bay, which lies on the eastern side of the island. Oysters were very scarce.

The Ritchie's Archipelago was surveyed from a base in Neill Is. On the southern coast of Outram Is. one pearl oyster was collected. On the south-eastern coast of Inglis Is. the density was 0.2 oyster/m². Similar was the observation on the south-eastern extremity of Sir William Peel Is. Havelock Is. proved to be a better area for *P. margaritifera*, particularly a virtually *Tridacna* bed lying on the north-eastern coast of the island, south of jetty. All the pillars of the jetty showed the presence of *P. margaritifera*, along with edible oysters and *Pteria penguin*. The rock oyster *Saccostrea cucullata* was the most dominant in this community. The 14 black-lip oysters examined were in the size range 45.4-91.2 mm and weight range 14.0-93.0 g. Three flat oysters were also observed in the collection. On the eastern side of the jetty in Neill Is., the density of black-lip oyster on the reef exposed during the neap tide was 1 oyster/m². The 14 specimens examined were in the size range 39.7-92.3 mm and weight range 10.0-125.0 g.

In the survey programme, areas around Port Blair received a wider coverage than all other centres. On the eastern bounds of North Bay, pearl oysters were collected in the area north of the jetty. It was a good *Tridacna* bed, but the pearl oyster population was poor. The Blair reef was a bed of large edible oysters and here was a moderate population of *P. margaritifera* on the exposed reef flat. In the Phoenix Bay, the shoreline was muddy but pearl oysters were found at 7-8 m depth. Between Atalanta Point and South Point, *P. margaritifera* was collected from Aberdeen jetty and Sesostris Bay. The reef on the western side of Ross Island had a pearl oyster population of 1-2/m² at 5-8 m depth. A sample of 23 specimens examined from the Port Blair collections was in the size range 38.2-109.5 mm and weight range 11.0-191.0 g.

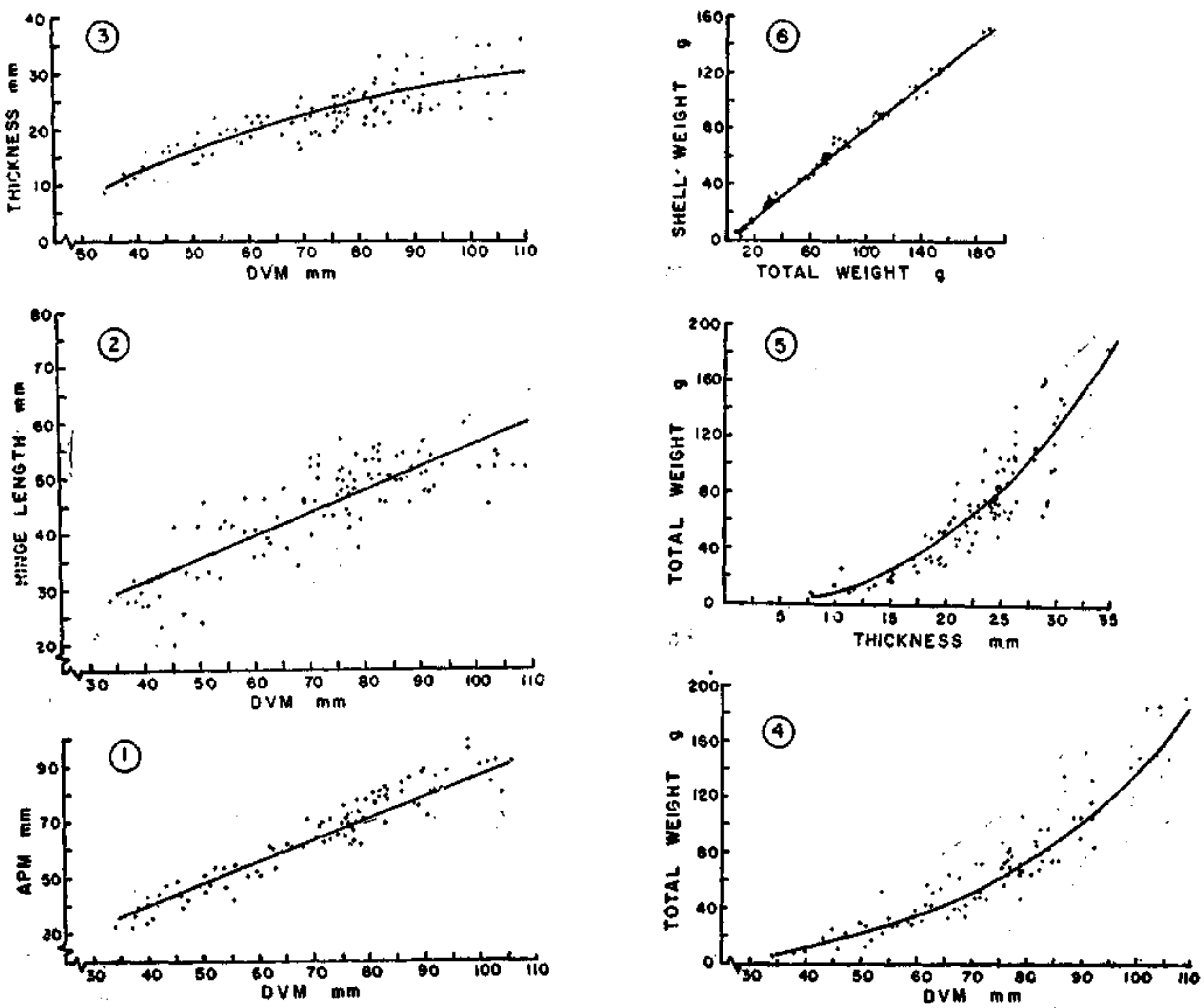
Pearl oysters were collected from the reef flat at Chiriyatapu and along the north-eastern shore of Rutland Is., the two areas being separated by the Macpherson strait. The oysters collected from this area were above 110 mm DVM.

The Hut Bay, on the east coast of Little Andaman, had a population of *P. margaritifera*, along with *P. sugillata* and *P. anomioides* which were predominant, on the western side of the jetty (South Point). The oysters were collected from the reef at a depth of 2 m. By far the highest density of pearl oyster population was noticed here. The long breakwater makes the area a sheltered place. The 10 specimens of *P. margaritifera* sampled had a size range of 50.2-104.2 mm and weight range of 42.0-149.0 g. The 65 flat oysters had a size range of 21.0-56.2 mm and weight range of 1.5-23.0 g.

The last pearl oyster collection of the survey came from Camorta in the Nicobar group. *P. margaritifera*

Notes on biology of P. margaritifera

Size composition : A total of 106 numbers of *P. margaritifera* sampled from different centres had an overall DVM range of 34.0-109.5 mm. The modal size group was at 70-80 mm. The weight range was 7.0-191.0 g and the modal weight group was at 60-80 g.



Figs. 1-6. *Pinctada margaritifera* : Dimensional relationships among shell characters and weights. (1) Anteroposterior measurement (APM) and dorsoventral measurement (DVM) ; (2) Hinge length and DVM ; (3) Shell thickness (exterior width of animal) and DVM ; (4) Total weight (formalin preserved oysters) and DVM ; (5) Total weight and shell thickness ; (6) Shell weight (both valves) and total weight. Regression equations of relationships are given in the text.

was found at the top 1-5 m column of the pillars of the jetty and as many as 15 oysters could be collected from each pillar. Two specimens of *P. fucata* and two of flat oysters were collected from this area. The 17 black-lip oysters sampled had a size range of 42.3-103.4 mm and weight range of 41.0-115.0 g. The two *P. fucata* measured 49.5 mm and 59.7 mm DVM.

Dimensional relationships : The availability of oysters of a wide size range made it possible to work out the relationships of shell dimensions and weights.

Fig. 1 represents the relationship of antero-posterior measurement (APM), which is the greatest distance between the anterior and posterior margins of the animal, to the dorso-ventral measurement (DVM) which is the distance between the hinge line and ventral margin. This relationship is expressed by the equation

$$Y = 9.6393 + 0.7685 X \quad \ldots\ldots\ldots\ldots \quad (1)$$

with r = 0.9257, where Y = APM and X = DVM in mm.

Fig. 2 describes the relationship between hinge length and DVM and the equation is

$$Y = 14.8224 + 0.4041 X \quad \ldots\ldots\ldots\ldots \quad (2)$$

with r = 0.7921, where Y = hinge length and X = DVM in mm.

Fig. 3 shows the relationship of thickness, the distance between the two valves measured externally, to DVM. This relationship was found best described by the asymptotic regression of the form $Y = a + b.c^x$, where Y = thickness (mm), X = DVM (mm), a = asymptotic value of Y, and b and c are constants. The fitted model is

$$Y = 41.331 - (50.8862) \quad (0.9864)^x \quad \ldots\ldots\ldots \quad (3)$$

with r = 0.8698. The dimension of thickness tends to approach an asymptotic value after reaching a certain size.

Fig. 4 depicts the DVM-total weight relationship and the equation is

$$Y = 0.0006 X^{2.6753} \quad \ldots\ldots\ldots\ldots \quad (4)$$

where Y = total weight (g) and X = DVM (mm). The logarithmic transformation of this equation is

$$\log_e Y = - 7.3626 + 2.6753 \log_e X \quad \ldots\ldots\ldots \quad (5)$$

which has r = 0.9610.

Fig. 5 gives the relationship of total weight on thickness and the equation is

$$Y = 0.0306 X^{2.4589} \quad \ldots\ldots\ldots\ldots \quad (6)$$

The logarithmic transformation of this equation is

$$\log_e Y = -3.4858 + 2.4589 \log_e X \quad \ldots\ldots\ldots \quad (7)$$

with r = 0.9427. The lower r value, as compared to equation (5), is attributable to the wider spread of the weights after a certain value of thickness which is due to the asymptotic nature of growth of thickness as explained in equation (3).

Fig. 6 illustrates the total weight-shell weight relationship which is of the form Y = a + b X, and the equation is

$$Y = -0.3841 + 0.8216 X \quad \ldots\ldots\ldots\ldots \quad (8)$$

where Y=shell weight and X = total weight (animal formalin preserved) with a very high correlation co-efficient r = 0.9995.

Food organisms : The stomach of preserved specimens was cut open and the inclusions were identified. The items included bivalve eggs (few), appendages of copepods and phytoplankters such as *Tetraselmis* (abundant), *Navicula, Nitzschia, Oscillatoria, Fragilaria, Chaetoceros, Euglena, Amphora* and *Diploneis.*

Sex composition and stages of maturity : Of the 85 pearl oysters examined for sex composition, 16 were indeterminate. Among others, 56.5% were males and 43.5% females. They were in the following reproductive phases :

Stage of gonad		*Males %*	*Females %*
Developing	..	46.2	43.3
Mature/ripe	..	51.2	50.0
Spent	..	2.6	6.7

From these data, it may be presumed that peak spawning might take place around June with the onset of the south-west monsoon.

The biological data presented here are sketchy and have severe limitations, but appear to be the only information available for the black-lip oyster in the area so far.

Discussion

The present survey has brought out *Pinctada margaritifera* as a resource of some importance in the Andaman and Nicobar Islands. This species is widely distributed in the Indo-Pacific region. Several varieties of this species such as *persica, erythraensis, zanzibarensis, cumingi* and *mazatlantica* are known from different parts of the world. Prashad (1932) referred all the Siboga collections of *P. magaritifera* to Jameson's var. *typica.* Prashad and Bhaduri (1933) noted that some of the black-lip shells from Andaman and Nicobar Islands resembled var. *zanzibarensis* but opined that these shells, as also others from a number of localities in the Indian Ocean present in the collections of the Indian Museum, must be referred to Jameson's (1901) var. *typica.*

The preliminary investigation has failed to throw any light on the occurrence of the gold-lip or silver-lip pearl oyster *Pinctada maxima* in the Andaman and Nicobar Islands. The Indo-Australian Archipelago is an important region for pearl culture, next to Japan, and the countries and species of pearl culture are represented in Fig. 7. It can be seen that *P. maxima* is a common factor of pearl culture in this belt. The pearl culture farms of Burma are located in Owen Is. and Sir Malcolm Is. in Mergui Archipelago which is on the eastern boundary of Andaman Sea. These centres are roughly opposite to Little Andaman of India. The farms of Thailand are located at Phuket, approximately opposite to Nancowry Is. of the Nicobar group. The juxtaposition of *P. maxima* production centres of Burma and Thailand to the Andaman and Nicobar Islands, across the Andaman Sea, would indicate the possibility of occurrence of this species in the latter region. Hynd (1955) mentions that, in Australia, this species has been taken from low tide level down to about 40 fm (73 m) but the bulk of the commercial catch comes from waters of 5-30 fm (9-55 m). The present survey was restricted up to 10 m depth and area coverage was also limited. Therefore, presence of this species, if available, has gone undetected.

The wing shell *Pteria penguin*, also called black-winged pearl oyster, has been collected from Mayabunder, Havelock Is. and Camorta. Wada (1973) states that this species is used for producing brilliant, pinkish half-pearls in the Fiji Islands and Borneo. Saraya (1982) mentions that this species is cultured in Thailand for pearls. Young and Serna (1982) indicate *Pteria* sp. among the commercially important bivalves and, according to Blanco (1972), *Pinctada maxima*, *P. margaritifera* and *Pteria macroptera* are the main species used in pearl culture in the Philippines. It is suggested that *P. penguin* may form a candidate species for pearl culture in the Andaman and Nicobar Islands.

Pinctada fucata, although recorded, is rare in the islands. This species does not contribute to pearl culture in the Indo-Australian Archipelago. However, Unar *et al.* (1982) mention that *P. vulgaris* (= *P. fucata*) occurs in Banten Bay of Indonesia. Any possibility of using this species for pearl production in the Andamans would be through transplantation from the mainland. But development of the local species would be of a higher priority. The 'flat' oysters, *P. sugillata* and *P. anomioides* abundant in Hut Bay are not good as pearl-producing molluscs and, hence, are not of any significance to pearl culture.

Seen from the survey results, the density of population of *P. margaritifera* is very low on the intertidal reef flats. This may be adduced, on the one hand, to poor survival and predation and, on the other, to the exploitation of the pearl oyster for human consumption by the Nicobarese. The fact that the pillars of the jetty at

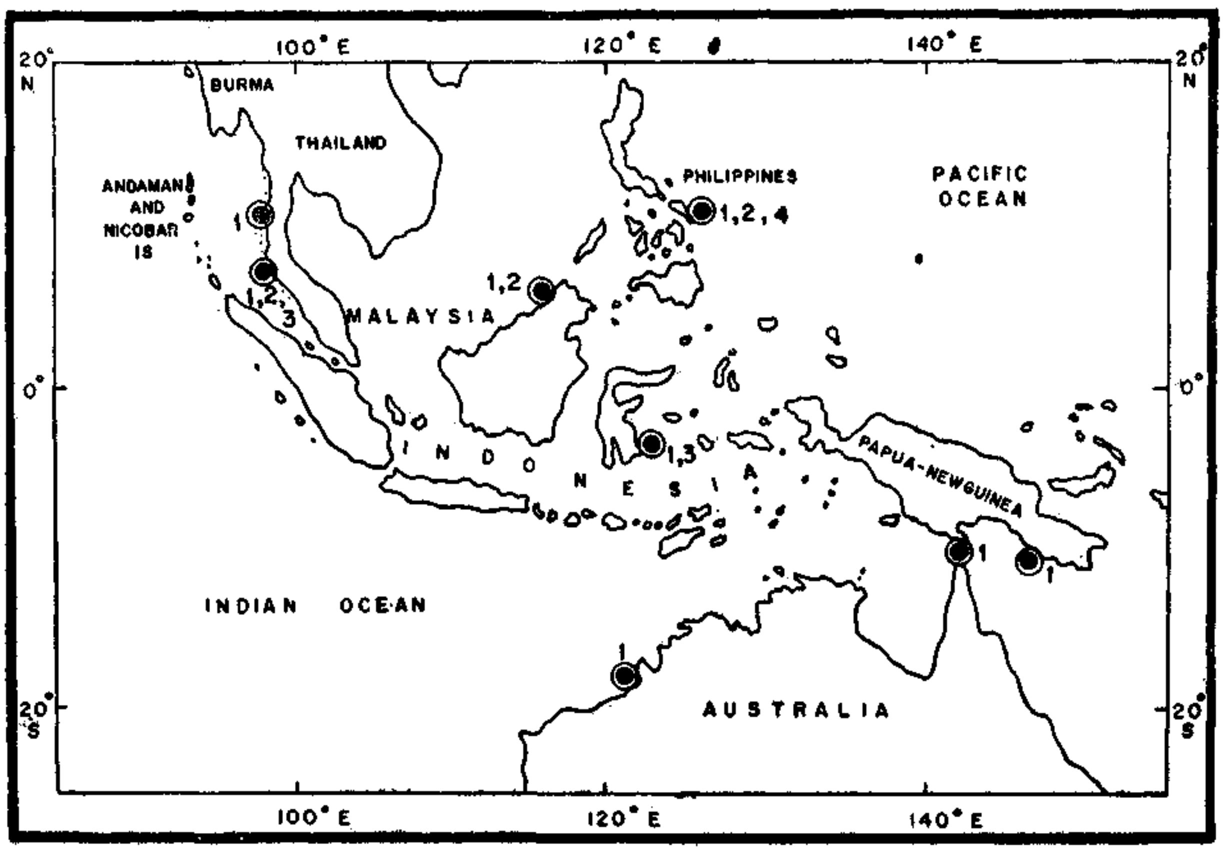


Fig. 7. Map of the Indo-Australian Archipelago, showing by enclosed dark circles the countries having commercial pearl culture operations. The Arabic numerals near the circles indicate species of pearl oysters used; 1-*Pinctada maxima*, 2-*P. margaritifera*, 3-*Pteria penguin*, 4-*Pteria macroptera*.

Mayabunder, Havelock Is. and Camorta showed a good number of pearl oysters would indicate that a better population could be raised in column waters than on the reef flat. In the Red Sea, the healthiest of pearl oysters are stated to be found in less than 5 fm (9 m) (Gideiri, 1980) and 3-5 fm was found to be the suitable depth stratum for spat collection (Crossland, 1957). The mother-of-pearl shell industry of Sudan in Dongonab Bay depends on collection of *P. margaritifera* spat in the column waters by using split bamboo shelf collectors and rearing them in nurseries and grow-out farms (Crossland, 1957 ; FAO, 1962). Lock (1982) reports that spat collection of black-lip oyster on plain nylon ropes was extremely successful in Papua New Guinea. It is possible to use one of these two methods of spat collection for the species in the Andaman and Nicobar Islands, especially at Mayabunder, Havelock Is. and the Nancowry region to augment the resource for pearl culture.

Mizumoto (1979) considers *P. margaritifera* the most suitable for the production of steel black pearls and half pearls. Outside the Indo-Australian Archipelago, the species is used in the Okinawa area of Japan, Tahiti and Fiji (Mizumoto, 1979 ; AQUACOP, 1982). Sudan made an attempt on pearl culture, as reported by Shirai (1970), but the oysters suffered a mass mortality in 1973 and 1975 (Gideiri, 1980). According to Shirai (1970), this species is more difficult to obtain, to raise and to use for culturing purposes. Therefore, it would be necessary to develop appropriate technologies for rearing this species and production of cultured pearls.

Pearl culture with *P. maxima* depends on natural stocks at all centres of culture and the major problem of this industry is the dwindling stocks. Only very recently some success has been achieved in the artificial breeding of this species in Australia (Tanaka and Kumeta, 1981). AQUACOP (1982) could succeed in rearing *P. margaritifera* larvae up to day 10 and only a few larvae developed normally to spat. Mizumoto (1979) observes that if technique of artificial seed production is established more stable production of pearls may be expected in *P. maxima* and *P. margaritifera*. In 1981, India achieved a major breakthrough in developing techniques for artificial breeding of *P. fucata* (Alagarswami *et al.*, 1983). This technology can be adapted with modifications for the artificial breeding of *P. margaritifera*.

Transplantation of *P. maxima* from the Mergui Archipelago or neighbouring region to Andaman and Nicobar Islands may be attempted. The material can be used as broodstock for experimental hatchery production of seed. Such transplantation should be through strict quarantine measures against introduction of diseases, parasites and predators. *P. maxima* of Western Australia has shown unusually high mortality rates in the recent years and this has been of considerable concern to the Australian pearl culture industry (Dybdahl, pers. comm.).

Summing up, it is evident that there are two favourable factors, namely a suitable ecosystem and the presence of the black-lip pearl oyster *Pinctada margaritifera*, for considering immediate development of pearl culture in the Andaman and Nicobar Islands. A research and development effort combined with more specific and target-oriented surveys should precede, for working out the details of resource development and techniques of pearl production. The wing shell *Pteria penguin* would form a supporting species. Hatchery production of pearl oyster would be required for sustained pearl production. Transplantation of gold-lip oyster *Pinctada maxima* is a distinct possibility.

References

ALAGARSWAMI, K. 1970. Pearl culture in Japan and its lessons for India. *Proc. Symp. Mollusca*, 3 : 975-993. Mar. biol. Ass. India.

ALAGARSWAMI, K. 1974. Development of cultured pearls in India. *Curr. Sci.*, 43 (7) : 205-207.

ALAGARSWAMI, K., S. DHARMARAJ, T. S. VELAYUDHAN, A. CHELLAM, A. C. C. VICTOR AND A. D. GANDHI. 1983. Larval rearing and production of spat of pearl oyster *Pinctada fucata* (Gould). *Aquaculture*, 34 : 287-301.

ALAGARSWAMI, K. AND S. Z. QASIM. 1973. Pearl culture—its potential and implications in India. *Indian J. Fish.*, 20 (2) : 533-550.

AQUACOP. 1982. Country Reports : French Polynesia. In : *Bivalve Culture in Asia and the Pacific* (F.B. Davy and M. Graham, Eds), International Development Research Centre, Ottawa, pp. 31-33.

BLANCO, G. J. 1972. Status and problems of coastal aquaculture in the Philippines. In : *Coastal Aquaculture in the Indo-Pacific Region* (T.V.R. Pillay, Ed.), Fishing News (Books) Ltd., London, pp. 60-67.

CROSSLAND, C. (Late) 1957. The cultivation of the mother-of-pearl oyster in the Red Sea. *Aust. J. mar. Freshw. Res.*, 8 : 111-130.

FAO. 1962. Report to the Government of Sudan on the Sudanese shell industry and Red Sea Fisheries. FAO/EPTA Rep. (1489), based on the work of William Reed, 47 pp.

GIDEIRI, A. 1980. Oyster culture in Sudanese Red Sea. *Symp. Coastal Aquaculture*, Abstract 180. Mar. biol. Ass. India.

HANCOCK, D. A. 1973. Kuri Bay pearls—some of the finest in the world. *Austr. Fish.*, **32** (4) : 11-12.

HYND, J. S. 1955. A revision of the Australian pearl-shells, genus *Pinctada* (Lamellibranchia). *Aust. J. mar. Freshw. Res.*, **6** : 98-137.

JAMESON, H. L. 1901. On the identity and distribution of the mother-of-pearl oysters : with a revision of the subgenus *Margaritifera*. *Proc. zool. Soc. London*, **1** : 372-394.

LOCK, J. M. 1982. Country Reports : Papua New Guinea. In : *Bivalve Culture in Asia and the Pacific* (F.B. Davy and M. Graham, Eds), International Development Research Centre, Ottawa, pp. 53-54.

MIZUMOTO, S. 1979. Pearl farming in Japan. In : *Advances in Aquaculture* (T.V.R. Pillay and Wm. A. Dill, Eds), Fishing News Books Ltd., England, pp. 381-385.

PRASHAD, B. 1932. The Lamellibranchia of the Siboga Expedition, Systematic Part II, Pelecypoda (exclusive of Pectinidae). *Siboga Exped. Monogr.*, 53C, 353 pp.

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

RAO, K. V. 1970. Pearl oysters of the Indian Region. *Proc. Symp. Mollusca*, **3** : 1017-1028. Mar. biol. Ass. India.

SARAYA, A. 1982. Country Reports : Thailand. In : *Bivalve Culture in Asia and the Pacific* (F.B. Davy and M. Graham, Eds), International Development Research Centre, Ottawa, pp. 73-78.

SHIRAI, S. 1970. *The story of pearls.* Japan Publications, Inc. Tokyo, 132 pp.

TANAKA, Y. AND M. KUMETA. 1981. Successful artificial breeding of the silver-lip pearl oyster *Pinctada maxima* (Jameson). *Bull. Natl. Res. Inst. Aquaculture*, **2** : 21-28.

UNAR, M., M. FATUCHRI AND R. ANDAMARI. 1982. Country Reports : Indonesia. In : *Bivalve Culture in Asia and the Pacific* (F.B. Davy and M. Graham, Eds), International Development Research Centre, Ottawa, pp. 44-46.

WADA, K. 1973. Modern and traditional methods of pearl culture. *Underwater J.*, **5** (1) : 28-33.

YOUNG, A. AND E. SERNA. 1982. Country Reports : Philippines. In : *Bivalve Culture in Asia and the Pacific* (F.B. Davy and M. Graham, Eds), International Development Research Centre, Ottawa, pp. 55-68.

16

GIANT CLAM (*TRIDACNA*) RESOURCES

K. RAMADOSS[1]

INTRODUCTION

Tridacna spp. which are known as giant clams are highly specialized bivalves. They live exclusively in shallow waters of the coral reef formations. They are sessile, found attached to or buried in corals and are tightly fastened to the substrate with byssus. The family Tridacnidae are protandrous hermaphrodites (Wada, 1952). The growth is slow which is about 5 cm/year (Rosewater, 1965). The lifespan is presumed to be long but no precise information is available. Tridacnids are not entirely dependent on the ciliary mechanism for food. They are able to 'farm' their food in their own tissues due to an unusual association with large numbers of unicellular symbiotic algae—Zooxanthellae (Yonge, 1963). In addition to that, the Tridacnidae serve as hosts to a number of other organisms such as shrimps as commensals. The giant clams are a common resource in manv parts of the Andaman and Nicobar Islands and the paper presents their distribution as observed at the centres surveyed.

DISTRIBUTION OF TRIDACNIDS IN THE STUDY AREA

Rosewater (1965) has reviewed the family Tridacnidae in the Indo-Pacific region. Of the six known living species, four have been reported from Andaman and Nicobar Islands (Rosewater, 1965). Among them, *Tridacna crocea*, *T. maxima* and *T. squamosa* were recorded during the present survey. The fourth species *Hippopus hippopus* was not observed.

Table 1 shows the distribution of the 3 species in the areas surveyed. *Tridacna crocea* was more abundant in Andamans than in Nicobars. Havelock Island is rich in this species. Next in importance is *T. maxima* which was again more abundant in the Andamans. In Nicobars, Trinkat region appears to be rich for this species. *Tridacna squamosa* was sparsely distributed in Andaman and Nicobar Islands.

In the North Andaman (Diglipur area), survey was carried out in Ariel and Durgapur bays and Table and

TABLE 1. *Distribution of Tridacnidae in intertidal and deeper areas in the Andaman and Nicobar Islands*

Area	Density of population in no./sq. m of *Tridacna* in the areas surveyed: *T. crocea* Intertidal	*T. crocea* Subtidal	*T. maxima* Intertidal	*T. maxima* Subtidal	*T. squamosa* Intertidal	*T. squamosa* Subtidal
Diglipur ..	10	3	0	1	0	1
Mayabunder ..	2	1	0	2	0	0.5
Havelock Island ..	15	5	1	2	0	0.1
Neill Island ..	2	0	0	1	0	0.5
Rangat ..	1	—	0.5	—	0	—
Long Island ..	2	0.5	0	2	—	0.5
Port Blair ..	1	2	0	1	0	1
Ross Island ..	—	3	0	1	0	1
Chiriyatapu ..	3	1	1	2	1	1
Little Andaman ..	—	2	—	1	—	0.5
Car Nicobar (Malacca) ..	1	1	0	0.5	0	0.5
East Bay (Katchall) ..	1	1	0	0	—	—
Camorta area ..	1	0	1	1	—	—
Campbell Bay ..	1	1	0	1	—	—

[1] *Present address:* CMFRI, Regional Centre, Mandapam Camp.

Turtle islands. The average density of population of *Tridacna crocea* in the intertidal area in the above places was 10/sq.m. In deeper waters *Tridacna maxima* was observed sparsely (1/sq.m.). At Mayabunder the shore line and intertidal areas were mostly sandy and very few corals were observed. The population of *T. crocea* was also few. In areas of 2-6 m depth *T. maxima* (Pl. I, A) was observed at a density of 2/sq.m. The tridacnid population in Rangat area was poor, but in the Long Island area *T. maxima* was found to be about 2/sq.m. at 2-6 m depth.

The most prominent centre for the collection of *Tridacna* was Havelock Island, where vast areas of intertidal coral reefs exist (Pl. I, B) and on this habitat *Tridacna* grows abundantly (Pl. I, C). The density of *T. crocea,* in the length range of 10-91 mm, was 15/sq.m. in the intertidal area. *T. maxima* of 40 to 50 cm was 2/sq. m., at depth of 2-6 m. *T. squamosa* (Pl. I, D) was collected from Neill Island.

In the Port Blair area, where survey was undertaken in the intertidal area of Corbyn's cove, Chatham Island, Blair reef and Atalanta point, *T. crocea* was very few. *T. maxima* was present in the slightly deeper areas of Ross Island and North point and the population was 1/sq. m. At Chiriyatapu the intertidal zone was extensive with coral formation and the population of *T. crocea* was assessed at 10/sq.m. in the size range of 30 to 90 mm. Since the bottom at 2-6 m depth was sandy *Tridacna* was absent. *Tridacna* was not observed in Hut and Butler bays of Little Andaman.

Although the Nicobar group is rich in coral reefs, perhaps due to constant exploitation by local tribal population, *Tridacna* are in less numbers. In Campbell Bay area, the deeper waters contained *T. maxima* (1/sq.m). At Camorta (Kakana area) the intertidal zone had a good *Tridacna* population. Since the bottom was muddy in Spiteful Bay (Nancowry Island) *Tridacna* was absent. Amongst the Nancowry group of islands *Tridacna* was dense in Trinkat where *T. crocea* was 10/sq.m in the size range of 20-70 mm. *T. maxima* was observed in the depth of 4-6 m at 1/sq.m in the size range of 30-40 mm among the Katchall reefs. At Car Nicobar *T. crocea* was found at 1/sq.m in the intertidal area and *T. maxima* was present in the depths beyond 2 m.

Remarks

Tridacnids are slow growing and long living animals, and their colonization and production resemble those of forestry (Yamaguchi, 1977). They are exploited for their meat and shells in several parts of the Indo-Pacific (Rosewater, 1965). The Nicobarese relish the meat of giant clams wherefore *Tridacna* are nearly absent around the Nicobari settlements. Banner (1952) reports that in Gilbert Islands these animals are collected from their natural habitat and are impounded in pen enclosures, giving suitable substratum and natural environment. In Papua New Guinea, studies have indicated that *Tridacna gigas* is suitable for mariculture and weights of 29 kg can be attained in six years (Lock, 1982). There is scope for adopting mariculture practices in the Andaman and Nicobar Islands for enhancing production of giant clams both for their meat and for their shells.

References

Banner, A. H. 1952. Preliminary report on marine biological studies of Onatoa atoll, Gilbert Islands. *Atoll Res. Bull.*, 12 (1) : 1-42.

Lock, J. M. 1982. Country Reports : Papua New Guinea. In : *Bivalve culture in Asia and the Pacific*, (F.B. Davy and M. Graham, Eds), International Development Research Centre, Ottawa, pp. 53-54.

Rosewater, J. 1965. The family Tridacnidae in the Indo-Pacific. *Indo-Pacific Mollusca*, 1 (6) : 347-394.

Wada, S. K. 1952. Protandric functional hermaphroditism in tridacnid clams. *The Oceanographic Magazine, Tokyo*, 4 (1) : 23-30.

Yamaguchi, M. 1977. *Biol. Concer.* 11 (1) : 13-20.

Yonge, C. M. 1963. The biology of coral reefs. *Adv. mar. Biol*, 1 : 209-260.

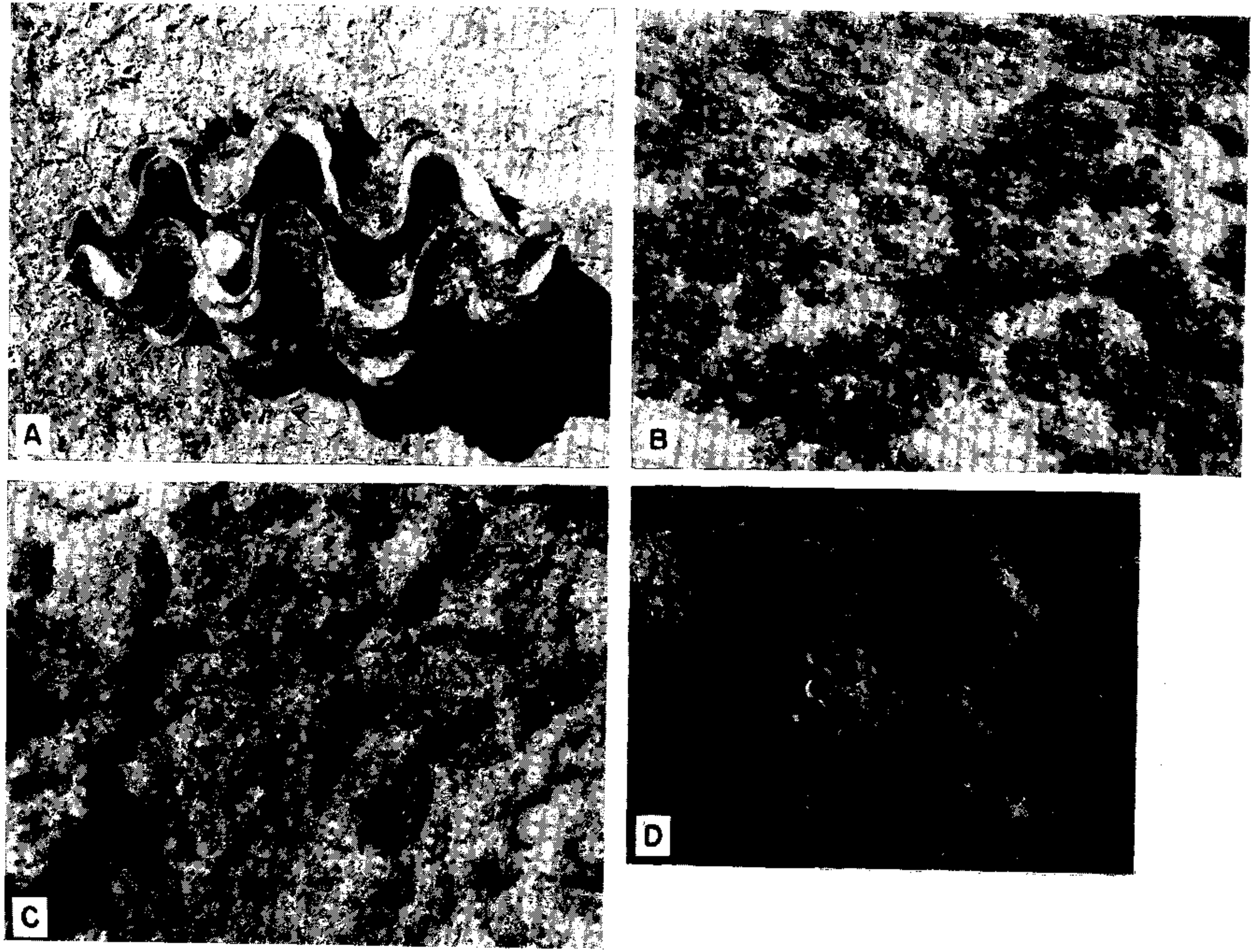


PLATE I. A. *Tridacna maxima* at Mayabunder. B. Exposed intertidal area during low tide at Havelock Island. C. *Tridacna crocea* popuation at Havelock Island. D. *Tridacna squamosa* at Neill Island.

17

TROCHUS AND *TURBO* RESOURCES

K. NAGAPPAN NAYAR[1] AND K. K. APPUKUTTAN[2]

INTRODUCTION

Among the commercially important molluscs in the Andaman and Nicobar Islands, *Trochus niloticus* Linné and *Turbo marmoratus* Linné occupy a prominent position because of their abundance and economic value. Commercial exploitation of these shells may be deemed to have started from 1929 (Panikkar, 1938) although, even earlier to this, Japanese fishermen from Singapore had been fishing for them around these islands unauthorisedly (Rao, 1939). Of these two species, *Trochus niloticus* was found to be more abundant in all the islands surveyed. Though there were good landings of these shells in the earlier years, they started declining in later years, which prompted the Andaman Administration to appoint a Special Officer to carry out scientific studies on the fishery. A consolidated report on the shell fishery of these islands during 1930-35 was published by Rao (1939). Amirthalingam (1932), Setna (1933), Prashad and Rao (1933, 1934), Rao (1936 *a*, *b*, 1937, 1941) and Panikkar (1938) made more detailed observations on the shell fishery of the Andamans, with accounts of the feeding habits, breeding seasons, size at sexual maturity, growth rate and other biological details of *T. niloticus*. Anon (1939) has briefly reviewed the results of the investigations made by the Zoological Survey of India in Andamans. Menon (1976), Chatterjee (1976) and Appukuttan (1977) have described the importance of *Trochus* and *Turbo* in the shell-craft industry. The *Trochus* and *Turbo* resources of the different islands were surveyed during 1978 by the Central Marine Fisheries Research Institute, the results of which, along with notes on the fishery, are presented here.

OBSERVATIONS

In the present survey, Table Island and Smith Island in the North Andaman were the northernmost areas covered for observations on the distribution pattern and abundance of *Trochus* and *Turbo* resources, by diving upto 4 to 6 m depths. The sea bottom was strewn with black rocks and corals supporting a luxurious seaweed growth. *Trochus* was found in fairly good numbers with an average of 5 nos. in 10 sq. m area. The survey of Diglipur, Ross Island, Ariel Bay, Stewart Island and Sound Island present in fishing zones I and II revealed that *Trochus* are available in these areas also in good quantity.

From the eastern side of Mayabunder and Rangat which are grouped under zone III, 16 specimens of *Trochus* ranging from 8.5 to 11.8 cm height were collected. At Sicmandera in Long Island, heaps of already fished *Trochus* shells of medium and large size were observed. This area comes under zone IV. Diving done here indicated that the bottom was sandy with good coral and algal growth and the shells were available in 2-4 m depth. Six specimens collected had diameter ranging from 8.2 to 11.6 cm and length between 6.9 and 9.5 cm.

Survey of zones V and VI in South Andaman consisting of Neill Island, Port Blair, Ross Island, Burmanalla, Corbyn's Cove south and Chiriyatapu was done. In Neill Island, 3.5-4.5 cm sized *Trochus* shells were abundant (1 no. per sq. m). From Ross Island, Wandoor and South Point in Port Blair also *Trochus* were collected. From Burmanalla area three small sized shells were collected at depths ranging from 2 to 4 m. From Corbyn's Cove south and Chiriyatapu *Trochus* ranging from 5.8 to 9.7 cm diameter were collected from a depth of 6-8 m with plenty of algal growth. The bottom was sandy.

Henry Lawrence Island and Inglis Island in zone VII were also surveyed. In Inglis Island 15 shells were collected indicating the presence of shell beds around the island. At Havelock Island also *Trochus* population was observed at a density of 1 number per sq. m.

In Little Andaman Island, two stations in Butler

Present address :

[1] CMFRI, Research Centre, Tuticorin 628 001.

[2] CMFRI, Research Centre, Vizhinjam 695 521.

Bay were covered, where *Trochus* was noticed. In Hut Bay, *Trochus* was found in a few places.

In Car Nicobar, Passa, Teetop and Hog Point to Sawai Bay were surveyed. From Sawai area 30 numbers of *Trochus* ranging from 6.6 to 10.7 cm in diameter were collected. This area appears to be potentially rich for *Trochus* shell compared with other centres of this island.

In Nicobar group a few places in Camorta, Trinkat, Nancowry and Katchall were surveyed. All these centres come under zone VIII. In Teressa reefs a fair population of *Trochus* was found at depths ranging from 1.5 to 3 m. On the reefs near Kakana (Camorta), 5 numbers of *Trochus* (1 no. for 50 sq. m) were collected at depths ranging from 0.5 to 1.5 m. In Camorta and Nancowry Islands *Trochus* were found to occur (2 nos. for 50 sq. m) in the reef area at 6-8 m depth. In Spiteful Bay *Trochus* was noticed in the shallow zone. At Katchall (East Bay area) congregation of 4-5 numbers of *Trochus* was seen per sq. m and this feature was found restricted to 4 m depth. Local enquiries revealed that in West Bay area *Trochus* is collected from 1.5 to 3 m depth. The present observations show that zone VIII is another potential area for *Trochus* shells and regular exploitation is bound to yield good results.

Due to paucity of time only a few centres in Great Nicobar area were covered. Cursory survey done in Campbell Bay (zone IX) revealed that this area is also a potential one for *Trochus* fishery. Eleven shells with sizes ranging from 4.3 to 7.8 cm height were collected.

Though *Trochus* shells were collected from the centres of all 9 fishing zones, *Turbo* shells were not obtained during this survey for determining the places of abundance. Earlier records of the Administration and enquiries with local fishermen revealed that zones I, II, III and IV are being exploited for *Turbo* shells. In zone V, 'Karen' fishermen of Burmese origin exploit *Turbo* shells in fairly good quantity and extract meat for culinary purpose. In Little Andaman, Butler Bay and Hut Bay and in Car Nicobar, Passa, Teetop and Hog Point to Sawai Bay are considered to be good grounds for exploitation of *Turbo* shells from zone VIII. Nicobarese engaged by Nancowry Mercantile Corporation exploit good quantity of *Turbo* shells from Teressa Island, Kakana in Camorta Island, Trinkat Island, Nancowry Island and Katchall. In zone IX (Great Nicobar), it is understood that though there is no organised exploitation of *Turbo* at present, the Campbell Bay is a potentially rich ground for commercial exploitation of this shell.

Notes on Fishery and Biology

From the inception of legalised shell collection in Andaman and Nicobar Islands, the following nine fishing zones have been demarcated with specified authorised ports of call for the delivery of the exploited shells.

Fishing zones and ports of call

I. Cape Price to Mayabunder, between Lat 12°56.5′ and 54.5′N. Port — Mayabunder

II. Cape Price to Austin Straight, between Lat 12°54′ and 13°34.5′N. Port — Mayabunder

III. Mayabunder to Long Island, between Lat 12°24′ and 12°55′ N. Port — Long Island

IV. Long Island to Shoal Bay, between Lat 12°0.5′ and 12°18′N. Port — Long Island

V. Shoal Bay to Chiriyatapu, between Lat 11°29′ and 11°56.4′N. Port — Port Blair

VI. Chiriyatapu to Port Mouat, between Lat 11°29′ and 11°38′N. Port — Port Mouat

VII. Ritchie's Archipelago Islands and Islets, between Lat 10°46.5′ and 12° 19′N. Port — Port Blair

VIII. Nicobar Central Group, between Lat 7°52′ and 8°35′N. Port — Nancowry

IX. Nicobar Southern Group, between 6°45′ and 7°31′N. Port — Nancowry

Under the present system, licences are issued by the Andaman Administration to the owners of power boats and to smaller country crafts (*Sampan*). Royalties are levied and fines imposed for infringement of regulations. *Trochus* shells which pass through a circular gauge of less than 9 cm in diameter and 6.35 cm in case of *Turbo*, are deemed to be undersized as per the Fishing Rules, 1955. Undersized *Trochus* and *Turbo* shells obtained during shell fishing are returned to the sea alive. Divers who are familiar with the coastal shell beds are employed by the shell merchants for fishing. These divers do not use any modern diving equipments or gadgets while fishing. They reach the fishing ground by means of a dinghy called *Sampan* or *Bongra dongi*. Although 20-80 such boats are engaged in the shell fishing during fishing season, at a time only 2 to 6 *Sampans* are seen fishing. Each dinghy can carry 10 divers and the diving commences by 6 a.m. and closes by 2 p.m. During low tide they pick *Trochus* shells from the intertidal and mangrove areas where the animals are found to congregate underneath rocks and coral blocks. *Turbo marmoratus* is found rarely in shallow waters, the shells being available in large numbers only at depths ranging from 12 to 25 m. The shells are of the size range 8-18 cm in diameter. *T. niloticus* ranging from 5 to 12 cm diameter size are collected from both intertidal and deeper areas. During the peak season daily fishing is carried out from all the important centres. Each diver collects a hundred or more shells a day. The main fishing season begins by October and lasts till April.

Trochus niloticus (Fig. 1) is found to occur in Sri Lanka, Mergui, Andaman and Nicobar Islands to

Fig. 1. *Trochus niloticus* from Ross Island, Andamans.

Samoa, Queensland, Western Australia, New Caledonia, Philippines, Fiji and Japan. *Turbo marmoratus* (Fig. 2) is reported from Andaman and Nicobar Islands and from Japan Coast. Rao (1937), in the course of his study on the biology of *T. niloticus* from Andamans, reported that they commonly feed on minute brown and green algae and also on the organic and inorganic debris found on the sea bottom where it lives. It was observed that *Trochus* was most abundant on the reefs in the inshore waters and because of the reef surroundings the shell of the animal is liable to be bored and damaged by gastropods like *Saptadanta nasika* Prashad and Rao and *Patella* sp. and bivalves like *Lithophaga* spp. The present observations have shown that shells stored in the different godowns in and around Port Blair had 10-20% of wormed and damaged shells and the damage was mainly due to boring by polychaetes and lithophags. Boring was more in large sized shells.

Fig. 2. *Turbo marmoratus* from Car Nicobar Island.

Sexes are separate in both the species and spawning occurs during or immediately after the warm season (March-June), although in some instances protracted spawning has been observed (Rao, 1937). *Trochus* shells of all size ranges upto 50 mm diameter are obtained throughout the year amongst shingle and coral blocks, which also indicates that the breeding season is extended. The age at first maturity has been determined to be 3 years when the animal reaches 90 mm diameter (Rao, 1936 *a*). Observations on the rate of growth and longevity of *T. niloticus* in Andaman Island by Rao (1936 *a*, *b*) indicated that the growth rate of the shell is rapid for the first two years, but is slow and uniform thereafter. The longevity of *Trochus* in Andamans exceeds ten years and the incidence of mortality due to disease or other environmental factors is considered to be low. The shell in its first year of growth has a diameter of 5 cm, in the second year 5-8 cm, in the third year 8-10 cm, in the fourth and fifth years 10-11 cm, sixth and seventh years 11-12 cm and eighth and ninth years between 12 and 14 cm (Rao, 1936 *a*). *Turbo* breeds throughout the year and there is a great variation in the population density of shells in the different islands as well as in the different coastal areas of the same island (Setna, 1933).

The meat of *Trochus* is edible and is removed by a short pointed instrument resembling a gimlet, bent at the ends. The anterior portion of the animal, mainly the foot, is boiled, salted and dried for consumption, as is done for the sacred chank fished in the Gulf of Mannar. The meat of *Turbo* is also edible but the heavy operculum is a hindrance to the easy extraction of the meat. Usually the animal is kept exposed in the sun for a considerable time and when the animal creeps out, it is scooped out skilfully, the foot of the animal cut into pieces, boiled and dried for consumption (Setna, 1933 ; Rao, 1939). The bulk of the exploited shells are pit-cured and despatched to Calcutta and some of the South Indian markets where there is a good demand for those shells for the handicraft industry that fashions curios out of these by processes such as removal of the periostracum by mechanical abrasion, bleaching, cutting, shaping, fitting, engraving, enamelling and final finishing into different products. A small quantity of the shells landed is exported to Japan, Italy, Australia, France and Germany where modern industrial facilities exist for processing them into costume jewellery, buttons, etc.

The average annual landings of *Trochus* from the Andaman Islands vary between 400 and 500 tonnes and 100-150 tonnes for *Turbo*. The market price for the raw *Trochus* is Rs. 4,000 per tonne and cleaned and polished shells are sold at Rs. 5 to 15 per shell depending on size and quality. The *Turbo* shells cost Rs. 10,000 per tonne and a large polished shell costs between Rs. 20 and Rs. 50.

Remarks

Quite often young ones of *Trochus niloticus* in the size range of 2.5 to 3.5 cm had been observed particularly at depths up to 8 m in reef areas south of Port Blair. These small shells could be collected during fair season and the accumulated stock transplanted to other areas which are known to be favourable habitat and fishing grounds for *Trochus*, but are at present thinly populated, either because of regular exploitation or because of lack of replenishment of the stock. This would considerably help to revive the populations in the fishing grounds in due course. Similar transplantation can also be done in intertidal areas with boulders with good growth of algae, which lie along the coasts separated by sandy stretches, thus enriching particularly areas which have been impoverished by human interference.

While earlier investigations and Administration Reports show *Trochus* and *Turbo* resources of North, Middle and South Andaman Islands to be rich, the present observations have revealed that the Nicobar group of islands, especially Teressa, Trinkat, Katchall, Nancowry and Campbell Bay in Great Nicobar, are potentially rich areas for both these shells. It is interesting to note that while this survey was going on, the Fisheries Department of Andaman Administration raided Barren Island and confiscated about 2,000 large *Turbo* shells reported to have been clandestinely fished by unlicensed fishermen and kept hidden. Since the shells had flesh intact it was inferred that the catch should have been taken just prior to the confiscation. This also indicates that the Barren Island is also potentially rich for *Turbo* shells. If organised fishing is done in these areas, there is every possibility of increasing production.

References

Amirthalingam, C. 1932. Breeding of *Trochus* and preservation of the beds in the Andamans. *Curr. Sci.*, **1** (1) : 31.

Anon 1939. Shell fisheries in the Andamans. *Curr. Sci.*, **8** : 349.

Appukuttan, K. K. 1977. *Trochus* and *Turbo* fishery in Andamans. *Seafood Export Journal*, **9** (12) : 21-25.

Chatterjee, S. 1976. Andaman shell handicrafts *Yojana*, **20** (13) : 70-71.

Menon, P. M. G. 1976. Fisheries in Andamans. *Yojana*, **20** (13) : 65.

Panikkar, N. K. 1938. Recent researches on *Trochus*. *Curr. Sci.*, **6** : 552-553.

Prashad, B. and H. S. Rao. 1933. Notes on the bionomics of *Trochus niloticus* Linn. 1. On a new species of *Spiroglyphus* Vermetidae from the Andamans. *Rec. Indian Mus.*, **35**: 167-174.

Prashad, B. and H. S. Rao. 1934. Notes on the bionomics of *Trochus niloticus* Linn. 2. On two limpet-like gastropods from the Andaman waters. *Rec. Indian Mus.*, **35** : 409-412.

Rao, H. S. 1936 *a*. Observations on the rate of growth and longevity of *Trochus niloticus* Linné in Andaman Islands. *Rec. Indian Mus.*, **38** : 473-498.

Rao, H. S. 1936 *b*. A statistical survey of the data of growth in shell of *Trochus niloticus* Linné in Andaman. *Rec. Indian Mus.*, **38** : 499-502.

Rao, H. S. 1937. On the habitat and habits of *Trochus niloticus* Linné in the Andaman Sea. *Rec. Indian Mus.*, **39** : 47-82.

Rao, H. S. 1939. *Consolidated report on the shell fisheries in Andamans during the years* 1930-35. Zool. Survey of India, Calcutta, 130 pp.

Rao, H. S. 1941. Indian shellfish and its fisheries. *Sci. Cult.*, **7** : 69-78.

Setna, S. B. 1933. The Andaman shell fishery. *J. Bombay nat. Hist. Soc.*, **36** (1) : 94-100.

18

SEA CUCUMBER AND SEA URCHIN RESOURCES AND *BECHE-DE-MER* INDUSTRY

D. B. JAMES[1]

INTRODUCTION

The Andaman and Nicobar Islands offer one of the most suitable habitats for sea cucumbers and sea urchins due to the presence of sheltered bays and lagoons. The sea cucumbers prefer muddy or sandy flats and the sea urchins rocky coasts and algal beds. There have been very few reports on these echinoderms of the islands in the earlier years (Theel, 1882 ; Koehler and Vaney, 1908 ; Koehler, 1927). More recently James (1969) recorded several species of sea cucumbers and sea urchins from the islands. A specific account of the *beche-de-mer* resources of India was given by James (1973). A cottage level export-oriented *beche-de-mer* industry has been established in the Andamans since 1975. Kloss (1902) had made passing references to this resource.

SEA CUCUMBER RESOURCES

A list of echinoderms known from the Andaman and Nicobar Islands i given in the Annexure. Although there are more than 40 species of sea cucumbers in the shallow waters of Andaman and Nicobar Islands (James, 1969) only a few species are useful for *beche-de-mer*. Domantay (1961) has stated that, in the Philippines the following species are used in the fresh condition : *Holothuria pardalis, H. hilla, H. impatiens, H. scabra, H. edulis, Actinopyga miliaris* and *A. serratidens*. All the above species of sea cucumbers are available in plenty in Andaman and Nicobar Islands.

Holothuria atra is by far the most abundant sea cucumber around the islands. Though not of high quality, due to their numerical abundance this species can be used for *beche-de-mer*. It occurs usually on dead coral reef flats with sandy or muddy patches. It prefers areas where calcareous alga *Halimeda* sp. on which it feeds is present. In some areas, especially in Sesostris Bay, 10-15 specimens are found in 25 sq.m area. On the reef flat the size range is 200-300 mm and on the outer edge of the reef the specimens reach 500 mm in length. This species was processed for the first time in Andamans in 1976. It is to be noted that *H. atra* has a toxin in the body wall in the living condition. Probably boiling and processing renders the product harmless.

Holothuria scabra (Pl. I, A) is almost exclusively used in Andamans and on the mainland (Gulf of Mannar and Palk Bay) due to its abundance, large size and thick body wall. It is somewhat gregareous on muddy flats and is confined to shallow areas preferring low saline and brackish waters. It occurs in good numbers in North Andaman, especially around Mayabunder and Diglipur. Large numbers (10 per 25 sq.m) of juveniles 60-160 mm in length were noted during December to February in Sesostris Bay. Krishnaswamy and Krishnan (1967) observed that this species has two spawning peaks in July and October along the south-east coast of India.

Actinopyga mauritiana, A. echinites, A. miliaris and *A. serratidens* are found in Andaman and Nicobar Islands. The first three species are of value for culture. *A. mauritiana* is the most important species under this genus. This species was regularly collected by the Taiwanese who were stationed at Port Blair during 1975-76. It is smaller than the other two species and is usually found along rocky coasts and among rock pools. The largest of them reaches 400 mm in length. *A. echinites* (Pl. I, B) which occurs along with *A. mauritiana* reaches a larger size of 500 mm and is uniformly chocolate brown in colour. Often pieces of small corals are found attached to the animal. *A. miliaris* (Pl. I, C) which is said to yield high quality *beche-de-mer* is found at Wandoor (South Andaman) along the

Present address :

[1] CMFRI, Research Centre, Madras 600 105.

rocky coast at a density of 10-15 specimens per 25 sq.m. It grows up to 500 mm in length.

Under the genus *Bohadschia* only *B. vitiensis* (Pl. I, D) occurs in appreciable numbers on the reef flats. It is a burrowing form which comes out at low tide when the water recedes. A thin coating of mud sticks to the body wall. In the Blair Reef the density is 10-15 animals per 25 sq.m. It reaches 500 mm in length. The main difficulty in processing this species is the presence of abundant Cuvierian tubules.

Labidodemas rugosum (Pl. I, E) is a little known species from Andaman Islands. It grows to a length of 210 mm and is found on coral flats buried deep in sand. Full specimens can easily be pulled out of sand. specimens (5-10 per 25 sq.m) have been collected from South Point at Port Blair.

In Hut Bay (Little Andaman) *Holothuria leucospilota* was found in great numbers (25-125 per 25 sq.m). This species is not used at present in Andamans, but Panning (1944) mentions it to be a commercially important species.

Field Key to the Identification of Sea Cucumbers

1. Anus not guarded by five calcified 'teeth' or five groups of hardened papillae 2

1'. Anus either guarded by calcified 'teeth' or five groups of hardened papillae 4

2. Body translucent, calcareous ring ribbon-like with radials and interradials dissimilar in size...... *Labidodemas rugosum* (Ludwig)

2'. Body not translucent, calcareous ring stout with radials and interradials more or less of the same size......................................3

3. Colour uniformly black, body tubular, body wall not thick but leathery........*Holothuria atra* Jaeger

3'. Body although cylindrical, slightly flattened on the ventral side ; dorsal side pale grey or black crossed by irregular light bands or bars of white, pale yellow or grey ; ventral side snowy white dotted with many minute black specks ; body wall thick and slightly slimy .... *Holothuria scabra* Jaeger

4. Anus guarded by five groups of hardened papillae ; Cuvierian tubules white and copious and released at the slightest disturbance .... *Bohadschia vitiensis* (Semper)

4'. Anus guarded by five calcified 'teeth'; Cuvierian tubules sparce and pink in colour 5

5. Colour brown on the dorsal side and white on the ventral side .... *Actinopyga mauritiana* (Quoy & Gaimard)

5'. Uniform colour throughout 6

6. Colour uniformly black ; body wall very thick and hard .... *Actinopyga miliaris* (Quoy & Gaimard)

6'. Colour uniformly chocolate brown ; sand often settles on the dorsal side of the body .... *Actinopyga echinites* (Jaeger)

Sea Urchin Resources

Another group of echinoderms which is commercially important and edible is sea urchins. The gonads of sea urchins are said to be a delicacy and are eaten fresh adding a little vinegar or lime.

Tripneustes gratilla (Pl. I, F) is found on the algal beds of Sesostris Bay. In each shore seine haul three or four large sea urchins come up. The horizontal diameter of the tests varies from 100 to 120 mm. The gonads are massive in the ripe condition. In Aberdeen jetty area at Port Blair large number of *Diadema setosum* are found attached to the wall of the jetty. It is also found in good numbers in Nancowry Harbour. The diameter of the tests ranges 50-80 mm.

Echinometra mathaei is well distributed on the rocky coasts around Port Blair. It is light green in colour and lives under stones or crevices. *Echinometra mathaei* var. *oblonga* (Pl. II, A) is more common and in some places as many as 10 animals are found per sq.m. It is dark brown in colour and lives in burrows made by it.

Field Key for the Identification of Sea Urchins

1. Spines long, sharp and brittle ; colour black .... *Diadema setosum* Leske

1'. Spines short, not brittle, colour white, light green or dark brown 2

2. Size large, spines very small and white in colour .... *Tripneustes gratilla* (Linnaeus)

2'. Size medium, spines moderate ; colour either light green or dark brown 3

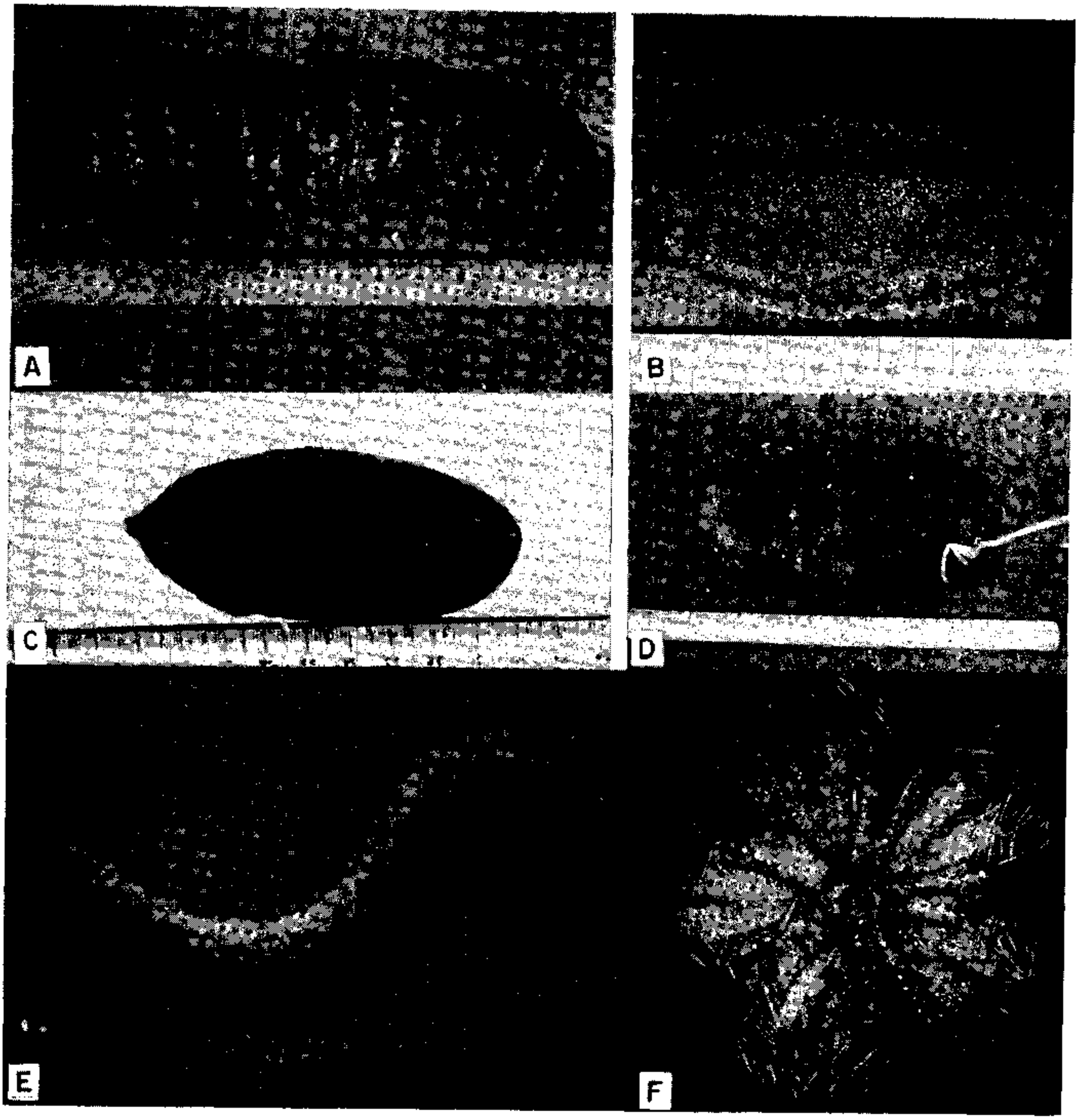


PLATE I. A. *Holothuria scabra* ; B. *Actinopyga echinites* ; C. *A. miliaris* ; D. *Bohadschia vitiensis* with Cuvierian tubules coming out ; E. *Labidodemas rugosum* ; F. *Tripneustes gratilla*.

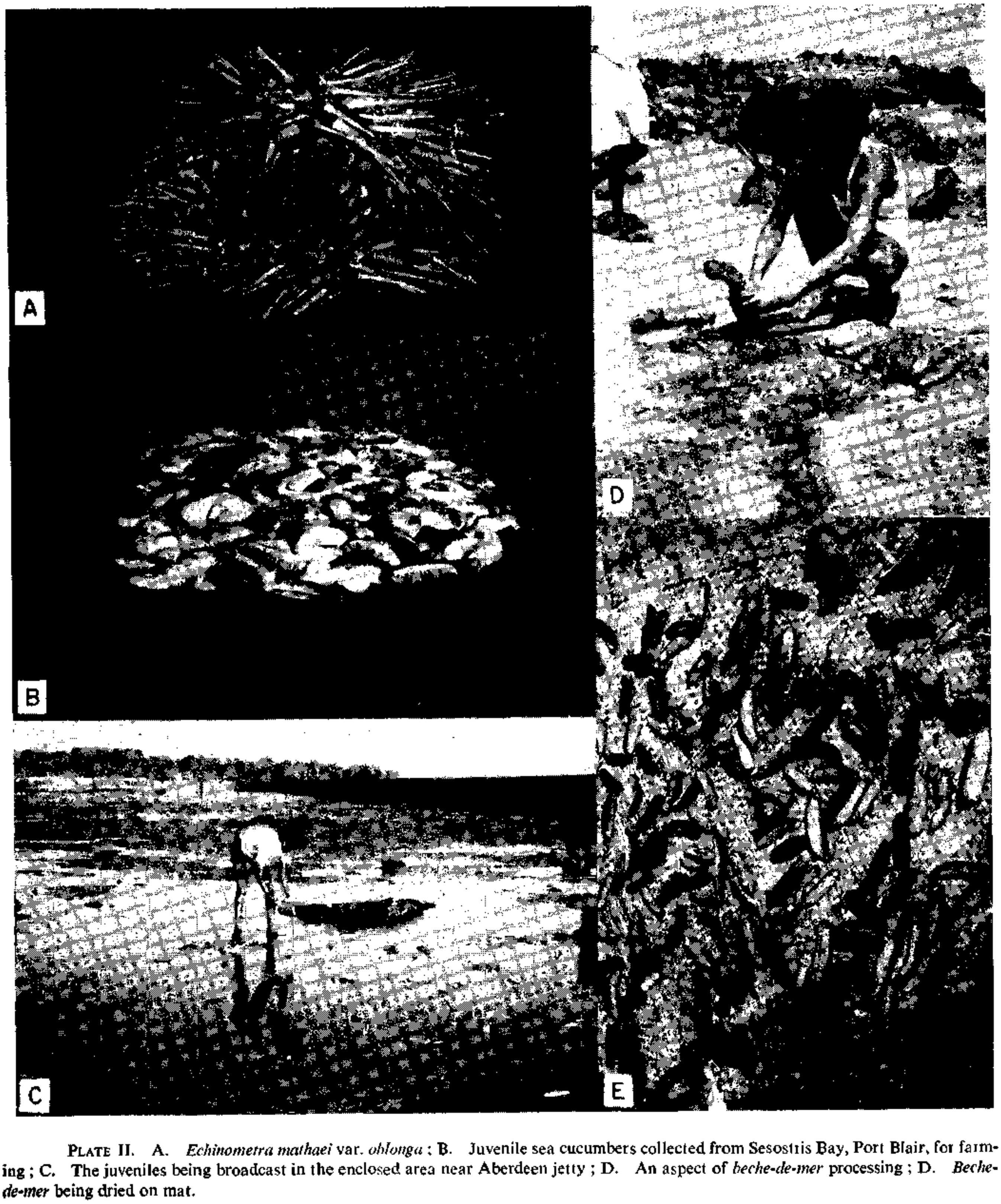


PLATE II. A. *Echinometra mathaei* var. *oblonga* ; B. Juvenile sea cucumbers collected from Sesostris Bay, Port Blair, for farming ; C. The juveniles being broadcast in the enclosed area near Aberdeen jetty ; D. An aspect of *beche-de-mer* processing ; D. *Beche-de-mer* being dried on mat.

3. Occurs under stones or inside crevices ; spines light green and arranged in a regular manner ....
Echinometra mathaei (de Blainville)

3'. Occurs only in tunnel-shaped burrows ; spines dark brown and arranged in groups..................
E. mathaei var. *oblonga*

FARMING POTENTIAL

Attempts were made to collect juveniles of sea cucumber *Holothuria scabra* and farm them in a sheltered area at Port Blair. In February 1978, a total of 462 juveniles in the length range 65-160 mm (modal class 81-90 mm) was collected from Sesostris Bay and broadcast in an enclosed area (1.5ha) near Aberdeen jetty (Pl. II, B, C). The bottom was muddy and partly sandy. At the end of July 1978, they had grown to 190-290 mm (Anon., 1978). The incomplete experiment gave some indication of the possibilities of semi-culture of sea cucumbers.

The mudflats at Diglipur, Mayabunder, Jenglighat near Port Blair and Campbell Bay are favourable areas for culture of sea cucumbers. Of the eight species described, *Holothuria scabra* is ideally suited for culture as it is gregareous in occurrence and juveniles are available in large numbers during certain seasons. Farming can be combined with factory level processing of *beche-de-mer* for export. At Mannar in Sri Lanka a factory was set up at a cost of Rs. 113,000 in 1974 and the venture was profitable at processing 1.2 tonnes a month (Paramanathan, 1974). Among sea urchins *Tripneustes gratilla* appears suitable for farming. It grows to a large size on algal beds in shallow waters. Juveniles can be collected from areas of abundance and stocked on enclosed algal beds for further growth.

BECHE-DE-MER INDUSTRY

Processing

Sea cucumbers (*Holothuria scabra*) are collected by hand picking during low tide and by diving in shallow waters with a mask. After collection they are heaped and crowded at one place which makes them to eviscerate. Those which fail are slit at one end and the internal organs flow out (Pl. II, D). The eviscerated animals are put in iron drums and boiled in sea water for 1-2 h depending on the size of the sea cucumbers used. While boiling the material is constantly stirred to make the product uniformly cylindrical. After a distinct cooked odour is emitted, they are removed and buried in a pit near the shore which is kept moist. After 12 h they are taken in a basket and cleaned to remove all chalky deposits. After thorough cleaning, it is once again boiled in clean sea water for a few minutes. Then the material is removed and sun dried for 3-4 days (Pl. II, E). The material can also be smoke dried. For species other than *Holothuria scabra* minor modifications in processing are made.

Prospects and constraints

The prospects for *beche-de-mer* industry in Andaman and Nicobar Islands are bright due to rich sea cucumber resource. Some of the sea cucumbers of the islands are of high quality and the product fetches 10-15 times higher value compared to the mainland species. There are vast unexploited areas for sea cucumbers. Processing is simple and fuel materials are cheap and plenty. Labour is easily available.

The major problem of this industry is its seasonality. Rains prevent processing for about eight months in a year. This can be solved by using artificial driers. Another serious problem is the lack of transport facilities. Though there are more than 300 islands, processing can be done only in a few places which have quick access to Port Blair from where it has to be shipped to the mainland for export. Processing should be done under more hygienic conditions. The humidity is very high in Andaman and Nicobar Islands and the product should be packed in polythene bags to avoid moisture absorption.

REFERENCES

ANON., 1978. Culture of sea cucumber at Andamans. CMFRI Newslet., 8 : 1-2.

DOMANTAY, J. A. 1961. The aquatic products of Zamboanga, Basilan and the Sulu Archipelago. *Philipp. J. Sci.*, 6 (1) : 17-39.

JAMES, D. B. 1969. Catalogue of echinoderms in the reference collections of the Central Marine Fisheries Research Institute. *Bull. cent. mar. Fish. Res. Inst.*, No. 7 : 51-62.

JAMES, D. B. 1973. The *beche-de-mer* resources of India. In : *Proc. Sym. Living Resources of the Seas around India*, pp. 706-711. Spl. Publ., Central Marine Fisheries Research Institute, Cochin.

KLOSS, C. B. 1902. *The Andamans and Nicobars*, Vivek Publishing House, Delhi, Reprinted 1971, 373 pp.

KOEHLER, R. 1927. *Echnioderma of the Indian Museum.* Part X. An account of the Echinoidea. Echinides Regularis 158 pp. Calcutta.

KOEHLER, R. AND C. VANEY. 1908. *Echinoderma of the Indian Museum.* Part IV. An account of the littoral Holothurioidea collected by the R.I.M.S. Investigator, 55 pp. Calcutta.

KRISHNASWAMY, S. AND S. KRISHNAN. 1967. Report on the reproductive cycle of the holothurian, *Holothuria scabra* Jaeger. *Curr. Sci.*, 36 (6) : 155-156.

PANNING, A. 1944. Die Trepangfisherei. *Mitt. zool. St. Inst. Hamb.*, 49 : 1-76.

PARAMANATHAN, S. 1974. Processing of *beche-de-mer* in factory. *Souvenir to mark the opening of the beche-de-mer factory, Mannar*, pp. 5.

THEEL, H. 1882. Report on the Holothurioidea dredged by H.M.S. *Challenger* during the years 1873-1876. Part I. *Rep. Sci. Res. Challenger, Zool*, 7 : 1-176.

ANNEXURE

List of Echinoderms Known from Andaman and Nicobar Islands

Class : CRINOIDEA

Order : ARTICULATA

Sub-order : ISOCRINIDA

Family : BOURGUETICRINIDAE

Bathycrinus wood-masoni A. H. Clark (West coast of Nicobar)

Family : PENTACRINIDAE

Comastrocrinus ornatus (A.H. Clark) (Andaman Sea)

Sub-order : COMATULIDA

Group : OLIGOPHREATE

Superfamily : COMASTERIDA

Family : COMASTERIDAE

Sub-family : CAPILLASTERINAE

Comatella maculata (P.H. Carpenter) (Nicobar Islands)

Capillaster mariae A. H. Clark (Andaman Island, depth 107 m)

Sub-family : COMASTERINAE

Comaster gracilis (Hartlaub) (Port Blair, depth 54 m)

C. multibrachiata (P.H. Carpenter) (Andaman Island, depth 31-54 m)

C. parvus A. H. Clark (Andaman Island, depth 96 m)

Sub-family : COMACTININAE

Comatula brevicirra (Bell) (Nicobar, depth 43 m)

C. micraster A.H. Clark (West of South Andaman Island, depth 100 m)

Superfamily : MARIAMETRIDA

Family : MARIAMETRIDAE

Dichometra protectus (J. Muller) (Andaman Island, depth 65 m)

Selenometra aranea (A.H. Clark) (Andamans, depth 52 m)

Stephanometra monocantha (Lutken) (Andaman Island, depth 52 m)

Family : COLOMBOMETRIDAE

Oligometra intermedia A.H. Clark (Andaman Seas)

Family : EUDIOCRINIDAE

Eudiocrinus minor A.H. Clark (Andaman Island)

E. ornatus A.H. Clark (Andaman Island, depth 76 m)

Family : HIMEROMETRIDAE

Amphimetra philiberti (J. Muller) (Port Blair)

Craspidometra acuticirra (P.H. Carpenter) (Andaman Island)

Heterometra bengalensis A.H. Clark (Andaman Island, depth 59 m)

Superfamily : TROPIOMETRIDA

Family : CALOMETRIDAE

Neometra spinossima A.H. Clark (Andaman Island)

Family : CHARITOMETRIDAE

Glyptometra invenusta (A.H. Clark) (Andaman Island, depth 1041 m)

Permissometra occidentalis A.H. Clark (South of Nicobar, depth 1024 m)

Family : THALLASOMETRIDAE

Crotometra eridanella A.H. Clark (Great Nicobar, depth 2049 m)

Thalassometra peripolos A.H. Clark (South of Nicobar depth 1024 m)

Group : MACROPHREATE

Family : ANTEDONIDAE

Eumetra indica A.H. Clark (Andaman Island, depth 777 m)

Iridometra nana (Hartlaub) (Andaman Island, depth 76 m)

Psathyrometra mira A.H. Clark (Andaman Island depth 741 m)

P. inusitata A.H. Clark (South of Ross Island, depth 484 m)

Sarametra nicobarica A.H. Clark (Off Nicobar Island)

Class : ASTEROIDEA

Order : PHANEROZONIA

Sub-order : PAXILLOSA

Family : ASTROPECTINIDAE

Astropecten monacanthus Sladen (Andaman Island)

A. griegi Koehler (Andaman Island, depth 237-744 m)

A. polyacanthus Müller and Troschel (Andaman Island 0-91 m)

A. tamilicus Döderlein (Andaman Island, depth 45 m)

A. zebra Sladen (Andaman Island)

Dipcaster pentagonalis Alcock (Andaman Island, depth 21 m)

D. sladeni Alcock (Andaman Island, depth 457 m)

Craspidaster hesperus (Müller and Troschell) Port Blair, depth 20 m)

Family : LUIDIIDAE

Luidia limbata (Sladen) (Andaman Island, depth 12-51 m

L. maculata Müller and Troschell (Andaman Island)

L. savignyi (Audouin) (Andaman Island)

Sub-order : VALVATA

Family : ARCHASTERIDAE

Archaster typicus Müller and Troschel (Andaman Island, littoral)

Family : GONIASTERIDAE

Anthenoides sarissa Alcock (Andaman Island, depth 237-457 m)

Asteroceramis fisheri Koehler (Andaman Sea, depth 409-519 m)

Calliaster mammillifer Alcock (Andaman Island, depth 448-493 m)

Dorigona belli Koehler (Andaman Island, depth 457 m)

D. nora Alcock (Andaman Island, depth, 1896 m)

Iconaster pentaphyllus Alcock (Andaman Island, depth 495 m)

Mediaster florifer Alcock (Andaman Island, depth 522 m)

Milteliphaster sp. (Andaman Island)

Nymphaster sp. (Off the coast of Andaman Island)

Pentagonaster arcuatus Sladen (Andaman Island, depth 495 m)

Anthenea rudis Koehler (Middle Andaman, intertidal)

A. pentagonula (Lamarck) (Andaman Island, intertidal)

Family : OREASTERIDAE

Culcita novaeguinea Muller and Troschel (Andaman Island 0-15 m)

C. schmideliana Retzius (Andaman Island, 0-15 m)

Protoreaster lincki (Blainville) (Nicobar Island)

Family : METRODIRIDAE

Metrodira subulata Gray (Andaman Island)

Family : OPHIDIASTERIDAE

Leiaster callipeplus Fisher (Andaman Island, depth 206 m)

Fromia indica Perrier (Port Blair, depth 10 m)

F. armata Koehler (Port Blair)

Linckia laevigata (Linnaeus) (Port Blair, intertidal)

L. guildingii Gray (Port Blair, intertidal)

Chaetaster vestitus Koehler (Andaman Island)

Ferdina offreti Koehler (Little Andaman, depth 18-62 m)

Nardoa aegyptica (Gray) (Andaman Island, depth 36 m)

N. carinata Koehler (Andaman Island, depth 18-96 m)

N. frianti Koehler (Andaman Island, depth 36 m)

N. lemonnieri Koehler (Andaman Island, Nicobar)

Ophidiaster armatus Koehler (Andaman Island, depth 31 m)

Tamaria dubiosa Koehler (Andaman Island)

T. fusca Gray (Andaman Island)

T. tubifer Sladen (Andaman Island, depth 96 m)

Sub-order : CRIBELLOSA

Family : PORCELLANASTERIDAE

Sidonaster batheri Koehler (Andaman Sea, depth 1224-2516 m)

Order : SPINULOSA

Family : ACANTHASTERIDAE

Acanthaster planci (Linnaeus) (Port Blair, Nicobar Intertidal)

Family : ASTERINIDAE

Asterina burtoni Gray (Port Blair, Intertidal)

A. sarasini (Koehler) (Port Blair, intertidal)

A. exigua (Lamarck) (Port Blair, intertidal)

Disasterina spinosa Koehler (Port Blair)

Nepenthina brachiata Koehler (Andaman Island)

Palmipes pellucidus Alcock (Andaman Island, depth 204 m)

Tegulaster ceylonica (Döderlein) (Port Blair, intertidal)

Family : ECHINASTERIDAE

Echinaster callosus Marenzelleri (Andaman Island)

E. purpureus (Gray) (Nicobar depth 5 m)

Cribrella mutans Koehler (Andaman Island)

Family : VALVASTERIDAE

Valvaster striatus Perrier (Andaman Island)

Family : PTERASTERIDAE

Euretaster cribrosus (V. Martens), depth 10 m

Order : FORCIPULATA

Family : ASTERIIDAE

Asterias mozophores Alcock and Wood Mason (Andaman Island, depth 457 m)

Family : BRISINGIDAE

Brisinga andamanica Alcock and Wood-Mason (Andaman Island)

Family : ZOROASTERIDAE

Zoroaster carinatus Alcock (Andaman Island, depth 237-437 m)

Z. gilesii Alcock (Andaman Island, depth 915 m)

Class : OPHIUROIDEA

Order : EURYALE

Family : GORGONOCEPHALIDAE

Gorgonocephalus cornutus Koehler (Andaman Island, depth 74-493 m)

Family : ASTEROSCEMATIDAE

Ophiocreas sp. (Andaman Island, depth 3008 m)

Order : OPHIURAE

Family : AMPHIURIDAE

Ophiocentrus verticellatus (Döderlein) (Port Blair, depth 40 m)

Amphipholis squamata (Delle Chiaje) (Port Blair, intertidal)

Ophiocnida picteti de Loriol (Andaman Island, depth 12 18 m)

Amphiura dispar Koehler (Andaman Island, depth 253-1215 m)

Amphiura misera Koehler (Andaman Island, depth 468m)

Amphioplus andrea (Lütken) (Andaman Island, depth 20 m)

A. intermedius (Koehler) (Port Blair intertidal)

Family : OPHIACTIDAE

Ophiactis savignyi (Müller and Troschel) (Port Blair, intertidal)

O. modesta Brock (Port Blair intertidal)

Family : OPHIOTRICHIDAE

Ophiothrix lepidus de Loriol (Andaman Island, depth 27-91 m)

O. stelligera Lyman (Andaman Island, depth 64 m)

O. trilineata Lutken (Andaman Island)

O. vitrea Döderlein (Andaman Island, depth 64-67 m)

O. propinqua Lyman (Andaman Island, depth 0-31 m)

O. aristulata Lyman (Andaman Island)

O. deligens Koehler (Andaman Island, 75 m)

M. speciosa (Koehler) (Port Blair, Nicobar Island)

M. longipeda (Müller and Troschel) (Andaman Island)

Ophiopteron elegans Ludwig (Andaman Island)

Family : OPHIOCOMIDAE

Ophiocomella sexradia (Duncan) (Port Blair, intertidal)

Ophiarthrum elegans Peters (Port Blair, intertidal)

O. pictum (Müller and Troschel) (Nicobar Island, Port Blair, intertidal)

Ophiocoma erinaceus Müller and Troschel (Port Blair, intertidal)

O. brevipes Peters (Port Blair, intertidal)

O. scolopendrina (Lamarck) (Port Blair, intertidal)

O. dentata Müller and Troschel (Port Blair, intertidal)

O. pica Müller and Troschel (Nicobar depth 5 m)

Ophiomastix annulosa (Lamarck) (Port Blair, intertidal)

Ophiopsila pantherina Koehler (Andaman Island, depth 6-67 m)

Family : OPHIOCHITONIDAE

Ophionereis porrecta Lyman (Port Blair, intertidal)

Ophiochiton modestus Koehler (Andaman Island, depth 484 m)

Family : OPHIODERMATIDE

Ophiorachnella gorgonia (Müller and Troschel) (Port Blair, intertidal)

O. infernalis (Müller and Troschel) (Port Blair, intertidal)

Ophiarachna incrassata (Lamarck) (Andaman Island)

Ophioconis indica Koehler (Andaman Island, depth 82m)

Ophiopeza custus Koehler (Andaman Island)

Family : OPHIOLEPIDIDAE

Ophiolepis cincta Müller and Troschel (Port Blair, intertidal)

O. superba H.L. Clark (Port Blair intertidal)

Ophiomusium elegans Koehler (Andaman Island)

O. scalare Lyman (Port Blair, depth, 204 m)

Ophiura kinbergi Ljungman (Port Blair, depth 20 m)

Ophioteichus nodosa (Duncan) (Port Blair, intertidal)

Amphiophiura ornata (Lyman) (Nicobar, depth 752 m)

Ophioceramis tenera Koehler (Andaman Island, depth 474-1163 m)

Ophioglypha aequalis Lyman (Andaman Island, depth 940-2196 m)

O. flagellata Lyman (Andaman Island, depth 741-1235 m)

O. forbesi Duncan (Andaman Island, depth 27 m)

O. sinensis Lyman (Andaman Island, depth 18-65 m)

O. sordida Koehler (Andaman Island, depth 36-64 m)

Ophiolyphus granulatus Koehler (Port Blair, depth 204 m)

Ophiomusa relicta (Koehler) (Nicobar, depth 1417 m)

Ophioplocus imbricatus (Müller and Troschel) (Port Blair, intertidal)

Ophiozona bispinosa Koehler (Port Blair, depth 204 m)

Family : OPHIACANTHIDAE

Ophiocamax fasciculata Lyman (Andaman Island)

Ophiocantha composita Koehler (Nicobar Island, depth 2909 m)

O. decora Koehler (Andaman Island, depth 36-65 m)

O. gratiosa Koehler (Andaman Island, depth 353-812 m)

O. pentagona Koehler (Andaman Island, depth, 219-525 m)

O. sociadilis Koehler (Andaman Island, depth 3299-3367 m)

O. vestita Koehler (Andaman Island, depth 356 m)

Ophiometra integra Koehler (Andaman Island)

O. rudis Koehler (Andaman Islands, depth 1290 m)

Family : OPHIOLEUCIDIDAE

Ophiernus adspersum Lyman (Andaman Islands, depth 766-3654 m)

Ophiopyren bispinosus Koehler (Andaman Islands, depth 470 m)

Family : OPHIOMYXIDAE

Ophiomyxa bengalensis Koehler (Andaman Islands, depth 316-457 m)

O. brevispina var. *irregularis* Koehler (Andaman Island, depth 51-65 m)

O. australis Lutken (Middle Andaman, intertidal)

Class : ECHINOIDEA

Sub-class : REGULARIA

Order : CAMARODONTA

Family : TEMNOPLEURIDAE

Temnopleurus toreumaticus (Klein) (Andaman Island, intertidal)

T. apodus Agassiz & H.L. Clark (Port Blair, depth 204 m)

Paratrema doderleini (von Martens) (Andaman Island)

Temnotrema scillae (Mazetti) (Port Blair, depth 27-448 m)

Trigonocidaris versicolor Koehler (Andaman Sea, depth 164-183 m)

Family : TOXOPNEUSTIDAE

Tripneustes gratilla (Linnaeus) (Port Blair, intertidal)

Toxopneustes pileolus Lamarck (Andaman Island)

Family : ECHINOMETRIDAE

Echinostrephus molaris (Blainville) (Port Blair, intertidal)

Echinometra mathaei (Blainville) (Port Blair, intertidal)

Colobocentrotus atratus (Linnaeus) (Andaman Island)

Order : AULODONTA

Family : DIADEMATIDAE

Astropyga radiata (Leske) (Andaman Island)

Diadema setosum (Leske) (Port Blair, intertidal)

D. savignyi Michelin (Port Blair, intertidal)

Echinothrix calamaris (Pallas) (Port Blair, intertidal)

E. diadema (Linnaeus) (Port Blair, intertidal)

Centrostephanus nitidus Koehler (Andaman Sea)

Family : ASPIDODIADEMATIDAE

Aspidodiadema nicobaricum Döderlein (South West of Nicobar)

Order : STIRODONTA

Family : STOMOPNEUSTIDAE

Stomopneustes variolaris (Lamarck) (Port Blair, intertidal)

Family : ARBACIIDAE

Pygmaeocidaris prionigera (Agassiz) (Andaman Sea, 1026 m)

Order : CIDAROIDA

Family : CIDARIDAE

Dorocidaris lorioli Koehler (Andaman Island)

D. tiara Anderson (Andaman Sea, depth 259-732 m)

Eucidaris metularia (Lamarck) (Andaman Island, depth 29-75 m)

Phyllacanthus verticillatus (Lamarck) (Andaman Island)

Procidaris purpureata Wyville-Thompson (Nicobar)

Prionocidaris brevicollis (de Meijere) (Andaman Sea, depth 82-457 m)

P. baculosa (Lamarck) (Port Blair, depth 5 m)

Sterocidaris alcocki (Anderson) (Andaman Sea, depth 237-1163 m)

S. indica Doderlein (Andaman Sea, depth 733-873 m)

Stylocidaris bracteata var. *albidans* H.L. Clark (Port Blair, 109-137 m)

Order : LEPIDOCENTROIDA

Family : ECHINOTHURIIDAE

Hygrosoma luculentum (Agassiz) (Port Blair)

Phormosoma bursarium A. Agassiz (Andaman Sea, depth 1163-1958 m)

P. verticillatum Mortensen (Andaman Sea, depth 1184-1958 m)

Sub-class : IRREGULARIA

Order : CLYPEASTROIDA

Family : CLYPEASTRIDAE

Clypeaster reticulatus (Linnaeus) (Andaman Island, depth 18-494 m)

Family : LAGANIDAE

Laganum laganum (Leske) (Andaman Island)

Family : SCUTELLIDAE

Echinodiscus auritus Leske (Andaman Island)

Family : ARACHNOIDEA

Arachnoides placenta (Linnaeus) (Port Blair, intertidal)

Family : FIBULARIIDAE

Echinocyamus crispus Mazetti (Andaman Island, depth 27-111 m)

Order : SPATANGOIDA

Family : BRISSIDAE

Metalia spatangus (Linnaeus) (West coast of Andaman Island)

M. sternalis (Lamarck) (Andaman Island)

Brissopsis luzonica Gray (Andaman Island, depth 36-148 m)

Family : PERICOSMIDAE

Pericosmus macronesius Koehler (Long Island, depth 100 m)

Family : SCHIZASTERIDAE

Brisaster indicus Koehler (Andaman Island)

Faorina chinensis Gray (Andaman Island, depth 84-183 m)

Moira stygia (Agassiz) (Andaman Island)

Prymnaster investigatoris Koehler (Port Blair)

Family : SPATANGIDAE

Breynia vredenburgi Anderson (Port Blair)

Maretia planulata (Lamarck) (Great Cocos Island, depth, 36-54 m)

Class : *HOLOTHURIOIDEA*

Order : DENDROCHIROTA

Family : CUCUMARIIDAE

Cucumaria alcocki Koehler (Andaman Island)

C. bacilliformis Koehler (Andaman Island, depth 14-36 m)

Havelockia herdmani Pearson (Andaman Island)

Thyone dura Koehler and Vaney (Andaman Sea, depth 80 m)

Family : PHYLLOPHORIDAE

Afrocucumis africana (Semper) (Port Blair, intertidal)

Pseudocucumis acicula (Semper) (Andaman Island)

Phyrella fragilis (Ohshima) (Port Blair, intertidal)

Order : ASPIDOCHIROTA

Family : STICHOPODIDAE

Stichopus chloronotus Brandt (Port Blair, intertidal)

S. variegatus Semper (Port Blair, intertidal)

S. herrmanni Semper (Port Blair, intertidal)

Family : HOLOTHURIIDAE

Labidodemas rugosum (Ludwig) (Port Blair, intertidal)

Holothuria moebii (Ludwig) (Andaman Island)

H. fuscocinerea Jaeger (Port Blair, intertidal)

H. edulis Lesson (Andaman Island)

H. impatiens (Forskal) (Port Blair, intertidal)

H. arenicola Semper (Port Blair, intertidal)

H. albiventer Semper (Port Blair, intertidal)

H. pardalis Selenka (Port Blair, intertidal)

H. scabra Jaeger (Port Blair, intertidal)

H. atra (Jaeger) (Port Blair, intertidal)

H. pervicax (Selenka) (Port Blair, intertidal)

H. hilla Lesson (Port Blair, intertidal)

H. leucospilota (Brandt) (Port Blair, intertidal)

H. erinaceus (Semper) (Port Blair, intertidal)

H. exilis Koehler and Vaney (Andaman Island, depth 65 m)

H. pyxis Selenka (South Andaman, intertidal)

H. prompta Koehler and Vaney (Andaman Island)

H. rigida (Selenka) (Port Blair, intertidal)

H. remollescens Lampert (Grand Coco Island)

Actinopyga mauritiana (Quoy and Gaimard) (Port Blair, intertidal)

A. echinites (Jaeger) (Port Blair, intertidal)

A. miliaris (Quoy and Gaimard) (Port Blair)

A. lacanora (Jaeger) (Andaman Island)

Microthele nobilis (Selenka) (Port Blair, intertidal)

Bohadschia marmorata (Jaeger) (Port Blair, intertidal)

B. argus Jaeger (Port Blair, intertidal)

B. vitiensis (Semper) (Port Blair, intertidal)

Family : SYNALLACTIDAE

Pelopatides gelatinosus (Walsh) (Andaman Island, depth 344-896 m)

P. mollis Koehler and Vaney (Andaman Island, depth 896 m)

P. ovalis (Walsh) (Andaman Island, depth 896 m)

Synallactes wood-masoni (Walsh) (Andaman Island)

Order : MOLPADONIA

Family : CAUDINIDAE

Acaudina molpadoides (Semper) (Andaman and Nicobar Islands)

Order : APODA

Family : CHIRIDOTIDAE

Polycheira rufescens (Brandt) (Port Blair, intertidal)

Family : SYNAPTIDAE

Protankyra errata Koehler and Vaney (Andaman Island)

P. innominata Ludwig (Andaman Island)

P. timida Koehler and Vaney (Andaman Island, depth 1024-1026 m)

Synapta maculata (Chamisso and Eysenhardt) (Port Blair, intertidal)

Patinapta ooplax (Marenzeller) (Port Blair, intertidal)

Ophiodesma grisea (Semper) (Port Blair, intertidal)

Family : MYRIOTROCHIDAE

Ankyroderma danielssenii Theel (Andaman Sea, depth 484 m)

A. musculus (Risso) (Andaman Island depth 484-1733 m)

Trochostoma andamanense Walsh (Andaman Sea).

19

SEA TURTLE RESOURCES IN THE ANDAMANS[1]

S. BHASKAR AND R. WHITAKER
Madras Snake Park Trust, Madras 600 022

INTRODUCTION

Of the 7 existing species of sea turtles found in the oceans of the world, 4 occur in the Andaman Sea ; they include four of five existing genera of sea turtles. All four are presently known to nest in the Andamans. Among them is the largest and rarest of sea turtles, the leatherback turtle. This turtle has been listed in the International Union for the Conservation of Nature (IUCN) Red Data Book for species immediately threatened with extinction. All Indian sea turtles are totally protected by law, having come under Schedule 1 of the Indian Wildlife (Protection) Act in 1977.

The presently known status of Indian sea turtles is summarized below :

Zoological Name	English Name	Status in Indian seas	World wide status
Lepidochelys olivacea	Olive Ridley Turtle	Very common	Not uncommon but declining rapidly
Chelonia mydas	Green Turtle	Common	Common but declining rapidly
Eretmochelys imbricata	Hawksbill Turtle	Not Common	Exterminated over most of their original range
Dermochelys coriacea	Leatherback Turtle	Common only in the Andamans	Uncommon

Sea turtle meat and eggs constitute an important food source in many countries. Turtle soup prepared from cartilaginous tissue called calipee is widely relished. The horny laminae on the shell of the hawksbill turtle are converted into highly priced curios. Turtle fat is used as a remedy for a variety of ailments and as caulking for boats. The hide is converted into shoes. If nesting occurs in sufficient concentrations, sea turtles could promote tourism. Carefully supervised 'turtle watching nights' (i.e. the organized observation of sea turtles as they come ashore and nest) have become popular tourist attractions in Australia and Malaysia. Aesthetic reasons apart, the uses cited above make it well worthwhile for us to protect and preserve sea turtles, whose populations have taken a downward plunge ever since man and dogs commenced colonizing their remote nesting areas, collecting their eggs, 'turning' them on land and netting, spearing and hooking them indiscriminately at sea. Dogs scent and excavate turtle eggs with disheartening efficiency. Turtle nesting beaches have literally been trucked away for construction purposes, as has occurred, for example, on the Betapur coast in Middle Andaman.

The Snake Park is currently carrying out a sea turtle survey in the Andamans and offshore islands. So far Great Andaman and Little Andaman have been surveyed.

SEA TURTLE SURVEY FINDINGS IN LITTLE ANDAMAN

The Island was surveyed from 29th December '78 to 5th January '79 by the Madras Snake Park Field Officer. Data were collected in two ways : (1) Walking the seashores of the island in order to locate turtle

[1] Invited Paper.

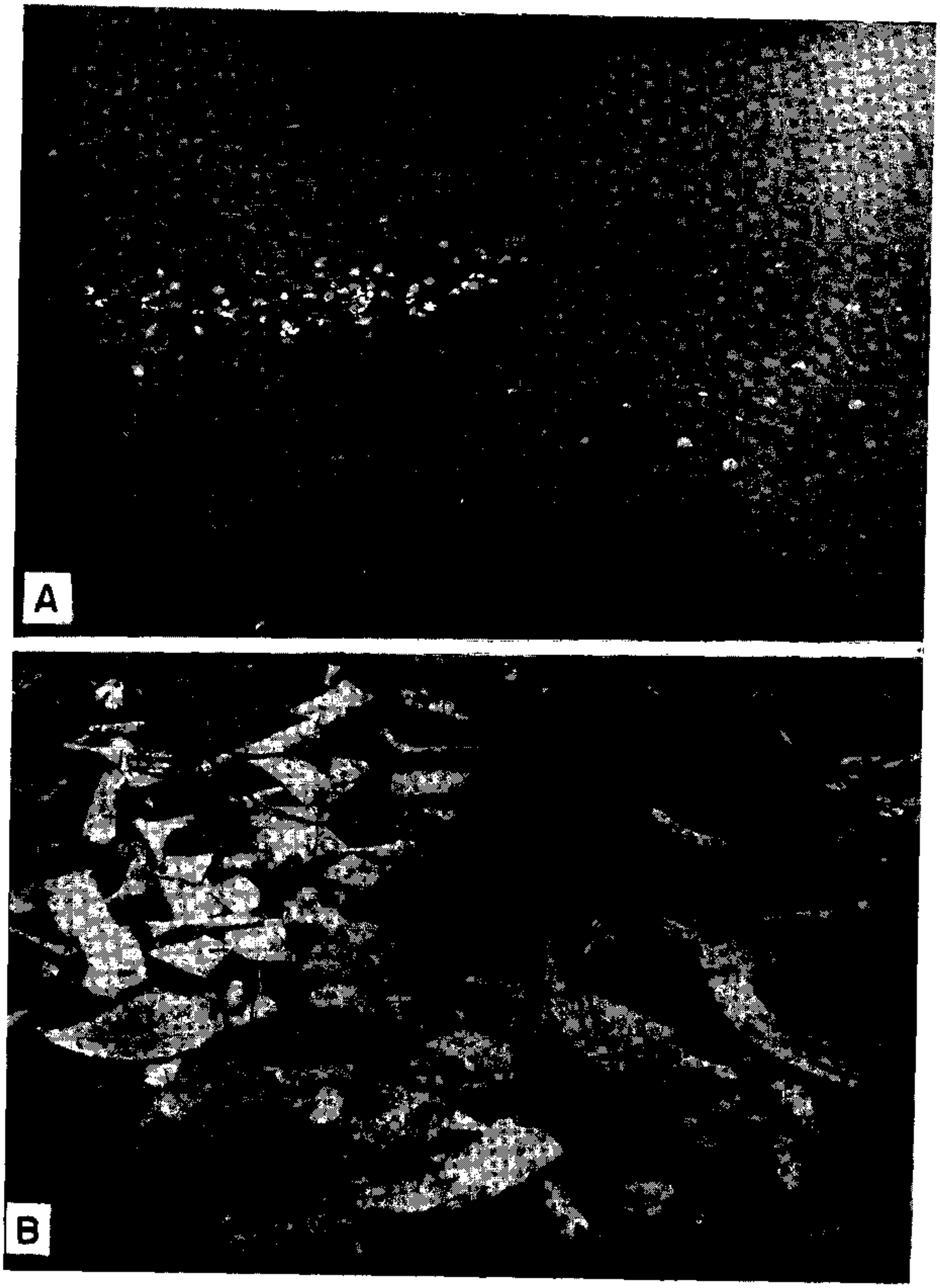


PLATE I. A. Sea turtle eggs are dug up and eaten by dogs, pigs, monitor lizards and man. B. Skulls and bones of green sea turtles caught for meat near Wandoor, South Andaman. (Photos by S. Bhaskar)

PLATE II. The eggs of hawksbill are the smallest of sea turtle eggs in the Andamans. (Photo by S. Bhaskar) nests, excavations, tracks, carcasses, skeletal remains and egg shells and (2) interviewing settlers and Onges who fish and hunt for a livelihood.

Most excavations of four species were found on Little Andaman, with leatherback nests prepondering. The breakup was as follows :

Species		*No. of excavations*
Leatherback	..	82
Olive Ridley	..	4
Green	..	3
Hawksbill	..	1

While nests of the Ridley, Green and Hawksbill turtles are often encountered on the coasts of mainland India and on offshore islands, the last confirmed account of a leatherback nesting dates back to 1928 at Quilon, Kerala where no nesting has occurred since, on account of predation by man on eggs and adult turtles.

Of the 82 leatherback excavations (meaning 82 nests, in all probability) about 15 had been made during or immediately prior to the week of the survey i.e. around late December '78 and early January '79.

On the night of 31st December a leatherback turtle was observed as it nested at West Bay, Little Andaman. This is the first occasion in 50 years that leatherback nesting has been observed and recorded on Indian soil.

Leatherbacks grow to 2.5 m in length and over 1000 kg in weight. The individual observed in Little Andaman measured almost 2 m in length and left a track 180 cm in breadth as it crawled up the beach sand. Large leatherbacks leave tracks reminiscent of those made by a tractor well over 2 m broad. The eggs (white in colour, encased in a flexible parchment textured outer skin) are laid and buried 60 to 75 cm below ground level in moist sand (temperature roughly 25°C) usually on broad sandy beaches at or above the spring hightide line. Roughly 100 eggs are laid, most of them with a diameter of 51 mm, larger than those of other sea turtle species that occur in India. The area excavated by the nesting turtle may measure 15 m by 3 m (the surveyor carefully reburied all eggs after measurements had been taken and data collected).

In spite of the leatherback turtle's impressive open-sea swimming ability and its far-ranging habits (the species is found in all but the coldest seas), only three large nesting concentrations are known to exist, to date : at Trengganu (Malaysia), Surinam and Costa Rica. It would be rash to assume, in the absence of more detailed investigation, an aggregation of comparable magnitude in Little Andaman. However, this pos ibility cannot be ruled out in view of the fact that the duration of the nesting season, its peak period and intensity have yet to be ascertained.

'Natural' predation on turtle eggs by monitor lizards and, possibly, by wild boar and civet cats exceeds 80% of the clutches laid, as was evident from the numerous occasions raided nests (with empty turtle-egg shells strewn about) were encountered (Pl. I, A). Monitor lizards were observed as they excavated turtle nests on four occasions. Wild pig and civet tracks were often found around turtle nests. Presumably this degree of natural predation has kept the leatherback population in a state of dynamic equilibrium—a situation which could easily be upset by the encroachment of man (and, inevitably, dogs) on turtle nesting beaches. This has evidently occurred at Hut Bay where fishermen state that nesting has dwindled and almost ceased over the past decade. The presence of only one leatherback excavation in Hut Bay during the survey period, in spite of the availability there of otherwise suitable nesting habitat, reinforces this belief. Today, nesting preponderates on the virtually undisturbed West Bay. South Bay which is visited occasionally by fishermen, predictably harbours a smaller nesting population.

Of vital importance for the continued survival of the unique Little Andaman leatherback population is the need to protect the beaches at West Bay and South Bay from all human intrusion, at least until these areas can be effectively and regularly patrolled by law enforcers. Under no circumstance should dogs be allowed to be brought to these areas.

The traditional hunting of turtles by Onges, may, however, have no adverse effect on the turtle population because of the antiquity of this interaction and the small scale on which it occurs at present. Onges spear sea turtles for consumption using a hand-propelled wooden harpoon with a detachable metal spike head. The green turtle is the species usually hunted. The imminent construction of a motorable road from Hut Bay to the vicinity of Jackson Creek will greatly jeopardize the existence of the West Bay nesting population. Crocodiles, reputed to occur in numbers in the area will be similarly threatened.

Follow-up surveys are necessary in order to collect more accurate and quantitative data regarding sea turtle nesting seasons, nesting populations and their fluctuation, sea migration routes, egg laying frequency, biology etc., with a view to conserving this resource.

Sea Turtles in the South Andaman Islands

Areas surveyed

1. The coasts of the main island of South Andaman barring those along the Jarawa Tribal Reserve.
2. The Rutland Island coast excluding its eastern face.
3. The 12 small islands that form the Labyrinth group which lies off Wandoor, South Andaman.
4. The Twins, two islands situated approximately due west of Wood-Mason Bay, Rutland Island.

Period of survey : 7 October to 4 November '78.

Prior to the Government ban in October'77 on the killing of sea turtles and on the collection of their eggs, turtles were actively hunted by fishing communities from the small townships of Maymyo and Wandoor (Pl. I, B).

Wandoor became the largest 'turtle depot' and butchering centre in South Andaman, where sea turtles that had been speared using hand-propelled harpoons or, less frequently, caught in nets or while nesting were brought and carved up before transportation to Port Blair where the meat fetched Rs. 3-5 per kg. Turtle eggs were consumed locally and occasionally sold for 5 paise a piece.

The turtle species usually killed for meat was (and to some extent still is) the green turtle (*Chelonia mydas*), as was evident from the presence of 34 *C. mydas* skulls at Wandoor in September 78, a year after the ban. Juveniles as well as adults were taken. The skull width ranged from 9½ to 13 cm and averaged 11½ cm.

Local estimates of the catch before October '77 range from 5 to 20 turtles during fishing days, the number of which is curtailed mainly by the prevalence of the south-west monsoon. Fishermen of Bengali origin who are reputedly experienced in the use of sails and adept at wielding harpoons state that the heaviest nesting occurs during August but do not state the species involved. At least 3 other species occur in the Andaman sea—the hawksbill (*Eretmochelys imbricata*), Ridley (*Lepidochelys olivacea*) and the leatherback (*Dermochelys coriacea*).

Hawksbills in South Andaman nest well into October (at least)—23 sets of fresh hawksbill tracks were found on the Twins, known locally as Kachua Tikeri (turtle Island). The Twins were the most remote of the areas surveyed but even so fishermen occasionally undertake the 3 to 7 hour journey from Wandoor and other coastal hamlets expressly to collect turtles and their eggs. Evidence of this was the presence of a stripped carcass of a green on the Eastern Twin island and many turtle egg shells strewn nearby.

Fishermen hesitate to use nets in the shark infested waters around the Twins. On a broad, kilometre-long sandy beach on Rutland Island directly opposite the Twins, both sets of green turtle tracks visible had been made by a turtle lacking the left fore-flipper—in all likelihood the result of a shark attack. The time elapsed between the laying of the two clutches probably represented an inter-nesting interval for the turtle, roughly a fortnight. Another green nest site visible nearby but with tracks obliterated may have been excavated during a still earlier nesting venture by the same turtle. If so, she must have first come ashore to nest about mid-September. This evidence is of course too meagre to delineate the green's nesting season in the Andamans.

Also on the same beach was a fresh hawksbill nest and 5 leatherback egg shells scattered over a 75 m front. Of these 5, 2 were intact and unbroken and, though discolored and desiccated, retained their roughly spherical shape, thus facilitating a rough measurement of their diameters. One of these contained the remains of a hatchling's carapace. The fact that the other did not, makes it likely that the eggs came from different clutches (75 m of sand carpeted by sparse vegetation and separating the two eggs reinforces this possibility). The two intact eggs exclude predation and the likely explanation for their presence on the sand surface is that they were uprooted inadvertantly by another nesting turtle of the same or different species. If correct, these presumptions lead one to the exciting possibility that the beach was, sometime during the previous few months, a reasonably heavily nested area used probably by leatherback, because these large turtles dig deeper body pits and egg chambers than other species do and are therefore more likely to accidentally excavate other nests. Though suitable as a leatherback nesting site (being sandy and remote), this beach which lies immediately south of Wood-Mason Bay offered no other signs of digging activity by leatherbacks ; but the excavations could have been obliterated during the south-west monsoon months (the beach faces west). About 5 km away were two leatherback nest sites excavated about 2 months earlier, i.e. in July or August, on a little disturbed beach on Rutland's southern coast.

About midway between the beaches mentioned were 6 sets of fresh hawksbill tracks on a 1 km wide front. This narrow beach is remote and fringed by tall pandanus. There was evidence of 5 nests. Of these, three had lately been robbed by monitor lizard (*Varanus salvator*). Unlike dogs and jackals, monitors leave behind few, if any, egg shells. The surveyor's visit surprised a 0.75 m monitor as it rested on a turtle nest after eating all the eggs. It was sluggish in making its getaway after the heavy meal. There were abundant monitor tracks on Rutland's beaches and on the larger Islands of the Labyrinth group, especially on Tarmugli and Redskin, where nesting occurs, as also on Boat Island.

Wild pigs inhabit Rutland Island but no evidence of predation by them on turtle eggs was found. The relatively heavy nesting on the Twins is at least partly attributed to the absence of monitors there.

Data relating to the green and Ridley turtles are each from a single nest; the hawksbill figures are average values from 4 clutches (Pl. II). The leatherback egg diameter is the average of 2 dry but intact eggs found on a Rutland beach. This is the first definitive evidence of leatherbacks nesting in the Andamans.

The representative figures suggest trends to aid in distinguishing between eggs of the four species. The overlap in egg size of the hawksbill and Ridley eggs prevent size alone being a criterion for distinguishing between eggs of the two species. Clutch size may overlap between any two of the species and is therefore even less distinctive.

TABLE 1. *Egg size of sea turtles from South Andaman*

Species	No. of eggs per clutch	Egg size, mm (Max. dimension obtainable)	Range in egg size, mm
Hawksbill ..	139 (range-96-177)	34.3 (avg. of 8 eggs)	33.0-37.8
Ridley ..	119	36.6 (avg. of 4 eggs)	36.2-36.9
Green ..	93	41.8 (avg. of 2 eggs)	41.4-42.1
Leatherback ..	?	50 (avg. of 2 dried eggs)	49-51 (dried eggs)

Sea turtle nesting also occurs on about 20 small, narrow debris-strewn coves on the rocky eastern coast of South Andaman island from Shoal Bay to Burmanalla, but the density of nesting is low, at least during the survey period. A *Lepidochelys* nest was found in late October on a narrow sandy cove 1½ km north of Madhuban. There was also a fresh Ridley nest site and two older nest sites about 2½ km north of Madhuban. One of these had been raided by humans. The reported penalties for possession of turtle eggs (Rs. 5 per egg) and for the killing of turtles (Rs. 50) will serve as effective deterrents if the turtle protection laws are enforced rigidly.

Data on the egg size of the 4 species from South Andaman is given in Table 1.

RECOMMENDATIONS

1. One of the authors (S. Bhaskar) has made the first observation of leatherbacks nesting on the islands. *D. coriacea* is a rare turtle and its nesting beaches such as those on Little Andaman and Rutland should be identified and strictly protected.

2. Adequate wildlife staff and strict enforcement of the Wildlife (Protection) Act of 1972 would go a long way toward ensuring the survival of sea turtles in the Andamans.

3. Since turtles are an important protein resource mariculture possibilities should be investigated.

4. The fact that turtles are protected should be publicized in the islands.

20

MARINE TURTLE RESOURCES

R.S. LAL MOHAN[1]

INTRODUCTION

The Andaman and Nicobar Islands with their numerous uninhabited islands and undisturbed sea shores offer ideal conditions for the nesting of sea turtles. However, many areas which were formerly frequented by the turtles for nesting have been abandoned due to increased human activities. Habitat destruction, removal of eggs and killing of the nesting females by the people have already caused some damage to the sea turtle resource of Andaman and Nicobar Islands.

Davis and Altevogt (1976), Whitaker (1977) and Bhaskar (1979) studied the marine turtles of Andaman islands. Bhaskar (1979) reported on the nests of eggs and hatchlings of *Chelonia mydas*, *Lepidochelys olivacea* and *Dermochelys coriacea*.

NESTING SITES OF TURTLES

During the survey of the Andaman and Nicobar islands efforts were made to locate the turtle nests along the coast of the islands. The nests were located with the help of the 'Karen' fishermen who are known for their ability to spot the turtle nests. The sea shore was probed with a pointed bamboo reaper.

In North Andaman, turtle nests were reported from almost all the islands, particularly from Landfall Island, Table Island, Turtle Island and Sound Island. In the Middle Andaman, turtle nests were found in Long Island and Strait Island. The Betapur shore near Rangat was another favoured nesting site for the turtles. The sea shores of Ross Island, Burmanalla, Chiriyatapu, Wandoor and Cinque Island are some of the areas where a large number of marine turtles frequent for nesting. In Little Andaman, the turtle nests were found in Hut Bay, Butler Bay and South Bay. Many areas in Nicobar Islands are also known for their turtle nesting sites. Bompoka Island, Katchall Island and Anderson Bay are some of the favoured nesting sites.

Present address :
[1]CMFRI, Regional Centre, Mandapam Camp.

FARMING OF SEA TURTLES

Turtle farming is practised in many Central American countries (Jones and Fernando, 1973). The high price obtained for turtle products like shells, calipee and turtle meat makes turtle farming viable. Davis and Altevogt (1976) and Whitaker (1977) suggested large turtle farms in Andaman and Nicobar Islands. The availability of turtle eggs and many suitable farming sites along the coast make the Andaman and Nicobar islands a preferred place for turtle farming for conservation of the resources.

Besides habitat destruction and large-scale collection of turtle eggs by the local tribes and settlers, many nests are destroyed along with the eggs by the wild dogs (Fig. 1) and monitors (*Varanus salvator*). Near

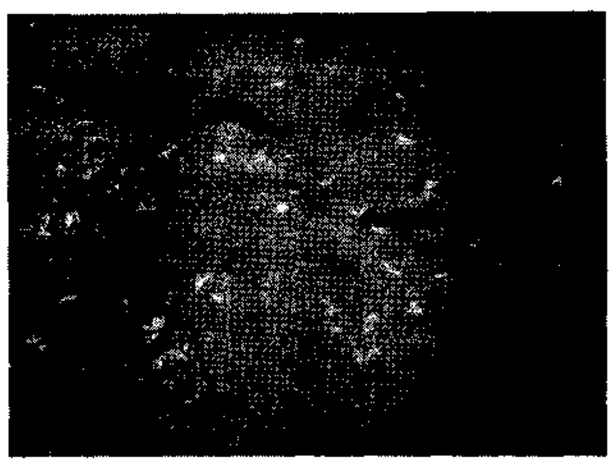


Fig. 1. Turtle egg shell remnants from a nest destroyed by dogs in Betapur beach near Rangat.

Rangat it was observed that about 20 nests had been damaged and the eggs eaten by wild dogs in an area of about 50 m^2. The local tribes Onges, Shompens and Jarawas subsist on the turtle eggs as they form part of their staple food (Man, 1883 ; Kloss, 1902). Nevertheless large number of eggs can be saved if timely action is taken to remove the eggs to safe places and hatch them. The hatchlings can be released to the sea as done by the Central Marine Fisheries Research Institute on the mainland (Anon., 1978).

References

ANON., 1978. The vanishing turtle. *CMFRI Newsletter*, 7 : 5-6. Central Marine Fisheries Research Institute.

BHASKAR, S. 1979. Discovery of nest of a rare turtle from Andaman Island. *Indian Express*, Jan. 1979.

DAVIS, T. A. AND R. ALTEVOGT. 1976. Giant turtles and robber crabs of the South Sentinel. *Yojana*, 20 (13) : 75-79.

KLOSS, C. BODEN. 1902. *Andaman and Nicobars*, Reprint 1971, Vivek Publishing House, Delhi, 373 pp.

JONES, S. AND B. FERNANDO. 1973. The present status of turtle fishery in India. *Proc. living Resources of Seas around India*, Special Publication, Central Marine Fisheries Research Institute, pp. 772-775.

MAN, E. H. 1883. *The aboriginal inhabitants of the Andaman Islands*. (Reprinted, 1978) Prakashask, Delhi.

WHITAKER, R. 1977. A note on the sea turtle of Madras. *Indian Forester*, 103 : 733-734.

21

CROCODILE RESOURCES IN THE ANDAMANS AND NICOBARS[1]

R. WHITAKER

Madras Snake Park Trust, Madras 600 022

INTRODUCTION

The saltwater crocodile (*Crocodylus porosus*) is the world's largest living reptile, growing to over 8 m and probably well over a ton in weight. It is an essential component in the mangrove creek environment being the master predator at the head of the food chain.

The saltwater crocodile (Pl. I, A) also produces the world's most valuable crocodile leather because of the small, fine scalation. Until 1972, crocodiles were legally killed by all and sundry throughout most of the Andamans (Pl. I, B). Formerly reported large crocodile populations (particularly the famous crocodiles of Mugger Nullah and the Kalpong River at Diglipur) have dwindled to a remnant few. The little nesting that still takes place is mainly on the west coast of North Andaman and the Kalighat—Parangara area in the southern drainage of North Andaman (Pl. I, C). No one knows what the status of crocodiles is in the Jarawa (tribal) Reserve. Approximate figures of crocodile population in the Andamans, excluding Jarawa Reserve, as estimated by Whitaker and Whitaker (1978) are as follows :

Place		*No. of breeding females*	*Total crocodiles*
North Andaman	..	50	100-200
Middle Andaman	..	20	50-100
South Andaman	..	10	20-30

Little Andaman, though fast being encroached upon by the Forest Corporation and several thousand Bengali and Ranchi settlers, reportedly has a somewhat intact breeding population in Jackson Creek. A proposed road across this island of the dying Onge tribe may endanger the stock of that relatively undisturbed area. Unless some attention is given to developing available natural resources, the effects of deforestation will be irreversible and many of the more vulnerable resources will be lost forever, notably the crocodiles.

[1] Invited Paper.

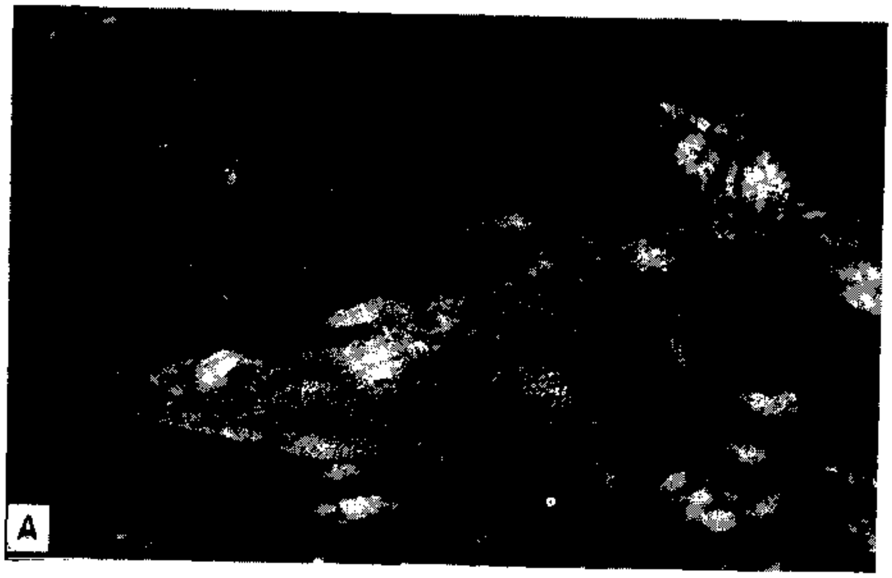
CROCODILE REHABILITATION

Since 1975 several states including Uttar Pradesh, Orissa, Andhra, West Bengal, Rajasthan and Tamil Nadu, with Government of India help, have been developing crocodilian rehabilitation projects based on a egg collection/rearing of young/release in protected habitat methodology set up by the FAO/UNDP consultant H.R. Bustard (de Waard, 1975). At present over 1500 gharial (*Gavialis gangeticus*), about 1500 mugger (*Crocodylus palustris*) and 200 saltwater crocodiles are being reared for release to help build up wild stocks back to a level viable for the species. Such a programme could be easily set up in the Andamans where holding pens can be cheaply constructed of natural materials and food is readily available in the form of crustaceans, insect life and fish. A careful survey would determine present nesting sites (most of which are already known and robbed annually by the settlers in North Andaman) as well as determine which islands and areas can be kept suitably free of human disturbance for crocodile reserves.

CROCODILE REARING AND FARMING

The potential for a crocodile rearing and farming industry in the Andamans is great and would help the crocodile to save itself from extinction. The climate is suitable ; the wild resource, though almost wiped out could recover ; cheap food sources for crocodile rearing are numerous ; and materials for construction of enclosures are cheaply available (poles and logs). Aborigines and settlers with aptitude could benefit from a crocodile farming industry. Crocodile meat is widely accepted protein which is becoming increasingly scarce.

Eggs and young could be collected from wild laid nests in protected areas and reared, a percentage for



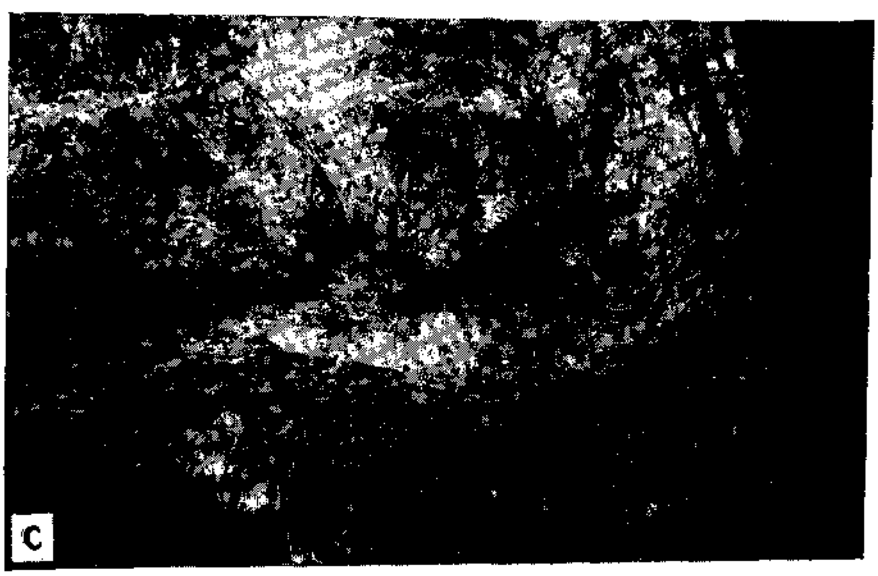


PLATE I. A. The saltwater crocodile *Crocodylus porosus* ; B. Most of the Andaman crocodiles were killed off in the 1960's. C. Habitat of the saltwater crocodile.

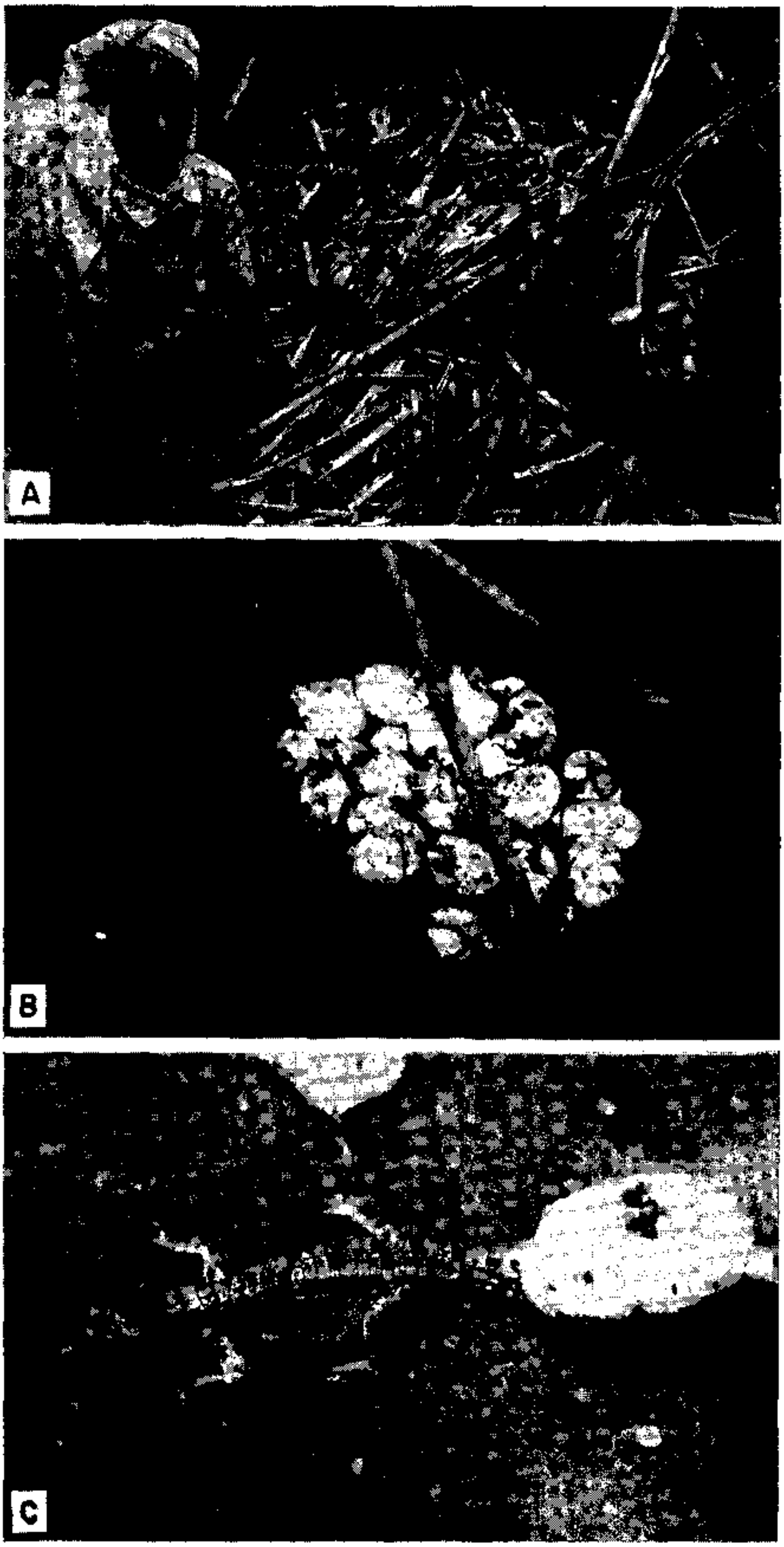


PLATE II. A. Mound nest of the saltwater crocodile ; B. Eggs in a saltwater crocodile nest, North Andaman ; C. One of the 39 hatchlings resulting from the nest.

release and a percentage for cropping. Rearing can be done by the Forest Department at a battery level (*i.e.*, hundreds or thousands in large enclosures) or young crocodiles could be reared as a cottage industry and sold back to the Forest Department at cropping size. Cropping size (about 1.5 m in length, 35 kg in weight with a 30 cm belly skin) is attained in 24-30 months if well cared for. A subadult crocodile eats only about 5 kg of food per month, is hardy and will remain healthy with moderate care. Actual crocodile farming (the maintenance of breeding adults) may not be practicable for the present considering the difficulty in feeding, handling and housing big crocodiles, and the territorial and aggressive nature of adult males and females. Right now the need is to protect the existing wild stock, particularly in Little Andaman and in the Nicobars, so that a sustained yield can be a reality.

A female saltwater crocodile makes a conspicuous, metre high mound nest in April-July in the freshwater drainage areas of palm, cane and grasses at the heads of the brackish, mangrove-lined creeks (Pl. II, A). She lays 40-90 eggs which hatch in about 70 days (Pl. II, B). Nest loss due to predation (by men and monitor lizards) and flooding is high. In a collection and rearing programme a yearly average of 40 surviving hatchlings could be expected from each nest. Each hatchling (Pl. II, C) will be worth about Rs. 800 (for skin, meat, fat and gall bladder) after 2½ years of growth. If 25% were released for recruitment of wild stocks and 25% accounted for overheads, the net gain from each nest is still Rs. 16,000 per annum. Thus we see that each female crocodile is a revenue earner at the rate of at least Rs. 16,000 per year and worthy of protection, propagation and management.

References

de Waard, J. M., 1975. Economic potential of gharial and saltwater crocodile schemes in Orissa, FAO, IND/71/003, May 1975.

Whitaker, R. and Z. Whitaker. 1978. A preliminary survey of the salt water crocodile *Crocodylus porosus* in the Andaman Islands. *J. Bombay Nat. Hist. Soc.*, **75** (1) : 43-49.

22

SALTWATER CROCODILE RESOURCES

R. S. LAL MOHAN[1]

Introduction

Crocodiles were reported from the Andaman and Nicobar Islands as early as 1870 (Stoliczka, 1870). Later, Smith (1939) and Mathur (1969) recorded their occurrence from various islands. However, detailed study on the species including its habitat, population, nesting habits and conservation received attention only very recently (Whitaker and Daniel, 1978 ; Whitaker and Whitaker, 1978 ; Bustard and Choudhury, 1981).

The saltwater crocodile, *Crocodylus porosus*, had a wide range of distribution from south-west coast of India eastwards to South China, extending southwards through Malaysia, Indonesia, Philippines to New Guinea and Northern Australia (Bustard and Choudhury, 1981). It is found along the coast of Tamil Nadu, Andhra Pradesh, West Bengal and Andaman and Nicobar Islands. In the mainland of India, the species is now restricted to an area of 176 sq. km, Bhitar Kanika sanctuary in Orissa and in Sunderbans (FAO, 1974). In North Andaman, *C. porosus* has been reported from the offshore islands such as North Reef and Landfall Island. They are found in Kalara creek (Fig. 1), Balmi creek, Parangara creek, Kalpang river and its tributaries, Casuarina and Hudson Bay. In the Middle Andaman, crocodiles have been reported from Betapur, Bakultala, Papitadera and Kadantulla creeks. In the South Andaman, crocodiles have been reported from Baratang. Jackson creek of Little Andaman has a population of crocodiles. In Nicobar Islands the Galathea river, Alexandria river and Dagmar river are reported to have crocodiles. The species has been reported from Teressa, Bompoka, Comorta, Trinkat, Katchall, Nancowri, Little Nicobar and Great Nicobar Islands (Whitaker and Whitaker, 1978).

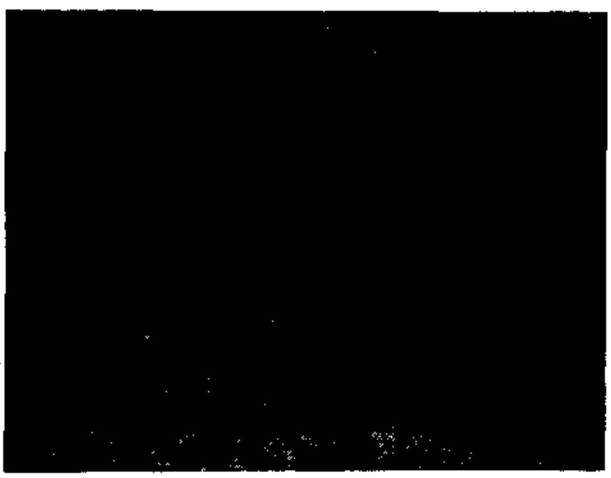


Fig. 1. A habitat of the saltwater crocodile in Kalara river near Kalighat, North Andaman.

Nesting Sites

Nests of crocodiles were located in the tidal cane fringes, creeping cane and evergreen vegetation and cultivable land. In the tidal cane fringes the nests were made of standing canes. The nests were found with a higher elevated base. In the creeping cane and evergreen vegetation zone, the nests were made of creeping cane and dry fallen leaves of evergreen trees. The nest in the cultivated land was made of grass and miscellaneous shrubs without mud. The nests were close to water though the distance between the high tide mark and the nest may vary. Choudhury and Bustard (1980) observed that 66.6% of the nests were found in the creeping cane and evergreen vegetation, 26.6% in tidal cane fringes and 6.6% in cultivated land. The nesting areas of crocodiles in Andaman Islands were found to be in and around Kalighat, Kalpang river and Kalara creek (Whitaker and Whitaker, 1978). Choudhury and Bustard (1980) reported nests from Kalara, Balmi, Parangara creek, Kalpang river and also along the banks of the streams emptying into the Casuarina and Hudson Bay.

Conservation

Bustard and Choudhury (1981) listed commercial hide hunting, loss of habitats due to massive depletion

[1] *Present address :*
CMFRI, Regional Centre, Mandapam Camp.

of mangrove forests, reclamation of alluvial soil built by the mangrove ecosystem for cultivation, human apathy towards the crocodile due to its size and behaviour, robbing of eggs and consumption of its meat for its medicinal value as the reasons for the decline of crocodile population in its range of distribution. They observed very high level of nest predation (84%) by the settlers in North Andaman. Nests were also destroyed by the monitor *Varanus salvator* and the wild pigs (*Sus andamanicus*). It is further reported that 7% of the nesting females were killed by the settlers in a single season. All these factors contribute greatly to the decline of crocodile population in Andaman and Nicobar Islands.

Bustard and Choudhary (1981) suggested establishment of crocodile farms in Andaman Island as a part of the conservation measures to safeguard the population. The number of breeding females in Andaman and Nicobar Islands was estimated to be 80 among the total crocodile population of 170-330 (Whitaker and Whitaker, 1978). Choudhury and Bustard (1980) located 30 nests after an exhaustive survey of the islands and estimated the breeding females to be 36 in North Andaman Island. The saltwater crocodile is a valuable resource and should be conserved by establishing crocodile sanctuaries and taking up husbandry work as suggested by Bustard and Choudhury (1981).

References

Bustard, H. R. and B. C. Choudhury. 1981. Conservation future of the saltwater crocodile (*Crocodylusporosus*)(Schneider) in India. *J. Bombay. Nat. Hist. Soc.*, 77 (2) : 201-214 (1980).

Choudhury, B. C. and H. R. Bustard. 1980. Predation on the natural nests of saltwater crocodiles (*Crocodylus porosus*) (Schneidar) in North Andaman island with notes on the crocodile population. *J. Bombay Nat. Hist. Soc.*, 76 : 311-323.

Fao. 1974. India—A preliminary survey of the prospects of crocodile farming (based on the work of H.R. Bustard, F.A.O. Rome) F.O. Ind./71-033.

Mathur, L. P. 1969. *History of the Andaman and Nicobar Islands* (1756-1966). Sterling Publishers, Delhi.

Smith, M. A. 1939. *Fauna of British India*, Vol. 1. London.

Stoliczka, F. 1870. Observations on some Indian and Malayan amphibians and reptiles. *J. Asiat. Soc. Bengal*, 39.

Whitaker, R. and Z. Whitaker. 1978. A preliminary survey of the saltwater crocodile (*Crocodylus porosus*) in the Andaman Islands. *J. Bombay Nat. Hist. Soc.*, 75 : 43-49.

Whitaker R. and R. C. Daniel. 1978. The status of Asian crocodilians. *Tiger paper*, 5 : 12-17.

23

GENERAL CONSIDERATIONS OF MARICULTURE POTENTIAL OF ANDAMAN AND NICOBAR ISLANDS

E. G. SILAS[1] AND K. ALAGARSWAMI[1]

1. *Base-line study of mariculture potential*

The rapid survey carried out at selected centres in the Union Territory of Andaman and Nicobar Islands during January-April 1978 was a base-line study to understand the potential of the islands for development of mariculture. Mariculture is assuming greater importance for increasing sea-food production and providing employment opportunities on the mainland of India and, to extend this development to the island territory, basic data on the species resources and environmental conditions are essential. The present survey, though indicative in nature, is the first to be made in that region with this specific objective and has thrown some light on its mariculture potential.

2. *Island ecosystem and possible types of culture*

The sea-locked Andaman and Nicobar Islands are in the tropical rain forests zone, with an annual rainfall of about 380 cm precipitated through nine months in a year during both the south-west and north-east monsoons. They are also subject to swift winds and gales of cyclonic weather commonly prevalent during the change of monsoon. Some of the islands are also subject to sea erosion. The islands are mostly grouped and are also moderately indented. As a result there are numerous bays, lagoons, creeks and inlets with varying depths and different substrata which are optimal for several types of mariculture operations. Ideal situations exist for raft culture and cage culture in the bays. Shallow lagoons are suited for pen culture. The water bodies in the creeks and inlets with the adjoining land area can be used for development of prawn/fish farms.

3. *Mangrove ecosystem*

The mangroves of the Andaman and Nicobar Islands are one of the well preserved ecosystems in the world and are very extensive. These should be preserved against human interference. The flora and fauna of the mangroves have been studied during the survey. Rich resources of juveniles of penaeid prawns, crabs and finfishes such as grey mullets and milkfish occur here. The productivity of mangroves is high. The mangroves form the nursery grounds for the coastal species of fish and shellfish and sustain natural production of these species. Some of the mangrove areas which can be considered for mariculture of prawns and fish are at Mayabunder, Rangat, Henry Lawrence Is., Neill Is., Chiriyatapu, Chippighat, Wandoor, Wright Mayo, Kimios and Spiteful Bay. Areas in the upper reaches of the creeks can be utilised for developing aquaculture farms without disturbing those on the sea front which protect the coastal zone against sea erosion. The 'tambak' type of farming as practised in Indonesia may be adopted in the mangrove ecosystem.

4. *Prawn culture*

The banana prawn, *Penaeus merguiensis*, is the most important commercial species among the prawns in the islands, although more than 20 species of penaeid prawns have been recorded. Presently banana prawn is caught by stake nets at Wright Mayo, Chauldari, Diglipur and other centres. *P. merguiensis* is closely related to the white prawn *P. indicus* which is the common species of prawn farming in the mainland of India. The technology of farming of *P. indicus*, as developed for the coastal brackish water areas on the mainland can be easily adopted for the banana prawn. Post-larvae and juveniles of this species for stocking can be collected from the mangrove areas.

5. *Crab culture*

Three species of portunid crabs *Scylla serrata*, *Portunus pelagicus* and *P. sanguinolentus* occur in the Andaman and Nicobar Islands. Of these *S. serrata* which grows to large size is collected and sold in the market. This is a good candidate species for culture. Young crabs can be collected from the mangrove areas and creeks

[1] *Present address*: CMFRI, Cochin 682 018.

for stocking. The technique of culture of this species has recently been developed at the Central Marine Fisheries Research Institute.

6. *Lobster culture*

Six species of spiny lobsters, *Panulirus homarus, P. ornatus, P. penicillatus, P. versicolor, P. polyphagus* and *P. longipes* have been recorded during the survey. It is significant that *P. longipes* which is a commercial species in the lobster fishery of Australia has been recorded in the Andaman and Nicobar Islands. The puerulii and juveniles of lobsters can be collected by suspending special types of collectors in the sea and these can be reared to marketable size. The Central Marine Fisheries Research Institute has developed methods by which growth rates faster than in nature can be obtained in culture and the young ones grown to table size in much shorter time.

7. *Pearl culture*

Pinctada margaritifera, the black-lip pearl oyster, is a resource of considerable importance for pearl culture in the islands. The species is known for the production of fine steel-black pearls under culture. There is scope for augmenting the resource through intensive spat collection employing methods practised elsewhere in the world. Ideal ecological conditions are present for pearl oyster farming in the islands. Mayabunder, the islands of Ritchie's Archipelago, Hut Bay and Camorta are some of the potential centres for pearl culture. Although the gold-lip oyster *P. maxima*, which is the most valued species for pearl culture, was not collected during the survey, the possibility of its occurrence, based on geographical distribution of the species in the Indo-Australian archipelago, has been indicated. This species can also be considered for transplantation from the neighbouring areas on the eastern bounds of Andaman Sea. The wing shell *Pteria penguin* could form a supporting species for pearl culture.

8. *Oyster culture*

The edible oyster, *Crassostrea madrasensis*, has been collected from a number of centres. There is also the rock oyster *Saccostrea cucullata* resource in abundance. The former species is of importance in oyster culture. Several sites around Port Blair can be considered for oyster farming. Spat collection will have to be established by using techniques already developed for *C. madrasensis* on the mainland.

9. *Mussel culture*

The green mussel *Perna viridis* occurs in Chippighat near Port Blair. Animals of large size have been collected indicating the growth potential. There is a possibility for mussel farming if the resource could be developed through spat collection.

10. Turbo *and* Trochus *resources development*

Turbo marmoratus and *Trochus niloticus* are two important species of gastropods exploited for their commercially valuable shells in demarcated zones in the Islands and shell fishing is controlled by rules made under the Andaman and Nicobar Islands Fisheries Regulation, 1938 (Regulation 1 of 1938). Exploitation appears to be intensive and there is need for management of the resource based on biological principles governing their reproduction and growth and a better monitoring system. Sea-ranching should be attempted for both the species, after developing appropriate artificial seed production techniques, to restore and improve the wild stocks.

11. *Abalone culture*

The tropical waters are not the best for abalone production, as compared to the temperate and subtropical waters where the species resources are rich and also the animals grow to large size. *Haliotis* sp. is occasionally collected for edible purposes by the Nicobarese. The possibility for culture of this species needs to be established.

12. *Giant clam culture*

The giant clams or the holy water clams *Tridacna crocea, T. maxima* and *T. squamosa* have been collected during the survey. Some of the reef flats are virtual *Tridacna* beds with a large resource. The Nicobarese relish the meat of giant clams. Elsewhere, *e.g.* in Gilbert Islands and Papua New Guinea, tridacnids (*T. gigas*) is considered suitable for mariculture. The possibility of *Tridacna* culture in the Andaman and Nicobar Islands has to be explored.

13. *Culture of grey mullets and milkfish*

Several species of grey mullets, including *Mugil cephalus*, and milkfish *Chanos chanos* have been recorded from the estuarine region and mangrove ecosystem. Fingerlings and juveniles have been collected from several centres. There is a distinct potential for taking up mullet and milkfish culture in the mangrove and swampy areas and this would form a major programme of mariculture in the Andamans. Milkfish culture is very important for the islands, both to increase supply for human consumption and as live bait for skipjack pole-and-line fishing and bait for tuna long-line fishing.

14. *Bait fish culture*

The fisheries development programmes of the Union Territory include introduction of pole-and-line fishing for tunas around the Islands on the pattern of the skipjack fishery of the Lakshadweep. The potential tuna resources of this area have been estimated to be high. Bait fish availability is a critical factor for the success of pole-and-line fishing for the surface tunas. Thus tuna fishery development in the islands is linked up with finding adequate resources of the right species of bait fish and employing appropriate techniques for capture, holding and transportation of live bait. Many species of forage fishes are available in the islands. These can be evaluated for their suitability as live bait and cultured in pens or cages in the lagoons and bays.

15. *Culture of perches*

Perches (groupers and rock-cods) are an important resource in the islands. These can be grown under cage culture in the bays, feeding them with low-value fish by-catch of trawlers.

16. *Seaweed culture*

The alginophytes *Turbinaria, Sargassum* and *Padina* are the dominant seaweeds in the islands. The agarophytes *Gracilaria, Gelidiella* and *Gelidium* appear to be poorly represented. Potential exists for the culture of alginophytic algae using the immense seed material. The edible seaweed *Halimeda peltata* has been recorded and this species can be cultivated. The lagoons of John Lawrence Is., Corbyns's Cove, Navy Bay and Chiriyatapu in the Andaman group, and Sawai Bay, Katchall East Bay and Spiteful Bay in the Nicobar group appear suitable areas for seaweed culture.

17. *Sea-cucumber and sea-urchin culture*

Beche-de-mer production has become an established export-oriented cottage industry in the Andamans. There is a good potential of sea-cucumbers of species *Holothuria atra, H. scabra* and *Actinopyga mauritiana* on the reef flats among the algal growth. A brief experiment on the culture of *H. scabra* at Port Blair has given encouraging results as to the possibility of collection of juveniles for stocking and growth. This has to be pursued further for taking up farming of the economically important species of sea-cucumbers, particularly *H. scabra,* on the extensive tidal reef flats of the Islands.

Among the sea-urchins, *Tripneustes gratilla* which grows to large size on algal beds in shallow waters may be a candidate species for farming using simple methods of collecting the young ones and rearing them on algal beds.

18. *Conservation of endangered sea turtle resources*

The Andaman and Nicobar Islands are one of the most important nesting grounds for sea turtles. All sea turtles are totally protected by law under the Indian Wildlife (Protection) Act. Of the seven species of sea turtles found in the world oceans, four—the Olive Ridley turtle *Lepidochelys olivacea*, green turtle *Chelonia mydas*, hawksbill turtle *Eretmochelys imbricata* and leatherback turtle *Dermochelys coriacea* occur in the Andamans. All the species are declining rapidly, and *D. coriacea* is listed in the International Union for the Conservation of Nature (IUCN) Red Data Book for species immediately threatened with extinction. A programme of collecting turtle eggs from their nesting grounds, hatching them and release of the baby turtles into the sea has been taken up on the mainland of India. Similar programme should be initiated in the Andaman and Nicobar Islands. Adequate protection should be given to the nesting grounds of all the species of sea turtles, particularly to those of the leatherback turtle.

19. *Rehabilitation of endangered crocodile resources*

The saltwater crocodile *Crocodylus porosus* which is the world's largest living reptile growing to over 8 m is found in the Andamans and its population has dwindled to a few. Experts have estimated the population of breeding females to be about 80 in the Andamans, excluding the Jarawa Reserve. On the mainland of India, some States have taken up crocodile rehabilitation projects. A similar programme for the farming of the saltwater crocodile should be taken up in the Andamans, primarily with a view to increasing the wild population and secondarily for any economic gains after natural population is restored to satisfactory levels.

20. *Artificial seed production for mariculture*

Any commercial mariculture programme cannot completely depend on the seed available in the wild for stocking the farms. Artificial seed production should form a component of farming. Fish and shellfish hatcheries will have to be established at selected centres for the production and supply of seed. Hatchery techniques for penaeid prawns, pearl oyster and edible oyster have been developed at the Central Marine Fisheries Research Institute and these are under constant improvement. These could be adopted for establishing hatcheries in the Andaman and Nicobar Islands. Water quality is one of the critical factors in hatchery management. The clear blue waters of the islands which are not polluted, except in a very few areas where wood-based industries have been established, can be used with minimum treatment in the hatcheries. Power generation and seawater pumping systems would need to be established for the hatcheries.

21. *Sea-ranching*

The protected bays and mangrove-lined creeks would provide the right environment for some of the sea-ranching programmes that could be taken up in the Islands. Production of juveniles on land-based hatcheries and their release into the sea has enhanced the natural populations of prawns and abalones in Japan. Similar programmes would be possible in the Andaman and Nicobar Islands for selected economically important species such as *Penaeus merguiensis*, *Turbo marmoratus*, *Trochus niloticus* and *Haliotis* sp. These programmes may be taken up by the State department to improve the natural resources. Hatchery development for seed production should be accelerated for successful sea-ranching programme.

22. *Use of Remote Sensing Techniques in site selection for mariculture*

Given the geophysical nature of the terrain and the problems of communication and transport, a good survey of all the islands for selection of sites for mariculture using conventional methods would be a difficult a task. Pictures of satellite imagery taken by remote sensing have become a very useful tool in understanding detailed geographical features of land and oceanographic conditions of the seas. This modern approach may be useful in identifying suitable sites for mariculture in the Andaman and Nicobar Islands.

23. *Infrastructure development*

Realisation of the mariculture potential of the islands would entirely depend on creating necessary infrastructural facilities. These would include land and farm development, shore establishments, energy and water supply, transport and communication, processing and storage and trade facilities. A planned approach to mariculture is necessary to take up integrated or closely linked up programmes to share common infrastructure facilities.

24. *Manpower development*

Manpower, at the managerial, supervisory and operative levels, will have to be developed for manning the programmes. Facilities for such training are available at the Central Marine Fisheries Research Institute. *Ad-hoc* training courses in prawn breeding and culture, pearl culture, oyster culture, musselfarming, finfish culture in tidal ponds, pens and cages, and seaweed culture are offered at the Institute. These could be availed of by the State department, public sector and also individual fish farmers of eligible categories.

25. *Fixing of priorities*

Development of mariculture in the Andaman and Nicobar Islands will have to be taken up in a phased manner and, therefore, it is necessary to identify the priority areas which have immediate potential. In their order, these would be : (1) pearl culture with *Pinctada margaritifera* resource for the production of steel-black cultured pearls ; (2) prawn culture for *Penaeus merguiensis* ; (3) fish farming for the grey mullets and milkfish and (4) seaweed culture.

26. *Need for pre-project surveys*

The general considerations for development of mariculture in the Andaman and Nicobar Islands presented here are based on a rapid survey conducted during a specific period and, therefore, are only indicative. Individual projects for development should take up fresh pre-project surveys in great detail. This Bulletin is intended to serve the limited purpose of indicating the overall potential of the archipelago for mariculture. In certain areas, the information presented is more than indicative and is of some critical value and could be used for planning mariculture development.

LIST OF PUBLICATIONS FROM CENTRAL MARINE FISHERIES RESEARCH INSTITUTE ON ANDAMAN AND NICOBAR ISLANDS[1]

The list includes only those publications resulting from direct observations made by the authors in the A & N Islands. Several others in which reference has been made to the resources in the islands are not included. The list is arranged in chronological order.

1961. JONES, S., E.G. SILAS AND E. DAWSON. New records of scombroid fishes from the Andaman - Nicobar waters. *J. mar. biol. Ass. India*, **2**(1) (1960) : 136-137.

1961. RAO, K. VIRABHADRA. The pearl wing shell, *Pteria penguin* (Röding) from the Andaman Islands, India. *J. mar. biol. Ass. India,* 3 (1 & 2): 259-262.

1961. SILAS, E.G. AND E. DAWSON. *Heteropneustes fossilis* (Bloch) a new addition to the freshwater fish fauna of the Andaman Islands. *J. Bombay nat. Hist. Soc.*, **58**(1) : 287-289.

1961. SILAS, E.G. AND C. SANKARANKUTTY. On the castle building habit of the crab *Cardisoma carnifex* (Herbst) (Family Geocarcinidae) of the Andaman Islands. *J. mar. biol. Ass. India*, **2**(2) (1960) : 221-225.

1962. SANKARANKUTTY, C. On Decapoda Brachyura from the Andaman and Nicobar Islands : 1. Families Portunidae, Ocypodidae, Grapsidae and Myctyridae. *J. mar. biol. Ass. India*, **3** (1 & 2) (1961) : 101-119.

1963. SANKARANKUTTY, C. On Decapoda Brachyura from the Andaman and Nicobar Islands : 2. Family Xanthidae. *J. mar. biol. Ass. India*, **4**(1) (1962) : 121-150.

1963. SANKARANKUTTY, C. On Decapoda Brachyura from the Andaman and Nicobar Islands. 3. Families Calappidae, Leucosiidae, Parthenopidae, Majidae and Geocarcinidae. *J. mar. biol. Ass. India*, **4**(1) (1962) : 151-164.

1964. JONES, S. AND E.G. SILAS. Mackerel from the Andaman Sea. *Proc. Symposium on Scombroid Fishes*, Part I : 255-282. Marine Biological Association of India, Mandapam Camp.

1964. TAMPI, P.R.S. AND K. RANGARAJAN. Some polychaetous annelids from the Andaman waters. *J. mar. biol. Ass. India*, **6**(1) : 98-121.

1968. JAMES, D.B. Studies on Indian echinoderms-I. Rediscovery of echinoid, *Breynia vredenbergi* Anderson from Andaman Sea, with an amended description. *J. mar. biol. Ass. India*, **8**(1) (1966) : 76-81.

1968. LUTHER, G. On the occurrence of *Steinegeria rubescens* Jordan and Evermann (Bramidae : Pisces) in the Indian Ocean. *J. mar. biol. Ass. India*, **8** (2) (1966) : 354-356.

1968. THOMAS, P. A. Studies on Indian sponges—I. *J. mar. biol. Ass. India.* **10** (2) : 245-249.

1969. PILLAI, C. S. G. Stony corals of the seas around India' *Proc. Symp. Corals and Coral reefs*, Marine Biological Association of India, pp. 191-216.

1969. PILLAI, P. PARAMESWARAN. *Calanopia seymouri* sp. nov. (Copepoda : Calanoida) from Andaman Sea. *Curr. Sci.*, **38** (13) : 317-319.

1969. RANGARAJAN, K. *Aulacocephalus temmincki* Bleeker (Pisces : Serranidae) a new record from the Andaman Sea *J. mar. biol. Ass. India*, **9**(2) (1967) : 442-444.

1970. MARICHAMY, R. On a large sized green sawfish, *Pristis zijsron* Bleeker landed at Port Blair, Andamans. *J. mar. biol. Ass. India*, **10**(2) (1968) : 394-395.

1972. LUTHER, G. *Anyperodon leucogrammicus* (Pisces : Serranidae), a new record from Andaman Sea. *Indian J. Fish.*, **19**(1 & 2) : 189-190.

1972. MARICHAMY, R. Food and feeding habits of the spotted herring *Herklotsichthys punctatus* (Ruppell) from the Andaman Sea. *Indian J. Fish.*, **17**(1 & 2) (1970) : 159-168.

1972. MARICHAMY, R. Maturity and spawning of the anchovy, *Thrissina baelama* (Forskal) from the Andaman Sea. *Indian J. Fish.*, **17**(1 & 2) (1970) : 179-187.

1972. MARICHAMY, R. Maturity and spawning of the spotted herring, *Herklotsichthys punctatus* (Ruppell) from the Andaman Sea. *Indian J. Fish.*, **18** (1 & 2) (1971) : 148-155.

1972. MARICHAMY, R. Food and feeding habits of the short-jaw anchovy, *Thrissina baelama* (Forskal) of the Andaman Sea. *Indian J. Fish.*, **19** (1 & 2) : 97-109.

1972. RANGARAJAN, K. Food and feeding habits of the snapper, *Lutianus kasmira* (Forskal) from the Andaman Sea. *Indian J. Fish.*, **17** (1 & 2) (1970) : 43-52.

1972. RANGARAJAN, K. Maturity and spawning of the snapper, *Lutianus kasmira* (Forskal) from the Andaman Sea. *Indian J. Fish.*, **8** (1 & 2) (1971) : 114-125.

1972. RANGARAJAN, K. On the occurrence of *Malacanthus hoedtii* Bleeker (Fam. Malacanthidae) in the Andaman Sea. *Indian J. Fish.*, **19** (1 & 2) : 183-185.

1972. RANGARAJAN, K. AND R. MARICHAMY. Seasonal changes in the temperature, salinity and plankton volume at Port Blair, Andamans. *Indian J. Fish.*, **19** (1 & 2) : 60-69.

1973. KUMARAN, M. The fishery potential of Andaman and Nicobar Islands. *Proc. Symp. Living Resources of the Seas around India, Special Publication*, CMFRI, pp. : 387-389.

1973. LUTHER, G. Observations on the biology and fishery of the Indian mackerel, *Rastrelliger kanagurta* (Cuvier) from Andaman Islands. *Indian J. Fish.*, **20**(2) : 425-447.

1974. MARICHAMY, R. The fishery resources of Andaman Sea. *Seafood Exp. J.*, **6**(10) : 27-31.

1974. SCHEER, GEORG AND C.S. GOPINADHA PILLAI. Report on the Scleractinia from the Nicobar Islands. *Zoologica*, Wien, **122** : 1-75.

1976. SILAS, E.G. AND M.S. MUTHU. On a new species of penaeid prawn of the genus *Metapenaeus* Wood Mason and Alcock from Andamans. *J. mar. biol. Ass. India*, **16**(2) : 645-648.

1977. APPUKUTTAN, K.K. *Trochus* and *Turbo* fishery in Andamans. *Seafood Exp. J.*, **9**(12) : 21-25.

1978. ANON. Culture of sea cucumber at Andamans. CMFRI Newslet., 8 : 1-2, Central Marine Fisheries Research Institute.

1979. APPUKUTTAN, K.K. *Trochus* and *Turbo* fishery in Andamans. *Seafood Exp. J.*, **11**(1) : 41-44.

1979. SILAS, E.G. AND M.S. MUTHU. Notes on a collection of penaeid prawns from the Andamans. *J. mar. biol. Ass. India*, **18**(1) (1976) : 78-90.

1980. APPUKUTTAN, K.K. On the occurrence of the green mussel *Perna viridis* (Linnaeus) in Andaman Island. *Indian J. Fish.*, **24** (1 & 2) : 244-247.

[1] Compiled by Library, CMFRI.