

MODERN QUATERNARY RESEARCH IN SOUTHEAST ASIA

edited by

GERT-JAN BARTSTRA
WILLEM ARNOLD CASPARIE
IAN C. GLOVER

Volume 3 (1977)

OFFPRINT



A. A. BALKEMA / ROTTERDAM / 1977

MARITIME ADAPTATIONS AND EXPLOITATION OF MARINE RESOURCES IN SUNDAIC SOUTHEAST ASIAN PREHISTORY

Received: 74. 10. 13

1 INTRODUCTION

1. 1 Southeast Asia

In the course of preparing this chapter on maritime adaptations in Southeast Asian prehistory a review of literature has brought to our attention the awkward implications of the term 'Southeast Asia' when applied to the past. This useful label for a contemporary geographical area loses its utility in reference to the past because the modern area does not correspond to a single prehistoric geographical entity. Of course we are not suggesting that 'Southeast Asia' be abandoned or that the title of this volume be changed. For analytic purposes, however, we do suggest that it may be helpful to examine the prehistoric record separately for each of three Southeast Asian geographical units. These units we shall hereafter refer to as 'sectors', viz. the Mainland, Sundaic, and Insular sectors. Suggested boundaries are set out in figure 1, and some significant characteristics of each sector are noted below:

1. 1. 1 Mainland Southeast Asia — During the Pleistocene and early Recent, changes in land mass were relatively minor in this sector. Each sea level lowering obviously increased, and each marine transgression reduced, the area of coastal lowlands. Sea level oscillations undoubtedly affected stream flow characteristics, even far inland, as gradients of downstream water-courses gradually changed. Except for such changes, however, it is probable that most of the non-coastal lands in this sector were relatively unaffected by sea level alterations. Thus, given only minor climatic 'amelioration', it is probably correct to state that the Pleistocene-Recent boundary brought little environmental change to any part of the Mainland sector except in its coastal zones. Gorman (1972:87) has commented on this apparent stability in his discussions of environmental conditions across the Pleistocene-Recent 'boundary' in the Spirit Cave region of present-day Thailand. In the terms of a speculative discussion of several years ago (Dunn 1970) there appears not to have been an adaptive threshold in most of the Mainland sector at the close of the Pleistocene.

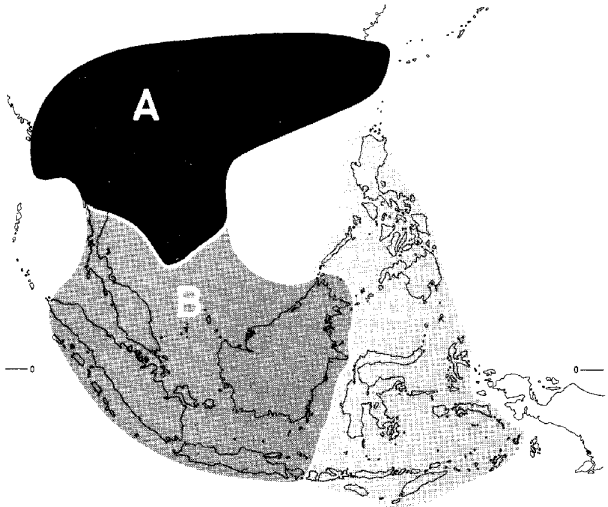


Figure 1. Sectors of Southeast Asia: A. Mainland, B. Sundaic, C. Insular

1.1.2 Sundaic Southeast Asia — In this sector the effects of rising and falling sea levels during and after the Pleistocene were profound. Major expansions and contractions in total land mass occurred, together with substantial changes in the total length of the coastline. With each subsidence of the sea a new 'Sundaland' emerged (Umbgrove 1938:154), and with each transgression the sector returned to an insular status. Successive Sundalands were formed by a penepain land surface — the Sunda shelf — uniting the present-day land masses of the Malay Peninsula, Sumatra, Java, Borneo, and many smaller islands. Molengraaff, who coined the term Sundaland, concluded that the "area of the shelf sea has been stable and has not been affected by diastrophism, at least since the end of the Pliocene Age" (1921:116). With each emergence of Sundaland, of course, a temporary land fusion occurred with the Mainland sector. In the Sundaic sector the close of the Pleistocene was accompanied by many changes — corresponding to a true adaptive threshold — as described in later sections of this chapter. In summary, the Sundaic has been the most geomorphologically dynamic of the three Southeast Asian sectors, varying among continental, intermediate, and insular conditions since at least the early Pleistocene.

1.1.3 Insular Southeast Asia — The Insular sector appears to have been even more stable than the Mainland throughout the Quaternary. Unlike the Mainland the eastern island sector did not fuse intermittently with Sundaland, or, for that matter, with the Sahul land mass to the east and south-east. Nor have the islands fused with each other to form a sub-continental land mass — although some local linkages probably occurred, especially in the Philippines, at times of low sea levels. Since many of the eastern islands are surrounded by deep-sea basins and shelves steeply into the sea, even the dimensions of most islands changed relatively little as the Pleistocene seas rose and fell.¹ The ranges of increases and decreases in land mass and of coastline lengths appear not to have been very great, to judge by modern bathymetric data for this sector.

It should be noted that terms such as Nuclear, Mainland, Insular, and Island Southeast Asia appear frequently in the literature (including the previous writings of one of us). Invariably, it seems, these terms have been used to represent a two- rather than three-unit division of prehistoric Southeast Asia. Generally the Malay Peninsula has been included in the mainland unit and all of the island from Sumatra to Timor have been lumped together as a second unit. We believe that such two-fold divisions have led to some confusion of thought about cultural evolutionary processes in the area as a whole.

1.2 Other introductory comments

In this chapter we restrict the discussion to Sundaic Southeast Asia, the sector in which, as noted above, marine influences seem to have produced the greatest degree of dynamic environmental change through time. The chapter does not attempt to review all data relating to marine resources and their use in the prehistoric record for the area, or even for the Sundaic sector. In any case the record is extremely sparse; and for this reason much that will be said is conjectural. We see no reason to apologize for this, especially in the light of the fact that until recently Southeast Asian prehistory has comprised little more than an elaboration of hypotheses originally set out by Heine-Geldern (Kaneko 1972; Dunn 1966:353).

The span of time covered here is from a few thousand years earlier than the last (Late Würm) glacial substage of the Pleistocene — 22,500 to 11,000 years BP according to Frerichs (1968) — to about 2,000 BP, a time corresponding to the beginning of the protohistoric period in Southeast Asia generally, and to the start of Solheim's (1972a:154; 1972b:38) period of Conflicting Empires.

In the sections that follow we examine Pleistocene and Recent environmental change in the Sundaic sector, especially in relation to human dispersal and adaptation in maritime settings; present and prehistoric marine resources in the sector; methodological possibilities; some existing data on potential and actual marine resource exploitation and utilization; and finally a set of conjectures.

The term 'subsistence zone' (Dunn 1973:108-109) appears frequently

in the following sections, and requires definition. It is that region around a community open to exploitation, and regarded as exploitable and familiar territory by at least some member(s) of the community. ('Community' carries a spatial as well as social connotation, but a community need not be fixed in space; thus the nomadic band also forms a community — in its place of residence, however transient the occupation may be.) The limits and shape of the zone will be determined by the means of transport available, the nature of the terrain, ecological diversity, the size of the human population, and a number of other factors that need not be considered in the present context. The lands and waters of a zone are not necessarily exploited exclusively; that is substantial zones may overlap so that the people of neighbouring communities may exploit portions of the surrounding territory simultaneously or sequentially, and co-operatively or competitively.

2 PLEISTOCENE AND RECENT GEOMORPHOLOGIC CHANGE IN SUNDAIC SOUTHEAST ASIA

2.1 Sea level changes during the last 35,000 years

Two estimates of sea level depression — 40 fathoms (about 73 m) and 125 m — appear repeatedly in publications concerned with the Quaternary history of Sundaic Southeast Asia. Considerable interest in the subject of Sundaic sea levels is evident in writings prior to about 1945. Molengraaff concluded as early as 1921 (p.116) that the modern shelf seas are derived from "a rise of the sea-level of at least 40 fathoms", and de Terra (1943: 461), while accepting the 40 fathom estimate for the 'Fourth glaciation', pointed out that the sea level drop was probably at least as much as 125 m during the 'Second Glacial'. Although Sundaic sea level change has continued to attract some research attention we still lack a definitive analysis based upon modern bathymetric and geological findings. In the circumstances it is necessary to look elsewhere for evidence bearing on the Sundaic situation.

Recently published studies of the Bering Strait land bridges have shed much light on Pleistocene and Recent sea level changes in the North Pacific (Hopkins 1967). Following the Woronzofian transgression — a period of flooding from about 35,000 to 25,000 years BP — the sea level fell to at least —120 m (about —66 fathoms) at the height of the Late Würm glaciation about 20,000 BP (Curry 1965; Hopkins 1967:461). A fall of such a magnitude is in accord with findings for other areas as well. Donn et al. (1962) have shown that the eustatic lowering for world seas at the height of the last Wisconsin glacial substage was almost certainly between 100 and 125 m. In a synthesis and speculative reconstruction Hopkins (1967:464-465) proceeds to outline the following sequence of events for the North Pacific: 1. Sea levels rose to about —38 m as early as 14,000 BP. 2. A fall occurred to —50 m about 13,000 BP. 3. Seas rose

again to at least -38 m, and possibly to -25 m, about 12,000 BP.

4. Another fall below -50 m took place about 11,000 BP. 5. A rapid rise occurred about 10,000 BP to a level near -15 m, followed by several oscillations until about 5,000 BP when the modern sea level elevation was established.

Given the unity of the Pacific ocean basin, and the apparent absence of late Pleistocene-Recent diastrophism affecting the Sunda shelf, the major elements of this North Pacific reconstruction can be applied to our area.² The following sequence will serve as a basis for subsequent discussion in this chapter:

1. The Sunda shelf was probably flooded approximately to the extent that it is today during the period 35,000 — 25,000 BP.
2. Between about 25,000 and 22,000 BP the sea level fell rapidly, probably to a level about 100 — 120 m below the modern elevation.
3. This ca. 120 m depression probably persisted for some 4,000 years from about 22,000 to 18,000 BP.
4. Thereafter the seas probably rose rapidly between 18,000 and 15,000 BP, and then oscillated at levels generally between about -60 and -40 m until about 10,000 BP when a final rise brought the seas within 10 — 15 m of the modern level.
5. At least one post-Pleistocene oscillation apparently carried the level a few metres above the present elevation. Marine shell middens at localities 10 km or more inland on the Sumatran east coast (Heekeren 1957: 71) and sites along the Malayan northwest coast (Collings 1938:111-112; Matthews 1961: 5, 26) provide good evidence that such a transgression probably occurred after the end of the Pleistocene.

2.2 Correlations of the Sundaic land mass with sea level changes

The greatest extent of late Pleistocene Sundaland has been conventionally defined by the 40 fathom (ca. 73 m) isobath. However, the array of new data for the North Pacific indicates that a more correct isobath — for the period from about 22,000 to 18,000 BP — may be that for 120 m (figure 2). During the terminal Pleistocene period between 18,000 and 10,000 BP the boundaries of Sundaland seem to have been in continuous flux, but especially after 15,000 BP isobaths between 60 and 40 m probably would best define the extent of the land mass. After 10,000 BP rapid transgression reduced the remaining land masses to surface areas close to those of today, but the modern limits were probably not finally reached until about 5,000 years ago.

Coastline and land area estimates for three isobathic definitions of Sundaic Southeast Asia are given in table 1. The 100 fathom (183 m) estimates refer to an entirely hypothetical ancient Sundaland, as suggested, for example, by de Terra's figure 106 (1943). With such a sea level depression Palawan would almost certainly have been linked to the Bornean end of the land mass. The maximum Pleistocene lowering is now

thought to have been between 137 and 159 m during the Third Glacial (Donn et al. 1962). The 120 m estimates correspond to the suggested maximum extent of Sundaland in the late Pleistocene. The 40 m estimates represent the land mass at about 10,000 BP, shortly before the last rapid rise in sea level. Note that the Sundaland of approximately 22,000 – 18,000 BP would have had a coastline only about half as long, and a total area about 75 per cent greater than that of the modern Sundaic sector, if the limits are correctly defined by the 120 m isobath. The terminal Pleistocene land mass (limits defined by the 40 m isobath) would have had a coastline about six-tenths as long as that of the modern Sundaic sector, and a total area about 60 per cent greater than today. It should also be noted that as the land mass decreased the proportion of highlands to lowlands increased substantially. These estimates provide a crude measure of the profundity of late Pleistocene-Recent change, but we should like to emphasize the complexity of the situation at the close of the Pleistocene. No single 'boundary' can be defined, chronologically or otherwise, and any generalization about human behaviour in the Sundaic sector must be tied to a specific time and consider geomorphological conditions at that time.

Certain points on the eastern coasts of Sundaland may be regarded as critical with respect to possible dryland travel by man during various stages of the Pleistocene:

1. Borneo to Palawan — Even a 120 m depression of the sea would have left a water barrier in the Balabac Strait between Banggi Island (close to the Kudat Peninsula) and Balabac Island (close to the southern tip of Palawan). The distance between 50 fathom (ca. 91 m) isobaths on the two sides of the Strait is 10 to 12 km according to bathymetric data on modern charts; the distance for the 120 m isobath would apparently have been no more than a kilometre or two shorter. A 100 fathom depression, on the other hand, would probably have created a dryland link. Whatever the possibilities may have been for dryland crossing between Borneo and Palawan

Table 1. Estimates of prehistoric coastline length and land mass for Sundaic South-east Asia

	Sundaland* defined by a 100 fathom (ca. 183 m) isobath	Sundaland defined by a 120 m isobath	Sundaland defined by a 40 fathom (ca. 73 m) isobath	Modern Sundaic Southeast Asia
Coastline length (based on map calculations in mm)	308	359	410	660
Coastline length (as % of the modern length)	47 per cent	54 per cent	62 per cent	100 per cent
Land mass (km ²)	1,850,000	1,725,000	1,600,000	990,000
Land mass (as % of modern land mass)	187 per cent	174 per cent	162 per cent	100 per cent

* Palawan excluded



Figure 2. Sundalic Southeast Asia showing the limits of a Late Pleistocene Sundaland as defined by a 120 metre isobath (at approximately 22,000 - 18,000 years BP)

earlier than 35,000 years ago, we must conclude that a short voyage would have been necessary at any time after 35,000 BP.

2. Borneo to the Sulu Archipelago — Even with a 100 fathom fall a water gap of many kilometres would have persisted between the Borneo mainland and the Tawitawi Group. It is almost certain that late Pleistocene crossings from Borneo to the western Sulu islands could only have been made by raft or boat.

3. Borneo to the Celebes (Sulawesi) — From the barrier reef along the eastern margin of the Borneo Bank the distance across Makassar Strait to Cape Onkona between 75 m isobathic contours is about 60 km (Umbgrove 1949:3). This distance would have been little shorter even with an additional sea level fall of 100 m. The deep water gaps farther north in the Makassar Strait are even wider.

4. Bali to Lombok — The Lombok Strait is sufficiently deep so that land bridging between Bali and Lombok probably never occurred during the Pleistocene. The modern distance between those islands is 35 - 40 km, and between the islands of Penida and Lombok about 25 km.

2.3 Early open sea voyaging in Southeast Asia

The data and conjectures reviewed in the foregoing section suggest that any travel by man eastward from Sundaland in the late Pleistocene must have required the use of rafts or boats. Additional and, in our opinion, conclusive evidence on this point is provided by a growing body of data showing that settlement of the Australian continent was well-advanced by 30,000 BP and that human occupation in the Papuan highlands dates back more than 20,000 years (Golson 1971:138). There appears to be no possibility that man could have reached the Sahul Shelf and thus Australia or New Guinea, even with a sea level depression of 100 fathoms (ca. 183 m), except by water crossings. The distance between the 100 fathom isobaths off the Sarangani islands (just south of Mindanao) and Marore (a small island north of the Celebes) is about 70 km. Farther east, the routes from the Celebes to New Guinea by way of Buru, Ceram, and Misool would have required water crossings of 70 and 80 km, even with -100 fathom conditions. To the south, the Timor-Sahul Shelf water crossing would have been about 130 km with a -100 fathom sea level and nearer 180 km under -40 fathom conditions.

From these observations we may conclude with reasonable certainty that late Pleistocene man in Sundaland had some knowledge of rafts or boats and was at least capable of making voyages of tens of kilometres on the open sea. It is probable, of course, that some, if not all, of the very earliest voyages - especially prior to 30,000 BP - were 'accidental', but we are confident that evidence of deliberate late Pleistocene seafaring in Southeast Asian waters will eventually come to light. In this connection it is important to note that quite firm evidence now exists for Mediterranean open sea voyages of at least 120 km more than 8,000 years ago (Anonymous 1973).

3 MARINE RESOURCES IN SUNDANIC SOUTHEAST ASIA

3.1 Definitions

The marine environment can be divided, generally along natural biological or physical lines, into several vertical and horizontal zones. A widely accepted scheme is that outlined by Hedgpeth (1957), who also discusses alternative terminologies that have been applied to the marine realm.

The waters of the oceans, termed the pelagic environment, are divided into the neritic, those waters extending over the continental shelves (which, by convention, extend to 200 m), and the oceanic, those waters beyond the shelves. In this chapter we are concerned almost exclusively with the neritic waters.

The sea bed constitutes the benthic environment. Its uppermost zone, the littoral, has come to be synonymous with the intertidal, by definition

that zone between the highest level reached by spring (extreme) tides and the lowest to which they recede. In most places the upper reaches are covered only occasionally and the lower bared but rarely. In modern Southeast Asia, the vertical tidal range is relatively small — about three metres (Vohra 1971). The width of the intertidal zone depends upon the slope of the shore and upon wave action, which can extend the influence of the sea by creating a supralittoral splash zone. The sublittoral zone extends below the littoral to the edge of the continental shelf.

Marine organisms living free in the water are termed pelagic. Plankton are those organisms that drift; nekton are active swimmers that control their own position. Organisms that live on the sea bed constitute the benthos. The nektobenthos are able to move above the surface but are tied closely to it. The epifauna and epiflora live on the surface of the sea bed, and the infauna and inflora are organisms that burrow into the substrate or are buried in it. During their life cycles, plants and animals can change categories. For example, an individual may pass a larval stage in the oceanic plankton, then drift ashore and attach to the rocks of the littoral zone to pass its adult life as a member of the benthos.

3.2 Marine resource diversity in Sundaic Southeast Asia

The tropics are far richer in numbers of animal and plant species than are the temperate and polar regions of the world, and this generalization holds true for the seas at least as much as for the terrestrial realm (Ekman 1953). Of the tropical seas, although none has been extensively examined, those surrounding the mainland and islands of presentday Southeast Asia are known to contain the greatest wealth of marine life. According to Ekman (1953), it has been estimated that 6,000 species of molluscs inhabit the area; there are about 100 endemic genera of decapod crustaceans (crabs, lobsters, etc.), many with numerous species; starfish, brittle stars and sea urchins number over 550 species; all except four of the families of tropical marine fish occur in the Indo-West Pacific, and over 60 species of sea snakes do also. The centre of this richness is Sundaic Southeast Asia, and Ekman's (1953:18) oft-quoted statement on this matter bears repeating here: "The further one moves away from this centre in any direction, the more the fauna appears as a progressively impoverished Indo-Malayan (Indo-Australian) fauna, where the addition of endemic elements only to a minor extent makes good the loss of Indo-Malayan forms." Recent studies of specific groups, for example those by Stehli and Wells (1971) on reef-forming corals, and by Kohn (1967) on cone snails, bear out this generalization (although Kohn considers the centre of dispersal to be a somewhat larger area).

An obvious source of this richness are the coral reefs which constitute an ecosystem unique to the tropics; and the Indo-West Pacific reefs are the most faunistically diverse of all (Wells 1957). The other uniquely tropical marine ecosystem is the mangrove association which also reaches its maximum development and richness in Malaya, Sumatra, and parts of

Borneo (Macnae 1968). The other littoral environments of Southeast Asia are the same as in other parts of the world — sandy, muddy, and rocky shores, and estuaries. Each of the six biotopes harbours a distinctive biota.

The pelagic species are less well studied than those of the shores, but it is known that the warmer oceanic waters have many more species than the colder ones (Moore 1958). However, these waters are notoriously barren (except along some western continental coasts in areas of upwelling) because of an absence of essential nutrients (Thorson 1971). It would be reasonable to conjecture that the neritic waters are richer in numbers of individuals than the oceanic waters because of their proximity to the land, reefs, and sea bottom, sources of scarce nutrients.

3.3 The effects of sea level changes on marine life

It is unlikely that the sea level changes we have discussed would have had any major effect on the faunal and floral composition of the marine environment. Pelagic species, of course, would have been entirely unaffected. Sea level changes are so slow relative to the life-spans of most marine organisms that even benthic species would have had sufficient time to accommodate to the changes by colonizing areas where they had not previously existed but that had become preferred habitat, relative to the new sea levels. However, proportions of the six littoral environments, along with their associated faunas and floras, could have been altered. For instance, if a sandy shore backed by a rocky cliff were inundated by a rising sea, sand-associated organisms would be eliminated from the locality, and the cliff, now intertidal in position, would be colonized by typical rocky shore organisms. Whole coral reefs would have been eliminated if sea level rose more rapidly than the corals could grow upward, since most reef-forming species are restricted to relatively shallow water (Wiens 1962), but this is unlikely. A third biological consequence of sea level change known to have occurred in several unrelated groups of animals, is the evolution of sibling or fully differentiated species on the eastern and western sides of Sundaland.

However, subspecies and sibling species usually occupy essentially identical ecological niches, and therefore probably would be exploited by man as identical resources.

3.4 Marine animals and plants as resources

All of the approximately 25 phyla of animals have marine representatives, and some are composed exclusively of marine species, but marine members of only seven phyla are of significant direct economic importance to man. These are the Porifera (sponges), Cnidaria (sea anemones, corals, jellyfish), Mollusca (snails, clams, squids, etc.), Annelida (worms), Arthropoda (lobsters, crabs, shrimp, etc.), Echinodermata (sea urchins, sea cucumbers, etc.), and Chordata (fish, turtles, whales, seals, etc.).

Sponges have no economic importance in the Indo-Pacific (Hyman 1940). Annelids are of limited economic importance in present-day Southeast Asia, although members of the class Polychaeta are collected as food in Thailand (personal observation) as they are in Fiji and Samoa (especially the palolo worm *Eunice viridis*) (Thorson 1971), and in Hawaii *Lanice conchilega* has been used traditionally as the source of an 'anticancer' drug (Tabrah et al. 1970). This discussion will therefore consider some species of five phyla that are available for use, mainly as food but as implements and ritual objects as well, and, where it is known, the actual extent of their exploitation. Since no inventory has been made of the Indo-West Pacific fauna, it is impossible to estimate the number of potentially useful species. However, the marine fauna of insular Southeast Asia is the most diverse in the world. With the exception of mangrove trees and associated higher plants, the marine flora of Southeast Asia is poorly known, and very little information is available about its economic use in the area.

Prior to the development of competent seafaring, man's exploitation of marine resources must have been restricted to the littoral and immediately subtidal areas, which are, coincidentally, probably the biologically richest parts of the marine realm. This is true to a large extent, even today, as reflected in Sopher's (1965:36) statement that ". . . the fishing techniques widely employed in this area are coastal and fairly close inshore in character . . ." He provides an excellent survey of fishes and other vertebrates that are potentially and actually exploited, but his consideration of invertebrates is limited. The following discussion will serve to supplement Sopher's survey.

Each of the six types of shallow marine environments has a distinctive biota, and most species are restricted to a single biotope. It is important to remember, however, that two or more such biotopes may occur together or within a small area. For example, a coral reef may fringe any type of shore, and rocks may occur in the midst of sand beaches. Such areas have a greater variety of species than has each biotope alone, and for that reason it is likely that mixed environments would be preferred as subsistence zones by peoples who exploit marine resources.

3. 4. 1 Rocky shores — Most species occurring in this environment are epifaunal and are therefore accessible for collection. High intertidal animals comprise such forms as barnacles, nerite snails, and periwinkles, many of them edible but most too small to be worth the effort of gathering and extracting the meat. An exception is limpets, which can grow large enough to serve as an important food resource. Lower in the littoral are snails of the family Trochidae, the shells of which are lined with mother-of-pearl and so are used for making ornaments, and the Turbinidae, the 'cat's eyes' opercula of which may be valued. Mussels, oysters, and some other edible bivalves occur on rocky shores. Many sorts of crabs range throughout this biotope, and some of them are gathered for food. In the low intertidal and on subtidal rocks, the fauna includes some large edible molluscs such as the strombid snails, and clams, including the

giant *Tridacna* and its smaller relative *Hippopus*. The shells of these species may also be prized, as are those of cowries, another gastropod group with rocky shore representatives. Octopuses, molluscs widely eaten in Southeast Asia, hide among rocks. The gonads of some species of sea urchins may be considered edible (e.g. in Hawaii), and the spines of some are used as ornaments. Several species of algae that grow on sub-tidal rocks are economically valuable, e.g. *Digenea* (as an anthelmintic), *Enteromorpha* and *Gracilaria* (as vegetables), and *Eucheuma*, from which agar-agar (a word of Malay origin) is made. (This brief inventory was assembled from Chapman 1970; Chuang 1961; Johnson 1964; Purchon & Enoch 1954; Quisumbing 1951; Stephenson & Stephenson 1972; and Zaneveld 1959.)

3. 4. 2 Sandy shores — Species diversity is lower in this environment than on rocky shores, but some forms are more abundant. Although nearly every species is infaunal, many of the molluscs have limited motility, hence can be collected predictably and easily. Procurement of other molluscs and most crustaceans requires specialized implements or traps. Turtle eggs, a resource of vertebrate origin but of sufficient economic importance that it should be mentioned here, are laid high on sand beaches, where ghost crabs occur. However, most species live down where the sand never dries completely. Bivalves such as cockles (*Cardium*, etc.) *Meretrix meretrix*, and *Arca* spp. may be extensively collected for eating. Another, the windowpane shell (*Placuna*) is valued for its shells, as are the gastropods *Oliva* (olive snails) and *Murex*. *Murex* is also the source of a purple dye. The edible *Strombus isabella* occurs in this biotope as does the species of sea cucumber (*Holothuria scabra*) most commonly eaten as 'trepang'.³ Another important edible species, the swimming crab *Portunus* (= *Neptunus*) *pelagicus*, inhabits sandy beaches, and nekto-benthic penaeid prawns sometimes approach shore in such areas. (Species that normally live in other marine environments may be washed up on sandy shores and gathered in fresh condition; and shells are frequently procured in this way.) (Sources of this information are Chuang 1961; Johnson 1964; and Vohra 1971.)

3. 4. 3 Coral reefs — This is the richest of the tropical marine biotopes, in part because of its composite character. Sections of the reef environment have a sandy substrate and others are composed of coral rocks, in which places the biota is similar to that of sandy and rocky shores, respectively. The largest reef crab is the edible species *Etisia utilis*, but a great many other species including *Portunus pelagicus* are eaten also. Penaeid prawns, spiny lobsters (*Panulirus* spp.) and the lobster *Thelus* are among other crustaceans important as food. Sea cucumbers and sea urchins are abundant. Among the diverse sorts of edible molluscs are clams, oysters, scallops, strombids, and octopuses. Shells of gastropods, including cowries and strombids, and bivalves may be prized, as is that of the primitive cephalopod *Nautilus*, which is eaten as well. Another

resource from molluscs of this environment are pearls. The diverse and rich fish fauna of coral reefs need not be discussed here. (This list was compiled from Chuang 1961; D. F. Dunn 1970; Johnson 1964; Sopher 1965; and Wiens 1962.)

3.4.4 Muddy shores, mangrove swamps, and estuaries — These biotopes are often coincident in Southeast Asia, and since they are also ecologically similar, it is appropriate to consider them together. Although the variety of species in mangrove forests is small, many of them are represented by large numbers of individuals (Macnae 1968), and the same can be said, although perhaps to a lesser degree, of the other two biotopes as well. The edible crabs *Scylla serrata* and *Portunus pelagicus* are of considerable economic value, and Delsman and de Man (1925) list eight other species that are also collected as food in lesser numbers from this general environment. Mud lobsters (*Thalassina anomala*) are also edible and fiddler crabs are common. Some species of prawns pass a portion of their life in mangrove swamps, and can be taken in quantity at certain times. Cockles (*Anadara*), oysters, and some other bivalves are gathered on muddy shores and in mangrove swamps. Algae of the genera *Bostrychia* and *Caloglossa*, which grow on the breathing roots of mangrove trees, are eaten (Zaneveld 1959). Macnae (1968) discusses the timber resources of mangrove associations, tannins from tree barks, the nipa palm as a source of thatch and salt, and some of the faunal resources. (Other sources for this information are Chuang 1961; and Johnson 1964.)

Few deeper water invertebrates are of direct economic importance to man, but planktonic jellyfish, nektonic squid, and nektobenthic prawns are commercially important in present-day Southeast Asia, although it is unlikely that they were available to exploitation on a significant scale until relatively recently. Jellyfish, being at the mercy of currents and winds, are occasionally swept ashore, and thus become available to non-seafaring people. Squid cuttlebones also wash ashore in considerable numbers and, if valued, could be collected. During the life cycle of some species of prawns they come into shallow water, as previously mentioned, and can be taken at those times.

This brief inventory gives some indication of the range of marine resources available and actually exploited in the modern Sundaic sector. As we suggested earlier, the modern biota probably does not differ significantly from that during the Pleistocene in species composition, diversity, or even in relative abundance of the various groups of organisms.

4 APPROACHES TO THE ARCHAEOLOGICAL STUDY OF MARINE RESOURCES

We must now consider briefly the archaeological process as it applies to marine resource exploitation. Four categories of information can be examined through this investigative and analytic process:

1. What kinds of resources were exploited?
2. How were they collected, gathered, or otherwise obtained?
3. Why were they exploited — or, how were they utilized?
4. What do the findings imply about the ancient cultural system and human population under investigation, about cultural evolution in the region, and about the ecological setting?

4.1 Approaches in determining which resources were exploited

In theory the archaeological record at any site can shed light, both directly and indirectly, on exploitation of animal, plant, and physical resources. Direct evidence is provided by the remains themselves, such as bones, shells, seeds, resins, pigments, and minerals. Such clues may be especially sparse with regard to marine resources because, except for mollusc shells, identifiable macroscopic remains of few marine invertebrates and plants would be preserved in archaeological sites. Evidence of exploitation can also be obtained indirectly if the site yields implements that could have been employed in collecting, for example, or in fishing or food preparation. Other forms of indirect evidence include imprints of fibres or grains on pottery, fragments of boats or rafts (availability of water transport implying that certain habitats could have been exploited), and artistic representations of subsistence activities, plants, or animals. A modern resource inventory for the ecological setting presumed to correspond to the subsistence zone of the site is, of course, essential to the process of reconstructing the prehistoric resource base, and then the list of resources actually exploited. A detailed discussion of direct and indirect resource evidence — with special reference to the prehistory of the southern Malay Peninsula — can be found in Dunn (1973). Others who have considered full ranges of archaeological resource evidence, indirect as well as direct, include Andrews (1969), Lange (1971), and Ryder (1969). Even today excavators frequently overlook and discard many kinds of direct resource evidence, especially microscopic materials (e.g. among marine resources, the plates of sea cucumbers). Very few site reports include consideration of indirect evidence (usually because the investigator's attention is concentrated on some problem other than that of resource exploitation). It is scarcely necessary to note that a thorough analysis of all direct and indirect evidence is absolutely dependent upon support of specialists in the appropriate disciplines.

4.2 How were the resources obtained?

The answer to this question must rest upon three lines of evidence. First and fundamental is the technological evidence that artifacts can provide to enable us to answer questions such as these: Did the people possess a fishing technology? If so, was it marine-orientated? Was it based upon use of boats? Some answers to such questions can also be obtained through the second line of evidence, ethnographic analogy. A study of modern subsis-

tence techniques and traditional technology, as applied to the exploitation of a particular resource, may offer clues to an understanding of how that same resource was exploited in the prehistoric past. A third line of evidence also begins with analogy. Where does a specified resource occur today, and what natural limitations would such localities have imposed upon prehistoric exploitation if the environmental distribution of the resource were similar in the past to that of today? A mollusc species, for example, that is exclusively subtidal today was probably also subtidal in the prehistoric past. If the shells of this species turn up in archaeological contexts (in more than sporadic numbers) it can safely be inferred that some means had been developed to exploit the species in its subtidal habitat.

4.3 Why were these resources exploited? How were they utilized?

These questions have attracted the attention of many workers whose excavations have yielded evidence of marine exploitation. Many lists have been published of possible uses (either domestically or in trade) of such resources; most cover some or all of the following categories: foods, medicinals, ornaments, ritual materials, raw materials for specialized uses (e.g. shell for pottery temper), dyes, pigments, currencies (especially cowrie shells), and tools — including agricultural, domestic, hunting, fishing, collecting, and gathering implements (see, for example, Biggs 1969; Dunn 1973; Evans 1969; Greengo 1954; Jutting 1940; Meighan 1969; and Shackleton 1969).

Ethnographic analogy has proven particularly useful in determining the prehistoric uses of certain categories of materials. Studies of modern but traditional pottery making techniques in Malaya, for example, have helped to explain the reasons for use of several tempering materials, and for the occurrence of basal mat markings and surface cord marks on pots. Glover (1968) has clearly demonstrated the value of this approach in his research in Timor. Further employment of the method is certainly warranted. The uses of other materials, such as shells when converted into implements or fishing lures, are readily apparent. It is usually obvious, also, that certain mollusc shell accumulations represent food remains. There are many materials, however, the use of which is obscure; all too often these are assigned to the 'ritual' category on no grounds other than the classifier's intuition. Although outside our area, Johnson's (1970) impressive historical and ethnographic study of the cowrie currencies of West Africa provides many insights of potential interpretative value for the archaeologist in Southeast Asia.

4.4 Wider implications of marine resource data

A few studies of marine resources extend interpretation of resource data into wider cultural and ecological fields. Andrews (1969) has presented us with a most convincing demonstration of the power of this approach in his study of the distribution of marine molluscs and their prehistoric use

in the Mayan area. Through his analysis of molluscan data he was able to prepare an outline of the marine ecology of Yucatan in the Mayan period and to reach many conclusions and develop new hypotheses relating to Maya trade and commerce, ceremony, and aesthetics. Biggs (1969) reviews some similar approaches by other workers; and Dunn (1973) has surveyed the available data and attempted an analysis somewhat similar to that of Andrews for the southern Malay Peninsula. Although Casteel (1972) deals with non-marine species his approach to the study of fish remains demonstrates convincingly how they can reveal environmental changes and also assist in both seasonal and absolute dating. Green (1967) shows how the evidence of a single artifact — in this case a pearl shell lure shank from an early New Zealand site — can be applied to the solution of important problems in cultural flow and human migration.

Shell midden analysis and reconstructive interpretation has nearly reached sub-disciplinary status within the field of archaeology. This is the only marine resource category for which there is an extensive body of writing (recently reviewed by Ambrose 1967 and Meighan 1969) and a fair elaboration of method and theory. Unfortunately most of the shell mounds that survived post-Pleistocene inundation in the Sundaic sector seem to have been badly disturbed or destroyed before the days of modern archeology. Midden studies (e.g. in California) have provided important clues about subsistence zone ecology, dietary patterns, and the demographic characteristics of the local population. If even one or two undisturbed shell middens could be located and carefully studied in the Sundaic sector an important missing dimension would be added to a store of knowledge that has been heavily dominated by the findings of cave archaeology.

5 PREHISTORIC ARCHAEOLOGICAL FINDINGS IN SUNDAIC SOUTHEAST ASIA

The substantive archaeological record for prehistoric maritime adaptation and marine resource exploitation in the Sundaic sector is still rather meagre. The record does, however, represent three distinctive types of sites:

1. Upland sites — those located far from the sea today (as well as in the past) which have yielded evidence, usually in the form of marine mollusc shells, to suggest that the occupants either visited the seacoasts occasionally or obtained marine materials through trade.
2. Coastal cave sites — those on coastal plains near modern seacoasts, some of which at times in the past may have been located on the coast itself. Many have revealed evidence of marine as well as terrestrial exploitation.
3. Open coastal sites — sites on modern coastal plains with marine shell midden accumulations presumably formed at times when the sites were on the seacoast. Most of these midden sites also reflect some exploitation of land resources.

5.1 Upland sites in the Sundaic sector

Marine or coastal mollusc remains have been recovered from many upland Sundaic sites, especially in Malaya and Java. These remains represent exploitation in coastal subsistence zones, but usually, in our opinion, by peoples other than the occupants of the upland sites. Thus the shells are presumed to have reached the interior as trade materials, perhaps passing through several hands before reaching the sites where they were ultimately preserved. Probably these materials were sought for utilitarian, ornamental, or ritual purposes. The evidence in support of this trading hypothesis is set out in some detail by Dunn (1973:314-323). T. van B. Jutting (1932:104) suggested such a possibility long ago, in discussing marine shells from the Sampung cave site near Ponorogo in the mountains of east-central Java: "The marine shells, collected at a far off coast about which only vague rumours penetrated inland, evidently appealed especially to the imagination of the primitive inhabitants and were considered as objects of great value, being used as gems for necklaces and other ornaments."

Reviews of Sundaic upland sites that have yielded evidence of contact with coastal zones can be found in Jutting (1940, especially a tabulation on page 27), Heekeren (1957), and Dunn (1973). Further discussion of these upland sites is not indicated here since we are concerned with coastal and maritime adaptations.

5.2 Coastal cave sites

Few Sundaic cave sites stand on the modern coastline, but sites farther inland on the coastal plains are not scarce. Assemblages recovered from many such sites reflect orientations to marine, brackish-estuarine, and mangrove resource exploitation, although always or almost always in some combination with terrestrial resource use. In Malaya the best known of such sites is Bukit Chuping in Perlis (Collings 1938). In Borneo a few such sites have recently been investigated on the coastal plain of Sabah (Harrisson 1972:21), and in Sarawak the cave complex of Niah is, of course, in this category (Harrisson 1972). Although coastal cave sites seem to be generally scarce or absent in Sumatra and Java, a number have been excavated near the northern coast of East Java, especially in the vicinity of Tuban and Besuki (Heekeren 1957:80-84, 104-105). Outside the Sundaic sector, but within or marginal to greater Southeast Asia, there are other notable sites in this category, e.g. the Arguni island site of Dudumunir in McCluer Gulf off the western coast of New Guinea (Roder 1940); the coastal sites in eastern Timor excavated by Glover (1971, 1972); and the eastern Taiwan cave sites recently investigated by W.-H. Sung (see Chang 1971).

In some of these localities it is evident that the sites would have been virtually at seaside, or even partially flooded, with a post-Pleistocene marine transgression of only a few metres. Collings (1938:111-112) dis-

cusses this point at some length in his report on Bukit Chuping and concludes that the sea must have been much closer to the cave at one time in the past. On the other hand, it is equally certain that many of these cave sites were far removed from the seacoasts prior to the end of the Pleistocene. With a sea level depression of 75 m Bukit Chuping would have stood more than 100 km from the shoreline, and even with only a 40 m depression the distance to the sea would have been at least 50 km. Similarly, a 40 m depression would have placed the Tuban sites of East Java well inland, and a 75 m depression would put Tuban about 150 km from the nearest coast. Niah in Sarawak is about 75 km from the 75 m isobath. We may conclude from these facts that sites like Bukit Chuping, Niah, and the East Javan caves near Tuban were located at a considerable distance from the seacoasts prior to the end of the Pleistocene, and any late Pleistocene inhabitants could not have had more than minimal contact with the coasts. At a site like Niah, however, it is tempting to suggest that riverine contact with the sea may have been feasible before the end of the Pleistocene, both because of the probable presence of a river and because of technological capability for river travel.

As hypotheses for future testing through excavation at coastal cave sites we therefore suggest the following:

1. Littoral and shallow sublittoral resource exploitation by the inhabitants of such caves probably intensified gradually as the seas rose during the last few millennia of the Pleistocene, but until the very end of the Pleistocene terrestrial resources were relatively much more important at such sites. In other words, the subsistence zones around many of these caves included coastal and marine habitats only marginally, if at all, before the end of the Pleistocene.

2. Even after the seas rose to modern levels the inhabitants of many of these sites tended to rely more heavily on land resources than on those of the coasts and seas.

3. On at least one occasion a post-Pleistocene oscillation raised the sea level a few metres above the modern level. During such a transgression marine, brackish-estuarine, and mangrove exploitation was probably greatly intensified by those cave inhabitants, at the expense of land-orientated subsistence. Good stratigraphic data on variations in the intensity of marine/coastal versus inland resource exploitation could assist in determining how many times the seas rose above the modern level after the close of the Pleistocene.

4. Finally it may be presumed that most coastal cave sites occupied in the late Pleistocene are now submerged and accessible only to the underwater archaeologist. Some cave-containing limestone hills or cliffs may be fully submerged, but more likely — if such caves exist — they lie on the sublittoral surfaces of rocky offshore islands. A survey of the submerged surfaces of islands in the southern portion of the South China Sea, or the Java Sea, might reveal a few such caves, and it is conceivable that one or more could then be excavated.

5.3 Open coastal sites

Open sites near the modern coastlines of the Sundaic sector are virtually unknown except on the opposing coasts of the northern third of the Strait of Malacca. On the Malayan side only a single shell mound site falls in this category, Guak Kepah in Province Wellesley (Callenfels 1936; Matthews 1961:5, 26-28). (Incidentally 'guak' or 'guar' means hillock in Malay and 'kepah' is a generic term for shells; thus the traditional name of the site seems to reflect longstanding knowledge of the nature of the mounds.) A few other traces of shell mounds have been reported in the northwest coastal region of Malaya but none seems to have been excavated. On the Sumatran side the picture is (or was) quite different. Heekeren (1957:70-74) summarizes the record for a series of excavations and surface collections relating to shell mounds ('kitchen middens') distributed along about 130 km of the northeastern coastal plain from the vicinity of Medan and Bindjai to Seruwai. Heekeren indicates the locations of 10 mounds (or groups of mounds) on an accompanying map, and he comments: "It is very striking . . . that this form of culture is so rare in other parts of the Archipelago [Indonesia] and that up till now there is no report of kitchen middens along the shores elsewhere." It is indeed remarkable; one must look far north, along the northern coast of Viet Nam, to find — in Bau Tro — a Southeast Asian site even remotely comparable to these Malacca Strait sites (see Gorman 1971:310).

The Malayan and Sumatran midden sites have so much in common that it is nearly certain, even without dating, that they are representative of the same cultural complex, a 'Hoabinhian' variant which we shall hereafter refer to as the Malacca Strait complex.

Guak Kepah consists of three shell middens on a sandy ridge of an old sea beach, about seven kilometers from the present coast of Province Wellesley. At the time of G.W. Earl's excavations at the site in 1860 the middens were apparently intact and about five metres in height (Matthews 1961:5) but when Callenfels worked at the site in 1934 (Callenfels 1936) the mounds had been reduced to between one and two metres in height because of quarrying by lime burners. While some subsurface remnants of the deposits may survive today, mound elevations were not detectable at the site in 1967. Callenfels described the middens as being built up of the unbroken valves (venus clam shells) of *Meretrix meretrix*, an edible mollusc of sandy shallow sublittoral habitats. Other molluscs identified from the deposits, all marine and all typically associated with sandy environments, included: *Arca granosa* (ark shells), *Melongena pugilina* (trumpets or crown conchs), *Ostrea rivularis* (?) (oysters), and *Turritella attenuata* (turritella snails). Fish bones were also common, belonging to a species of the marine family Arridae — a shallow water and estuarine form. Some beads made from fish vertebrae were also discovered. Associated with these remains were unidentified mammalian bones, pig tusks, a rhinoceros tooth, typical Hoabinhian tools including some unifacial 'Sumatraliths', pounding and grinding stones, and pottery, both plain and

cord-marked. Callenfels concluded that the site represented a sea beach settlement, and that the 'Hoabinhian' inhabitants exploited only shallow waters. The absence of bones of deep water fishes was considered to be associated with a lack of 'deep water canoes' and thus of means to exploit offshore waters. If Callenfels' conclusions are correct Guak Kepah represents a very different marine adaptation to that at Bau Tro — where marine fish bones provide ample evidence of skill in offshore fishing.

The Sumatran assemblages are very similar to those at Guak Kepah (Heekeren 1957:70-74). Again the midden mounds (some — at Seruwai — nearly 30 m in diameter and 4 m in height) were composed largely of *Meretrix meretrix* clam shells, together with a small proportion of oysters and smaller numbers of other marine mollusc shells. Large land vertebrate remains were found, together with Hoabinhian tools (primarily unifacial 'Sumatraliths'), grinding tools, and pounding tools. Fish, crab, and tortoise remains were found but identifications are not reported. Only one striking difference is evident: the absence of any mention of pottery on the Sumatran side of the Strait. This suggests, as one of us has noted before (Dunn 1970:1047), that the manufacture of pottery began in the Malay Peninsula after Sumatra was already separated from the Peninsula by the rising sea. It further suggests that the occupants of these strikingly similar midden sites on opposite sides of the Strait were not in contact with each other, perhaps for lack of skill in offshore boat travel. (This suggestion is consistent with Callenfels' idea that the people at Guak Kepah lacked good boats and thus found it necessary to confine their marine fishing to shallow and estuarine waters.)

The Malacca Strait complex suggests the following hypotheses:

1. Cave sites are 'fixed'; the cave must be abandoned to a rising sea, and it loses its value as a base for coastal exploitation if the sea recedes too far. Open site occupation, on the other hand, is an adaptable way of life. As seas advance or retreat open sites can also 'advance or retreat'. Thus it would appear that the archaeologically known shell middens are merely the highest isobathic representatives of sites (almost all of which are now submerged) that have existed along successive Sundaic shorelines at various times well back into the Pleistocene.

2. The great cultural similarity of the Sumatran and Malayan components of the Malacca Strait complex indicates that the remnant middens are late representatives of a coastal tradition that extended back at least to a time of lower sea levels (that is, before the end of the Pleistocene) when ancestral peoples were in direct communication with each other. Indeed, one can envision that successive arcs of middens followed the ancient Sundaic bayshores extending from northern Sumatra to the western side of the Peninsula. With the transgression that created the Strait of Malacca (by submerging what is now its southern end) the link between Sumatra and Malaya was finally severed. In other words, we suggest that much evidence of open coastal occupation ancestral to the archaeologically recognizable Malacca Strait complex lies on the submerged shelf of the northern Strait.

3. It is tragic that the Malacca Strait shell mounds were mostly destroyed before modern scientific archaeological investigations could be undertaken. If any such mounds do survive their excavation should be given the highest priority for we believe that the cultural complex represented by these midden sites is a direct descendant of a late Pleistocene complex that may have been characteristic of coastal Sundaland, at least along its northwestern margin.

5.4 A note on protohistoric coastal sites

Although Sundaic protohistoric sites fall outside the time span of direct concern in this chapter, such sites may provide data that can be of aid, by analogy, in interpretation of earlier sites, in much the same fashion that modern ethnographic data can have analogic value. We call attention in particular to two groups of sites, those of the Sarawak River delta (Harrison 1972:22-24) and those at Tanjong Rawa, Kuala Selinsing, on the Perak coast of Malaya. The assemblages at these sites are extraordinarily rich.

At Tanjong Rawa banks of cockle shells (*Cardium* sp.) were excavated, undoubtedly reflecting extensive use of cockles as food (Sieveking 1956:202). (These cockles are also 'indicators' of a sandy-mud shore environment. Their abundance at Tanjong Rawa suggests that sandy-mud shores were readily available then, as they are today in the same locality.) The site is particularly remarkable for its assemblage of ancient canoes and rafts (Evans 1932:108-109). Clearly Tanjong Rawa represents a late (? 2,000 - 1,000 BP) marine-orientated settlement. We suggest that a restudy of all materials from this site, together with a review of the published record, and hopefully some additional excavations, would provide a picture of late coastal adaptation that might prove valuable, both in itself, and by analogy in increasing our understanding of prehistoric coastal adaptations.

6 A CONJECTURAL OUTLINE: SUBSISTENCE CONDITIONS AND MARINE RESOURCE EXPLOITATION IN SUNDAIC SOUTHEAST ASIA

This chapter is not a review of the literature; nor does it provide a detailed cultural historical reconstruction for any time or place. In the current state of Southeast Asian prehistory, particularly in the Sundaic and Insular areas, any literature review can do little more than reveal how fragmentary our data really are. What is needed is much more field and laboratory research - critical, meticulous, and strongly multidisciplinary in methods and outlook. Our chapter can only be a guide to possibilities, offering some suggestions and outlining some hypotheses that require testing. We conclude the chapter, therefore, with a conjectural outline rather than a 'conclusion'. In reviewing this outline the reader is

reminded to refer to the hypotheses set out at the ends of sections 5. 2 and 5. 3.

6.1 Between 22,000 and 18,000 BP

Environmental assumptions:

1. Sea level probably standing between -100 and -120 m.
2. Land masses merged into a Sundaland of large surface area (ca. 1,725,000 km²).
3. Sundaland coastline relatively short (about 54 per cent of the coastline length of the modern Sundaic sector).
4. Extensive lowlands; only a small percentage of the surface area submontane (300 - 1,000 m above sea level) or montane (more than 1,000 m above sea level).
5. Numerous rivers, some of considerable length with large drainage areas.

Human population distribution and behavioural patterns:

1. Population density low; and 'community' size small.
2. Subsistence zones probably widely dispersed; on a statistical basis a substantial proportion of the total human population probably subsisting in inland zones.
3. Favoured inland subsistence zones probably riverine in lowland, dry-floored forest areas, especially in localities with limestone shelters or caves.
4. Coastal subsistence zones of two types: a. Probably most favoured - but scarce - were locations near rocky, forested headlands, especially at river mouths; a cave would presumably have added further to the attractiveness of the site; the subsistence zone around such a site could have included not only dry-floored forest but also estuarine, mangrove, rocky, muddy, sandy shore, and reef biotopes. b. Many coastal groups were probably forced to choose locations for settlement less favourable than headlands, with or without caves, as described above. In all likelihood such locations were open sites, probably often on or behind the beaches, i.e. similar to the midden sites of the Malacca Strait complex (see section 5.3). Of course we must also consider the possibility that inhabitants of cave or rocky headland locations abandoned these sites seasonally or periodically in favour of life on the open seaside beaches.
5. Seafaring technology limited, at best; perhaps rafting only; open sea or coastwise travel infrequent; navigational skills very little developed; coastal subsistence zones relatively small, defined by the limits of foot travel rather than travel by water.
6. Marine exploitation: probably limited to intertidal and shallow subtidal waters; primarily gathering; marine fishing technology and skills simple and limited.

6. 2 About 9,000 BP

Environmental assumptions:

1. Sea levels within 10 — 15 m of the modern level; most of the shelf submerged and margins of land masses approximately modern.
2. Sundaic land surface area reduced to about 990,000 km².
3. Sundaic coastline relatively long, almost double the total coast length at 22,000 — 18,000 BP.
4. Lowlands greatly reduced in area; much greater percentage of submontane and montane lands than in the late Pleistocene.
5. Rivers reduced in number; many reduced in length and in size of drainage area.

Human population distribution and behavioural patterns:

1. Population density low but perhaps double that of 9 — 13,000 years earlier, because a slightly enlarged population (allowing for some migratory loss) now occupies a land mass only 57 per cent as large as that of the earlier period; community size small.
2. Subsistence zones not widely dispersed; on a statistical basis a substantial proportion of the total human population probably subsisting in coastal zones (as a consequence of the disappearance of vast areas of non-coastal lowland, together with a near-doubling of coastline length).
3. Inland subsistence probably primarily in lowland and lower montane zones, preferentially near water courses and limestone hills with caves or shelters.
4. Coastal subsistence zones more diverse than in the late Pleistocene (because of greater competition for the most favourable zones), but the basic differentiation between coastal cave and open coastal sites persists. As in the late Pleistocene, coastal cave and rocky headland sites must have been scarce. While some earlier cave sites were flooded, others became available as bases for coastal subsistence as the seas approached the hills. Again only a minor part of the coastal population could have had access to such sites. The surviving shell midden sites of the Malacca Strait complex are probably more recent (corresponding to a later marine transgression above the modern sea level) but we suspect they represent a coastal adaptive mode that was still fairly widespread at 9,000 BP. Again, there may have been some alternation between cave and open site occupation on the part of some group.
5. Seafaring: probably boats as well as rafts in use by this time, probably some coastwise travel and reef exploration, as well as visits to mangrove, swampy, and riverine habitats with the aid of small craft: open sea voyaging probably still limited, both by technology and by lack of navigational skills. In a broad cultural evolutionary sense the terminal Pleistocene adaptive threshold associated with flooding of the Sunda shelf, contraction and dissection of the land masses, and lengthening of the coastlines may have served as a stimulus (although certainly not the only one) to the development of more effective seafaring. (A major environmental

determinant of cultural change is thus suggested, but no implication that change was solely a product of pure 'environmental determinism' is intended.)

6. Marine exploitation: gathering in intertidal and shallow subtidal zones as before, but also bolder exploration of off-shore reefs and neritic waters; many subsistence zones probably enlarged by coastwise boat travel; marine fishing skills improved as boating skills open new habitats to exploitation.

6.3 About 5,000 BP

Environmental assumptions:

1. Sea level near or at the modern level — after one or more rises of at least several meters above the modern stand during the millennia after 9,000 BP.

2. Sundaic land surface areas and coastlines roughly the same as those of today.

Human population distribution and behavioural patterns:

1. Population conditions stable; population density not much greater than that at 9,000 BP.

2. Inland subsistence zones as at 9,000 BP; perhaps some increase in competition for particularly favourable locations.

3. Coastal subsistence as at 9,000 BP, but many zones enlarged in size by seafaring.

4. Seafaring: by now truly 'effective' and 'competent' (Dunn 1970:1048, 1051). By this time advances in boat technology and in the navigational arts almost certainly permitted controlled (rather than 'accidental') open sea voyaging.

5. Marine exploitation: an important consequence of more effective seafaring was the extension of marine exploitation out to sea. Undoubtedly this outreach served to stimulate further improvement in marine fishing technology and in techniques for exploitation of deep benthic and nekto-benthic species, and of pelagic species in deep neritic and oceanic waters.

NOTES

- 1 Some areas in Insular Southeast Asia appear to have undergone uplift during the Pleistocene (e.g. see M.G. Audley-Charles & D.A. Hooijer 1973, *Nature* 241:197-8) and such a possibility cannot be ruled out for the Sundaic sector. However, no evidence seems to exist for substantial diastrophism affecting the Sunda shelf in the millennia since about 35,000 BP.
- 2 This North Pacific reconstruction is supported by some evidence, with minor differences in dates and sea stands, from the Timor Sea (T. van

- Andel & J. Veevers 1967, Morphology and Sediments of the Timor Sea, Canberra, Bureau of Mineral Resources Bulletin 83).
3. As Sopher (1965:243-4) notes, trepang is rarely consumed by modern indigenous peoples in Southeast Asia; its importance lies in its value as a component of Chinese cuisine. It is, however, a readily available auxiliary or emergency food.

REFERENCES

- Ambrose, W.R. 1967. Archaeology and shell middens. *Archaeology phys. Anthropol. Oceania* 2:169-187.
- Andrews, E.W. 1969. The archaeological use and distribution of mollusca in the Maya Lowlands (Publ. 34, Middle American Research Institute, Tulane Univ. New Orleans).
- Anonymous. 1973. *Mariner* 1. *Scient. Am.* 228(3):48.
- Biggs, H.E.J. 1969. Molluscs from human habitation sites and the problem of ethnological interpretation. In D. Brothwell & E. Higgs (eds.), *Science in Archaeology*. 2nd ed. London, pp.423-427.
- Callenfels, P.V. van S. 1936. An excavation of three kitchen middens at Guak Kepah, province Wellesley, Straits Settlements. *Bull. Raffles Mus. Series B*, 1:27-37.
- Casteel, R.W. 1972. Some archaeological uses of fish remains. *Am. Antiquity* 37:404-419.
- Chang, K.-C. 1971. Review of: Changpinian: A newly discovered preceramic culture from the agglomerate caves on the east coast of Taiwan (preliminary report). *Asian Perspectives* (for 1969) 12:133-136.
- Chapman, V.J. 1970. *Seaweeds and their uses*. 2nd ed. London.
- Chuang, S.-H. 1961. *On Malayan shores*. Singapore.
- Collings, H.D. 1938. An excavation at Bukit Chuping, Perlis. *Bull. Raffles Mus. Series B*, 1:94-119.
- Curray, J.R. 1965. Late Quaternary history, continental shelves of the United States. In H. E. Wright & D. G. Frey (eds.), *The Quaternary of the United States*. Princeton, pp. 723-735.
- Delsman, H. C. & J. G. Man. 1925. On the 'radjungans' of the Bay of Batavia. *Treubia* 6:308-323.
- Donn, W. L., W. R. Farrand & M. Ewing. 1962. Pleistocene ice volumes and sea-level lowering. *J. Geol.* 70:206-214.
- Dunn, D. F. 1970. Some observations on marine life at Pulau Aur, Johore. *Malayan Nature J.* 23:158-167.
- Dunn, F. L. 1966. Radiocarbon dating of the Malayan Neolithic. *Proc. prehist. Soc.* 32:352-353.
- Dunn, F. L. 1970. Cultural evolution in the late Pleistocene and Holocene of Southeast Asia. *Am. Anthropol.* 72:1041-1054.
- Dunn, F. L. 1973. Rain-forest collectors and traders: a study of resource utilization in modern and ancient Malaya. Ph. thesis, Univ. Malaya, Kuala Lumpur (unpubl.).

- Ekman, S. 1953. Zoogeography of the sea. London.
- Evans, I. H. N. 1932. Excavations at Tanjong Rawa, Kuala Selinsing, Perak. J. fed. Malay States Mus. 15: 79-134.
- Evans, J. G. 1969. The exploitation of molluscs. In P. J. Ucko & G. W. Dimbleby (eds.), The domestication and exploitation of plants and animals, Chicago, pp. 479-484.
- Frerichs, W. E. 1968. Pleistocene-recent boundary and Wisconsin glacial biostratigraphy in the Northern Indian Ocean. Science 159: 1456-1458.
- Glover, I. C. 1968. Pottery making in Oralan village, Portuguese Timor. Aust. nat. Hist. 16: 77-82.
- Glover, I. C. 1971. Prehistoric research in Timor. In D. J. Mulvaney & J. Golson (eds.), Aboriginal man and environment in Australia, Canberra, pp. 151-181.
- Glover, I. C. 1972. Excavations in Timor. Ph.D. thesis. Aust. Natn. Univ., Canberra (unpublished).
- Golson, J. 1971. Both sides of the Wallace Line: Australia, New Guinea and Asian prehistory. Archaeology phys. anthrop. Oceania 6: 124-144.
- Gorman, C. 1971. The Hoabinhian and after: subsistence patterns in South-east Asia during the late Pleistocene and early recent periods. World Archaeology 2: 300-320.
- Gorman, C. F. 1972. Excavations at Spirit Cave, North Thailand: some interim interpretations. Asian Perspectives (for 1970) 13: 79-107.
- Green, C. R. 1967. Sources of New Zealand's East Polynesian culture: the evidence of a pearl shell lure shank. Archaeology phys. anthrop. Oceania 2: 81-90.
- Greengo, R. E. 1954. Appendix I: Archaeological marine shells. Papers Peabody Mus. Archaeology and Ethnol., Harvard Univ. 49: 141-150.
- Harrison, T. 1972. The prehistory of Borneo. Asian Perspectives (for 1970) 13: 17-45.
- Hedgpeth, J. W. 1957. Classification of marine environments. Geol. Soc. Am. Memoir 67: 17-27.
- Heekeren, H. R. van. 1957. The Stone Age of Indonesia. 's-Gravenhage.
- Hopkins, D. M. 1967. The Cenozoic history of Beringia — a synthesis. Chapter 24 in D. M. Hopkins (ed.), The Bering land bridge. Stanford, pp. 451-484.
- Hyman, L. H. 1940. The invertebrates: Protozoa through Ctenophora. New York/London.
- Johnson, D. S. 1964. An introduction to the natural history of Singapore. Kuala Lumpur.
- Johnson, M. 1970. The cowrie currencies of West Africa. Parts I and II. J. African Hist. 11: 17-49 and 331-353.
- Jutting, T. van B. 1932. On prehistoric shells from Sampoeng Cave (Central Java). Treubia 14: 103-108.
- Jutting, W. S. S. van B. 1940. Molluskenschalen von prähistorischen Mahlzeitresten aus der Höhle Dudumunir in West Neu Guinea. Nova Guinea N.S. 4: 11-29.

- Kaneko, E. 1972. Robert von Heine-Geldern: 1885-1968. Asian Perspectives (for 1970) 13:1-10.
- Kohn, A. J. 1967. Environmental complexity and species diversity in the gastropod genus *Conus* on Indo-West Pacific reef platforms. *Am. Naturalist* 101:251-259.
- Lange, F. W. 1971. Marine resources: a viable subsistence alternative for the prehistoric lowland Maya. *Am. Anthrop.* 73:619-639.
- Macnae, W. 1968. A general account of the fauna and flora of mangrove swamps and forests in the Indo-West Pacific region. *Adv. marine Biol.* 6:73-270.
- Matthews, J. 1961. A check-list of 'Hoabinhian' sites excavated in Malaya 1860-1939 (Papers S.E. Asian subjects 3, Dept. History, Univ. Malaya, Kuala Lumpur). Singapore.
- Meighan, C. V. 1969. Molluscs as food remains in archaeological sites. In D. Brothwell & E. Higgs (eds.), *Science in Archaeology*, 2nd ed. London, pp. 415-422.
- Molengraaff, G. A. F. 1921. Modern deep-sea research in the East Indian archipelago. *Geogr. J.* 57:95-121.
- Moore, H. B. 1958. *Marine ecology*. New York.
- Purchon, R. D. & I. Enoch. 1954. Zonation of the marine fauna and flora on a rocky shore near Singapore. *Bull. Raffles Mus.* 25:47-65.
- Quisumbing, E. 1951. *Medicinal plants of the Philippines* (Republic Philippines Dept. Agriculture and Natural Resources Technical Publ. 16).
- Röder, J. 1940. Ergebnisse einer Probegrabung in der Höhle Dudumunir auf Arguni, Mac Cluer-Golf (holl. West Neuguinea). *Nova Guinea N.S.* 4:1-10.
- Ryder, M. L. 1969. Remains of fishes and other aquatic animals. In: D. Brothwell & E. Higgs (eds.), *Science in Archaeology*. 2nd ed. London, pp. 376-394.
- Shackleton, N. J. 1969. Marine mollusca in archaeological sites. In D. Brothwell & E. Higgs (eds.), *Science in Archaeology*. 2nd ed. London, pp. 407-414.
- Sieveking, G. de G. 1956. Recent archaeological discoveries in Malaya (1955). *J. Malayan Brch. R. Asiatic Soc.* 29:200-211.
- Solheim, II, W. G. 1972a. Northern Thailand, Southeast Asia, and world prehistory. *Asian Perspectives* (for 1970) 13:145-162.
- Solheim, II, W. G. 1972b. An earlier agricultural revolution. *Scient. Am.* 226(4):34-41.
- Sopher, D. E. 1965. The sea nomads. A study based on the literature of the maritime boat people of Southeast Asia (*Memoirs Natl. Mus.* Singapore 5).
- Stehli, F. G. & J. W. Wells. 1971. Diversity and age patterns in hermatypic corals. *Syst. Zoology* 20:115-126.
- Stephenson, T. A. & A. Stephenson. 1972. Life between tidemarks on rocky shores. San Francisco.
- Tabrah, F. L., M. Kashiwagi & T. R. Norton. 1970. Antitumor activity in mice of tentacles of two tropical sea annelids. *Science* 170:181-183.

- Terra, H. de. 1943. Pleistocene geology and early man in Java. Trans. Am. phil. Soc. 32: 437-464.
- Thorson, G. 1971. Life in the sea. New York/Toronto.
- Umbgrove, J. H. F. 1938. On the time of origin of the submarine relief in the East Indies. Comptes rendus du Congrès International de Géographie Amsterdam 1938, Tome 2, Section IIb: Océanographie, pp. 150-159.
- Umbgrove, J. H. F. 1949. Structural history of the East Indies. Cambridge.
- Vohra, F. C. 1971. Zonation on a tropical sandy shore. J. Animal Ecology 40: 679-708.
- Wells, J. W. 1957. Coral reefs. Geol. Soc. Am. Memoir 67: 609-631.
- Wiens, H. J. 1962. Atoll environment and ecology. New Haven/London.
- Zaneveld, J. S. 1959. The utilization of marine algae in tropical South and East Asia. Econ. Botany 13: 89-131.

Bartstra, Gert-Jan, Willem Arnold Casparie & Ian C. Glover, eds. June 1977
MODERN QUATERNARY RESEARCH IN SOUTHEAST ASIA

Volume 3 (1977). (An annual publication)

Balkema, Rotterdam. 23 cm., 171 pp., 5 pls.

ISBN 90 6191 016 1

Cloth, Hfl./DM 25 / £ 6 / \$ 10

SCOPE: This volume focuses on problems of cultural evolution mainly in the Holocene period and in continental and Sundaic Southeast Asia.

CONTENTS: Maritime adaptations and exploitation of marine resources in Sundaic Southeast Asian prehistory; Laang Spean and the prehistory of Cambodia; Phu Wiang pottery and the prehistory of Northeastern Thailand; The prehistory of the Southern Khorat Plateau, North East Thailand, with particular reference to Roi Et Province; The height of the river terraces in the transverse Solo valley in Java.

EDITORS: Dr Bartstra & Dr Casparie both work at the Institute for Biological Archaeology, Univ. Groningen and Dr Glover at the Institute of Archaeology, Univ. London.

READERSHIP: Archaeologists and students of SE Asian culture history.

Volume 1 (1975): Papers read at a colloquium on modern Quaternary research in Indonesia. 108 pp. Cloth, Hfl./DM 18 / £ 4.30 / \$ 8

Volume 2 (1976): Research reports from Indonesia. Solo terraces; Man in Indonesia; Hoabinhian of Sumatra; Animal remains Ulu Leang I Cave.

7 loose maps, 82 pp.

Cloth, Hfl./DM 22,50 / £ 5.40 / \$ 9

From the same publisher:

THE EQUATORIAL GLACIERS OF NEW GUINEA — Results of the 1971-1973 Australian Universities' Expeditions to Irian Jaya: survey, glaciology, meteorology, biology and palaeoenvironments, edited by G. S. Hope (ANU), J. A. Peterson (Monash Univ.), I. Allison & U. Radok (Univ. Melbourne).

Nov. 1976, 23 x 15 cm, cloth, 270 pp. Hfl. 39,50 / \$ 14.80 / £ 8.50

PALAEOECOLOGY OF AFRICA AND THE SURROUNDING ISLANDS AND ANTARCTICA, Volume 9, edited by E. M. van Zinderen Bakker.

Progress reports and some larger articles on different regions of Africa. Sept. 1976, 22 x 14 cm, cloth, 231 pp. Hfl. 45,- / \$ 17.50 / £ 9.50

Send your order to your bookseller or directly to the publisher:

A. A. Balkema, P. O. Box 1675, Rotterdam, Netherlands