Dissertation submitted for the degree of Ph.D.

in the

University of Cambridge

THE ROLE OF SHELL MIDDENS

IN

PREHISTORIC ECONOMIES

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Cambridge

July,
1975

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PREFACE AND ACKNOWLEDGEMENTS

This investigation takes its inspiration from a view of the human economy which has been developed in recent years by the British Academy Major Research Project on the Early History of Agriculture, that the problem of the origins of agriculture in the narrow sense can admit of no satisfactory solution unless examined in relation to a unifying framework of theory and concepts which applies to the whole range of man-resource relationships, irrespective of their placement within the traditional categories of hunting and gathering and irrespective of their chronological or geographical context. It is to the continuing development of this approach that this thesis is offered as a contribution.

The thesis falls into two major sections. The first comprises Chapters I to IV, which set the study of shell-midden economies in a global context and provide a general analysis of the theoretical background to their study, using archaeological, ecological and ethnographic data. Chapter I is an introduction to the problem and to the theoretical framework used in its solution, together with a justification of the wide-ranging comparative approach adopted; Chapter II is a general survey of the archaeological and ecological background to the study of prehistoric shell-food exploitation; Chapter III is a detailed study of the economic potential of shellfood, combined with an analysis of theoretical concepts; and Chapter IV is a survey of the ethnographic literature on shell-midden economies.

The second section, comprising Chapters V to X, is concerned with the analysis and interpretation of the archaeological field data. Chapter V discusses the techniques employed; Chapters VI to IX are the central core of the work, comprising the four archaeological case studies, which refer respectively to northern New South Wales and the Cape York Peninsula

in Australia and to Denmark and northern Spain in Europe; and Chapter X is a general conclusion viewing the whole field of enquiry.

The detailed archaeological case studies are based on my own excavations and on my own observations in the field and the laboratory. Specialist identification of specimens or analysis undertaken by others is acknowledged below. References are cited in the text according to the name of author and date of publication, and details are supplied in a list of references in Volume II. Maps and aerial photographs consulted in the course of detailed archaeological work are listed after the references. For ease of consultation, appendices, figures and plates have been grouped with the references in Volume II. Abbreviations used in the text follow, as far as possible, British Standards 1991 : Part 1 : 1954. To the best of my knowledge, the ideas and interpretations proposed and the syntheses of existing data, unless otherwise specified, are original.

Acknowledgements

For assistance in carrying out investigations in such a diversity of areas I am indebted to many individuals and institutions. In particular I would like to record my thanks to my supervisor, Mr. E.S. Higgs, for stimulus and encouragement and for his reading of the manuscript, to Professor J.G.D. Clark for his assistance in launching the project in its present form, and to Mr. R.V.S. Wright, my supervisor at Sydney University, without whose generous assistance and advice the results of my work in Australia would not have been possible.

The field work commenced in Spain in 1971, and I am grateful to Excmo. Sr. D. Martín Almagro Basch, Inspector Nacional de Excavaciones Arqueológicas, for his co-operation in allowing the work to proceed; to Prof. Dr. D. Luis Pericot García, Prof. Dr. D. Francisco Jordá Cerdá, Prof. Dr. D. José Manuel Gómez Tabanera, Dr. D. Joaquín González Echegaray

and Dr. D. Jesús Altuna, for assistance at various stages of my visit to Spain; and to Srta. Da. Matilde Escorial Pousada, Directora del Museo de Arqueología, Oviedo, for permission to examine faunal collections.

Investigations in Australia were undertaken in 1972, and I am grateful to the National Parks and Wildlife Service, N.S.W., for granting a permit to excavate at Ballina; to Mr. Albert Barlow and Willmore & Randell Pty. Ltd. for permission to use their land; and to Mr. Trevor Blackman and Mr. Barry Regan for assistance at Ballina. The field work in Cape York Peninsula was made possible through the co-operation of the Department of Aboriginal and Island Affairs, Queensland; the Aboriginal Councils at Weipa, Aurukun and Edward River; the Presbyterian Mission at Aurukun; and the Comalco Mining Company. I would also like to thank Professor John Mulvaney, Dr. Isabel McBryde and Dr. Malcolm Calley for assistance in the preparations for the field work; Dr. John Taylor, Queensland Institute of Medical Research Field Station, Mitchell River, for assistance and hospitality in the field; and the Department of Anthropology, Sydney University, for the use of facilities in the field and the laboratory.

In Denmark I would like to thank Mag. Art. Søren H. Andersen, Institut for Forhistorisk Arkaeologi og Etnografi, Aarhus University, for hospitality and assistance during the summer of 1973 and, in particular, for kindly allowing me to excavate on sites which are currently being investigated under his direction and for putting at my disposal the facilities of the Institut.

The bone material recovered from the Australian excavations was identified by Mr. P.W. Thomson, the Australian Museum, Sydney; the molluscs by Mr. P.H. Coleman, the Australian Museum, Sydney, and Mrs. G. Poiner, Department of Anthropology, Sydney University. The rock types represented by the Weipa artifacts and their sources were identified by Dr. A.H. White, Comalco Exploration, Cairns; Mr. P.H. Wolf, New South Wales State Fisheries, kindly supplied the data on oyster yields in the Richmond River; and

Mr. P.R. Lerman, Department of Applied Biology, Cambridge, advised in the use of statistical data. Thanks are also due to Mrs. Jenny Starling, National Parks and Wildlife Service, N.S.W., for allowing me to examine her unpublished survey of coastal sites in northern New South Wales; to the Royal Australian Historical Society for permission to consult archives; and to the Mapping and Charting Establishment, R.E., Ministry of Defence, and the Map Room of the University Library, Cambridge, for assistance with maps.

The major financial support for the work was provided by the Department of Education and Science in the form of a Major State Studentship for the period 1970 to 1973, held in an honorary capacity during 1972. The opportunity to extend the range of investigations and to benefit from the experience of working in Australian field conditions was made possible by the generous support of the Royal Society and the Leverhulme Trustees through the award of a Leverhulme Studentship in 1972. Additional field expenses were met from awards made by the Society of Antiquaries' Lambarde Fund, the British Universities Students Travel Association and the Australian Institute of Aboriginal Studies. The latter also financed the analysis of radiocarbon samples. The crucial phase of writing up was greatly assisted by the award of a Senior Research Studentship for the period 1973 to 1974 by the Master and Fellows of Corpus Christi College, Cambridge.

Completion of the field investigations would not have been possible without the enthusiastic participation of student volunteers: C. Baxter, B. Freeman, M. Gallagher, M. González Morales, D. Harriss, K. Højrup, J. Jacobsen, J. Jebersen, C. Kremer, W. Mackenzie, G. Price, J. Rodríguez Muñoz and J. Slatyer.

For hospitality and discussion in the course of my travels and for the opportunity to observe at first hand some of the results of their own

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investigations concerning shell middens, I am grateful to Richard Cassels, Wilf Shawcross and Paul Mellars.

For discussion of matters arising in the text, I am grateful to I. Davidson, R.W. Dennell, R.J. Fletcher, M.R. Jarman, J.E. Parkington and S.J. Rudnick.

To all these institutions and individuals and to all the many others too numerous to mention who assisted in my work, I would like to express my thanks.

Finally it is a pleasure to acknowledge the support of my parents, Reginald and Phyllis Bailey, who have been an invaluable source of help and encouragement throughout the period of my studies.

CHAPTER I

INTRODUCTION

1. Problems Of Interpretation And Their History

Shell middens are a world-wide phenomenon of considerable antiquity and are found on many shorelines of the world from Alaska to Tasmania and from Jutland to Tierra del Fuego. They are usually defined as archaeological deposits which contain shells of edible molluscs discarded as by-products of subsistence activity. Their number, though difficult to assess with any precision, can be conservatively put at tens of thousands; their time span from at least as early as the Middle Pleistocene up to the modern era; their size range from surface scatters no more than a few metres in extent to large mounds as high as a three-storey building and with as many as a billion mollusc shells. In many areas they are the most abundant and readily available source of information about the human past and, since the establishment of the first Kitchen-Midden Commission in 1848 by the Danish Academy of Sciences, they have attracted attention in relation to such diverse archaeological problems as absolute chronology, culture sequences, climatic and ecological reconstruction, trade, diet and population size.

In the present investigation we shall be concerned primarily with economic interpretation and specifically with two questions: how important were the molluscs as a source of food to the people who used the shell middens; and what factors determined the persistent exploitation of shellfood to form archaeologically impressive deposits of shells?

At first sight these two questions might seem so obvious as scarcely to justify a major investigation. One might suppose from the size of many of the shell accumulations that marine molluscs were a staple resource of considerable importance and that the occurrence of shell

middens was determined quite simply by variations in the reliability and abundance of the local shellfood supply.

From an early stage of the investigation, however, it was apparent that there were discontinuities in the distribution of shell middens, both chronological and geographical, not all of which were easily reconciled with discontinuities in the potential shellfood supply except by recourse to the archaeologist's favourite intellectual escape route - differential destruction of the evidence, or the more recently enshrined deus ex machina of differential demographic behaviour (Bailey 1973). A preliminary nutritional comparison with other resources also suggested that molluscs might generally have been of much less dietary importance than the archaeological quantities alone indicated, a view which was subsequently confirmed in detail as the enquiry progressed (Bailey 1975). It was thus felt necessary to broaden the scope of the study to include the general inter-relations between marine and terrestrial resources, a development which has often taken the investigation far from its initial starting point on the sea-shore.

Large-scale chronological discontinuities are of particular interest because of their potential bearing on the long-term development of the human economy. The earliest certain evidence for the consumption of marine molluscs dates from about 300 000 years ago at the open site of Terra Amata on the French Riviera (de Lumley 1966), and sporadic evidence has been recorded from other Pleistocene deposits in Europe, Africa and Australia. But by far the largest quantities of shell in all the major continents are exclusively confined to the Postglacial period, a feature which has suggested to some (e.g. Washburn & Lancaster 1968) the possibility of widespread intensification of economic activity preceding and perhaps causally connected with the complex economic developments commonly referred to as the emergence of agriculture, although the evidence is far from unambiguous because of the probable destruction of Pleistocene coastal sites by subsequent rises of sea-level. The problem of

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chronological trends in the occurrence of shell middens is, in any case, one which can only be solved after establishing the underlying factors which determine shellfood exploitation, and it is thus one on which the solution of the two problems which form the main focus of our enquiry should throw some light.

That the answer to the two questions we have posed is anything but obvious is indicated by the variety of opinions found in the major centres of midden analysis, especially with regard to the dietary role of the molluscs, ranging from the Danish view that shellfood is a resource of minor significance (Clark 1975, p.194; Petersen 1922; Troels-Smith 1960) to the view, commonly expressed in America and New Zealand, that it should be treated as a major food supply representing a staple resource, at least on a seasonal basis (Cook & Treganza 1952; Gabel 1967; Meighan 1969; Shawcross 1967a, 1970). The possibility that economies have occurred in which shellfood was the dominant resource has also been raised (Baumhoff 1963, p.230; Clark 1952, p.63; Evans 1969).

Much of this difference of opinion arises from the use of different methods of analysis and from the biases inherent in the various types of data available for study. On the one hand, it is arguable that molluscs are numerically very abundant in middens. Ecological sampling also suggests that the common edible molluscs are capable of yielding very high outputs of food. The bivalves, in particular, can, under certain circumstances, produce levels of output which, hectare for hectare, compare favourably with production on land (Shawcross 1967b; Wright 1927). On the other hand, it is arguable that these high levels of output are only possible with the application of intensive methods of cultivation and an advanced technology, or in relation to small areas, and that mollusc shells have a relatively high immunity to the usual sources of destruction which affect other food remains.

Varying opinions have also been expressed about the role of shell middens and the factors which influence their formation. A common hypothesis of long standing is that shell middens were permanently occupied settlements, a view which appears to have originated in the classic investigations undertaken in Denmark in the 19th century. The reasons for its adoption are of some interest, for it was clearly recognised as an alternative possibility that the Ertebølle shell middens might represent temporary summer camps used primarily for oyster consumption. Steenstrup, the zoologist on the Commission, suggested that this might explain the absence of polished stone, which at that time was thought to be characteristic of the period when the sites were occupied, on the assumption that the oyster gatherers had left their finer implements at settlements elsewhere. Worsaae the archaeologist, however, claimed that the middens were actual settlements which preceded in time the adoption of polished stone (Bibby 1967).

Further excavations undertaken to resolve the dispute failed to yield any polished stone, but they did reveal evidence of substantial occupation with abundant stone tools and other artifacts, pottery, numerous hearths, human skeletons and a diverse fauna of bird, fish and mammal bone, including evidence of exploitation in winter as well as summer, results which were presented in Affaldsdynger fra Stenalderen i Danmark, the publication in 1900 of the report of the second Kitchen-Midden Commission, and which were assumed to exclude the possibility of seasonal occupation (Madsen *et al.* 1900). Thus seasonal factors had been considered in these early investigations, but largely as an incidental element in what was then the more pressing problem of classifying the Stone Age.

A third possible hypothesis, that the shell middens represent seasonal settlements, as opposed to temporary shellgathering sites or continuously occupied settlements, does not seem to have been considered by the 19th century Danes, although the data available to them were

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equally consistent with such a hypothesis. In America the possibility of seasonal occupation was recognised from an early period (Nelson 1909) and continued to be raised as an alternative hypothesis from time to time throughout the middle decades of this century (Heizer 1960; McGeein & Mueller 1955), when the quantitative revolution stimulated by the analysis of shell-midden deposits in California was at its height. Yet the full implications of seasonal occupation failed to make much impact, and the preferred hypothesis of permanent occupation persisted (Ascher 1959; Cook 1946; Shumway et al. 1961), partly, it seems, because of the inconvenience of introducing yet a further variable into the already uncontrollable equation between population size, diet and chronology, and partly because of the ambiguity of the local ethnographic picture on the California coast, in which seasonal occupation is not everywhere a clearly defined characteristic. Seasonality of occupation was also being demonstrated in Europe at this time, although here too it failed to have much effect on interpretation until quite recently (Clark, J.G.D. 1954, 1971).

Donald Thomson, the Australian ethnographer, had demonstrated in 1939 the influence of seasonal factors on Aboriginal life and had emphasised for the benefit of the archaeologist the extent of movement between different sites according to the season of the year and the different activities carried on at each site. Yet this idea only began to have an impact on archaeological interpretation nearly a quarter of a century later, when Davis (1963) applied ethnographic data on seasonal transhumance to the prehistoric Desert Cultures of the Great Basin and showed how sites used at different seasons of the annual round were associated with different artifact assemblages and different types of food remains. In Europe similar ideas were being applied to the Palaeolithic occupation of northern Greece (Higgs et al. 1967). Since that time the influence of seasonality on the use of coastal middens and the importance of relating them to complementary sites in the hinterland

has become widely recognised in Europe (Coles 1971), Africa (Parkington 1972), Australia (Lourandos 1968; White & Peterson 1969) and New Zealand (Shawcross 1967b).

Another hypothesis prominent in the literature, especially in Europe, is that shell middens are indicators of a strandlooping economy (Clark 1952; Evans 1969), that is, a mobile economy, but one which is restricted to the sea-shore and whatever resources can be found in its immediate vicinity. The chief source of inspiration for this concept is the ethnographic record of Tierra del Fuego, where, as we shall discover in Chapter IV, there is evidence to suggest that economies of this type were associated with the formation of large shell mounds, and the introduction of the idea into the European literature appears to be due to Lubbock (1913), who compared these South American sites with the prehistoric shell mounds of Denmark, although the term strandlooping stems from the much older writings of the Dutch travellers in South Africa.

Apart from occasional references to the importance of water supply and shelter, there has been little serious discussion of the factors which determine the exploitation of molluscs and their accumulation as middens. Yet, if seasonal complementarity between coastal and hinterland sites was as widespread as has been suggested in the recent literature, then it must follow that the use of shell middens would have been dependent, at least to some extent, on the distribution and economic potential of the available non-molluscan resources, and a potentially rich field of enquiry into resource interactions is opened up. Only Shawcross (1970) has recently sought to develop a framework of analytical concepts, based on energetic principles, and mention may also be made of Peterson's (1973) analysis of mound formation in Australia, which involves somewhat similar considerations.

2. The Theoretical Basis

Economic Directives

The organisation of the human economy is subject to a variety of constraints or directives, some derived from the physical and biological environment, others from the socio-cultural environment. A useful means of integrating these various factors into a unified framework is the concept of economic directives.

These directives arise from the fundamental relationship which exists between the input of calories expended as subsistence effort and the output of calories gained from the food so acquired. They are, therefore, partly a function of intrinsic limitations of human behaviour and partly a function of external limitations in the biotope. On the input side major limitations are human nutritional requirements and extractive capacity, the latter varying with technological change; on the output side the productive potential of the available resources, which can be conveniently subdivided into four inter-related elements - nutritional value, potential food output per unit area, accessibility, and seasonal variability.

Potential food output per unit area, combined with nutritional value, is perhaps the most important of the economic directives, for it is this which ultimately determines how many people can be supported at a given site and for how long (Wynne-Edwards 1962). But the pattern of its operation is influenced and often distorted by two proximate limitations on economic output: accessibility and seasonality, directives which are of the first importance in understanding what constitutes a successful economic system.

(i) Accessibility and the Time-Distance Factor

A viable food supply must not only provide an abundant output of calories but it must also be available for consumption without requiring an excessive input of calories in the form of energy expenditure.

The most convenient expression of accessibility for archaeological purposes, because it links theory and practice via the concept of territory, is the time-distance factor (Higgs & Jarman 1975). This is a statement of the maximum distance over which it is feasible to walk from a given site to exploit a given resource, usually expressed in terms of time to accommodate impediments of topography or vegetation. The further away a resource lies from a given site, the less likely it is to be exploited from that site, until certain threshold limits are reached, beyond which the loss of calories expended in daily movement exceeds the gain of calories acquired as food.

The time-distance factor is a variable quantity, depending on the nature of the resource under consideration and the technology available for its exploitation. In the case of shellfood it is exceptionally low, resulting from the relatively low output of calories produced by a given live weight of shells, and is thus of crucial importance in directing how molluscs are exploited, where they are consumed and in what circumstances their shells are accmmulated as archaeological middens.

Indeed problems of accessibility are a major limiting factor in the exploitation of marine resources generally and place a high premium on the development of technology, especially water transport. This follows from the fact that the human species is essentially a terrestrial animal, incapable of distributing its numbers with comparable ease across sea as across land, and questions of access play a large part in our analysis of coastal economies.

(ii) Seasonal Directives

Seasonal directives arise in part from seasonal variations in the availability, accessibility or abundance of food supplies, but they also arise from the limiting effects of the time-distance factor and are thus likely to be present even in areas where there is little apparent seasonal fluctuation of resources. For, a group of people who stay in one place are likely in time to eat out the resources within easy reach and, by their continued presence, to cause a progressive increase in the energy costs of subsistence activity, until movement to another site becomes less "expensive" than staying in the same place.

Seasonal movement therefore offers two advantages to human groups: the integration of geographical and seasonal inequalities in the availability of resources, allowing a higher population to be supported than would otherwise be the case; and the maintenance of a stable, year-round food supply with the minimum of effort.

If it is correct to assume that the potential of population to increase in geometric ratio ensures that in the long run human numbers rise to the highest safe level commensurate with the resources accessible to exploitation and the available technology, then we would expect the palaeoeconomic record, as a reflection of long-term trends rather than short-term fluctuations or isolated episodes, to provide evidence of mobile economies as the general rule rather than sedentary ones.

As an illustration of some of the advantages to be gained from seasonal mobility, let us take the case of two complementary resource zones, for the sake of argument a coastal zone with an emphasis on marine resources and an inland zone focused primarily on terrestrial resources. Let us further suppose that each zone is subject to seasonal fluctuations of resources, such that the former is capable of supporting 500 people in the summer but only 100 people in the winter, whereas in

the latter zone the position is exactly the reverse. Then it follows that a mobile economy incorporating both resource zones would support a total annual population of 500, whereas two sedentary economies, each confined to a single zone, would be limited to the numbers that could be supported in the leanest season of the year, so that the total combined population would only be 200.

(iii) Food Storage and Investment Activity

The first potential objection to the hypothesis of a mobile economy is the possibility of food storage. Simple techniques of smoking, drying or freezing could easily have been applied in a great variety of circumstances, and it might be argued in the example above that preservation of the seasonal surplus in each regional zone would allow two sedentary populations to overcome the limitations of their respective lean seasons and to co-exist with a combined population at least as high as that supported by a mobile economy, but without the additional effort of large-scale population movement or the limitations imposed by a mobile existence on the accumulation of durable wealth.

Food storage, however, is an investment activity. It requires the expenditure of calories as subsistence effort without any immediate return of calories as food. Not only does it remove food from the current system of exploitation which might otherwise be available for immediate consumption, but it also diverts inputs of energy expenditure which might otherwise be harnessed to satisfy immediate food requirements. Large-scale food storage is thus likely to exacerbate in double measure the limiting effects of diminishing returns imposed by the time-distance factor by simultaneously decreasing the amount of calories available as food while increasing the amount of calories expended in exploitation. Whatever the longer term benefits to be gained from such a course of action, it is hardly surprising that seasonal movement should be the preferred response, since it offers comparable outputs of food but for

lower inputs of energy, except where exceptionally abundant seasonal resources suitable for storage occur or where complementary resource zones are not available or easily accessible.

This does not mean that food storage is unknown in simple economies. There are numerous ethnographic records of such activity on a small scale, but it is frequently combined with seasonal movement as an additional means of smoothing irregularities in the availability of food rather than as a complete substitute, and it is highly significant that one of the best known ethnographic examples of large-scale food storage refers to the Northwest coast of America, not only an area with a great seasonal abundance of salmon - resources which considerably mitigate the time-distance factor by travelling in large numbers to the consumer rather than requiring him to travel to them, but an area with a relatively inaccessible hinterland poor in complementary resources, as we shall discover in our examination of the ethnographic record in Chapter IV.

(iv) The Economic Optimum

A second potential objection to the hypothesis of seasonal movement lies in the concept of the economic optimum and specifically in the underlying assumption of the whole palaeoeconomic approach, that the patterns of economic behaviour prominent in the archaeological record can be accounted for solely in terms of the interaction between economic directives, reflecting the highest safe level of population size that can be supported with the accessible resources and the available technology.

This assumption directly conflicts with the much discussed proposition that hunter-gatherer populations underutilise their environment, stabilising their numbers below some postulated theoretical maximum and preferring to maintain a sufficiency of food rather than to take advantage of all the resources potentially available, a proposition which is

supposed to require the consideration of social behaviour (Sahlins 1972) or demographic behaviour (Binford 1968a; Smith 1972) as essential variables in explaining long-term economic trends.

Much spurious evidence has been claimed in support of this view, but the discussion here will be confined to the main points. In the first place there is a sense in which all societies underutilise their resources, and there is no reason why such behaviour should be regarded as an exclusive attribute of hunter-gatherers. Even our own society with its high-powered technology and its obviously growth-oriented approach to economic exploitation fails to utilise fully some parts of the environment, for example the aquatic resources of the deep oceans, because production is too expensive although technically feasible. The expense in modern terms is measured in money, but the principles involved are not essentially different from the operation of the calorific equation which we have suggested above as the fundamental directive of simpler economic systems. The critical question in every case is not what is potentially available but what is accessible without excessive expenditure of effort, and any theoretical maximum level of food output is meaningless unless stated in terms of the inputs of energy available for its exploitation. The life of idle affluence which is supposed to characterise hunter-gatherer populations is not so much a symptom of their unwillingness to exploit the environment more effectively but a measure of their success in achieving an optimum level of exploitation, that is a level at which the maximum return of food is obtained for the minimum expenditure of effort.

Once the problem has been stated in these terms, it becomes easier to understand the central paradox which has supported the protagonists of a socio-demographic approach in their view of economic prehistory, the apparent and widespread reluctance of hunter-gatherers to increase

their numbers by adopting agriculture as the basis of their economy in spite of the opportunity to do so.

The classic illustration of this paradox is the case of the Australian Aborigines, who never adopted more intensive methods of food production in spite of a long history of contact with their horticultural neighbours in New Guinea; in spite of the indigenous presence of several potential cultivars, including species of rice, millet, sorghum and yams; and in spite of a traditional knowledge of techniques of plant cultivation, probably of great antiquity, and their occasional application on a small scale (Campbell 1965). A similar phenomenon has been recorded from prehistoric California (Baumhoff 1963).

Plant cultivation, however, like food storage, is an investment activity. It requires that part of the current food supply be set aside to provide the basis of the following year's crop and that energy be expended not only in supplying immediate food requirements but in activities such as digging, planting and weeding, which will only yield a return of food at some later date. The immediate effect of a shift to large-scale cultivation, as with food storage, is thus likely to be an instant and sharp decrease in food output and a simultaneous increase in energy input - harder work for less food. Faced with the prospect of starvation in the short term for the sake of an uncertain and unguaranteed increase in food in the following year, it is hardly surprising that many well-established hunter-gatherer economies should resist the introduction of techniques of cultivation except on a small scale or as an occasional practice, and there is no need to invoke inflexible social systems resistant to change or a persistent lack of population pressure in order to explain the situation. In short, if selection pressures towards increasing food production are an underlying theme in the long-term development of the human economy, they are channelled and

checked by equally powerful selection pressures towards the reduction or minimisation of energy expenditure.

(v) Resource Interactions

A second source of evidence of some influence in promoting the view that hunter-gatherer economies are in some sense inefficient is Lee's (1968) work on the ! Kung Bushmen of South Africa, which showed that large quantities of mongongo nuts, one of the staple foods, were left to rot on the ground each year. It is clear, however, that water supply is a crucial limiting factor in the area, and, although precise data are not available, it is not difficult to appreciate that, if there is only sufficient water to support 200 people, then no amount of population pressure or ingenuity in social organisation will allow more than this number of people to survive in the long term however many more could be supported by the potential supply of mongongo nuts. There is the further limitation in arid conditions that exploitation is likely to be confined to those food supplies which are found close to a water supply, for water, unlike food, is not primarily a source of calories and is thus likely, when scarce, to exercise severe time-distance limitations on exploitation generally.

In the absence of more complete information about water supply, the case of the ! Kung Bushmen can hardly be used as a basis for generalising about the inefficiency of simple economies. Rather it underlines an important element in the operation of economic directives. For most economies involve more than one resource. Shell midden economies, for example, involve resources other than molluscs. Thus economic directives may operate at two levels. At one level there are those directives which derive solely from the intrinsic limitations of shellfood as a resource without reference to other aspects of the economy. At another level are those directives which derive from the exploitation requirements of the other resources in the economic system and which checked by capacity potential reflected [illegible]

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[illegible] There is the further limitation on such conclusions that cooperation is likely to be confined to those food supplies which are forced within a [illegible] [illegible], and it then likely, [illegible], to consider [illegible] [illegible] cooperation generally.

In the absence of more complete information about these supply, the case of the [illegible] can hardly be used as a basis for generalizing about the applicability of [illegible] cooperation. Rather it underlines an important element in the operation of [illegible]. For most commodities involve more than one processor. Small [illegible] processing, for example, involves processes other than extraction. Their [illegible] directives may operate at two levels. At one level there are those directives which [illegible] solely from the technical limitations of [illegible] defined as a [illegible] without reference to other aspects of the economy. At another level are those directives which derive from the requirements of the other processes in the economic system and their [illegible] may interact in such a way as to impose an over-riding directive on the exploitation of shellfood. Therefore, what constitutes an optimum level of exploitation for any given resource considered in isolation may well conflict with the optimum level of exploitation for the economy as a whole.

This is not to deny that social and demographic variables are important concomitants of successful economic activity or that, in the short term, they may conflict with economic directives, distorting the pattern of their operation or over-riding them completely. Indeed there is abundant evidence to suggest that small-scale fluctuations of this kind are a recurrent if short-lived phenomenon, their amplitude confined within the more or less narrow limits prescribed by economic necessity. The matching of human "demand" for food with potential supply is invariably a stochastic process even in the simplest economies, resulting in temporary instances of underutilisation or overexploitation of the environment. On the other hand, persistent disregard of the limitations imposed by economic directives may be expected to result before long in a correspondingly drastic corrective. Since prehistoric subsistence data commonly reflect smoothed trends of hundreds or thousands of years' duration, it seems reasonable to suppose that economic directives will be of primary importance in their interpretation, offering a secure vantage point from which to place non-economic variables in perspective, where the data demand their consideration, and a definable norm against which to assess the nature and extent of deviations, when these do become prominent in the palaeoeconomic record.

<u>Application of the Theory</u>

The study of shell middens offers a useful context in which to observe the application of the theoretical basis outlined above. For may interact, in more or less subtle ways, to determine [illegible] of the distribution of small towns. Ultimately, this combination of systems [illegible] level of explanation [illegible] given [illegible] explained in isolation may each [illegible] that highest level of explanation for the system as a whole.

[illegible] and demographic variables and [illegible] between [illegible] in time, in the [illegible] conditions, describing the [illegible] -- at [illegible] Fixed times [illegible] distinctive characteristics of each [illegible] developments, their amplitude [illegible] represented by [illegible] technology. The [illegible] the "law of" the [illegible] principal supply of inventories a [illegible] with [illegible] the tangible [illegible], resulting in temporary [illegible] of underrepresentation or overrepresentation of the settlements. On the other hand, persistent [illegible] of the distribution [illegible] may be expected to persist [illegible] long in a [illegible]. Since quantitative relations were commonly [illegible] of [illegible], it seems reasonable to suppose that [illegible] will be [illegible] in their interrelations, offering a secure vantage point from which to gauge non-economic variables or perturbations, where the data permit their consideration, and a reliable base against which to assess the nature and extent of deviations, when these do become prominent in the palaeoeconomic record.

Application of the Theory

The study of small [illegible] offers a useful [illegible] in which to observe the application of the theoretical bases outlined above. The if this has any validity, then the discontinuities which we have already noted as a general feature in the distribution of shell middens should yield simple explanations in terms of the operation and interaction of economic directives without the need to resort to social or demographic factors, and it is this expectation which has guided the general course of investigation.

(i) Territory

In one sense archaeological concepts of territory are simply operational devices, techniques for collecting data. But it should also be recognised that territories are theoretical entities, potentially powerful tools for interpreting continuity and change in economic behaviour (Higgs & Jarman 1975). This follows from the basic assumption of territorial analysis that the time-distance factor is a crucial variable in economic exploitation.

The practical value of territorial concepts is that they allow the analysis of economic directives to be transformed into a spatial framework which can be directly applied to archaeological data. As such the principles involved and the techniques of application play an important part in the present investigation and are considered in greater detail in Chapter III and Chapter V respectively. For the present it will suffice to introduce the two major types of territory in current usage, the site territory, which is the area habitually exploited around a given site, and the annual territory, the area covered in the course of the year, which may comprise two or more sites with complementary site territories (Higgs *et al*. 1967; Vita-Finzi & Higgs 1970).

(ii) Food Resources

The number and variety of resources exploited by a single human group is often a matter for comment, and ethnographic studies are notorious for their long lists of species, sometimes running into several

hundred names. In practice relatively few of these have any significant influence on population size and economic organisation. As Baumhoff (1963) has demonstrated for the California Indians, only three resources or resource groups were of major importance: deer, acorns and salmon. For analytical purposes, simplification of the resource list is both possible and necessary, especially with wide-ranging comparisons between different biotopes. It is therefore customary to distinguish staple resources, resources exploited on a regular and intensive basis which form a major support of the economy, and casual resources, occasional resources used as "medicines, relishes, and the like" (Higgs 1975; Vita-Finzi & Higgs 1970).

It has also been found useful in the present investigation to distinguish a further category of supplementary resources, resources exploited on a regular and intensive basis but which form only a minor contribution to the economy. The difference between supplementary and staple resource is one of degree rather than kind, but it does seem necessary to distinguish a resource which supported a human group for, say, six months of the year from one which supported it for only six days. The latter clearly has a different order of importance in its influence on the overall operation of the economy, although it may nonetheless be of crucial importance for those six days, when the human group might otherwise go hungry.

The exact boundary line between a supplement and a staple is necessarily an arbitrary one, and some resources may be of indeterminate importance, lying somewhere between the two extremes. But, in general, resources placed in the supplementary category are ones which appear capable of supporting the economy for a matter of days rather than months. It is arguable that such resources should be classified as casual, in order to avoid unnecessary additions to the terminology, but this term is hardly congruent with the idea of regular and intensive [illegible] In practice, relatively few of these have any significant [illegible] economic organisation. In [illegible] [illegible] only three parameters [illegible] [illegible] of the [illegible] in both [illegible] comparisons between [illegible]

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The chief boundary line between a supplement and a complement is necessarily an arbitrary one, and some parameters may be of indeterminate character, lying somewhere between the two extremes. This, in general, [illegible] placed in the supplementary category [illegible] rather than [illegible]. It is arguable that such [illegible] should be classified as [illegible] in order to avoid [illegible] but this is hardly consistent with the [illegible] exploitation, and it seems preferable to maintain a separate category, even if this should sometimes appear difficult to distinguish from staples and casuals at the extreme limits of its range, especially in view of the uncertainty about the relative importance of shellfood.

In view of the importance attached to seasonal directives, considerable attention has been focused on the identification of <u>complementary resources</u>. These are staple resources with mutually exclusive distributions which allow the support of a higher population when integrated into a single economic unit (Higgs & Vita-Finzi 1972). Seasonal movement is usually implied but is not a necessary condition of integration. For example complementary marine and terrestrial, or plant and mammalian, resources may lie within reach of a single site location, but these in their turn are likely to be complemented by additional resources elsewhere, except in the rare circumstance where they have exactly matching economic potentials, able to sustain a sedentary population throughout the year without seasonal underutilisation or overexploitation of the site territory. Some resources may also be economically complementary without having mutually exclusive distributions in the geographical sense, for example fish and aquatic mammals.

(iii) Archaeological Sites

An archaeological site may be defined as any deposit with evidence of human activity. Some archaeological sites, such as art sites and workshop sites, are not directly related to subsistence, although they may be useful indicators of a human presence, and they generally play a subsidiary role in this investigation.

Sites directly concerned with subsistence can be classified in two basic categories: <u>transitory sites</u>, used for a brief period of the year, usually for some limited aspect of the economy or in areas of intrinsically low economic potential; and <u>home-base sites</u>, used for a

more prolonged period of the year for the extraction of resources from a site exploitation-territory. The home-base cluster is a group of closely related sites which, in aggregate, are equivalent to a single home base but which, individually, are related to different aspects of its economy or to different periods of its occupation whether seasonal or secular. Factors which may influence such a clustering are the number of people supported by the site territory, which may be too numerous to be accommodated on a single site; seasonal shifts in economic emphasis from one part of the territory to another; or micro-factors such as shelter and water supply, which may be sufficiently crucial to influence changes of site location over small distances.

Preferred sites (Higgs 1975) are sites used over a long period or repeatedly visited and are usually contrasted with transit sites, with evidence of only brief occupation. These categories refer to the appearance of the archaeological data rather than to the economic function of the site. For, although it is generally the case that preferred sites are home bases or closely associated with home-base clusters, transitory sites may also come to be repeatedly visited over many hundreds of years, although never occupied for more than a few days in each year. Equally, not all home bases necessarily give rise to preferred sites but may sometimes comprise a cluster of transit sites. But, in general, it is assumed that there is a fairly close correlation between economic function and density of occupation as reflected in quantity of archaeological remains and duration of depositional sequences.

3. Intercontinental Comparisons

The differences of opinion illustrated above, whether about the interpretation of shell middens in particular or of economic behaviour in general, arise in part from attempts to generalise on the basis of

inadequate samples of human behaviour drawn from localised contexts or limited time periods. Every context includes local or temporary factors which impinge to greater or lesser extent upon universals of behaviour, distorting the pattern of their operation or concealing their presence. Thus observations confined to a limited chronological or geographical perspective are liable to confuse local factors of lesser theoretical significance with universal principles of organisation or even to deny that the latter exist; they are liable to give undue prominence to patterns of data which may be the product of unperceived biases inherent in the local record; and they are liable to prolong the uncritical acceptance of locally received opinions and hypotheses.

Considerable emphasis has therefore been placed in this investigation on wide-ranging comparative studies which cut across some of the conventional divisions of time, space and environment. An approach of this sort is to some extent demanded by the theoretical orientation of the thesis; if there are underlying continuities of economic behaviour, then it is only by long-range comparisons that we can expect to perceive and demonstrate their existence. It is also an approach which is greatly facilitated by the nature of the basic subject matter, shell middens, which, by their general uniformity throughout much of the archaeological record, provide a convenient axis of comparison along which to conduct such an investigation.

There are, of course, potential dangers involved in global perspectives: they may overlook local details which are arguably of great significance; they may encourage a superficial analysis of local data; and they may produce generalisations which are little better than banalities, reductions to a lowest common denominator of complex and variable phenomena. Yet, in spite of the risk of trivialisation and oversimplification which attends a global point of view, it is also the case that local facts and small-scale details can often be assigned

some significance only when viewed in a wider perspective. "Some information can be relevantly organised only at a small scale, whereas the orderly large-scale patterns of information are blurred or swamped altogether on the local scale." (Chorley & Haggett 1967, p.20).

Archaeological data would appear to be especially susceptible to large-scale thinking, not only because of the sweeping chronological and geographical perspectives which are opened up to view, but because of the many biases and deficiencies which affect the local record, putting many local details out of focus and rendering the successful analysis of small-scale problems beyond the resolution of the most powerful archaeological techniques. As Jarman (1972a) has recently demonstrated, prehistoric faunal remains are often inadequate to provide information about many detailed aspects of past economic practices but may, nevertheless, reveal broad regularities on the large scale and throw light on the operation of long-term trends of considerable value in the interpretation of the archaeological record.

Recent studies of the large-scale transformations involved in the growth of agricultural economies have also drawn attention to the broad similarity of the process in many different areas, stressing the presence of behavioural continuities beneath the façade of local diversity and the value of intercontinental comparisons in the development of a general theoretical framework (Carneiro 1970; Higgs & Jarman 1972).

The Archaeological Case Studies: Australia and Europe

In keeping with the theoretical basis of the investigation and the emphasis on wide-ranging comparisons, work has been carried out in Australia and Europe, and on each continent two areas have been selected for detailed examination in order to control the effects of regional distortion and to provide a balanced continental perspective.

In Australia many hundreds of shell middens are dotted around some 5 000 km of coastline. In order to select from this vast potential,

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attention was directed to areas with large shell mounds. Since many of these have been damaged or destroyed, there was little difficulty in narrowing the field of enquiry, and work was centred on the Richmond River of northern New South Wales near Ballina and at Weipa on the west coast of the Cape York Peninsula in northern Queensland.

Substantial mounds of oyster shell occur at Ballina, and, although much destroyed, there are records of their original extent and sufficient deposit available for excavation as well as an unusual combination of ethnographic and ecological data directly relevant to Aboriginal oyster exploitation. At Weipa there exists one of the finest series of shell mounds in Australia. There are about 500 sites in all, representing 200 000 t of shell, and the largest sites rise to heights of 12 m, which puts them among the largest shell mounds of the world. In both areas the total time range does not exceed 2 000 years and extends up to the period of European contact.

In Europe discontinuities in the distribution of shell middens are more marked. In part this may reflect differential preservation, but other factors are also involved. In any case only two areas have concentrations of shell middens in any abundance, Denmark and northern Spain. These two areas together provide a record of shellgathering extending over some 40 000 years, from the Mousterian period to the Bronze Age, although large shell middens in both areas are confined to a relatively restricted portion of this span - c. 6 000 to 5 000 BP in the former area and c. 9 000 to 5 000 BP in the latter. In Denmark the general distribution and size of the oyster mounds are not unlike some of the Australian sites and thus provide a convenient link between the two continents. The Spanish middens are much smaller on the whole, rarely more than 1 m in thickness and invariably accumulated in the mouths of shallow caves.

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These four case studies vary widely in their chronological span, in the character of the shell middens, and in the nature of the associated environments, which range from the Last Glacial conditions of northern Spain to the Australian tropics, so that they offer a diversity of contexts in which to examine the validity of generalisations and underlying principles.

They also vary considerably in the nature of the data available for study. In Australia, destructive processes have had less time to obscure the archaeological data relevant to the period when shell middens are most numerous than is the case with the older European sites. Many Australian middens have been dug away for lime in the course of industrial development during the past one hundred years or so, but there are some records of the extent and scale of destruction, so that its distorting effects on archaeological interpretation can be mitigated. The contemporaneous environment of the archaeological sites has also had relatively little time in which to undergo major changes since the time of occupation, so that certain features of the modern environment, particularly in the marine sector, can be used with some confidence in assessing the prehistoric economies. Anthropogenic change is a major factor in some areas, but is also largely confined to a recent period, so that reconstructions of the original situation are readily available. Ethnographic records can often be used to supplement the archaeological data too.

By contrast, the European midden data, although they largely lack these particular advantages, have two compensating factors, which allow a control on archaeological interpretation which is at present unavailable in Australia: a long time-depth extending back to at least 40 000 years; and more than a century of archaeological investigation, providing a basic framework of data from which to work. In Australia, human occupation

has been recorded as early as 30 000 BP (Bowler et al. 1970), but the majority of known sites are confined to the last few thousand years of this time span, and most of these are coastal middens. Many sites in the hinterland most probably exist but await discovery. Even on the coast, excavations designed to establish a local archaeological sequence are still very much a priority.

Thus, what Australiandata gain in potential detail of analysis and reconstruction is tempered by a lack of focus at a larger scale of interpretation. Conversely, what Europe lacks in terms of small-scale details is compensated by the broader scale of observation which the data allow. The contrasts between the two continents in this respect are a striking illustration of the way in which the gaps and biases of archaeological data in different areas may complement each other, allowing the possibility of a more balanced interpretation than would be available if attention were confined to a more limited perspective, and an attempt has been made to develop this opportunity to the fullest advantage in the interpretation of the archaeological analysis.

To some extent the detailed exposition within each case study is bound by the nature of the locally available data to follow a somewhat variable course, but as far as possible a standard format has been maintained throughout in order to concentrate on the central problems of interest and to facilitate long-range comparisons. There is first an opening section which introduces the archaeological background of the area, the nature of the available data and the problems posed by them. This is followed by a review of the major resources available for prehistoric exploitation and the climatic, topographical and vegetational limitations on their economic potential. Particular attention is focused on the distribution of potentially complementary resources, and the probable pattern of economic integration is hypothesised and substantiated, where possible, by already existing archaeological data from

site distributions, excavation reports and ethnographic data. There follows the detailed analysis of the archaeological data under the major headings of midden analysis and site catchment analysis and a concluding section reviewing and integrating the various results.

Although each case study can be treated in isolation as a self-contained piece of analysis, each area has offered unique opportunities to examine in closer detail a particular aspect of the general theme of investigation, and the four case studies together form a logical progression, commencing with detailed, small-scale analysis in New South Wales. Each of the subsequent chapters extends and builds on the results of the preceding, culminating with large-scale interpretation in northern Spain.

The archaeological analysis opens in Chapter VI with the Ballina oyster mounds. This case study focuses in particular on the crucial problem of the relative dietary importance of molluscs and the occupational significance of large mounds of shell, since it is here that the most detailed analysis of these issues has been possible. The Queensland area examined in Chapter VII allows these results to be extended to the more substantial group of mounds at Weipa and also broadens the discussion to a more detailed consideration of site distributions and their relationship to patterns of access. Large-scale geographical discontinuities also come into focus for the first time. Analysis of the European data commences in Chapter VIII with the Ertebølle middens of prehistoric Denmark. The shell middens of this area are generally similar to the Australian sites in terms of size and distribution and thus offer the smoothest transition from an Australian to a European perspective. As well as testing the conclusions already arrived at, this area allows the discussion to be extended to the question of chronological discontinuities. Chapter IX considers the Asturian shell middens and related

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sites of northern Spain. Althogh this area is the least satisfactory for small-scale studies, especially with regard to the analysis of on-site data, it also presents the most sweeping regional perspective, in which large-scale chronological and geographical discontinuities come into sharp focus, and it thus provides a fitting framework in which to bring the analysis to a close.

CHAPTER II

CONTINUITIES OF SHELLFOOD EXPLOITATION
THE ECOLOGICAL BACKGROUND

There is a substantial body of data available about the major species of molluscs exploited in prehistory, and, although the quality of these data is highly variable, a coherent pattern emerges on the global scale which offers a convenient basis for examining the influence of ecological factors on shellfood exploitation and a useful introduction to the problems posed in interpreting continuities of economic behaviour.

1. The Major Types Of Edible Molluscs And Their General Ecology

The term "shellfish" embraces a wide range of marine and terrestrial organisms from several different phyla. There are crustaceans such as barnacles, lobsters and crabs; echinoderms or sea-urchins; and the molluscs themselves. The mollusca are the second largest major group in the animal kingdom with over 100 000 species, of which about 50 000 are marine, and they are subdivided into five classes: Amphineura - chitons or coat-of-mail shells; Scaphopoda - tusk shells; Cephalopoda - including squid and cuttlefish; Bivalvia - also known as Pelecypoda or Lamellibranchia, which include marine and freshwater forms; and Gastropoda - snail-like creatures of marine, freshwater or terrestrial habitat.

All these groupings have left their trace in the record of past subsistence, but we shall be concerned in detail only with the marine bivalves and gastropods. These are the most abundantly represented in the archaeological record and they also form a convenient and relatively homogeneous grouping in terms of general ecology and economic potential. It is true that consumption of terrestrial and freshwater molluscs has occasionally resulted in large mounds of debris,

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notably the escargotières of north-west Africa (Vaufrey 1936) and the fresh-water shell mounds along the larger inland rivers of Australia (Mitchell 1949) and North America (Morrison 1942), but such deposits are less numerous than their coastal counterparts and will not be examined in detail. Unless otherwise stated, the use of general terms such as "shell" or "shellfish" refers only to the marine bivalves and gastropods.

The number of edible species within these two groupings runs into many hundreds, if not thousands, on the world scale, and it is a commonplace that the total list of species recovered from a single midden may be quite extensive, especially in tropical areas. The most impressive "shopping list" of this kind is recorded from the island of Yap in the western Pacific, where 167 species are listed from coastal sites (Gifford & Gifford 1959). However, it is usually the case that up to 90% or more of the molluscan remains from a given midden can be accounted for by one, or at most two, dominant species, and, if one considers only these dominant species, it is possible to reduce this list to more manageable proportions.

A sample of middens across the world and the major types of molluscs represented in them are shown in Appendix A and Figure II:1. This sample is not intended as a complete catalogue and, being based mainly on published reports, it is obviously limited by the progress of investigations in different areas and the quality of the available information. However, general surveys are sometimes available to supplement the data from site reports, and personal experience of the overall situation in Europe and Australia suggests that the sample is sufficiently representative to bring out some general features in the distribution of molluscan types. If there is any bias, it is most probably towards under-representation of the situation in tropical latitudes, where relatively little information is available.

In practice much of the diversity of species names in Appendix A reflects variations in ecological factors such as temperature, which are not directly relevant to discussions of human subsistence, and it is possible to reduce the list to a small group of categories which can be treated as internally homogeneous from the point of view of economic potential. Of these, six have

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been isolated for detailed study: abalone, limpet, clam, cockle, mussel and oyster. While these are not fully comprehensive, they do account for the greater part of world shellfood consumption, and they are adequate to provide a broad understanding of the ecological factors which affect economic exploitation. Although the abalone is not recorded as a dominant species in Appendix A, it has been placed in the basic list in preference to other gastropods, such as the turban shell, because it is quite an important secondary species in the shell middens of at least three continents. Also its distinctive behaviour illustrates some important limitations of shellfood exploitation.

All the marine molluscs of economic importance to man are sedentary, bottom-dwelling animals which live in the shallow-water zone of the sea. They are "grazers", feeding on the microscopic plant organisms - collectively known as phytoplankton - which occur in great abundance in the shallow-water zone, where exposure to sunlight and consequent photosynthetic activity are greatest, or on the weeds and algae which grow attached to the bottom. Although commonly regarded as intertidal organisms, they are not exclusively confined to the area between tide-marks but may be found at any depth where conditions of substrate, food-supply and protection from predators allow.

The representatives of the gastropod grouping, the limpet and the abalone, are snail-like creatures with a large foot which enables them to adhere to hard surfaces and to move around to a limited extent in search of food. They are confined to exposed rocky shores and scrape off the weed and algae covering of the hard bottom with radulae - long tongue-like ribbons with rows of microscopic teeth. They are not particularly prolific as a source of food for human consumption because of ecological factors limiting their abundance or because of difficulties of access.

The bivalves occur in a variety of ecological situations, depending on the method by which they attach themselves to the bottom. Some, like the clams, are burrowing creatures and are therefore restricted to soft sediments; others, like mussels, can attach themselves to a wide variety of surfaces.

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However, it may be stated as a general rule that the greatest abundance of bivalves occurs in shallow, sheltered waters, such as river estuaries, lagoons or sheltered inlets, although there are some exceptions to this, notably in North America, where sand-burrowing clams are sometimes found in enormous numbers on exposed beaches (Fitch 1950).

The preference of bivalves for estuarine situations is determined by a complex of factors. Some of the species of the clam and cockle group are restricted to such areas by the need for undisturbed muddy sediments. However, there are several other, more general advantages: the shallow-water zone in estuaries is often very extensive, allowing the establishment of large breeding populations; the formation of eddies and areas of slack water ensures dense settlement of the spat; and the movement of water across the shallow tidal flats provides a constant replenishment of nutrients. The reduced salinities that are commonly found in river estuaries may also be a favourable factor, either because they directly favour the food supply of the organism, or because they discourage predators.

Like the gastropods, the bivalves are grazers, but their method of feeding is quite different. Being permanently attached to a given spot, except for a brief free-swimming period as larvae, they are dependent on the food that is brought to them by the movement of the water. They are mostly filter feeders - that is they open their valves when covered by the tide and pump water through their digestive tracts where phytoplankton and other small particles of food and detritus are trapped. The burrowing species have long syphons for this purpose.

Although an individual mollusc may yield many millions of larvae, annual production fluctuates considerably and recruitment is often irregular. Major sources of mortality are climatic disturbances, such as storms, frost damage or heat kills, and predation. Living on the junction between sea and land, molluscs are liable to predation from a variety of animals apart from man, including bottom-feeding fish, boring whelks, crabs, starfish and gulls.

Limpet

The conical shell of the limpet is a common sight on most rocky shores. During feeding, which occurs usually when it is covered by high water, the limpet moves up to 60 cm from a central resting spot, browsing in a rough circle around its home (Yonge 1969). This is, incidentally, an interesting illustration of the influence of the time-distance factor on the economic life of the limpet, and suggests that the principles involved in the application of archaeological concepts of territory may have a wider relevance to the animal world as a whole. At low tide the limpet may continue to move around slightly, but it is more likely to be found with its shell tightly clamped to the rock in order to resist dessication or the approach of a potential predator.

The limpet is one of the few edible molluscs which is strictly intertidal in habits, and the extent of its distribution is therefore closely tied to the degree of tidal movement and the slope of the shore. In general it thrives most successfully on exposed wave-beaten rocks (Southward 1964; Sutherland 1970). Since these are often by their very nature steeply-shelving, the area available for habitation is inevitably narrow, and the quantity of food represented is quite small and difficult of access. Even on gently shelving shores, limpets are likely to occur in a relatively narrow band no more than about 50 m wide and, while the maximum density in areas of maximum concentration may be quite high - up to 1 000/m^2 in Europe (Fischer-Piette 1948) and 1 700/m^2 in America (Sutherland 1970), average density over a stretch of shoreline is naturally much lower.

If approached cautiously, limpets may easily be removed by a sharp kick or a blow from a stone or piece of wood. However, if they are tightly clamped to the rock surface, no amount of exertion will remove them without first crushing the shell, unless a steel-bladed knife is to hand. Lothrop (1928) illustrated the head of a "limpet-spear" used by the Yahgan of Tierra del Fuego. This consists of two wooden prongs about 40 cm long with flattened chisel-like ends forced apart by a small toggle. Attached to a long stick

this would seem to provide an ideal labour-saving device for scooping up limpets unawares. In its simplest form the collection of limpets could be carried on without any technology at all; limitations on their exploitation arise more from problems of access imposed by high tides and rough seas than from lack of tools.

Abalone

The abalone, like the limpet, is found on wave-beaten rocky shores, where it clings to the bottom with its powerful foot and makes occasional forays to feed on weed and algae. Unlike the limpet its distribution tends to be subtidal. Although some individuals may occur in small numbers in the intertidal zone, the largest specimens and the densest concentrations occur in deeper water down to about 40 m. Thus, while some collecting is possible in the intertidal zone without getting wet, or by wading in shallow water, the supply at this level is easily exhausted; further exploitation requires diving and the use of boats to reach offshore grounds (Anon. 1964; Bonnot 1948; Newman 1966). Apart from the problem of gaining access to deeper water, weather conditions may also limit exploitation. For example, it is worth noting that, even under modern conditions with motorised boats and diving gear in the California fishery, the abalone diver averages only about 12 working days per month because of unsuitable bottom conditions or bad weather (Ebert 1969).

Abalones may occur in large aggregations of up to 20 000 individuals with densities of 15-20/m^2 and are sufficiently abundant to support commercial fisheries in certain parts of the world (Ebert 1969). Individual abalones may reach a weight of nearly 2 kg - more than 100 times bigger than the largest limpet - and can be levered from the bottom with comparative ease using wooden or bone spatulae like those recorded for the purpose in ethnographic accounts (Hamilton 1908; Hiatt, B. 1968; Kroeber & Barrett 1960), so that they offer some advantages to compensate for the greater difficulties of access involved in their exploitation.

Clam

Clams are characterised by a preference for soft shores where they can burrow beneath the surface - up to 20 cm in the case of Scrobicularia for example (Hughes 1969) - and the possession of siphons with which to suck food from the surface. They usually occur from the midtidal level down and are often most abundant near the low water mark or in the subtidal zone. Large, densely concentrated beds occur, but these are erratic in their distribution and may vary from year to year (Hanks 1969).

They occur in both estuarine and exposed-shore situations, but the species which prefer exposed sandy beaches are more liable to disturbance and destruction and generally represent a less abundant and reliable resource. At least this is the case with the "pipis" of Australia and New Zealand (Plebidonax sp., Amphidesma spp.). On the other hand the Pismo clam (Tivela stultorum) of Lower California is capable of yielding commercial quantities, albeit with the aid of such modern devices as spades, forks, rakes and boats (Fitch 1950; Tressler & Lemon 1951). However, there is no clear information about the abundance of this sand-beach species in prehistoric middens, and viewed on the world scale the most abundant deposits of clam shells usually occur in estuaries.

In simple economies clams can be collected either by searching for the siphon holes at low tide and digging the shells out individually using a wooden or bone lever or by wading in shallow water and feeling for the shells with bare feet - a method which also allows the mud to be washed off (Greengo 1952). Boats are not essential but would provide easier access to mud flats at some distance from the shore. Lack of effective digging equipment would also limit the exploitation of the deeper burrowing species, as for example with Panope generosa, a large and meaty Californian mollusc which burrows to a depth of 1 m and more and is consequently absent from the prehistoric middens of the area (Greengo 1951).

Cockle

Cockles are quite similar to clams in general habits except that they lack siphons and prefer sandier conditions where they can lie half buried in the surface instead of burrowing beneath. They occur in densely populated and irregularly distributed beds between the mid-tide and low-tide level and sometimes in the subtidal zone as well. In the Burry Inlet of South Wales for example there are about 60 km^2 of tidal flat suitable for cockles (Cerastoderma much of it exposed at low tide, but only about 20% has dense settlement (Hancock & Urquhart 1966), and similar irregularities of distribution are typical of Anadara and Chione (Pathansali & Soong 1960; Shawcross 1972). Cockle beds are also liable to shift from year to year because of failures in spatfall recruitment, smothering by siltation, storm disturbance, frost damage or other factors (Wright 1927).

The effects of accessibility on exploitation and the technological requirements are much as for the clams - diving, treading under water and collection from boats or by hand at low tide all being used. The difficulties of access are illustrated by the British cockle fishery, where the richest beds lie several kilometres offshore, and viable exploitation is only possible with the aid of mechanical transportation. In South Wales the horse and cart is used to carry bags of cockles across the mud flats at low tide; elsewhere boats are used (Franklin 1962).

Mussel

Mussels attach themselves to hard surfaces by means of the byssus - a network of threads secreted from the beak of the shell. They are usually limited to stony beaches and rock surfaces, but they are also capable of colonising firm muddy tidal flats by clinging together in clusters, especially where the water current is weak. However, mussels in the latter situation are vulnerable to destruction by smothering with silt or by slight changes in the river channel (Wright 1917). They may be found in some quantity at any level of the intertidal zone down to a few metres depth in the subtidal. Some

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species such as the California mussel (Mytilus californianus) are found in greatest abundance on exposed rocky shores, but the largest beds of the European mussel (Mytilus edulis) usually occur in dense aggregations at or below low-water mark in river estuaries (Simpson 1960). Individual meat weight is likely to be greater at this level also since feeding activity is less often interrupted by exposure at low tide (Baird 1966).

Mussels can easily be collected by hand at low tide, especially in open-shore situations, while subtidal beds would require wading at least, if not swimming and diving. Bird (1946) supplies detailed information about the methods used by the Alacaluf of Tierra del Fuego to collect the South American mussel (Mytilus magellanicus, M. ungulatus), which is evidently found to a considerable depth in the subtidal zone. Mussels down to a depth of 5 m were collected from boats using long spears, and in deeper water down to about 10 m either by swimming out from the shore and diving or by diving from boats. In the latter case the shellfish were removed from the bottom by hand and placed in baskets held in the mouth. Data on the size of these underwater mussels are not given, but it is clear that they were larger than the inter-tidal mussels, and it is probable that, like the abalone, their size was sufficient to justify such energetic measures even in water which was scarcely above freezing temperature.

Oyster

There are two types of oyster, Ostrea and Crassostrea, distinguished by different methods of reproduction and slightly different ecological preferences. The former prefers more saline conditions near the mouths of estuaries, the latter waters of lower salinity further upstream, but in other respects they can be treated together. Both require a firm substrate of firm mud, muddy sand or muddy gravel mixed with shells. The most productive beds usually occur near the low-water mark or permanently submerged, since growth is unsatisfactory if they are exposed for long periods of the tidal cycle, as with the mussel (Cole 1956a; Waugh 1960).

The oyster larvae have a well developed gregarious tendency and show a marked preference for settling on surfaces used by previous generations of oysters, so that, as a general rule, oyster beds are comparatively stable and enduring in contrast to other bivalves.

Relative Frequency

In so far as it is possible to assess the relative representation of these major categories of molluscs in the rather heterogeneous sample of world middens available for study, oysters would appear to be the type which recurs most often and in greatest abundance, while clams and cockles come a close second. Mussels are further behind, although differential preservation may be a particularly potent bias for this category with its relatively fragile shell; it is, in any case, of wide distribution. Limpets are also widely distributed but generally of lesser importance than the others. The abalone, although potentially abundant, has a rather more local distribution and lies at the bottom of the list.

2. Distributional Trends And Biases

It is only to be expected that local and regional variations in shore ecology have some effect on the representation of molluscan types. Long-term ecological changes are also likely to have occurred, especially in response to the eustatic rise of world sea-levels, which appears to have progressed rapidly from -130 m about 14 000 years ago to about -20 m 7 000 years ago and thence more slowly to the present day (Emery & Milliman 1970). This has not only been a major cause of changes in shore ecology but most probably a major destructor of midden evidence.

Europe

Major biases in the European data result from destruction of evidence rather than inadequacies of investigation: most of the evidence of prehistoric

shellgathering refers to a period of 5 000 years ago or more, since when major changes of sea-level in relation to land have occurred. Quite apart from the eustatic rise of sea-level, large areas of the European coastline have been sinking quite rapidly during the past 10 000 years, especially in south-east England and the Low Countries (Churchill 1965), so that any coastal sites that may have been formed in these areas during the Mesolithic period or earlier have long since been washed away or buried under many metres of silt. Those that remain have survived because of isostatic uplift, as in Britain and Denmark, or because of their fortuitous location at some distance away from and above the contemporaneous shoreline, as in Spain and Portugal. More detailed examination of the effects of changing sea-levels will be found in Chapters VIII and IX.

The regular recurrence of Cerastoderma, Ostrea and Patella is worth emphasising and in general reflects the dominant edible species available on European shorelines. The mussel (Mytilus edulis) is a regular occurrence in prehistoric middens but rarely in any quantity. This contrasts with its great commercial abundance in the estuaries of north-west Spain, England, France and Holland. It is possible that mussel-dominated middens once existed in the above areas but were subsequently destroyed by changes in the level of land and sea or by weathering of the relatively fragile mussel shell. Another possibility is that mussels only thrive in abundance under modern methods of cultivation. Clams are also rare in European shell middens, in contrast to the situation elsewhere. This too may reflect biases of preservation. Ecological factors may also be involved, although Mya arenaria is certainly common in British waters (Yonge 1969). At any rate clams play as small a role in modern shellfisheries as in the prehistoric record, which suggests the presence of some persistent local deterrent to their exploitation.

Another feature worth noting is the continuity over time in the species represented; the dominant species of the prehistoric past are often the ones that play a dominant role in modern exploitation. The major apparent discrepancy here is the limpet, which, unlike the bivalves, is not only not

of commercial importance today but also of far greater antiquity in the record of prehistoric exploitation. It is certainly recorded at least as far back as the Mousterian period, about 40 000 years ago or more, at Cueva Morin in northern Spain (González Echegaray et al. 1971) and at Devil's Tower on Gibraltar (Garrod et al. 1928), although not in especially large quantities. As for their lack of commercial importance, limpets, as a rocky-shore species, simply do not occur in sufficient abundance or in circumstances susceptible to efficient methods of collection. However, limpet-dominated middens are recorded from most periods up to at least Roman times (Townsend 1967); limpets were also collected during the Irish famines of the last century (Patterson 1839); they are commonly collected today on the coasts of France and Spain; and, as far as one can judge, they have persisted as a local item of diet more or less continuously from the late Pleistocene up to the modern era.

Bivalves, on the other hand, although potentially more abundant than limpets, make a relatively late appearance in the prehistoric record. There are scattered specimens in Palaeolithic deposits, but there is no evidence of collection in quantity until about 7 000 BP - well into the Postglacial period. While it is possible that this may reflect long-term trends in subsistence behaviour, ecological factors may also be involved. Limpets are especially characteristic of steep, rocky shores; they are therefore more likely to be carried back to middens at some distance from the shore and some altitude above it; thus they have a better chance of surviving destructive changes of sea-level. There is no reason to read into the late appearance of bivalve middens anything more than the hazards of preservation.

Africa

In contrast to Europe, the major gaps in the record of shell middens are probably the result of lack of investigation. Only the Mediterranean coastline in the north, Cape Province at the southern tip of the continent and parts of west Africa have so far been extensively investigated. In the two former areas rocky-shore species predominate - limpets in the north, limpets and mussels

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in the south - which reflects the more open nature of the coastline in both areas and the relative lack of large inlets and estuaries. Abalones (<u>Haliotis midae</u>) are also quite abundant in some middens (Parkington <u>pers. comm.</u>). Only in west Africa has recent investigation shown the existence of extensive bivalve middens alongside the coastal lagoons and river estuaries of Mauretania (Elouard 1969), Senegal (Linares de Sapir 1971) and the Ivory Coast (Mauny 1973).

Shell middens are particularly sparse along the Mediterranean coastline, being chiefly confined to occasional small deposits of limpets in coastal caves in Libya, Algeria and Morocco, of which the Haua Fteah is the best known and most important (McBurney 1967). Under natural conditions the Mediterranean is rather unproductive of shellfish. The steep, rocky nature of much of the shoreline is partly responsible for this, but the major factor is the lack of tidal movement. This means that rocky-shore species such as limpets, whose distribution is closely controlled by the extent of the intertidal zone, are restricted to a narrower band of shore than usual, while the soft-shore bivalves are inhibited by the high rate of sedimentation resulting from lack of tidal scour in inlets and estuaries and by the more sluggish turnover of phytoplankton. That concentrations of bivalves may occur is demonstrated by some of the middens on the European side, such as Coppa Nevigata (Puglisi 1955) and Sidari (Sordinas 1969), in which <u>Cerastoderma</u> predominates. But these sites are not as numerous, large or as long-lived as the estuarine mounds of Atlantic Europe or west Africa, and the extensive development of the oyster and mussel industry in the Mediterranean in recent times has been made possible only by the introduction of intensive methods of cultivation.

African shorelines have yielded two sites of importance in extending the record of shellgathering back into the Pleistocene, the previously mentioned Haua Fteah in Libya and Klasies River Mouth in South Africa (Voigt 1973). Both sites have deposits containing molluscs which extend from recent times back into the Last Interglacial period about 70 000 or more years ago, although the sequence at the latter site is not continuous. In both cases limpets are the dominant species throughout, providing a comparable record of long-term

continuity to the European data. Also as in Europe, bivalves make a late appearance; apart from small quantities of mussels in the Klasies River Mouth sequence, the large bivalve middens do not appear until about 6 000 BP (Elouard 1969).

Asia

There are numerous shell middens recorded in south-east Asia, the best described groups being in the Soviet Far East (Okladnikov 1965) and in Japan (Groot & Sinoto 1952; Kidder 1959). Elsewhere there are only scattered reports, and the overall reliability of the molluscan data is difficult to assess. Crassostrea and Meretrix are clearly of widespread importance and both are intensively cultivated at the present day, especially in Japan.

Mussels appear to have been of at least secondary importance along the Russian coastline but are not recorded in Japan or elsewhere, in spite of the presence of various species of mussel throughout the area today (Davies 1969). Their absence in middens may be due to their preference for hard surfaces or open-shore situations, whereas the most detailed archaeological information comes from estuaries where such conditions would typically be lacking. It is also worth observing that mussels are not commercially exploited anywhere in the region in spite of the intensive economic pressure exerted on other species, so that their absence from the prehistoric record may be due to some local factor inhibiting any form of human exploitation.

The absence of any record of limpets may also be accounted for by bias in the location of the middens so far studied or, less probably, by the unsuitability of the shore ecology.

Cockles are intensively cultivated in parts of Malaya today (Pathansali & Soong 1960), but are a secondary, albeit regular, occurrence in prehistoric middens. Whether this contrast is due to gaps in the archaeological data or to other factors, it is not possible to say.

Australasia

Apart from small groups of middens on some of the South Pacific islands

and New Guinea, major concentrations occur on the southern and eastern littoral of Australia and on the North Island of New Zealand. Australia provides the largest sample of middens as well as the most varied, although many sites in the south-east have been dug away since the last century to provide building material (Carne & Jones 1919). However, sufficient remnants and records exist to provide data on the dominant species, and many sites remain intact as intensive surveys in several areas have recently demonstrated (Campbell 1969; Jones 1967; Lampert 1971a; Ponosov 1965).

The shorelines in this part of the world are characterised by open coastlines with rocky headlands and rock platforms alternating with long, sweeping, sandy bays and punctuated at more or less frequent intervals by river estuaries with extensive tidal flats, and all the major categories of shellfish are represented in prehistoric middens. Cockles (Anadara spp.) and oysters (Crassostrea and Ostrea) are the most abundant, followed closely by clams, which are represented most frequently by the surf clam, or "pipi", of the open sandy beach (Plebidonax) and less often by mudflat species such as Dosinia. Mussel-dominated middens are less frequent and the best known are in open-shore situations, as of course are the limpet middens. Abalone (Notohaliotis ruber) is consistently represented, although rarely in a dominating position, in the open-shore middens south of Sydney to Victoria and Tasmania, coinciding with the natural distribution of this species in this region. The most important addition to the basic list is the turban shell (Subninella undulata), a large and meaty gastropod of rocky shores which is quite easily collected low down in the intertidal zone. It is a regular secondary occurrence in many open-shore middens and occasionally the dominant species as in the quite substantial mound of West Point in Tasmania (Jones 1966).

Abalones, oysters and mussels are all exploited on a commercial scale at the present day. The open-shore clam rarely occurs in sufficient abundance or regularity to justify such attention, while the cockle has not so far been the object of commercial interest, although the extensive beds in Port Hacking south of Sydney were the scene of intensive collecting by Italian immigrants

until recently when the area had to be closed off to the public because of overexploitation. Aboriginal exploitation along traditional lines still persists in parts of northern Australia.

America

The major evidence of shellgathering is in North America. As in Australia there is a varied coastline which has yielded a large sample of middens extending up to the modern era and impaired only by the destructive activity of commercial enterprise since the last century (Holmes 1910). In addition to numerous site reports, surveys of Aboriginal shellfood exploitation are available (Greengo 1952; Hubbs & Roden 1964; Lambert 1960).

Oysters, especially Crassostrea virginica on the Atlantic coast, and clams are the two groups most abundantly represented. In addition to the species mentioned in Appendix A, the Pismo clam (Tivela stultorum) and the razor clam (Siliqua patula) are of local importance on sandy beaches and Protothaca staminea in estuarine conditions. Cockles are of importance in some areas, notably Clinocardium on the north California coastline and to a lesser extent Chione. Mussels are represented by open-shore species (M. californianus) and estuarine (M. edulis) and appear to be of most importance on the Pacific coastline. Abalones (Haliotis cracherodii and H. rufescens) are quite abundant in California, and limpets of various species (Acmea spp., Megathura, Lottia, and Fissurella) are of regular secondary importance throughout the Pacific coast. Turban shells (Tegula spp.) are also of importance in certain areas.

Clams, especially Mya arenaria on the Atlantic and Tivela on the Pacific, support commercial fisheries as does Crassostrea on the Atlantic and abalone (mainly H. rufescens and H. corrugata) in California. The Pacific oyster (Ostrea lurida) rarely dominates in middens, nor is it of commercial importance to-day having been ousted since the 1930's by the importation of the Japanese oyster (C. gigas).

Shell middens in South America appear to be equally as abundant as in the North, but, apart from brief notes on the concentration of middens in

Tierra del Fuego and incidental data elsewhere (Gilmore 1946), little detailed information is available. Middens dominated by oysters, clams or mussels all occur, although it is not clear what is their relative importance on the continental scale. Limpets are represented by species of Fissurella and Concholepas. Abalones are not recorded, not surprisingly, since few are known to inhabit this area of the world. The only other species recorded in any abundance, apart from Cyrena, which is strictly a brackish or fresh-water species, is Strombus pugilis, a large gastropod described as the "staff of life" of the inhabitants of the Antilles in the Caribbean (Gilmore 1946, p. 422).

In California there is evidence of a transition from gastropods to bivalves not unlike that discussed in Europe and Africa. On the middens of the open shore there appears to be a change-over from rocky-shore species, such as limpets, in the early periods of the Postglacial to the sand-dwelling Pismo clam in the later. Although this was originally explained as cultural preference (Meighan et al., 1958), Hubbs and Roden have offered a more plausible ecological explanation: the rise of sea-level in the early Postglacial would have maintained rocky shores by continuous erosion of cliffs, but the more recent approach to a steady state would have allowed an increase in the formation of sandy beaches (Hubbs & Roden 1964, p. 174). A similar transition occurs in the middens of San Francisco Bay. Oysters are abundant in the lower levels but give way to the estuarine clam, Macoma, in the upper levels. This transition has also been explained by the rise in sea-level and the effect this would have in increasing sedimentation and altering the substrate in favour of the burrowing clam (Greengo 1951).

Continuities

Viewed from such a lofty point of view, it is inevitable that local details and variations will be blurred and only the broadest of regularities will be visible. However, it is precisely this broad perspective which we wish to

concentrate on here, for it does bring into focus the presence of some general order in the data, subsuming the many local and regional patterns which are the individual elements of the world picture.

The influence of ecological variation is clearly visible at this level. Wherever data are available, the dominant species in prehistoric middens are those which dominate the available supply in the local environment. Continental patterns of variation emphasise this ecological relationship on a broader scale. For example, the predominance of clams and oysters in North America and of mussels and limpets in South Africa reflects the contrast between the American seaboard with its large inlets and lagoons on the one hand and the more open, rock-bound coastline of Cape Province on the other.

That this relationship is not simply a question of ecological coincidence, however, is suggested by the way in which essentially five basic categories of molluscs - and five only - recur throughout the geographical range of human exploitation. In itself this suggests underlying continuities beneath the pattern of ecological differences, and the evidence of continuity is all the more impressive on the chronological axis, where the same species may recur in midden sequences extending over hundreds if not thousands of years and, in those rare cases where sequences extend sufficiently far back in time, over tens of thousands of years. It is a continuity which also extends forwards in time to the modern era: the molluscs which are locally prevalent in prehistoric middens are often the same species which form the basis of commercial exploitation today. Some changes within local sequences occur, but these are the exception rather than the rule, and where they are apparent, as in the middens of California, they are most simply explained in terms of changes in the local environment rather than changes in human attitudes to its exploitation.

It is true that the broad categories we have defined comprise a much larger range of species and genera. It is also true that some parts of the world are under-represented in the sample of data on which the definition of these categories is based. But other comparable categories of world-wide [illegible] so many, for it does bring into focus the presence of some general [illegible] in one area, [illegible] the many [illegible] between the [illegible] individual [illegible].

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distribution and abundance could equally well be defined - for example periwinkles and scallops. If human exploitation were simply a passive reflection of ecological availability, we would expect these and others to be recorded as dominant types in midden deposits. Conversely, if the total pattern were simply the product of an infinite multitude of individual choices or cultural influences, we would expect no large-scale continuities to be visible at all. At least there is sufficient evidence to suggest that the preferred molluscan resources are confined to a relatively restricted range of categories and that they have features which make them fundamentally attractive to human exploitation, exercising an over-riding directive on subsistence activity irrespective of cultural or ecological boundaries. Some of the factors involved have already been noted in passing, such as abundance and accessibility, but they are a separate field of inquiry which requires a fuller discussion in its own right and to which the following chapter will be devoted.

Discontinuities

There is, however, one major chronological discontinuity in the data viewed at this general level which requires further comment. It is partly a discontinuity in the types of molluscs represented, as already noted in discussing the relative antiquity of bivalves and gastropods in European and African sequences, but more generally it is a discontinuity in the quantities. For, while it is true that shell middens in the general sense - deposits with edible molluscs - extend well back into the Pleistocene, the sites which precede the Holocene rarely contain more than a thousand or so mollusc shells apiece. On the other hand, the concentrated midden deposits which are so typical of later periods usually contain shells numbered in millions rather than thousands, which represents a quite different order of magnitude.

In Europe the earliest concentrated middens are the limpet middens in the Asturian caves of northern Spain, which first appear at about 9 000 BP (Clark, G.A. 1971). The open sites, in which bivalves predominate, are later and make

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their first appearance more or less simultaneously in Britain (Coles 1971), Denmark (Andersen & Malmros 1965) and Portugal (Roche 1965), that is at about 7 000 BP. Similarly in Africa the earliest dense shell middens are those in caves on rocky shores and first appear at about 12 000 BP (McBurney 1967; Voigt 1973), while the large, open middens of west Africa do not appear before about 6 000 BP (Elouard 1969). In Asia, Australia and America there is little record of early cave middens, and the earliest sites are all large, open middens dated respectively to 9 000 BP (Clark 1969, p. 245), 8 000 BP (Jones 1965) and 8 000 BP (Hubbs & Roden 1964).

There is some suggestion that there may be a very early shell midden at the base of the Haua Fteah sequence in Africa. Before about 12 000 BP molluscs are quite rare in the sequence until the Pre-Aurignacian levels of the Last Interglacial, dated to about 70 000 BP, are reached, where molluscs re-appear again in some quantity. However, the information for this level is based on a very small sounding, and the exact quantities of shell are unclear, although it appears that they were less abundant than in the Postglacial deposits (McBurney, pers. comm.). Therefore, this can be hardly be taken as evidence of the early existence of intensive shellgathering. The same comments apply to the Mousterian shells on Gibraltar (Garrod et al. 1928). Similarly, in the Klasies River Mouth sequence shells are recorded in deposits assigned to the Last Interglacial period, but there are no data available that would allow quantitative comparison with the Postglacial levels (Voigt 1973). If any conclusion can be drawn from the Haua evidence, it is that there is probably some relationship between sea-level changes and molluscan quantities, since the period in which molluscs are least abundant in the deposit more or less coincides with the period when the sea would have been furthest away from the cave. However, the data are by no means adequate to show that this is the only factor involved. On the other hand, it is certainly suggestive that in Europe and Africa rocky-shore middens formed in caves, which are more likely to occur at a greater distance away from and above the level of the contemporaneous shoreline, appear somewhat earlier than the open middens, which are

invariably located near shallow water, and the overall uniformity of the dates for the earliest open middens in the major continents seems consistent with the operation of some systematic bias in the destruction of midden deposits, resulting from the rise of world sea-levels in the late Pleistocene and early Holocene.

An unknown factor here is the distance over which the human consumer would be prepared to carry his meal of molluscs from the source of supply to the scene of consumption. There is a general assumption that this distance would usually be rather small for transportation in quantity - perhaps no more than a kilometre or so (e.g. Speed 1969). If this were generally the case, then midden sites would obviously be susceptible to destruction by quite small rises in sea-level - or minor tectonic disturbances lowering the level of the land. But more needs to be known about the time — distance factor in shell-food exploitation.

Although freshwater molluscs fall outside our immediate scope, it is, perhaps, worth noting here the evidence of freshwater mussel shells (<u>Velesunio ambiguus</u>) in association with human remains dated to about 30 000 BP at Lake Mungo in Australia (Bowler <u>et al</u>. 1970). Here too precise quantities are not recorded, although the general order of magnitude seems small and is probably quite comparable to the quantities found in Pleistocene coastal middens. Thus the data in themselves do not add much to the picture, but they do raise the possibility of circumventing some of the biases which afflict the economic record, for it is presumably the case that inland lakes and rivers are not exposed to destructive changes of water level to quite the same degree as coastal areas, so that there should be a higher chance of finding early shell middens, if they ever existed. As against this it must be said that all the known inland shell middens of any size belong to quite a recent period of prehistory.

Another possibility that might conceivably be worth pursuing is the examination of old shorelines formed during periods when sea-level was higher than at present, as appears to have been the case during the Last Interglacial

period. That none of the known shell middens formed in the open can be related to such an early period does not, however, hold out much hope for the discovery of diagnostic evidence.

The best that can be said about the chronological evidence is that it is ambiguous. Quite apart from changes of sea-level in relation to land, other biases, such as weathering processes or lack of discovery, may have served to obscure the existence of early shell middens, and it is now widely accepted that the possibility of large Pleistocene shell middens cannot be excluded (Butzer 1972; Newell 1973). There is certainly no justification for the confident assertion that shell middens are exclusively a Postglacial phenomenon (Washburn & Lancaster 1968. p. 294), but equally little evidence to refute it, and interpretations of population pressure which have been invoked to explain the late appearance of shell middens in Europe (Clark 1952) and Australia (Wade 1967) or more widely in connection with aquatic resources generally (Binford 1968a) must regarded as, at best, premature. As far as shell middens are concerned, the search for early sites does not appear likely to prove a very productive exercise. Even if successful, it would not solve the basic problems involved in the palaeoeconomic study of shell middens. More needs to be known about the factors which direct the occurrence of shellfood exploitation and the formation and preservation of shell middens. This, at least, is a line of inquiry which can be pursued with the available data. It is also likely to be an essential prerequisite to the interpretation of long-range economic transformations visible in the prehistoric record, and its results may have a further value in predicting where changes in the chronological record should occur and where evidence might reasonably be sought to throw further light on such changes.

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CHAPTER III

ECONOMIC DIRECTIVES OF SHELLFOOD EXPLOITATION

In the final analysis, the non-molluscan resources may be seen to impose over-riding directives on shellfood exploitation, and consideration of this possibility should play an important part in the economic interpretation of shell middens. But, in order to understand why this is so, we must first examine the intrinsic limitations of molluscs as a potential source of food, and this chapter is primarily concerned with this aspect of the problem. Also, although the preceding discussion of ecological factors suggests that analysis of economic directives might usefully be extended to the problem of why certain types of molluscs are consistently preferred over others, there are insufficient data readily available to justify such a step, and the main emphasis here is focused on the major categories of shellfood and their overall potential in comparison with other types of resources.

It should be stressed that the data examined are of a general nature and are probably subject to margins of error of uncertain extent. In spite of this limitation they can serve two useful purposes. They provide an introduction to the problems involved in analysing economic potential and a basis for hypotheses in the light of which to view the archaeological data.

1. Nutritional Factors

Food Requirements of Man

Nutritional needs fall into four main categories: calories, protein, vitamins and minerals. Calories are derived from the fat and carbo-hydrate content of food tissue and are the most important component for day-to-day survival, providing the basic energy for physical activity and bodily warmth Individual calorie requirements may range widely between extremes of c. 1 500

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and c. 4 000 kcal/day, depending on age, body weight, degree of physical exertion and climate (Davidson & Passmore 1969). For archaeological purposes, however, what is required is a mean figure for the population at large. This is naturally a much less variable quantity, and it has been assumed that all the above factors except climate can be discounted or treated as constants in comparing food requirements of different groups of people represented in the prehistoric record.

Recommended mean individual calorie intake for Aborigines in northern Australia is 2 050 kcal/day for adults and 2 200 kcal/day for children (McArthur 1960). For a biological family of two adults and three children, the mean individual calorie intake would therefore be 2 140 kcal/day. Mean figures for subsistence farmers in hot climates are as low as 1 625 kcal/day (Clark 1968, p. 128), suggesting that, even where climate is constant, additional variables may be involved, and it has to be accepted that any generalised mean is likely to involve some margin of uncertainty. Further consideration may be given to these uncertainties where additional refinement is required in relation to specific problems, but for general purposes a mean of 2 000 kcal/day has been accepted as a reasonable assessment for tropical conditions in Australia, and this figure has been applied to the calculations which refer to such areas in Chapters VI and VII. For the cooler conditions of Mesolithic Europe, Clark (1972) has used a figure of 11 400 kcal/day as the mean requirement of a biological family, which represents a mean individual intake of c. 2 500 kcal/day, and this has been accepted as a reasonable basis for the calculations in Chapters VIII and IX. As a convenient reference standard against which to compare the economic potential of different resources in the following analysis, the figure of 2 000 kcal/day has been used.

Protein is important in maintaining and repairing body tissue. Minimum daily requirements are variable, and there is disagreement among the experts, but figures as low as 17 g/day have been quoted, and 50 g/day would seem to be a generous standard of sufficiency for most circumstances (Davidson & Passmore 1969). As a general rule most food resources except some root

vegetables would provide an adequate quantity of protein, if consumed in sufficient amounts to satisfy calorie requirements. But the quality of the protein is also important. In this respect animal protein is generally regarded as being of highest quality, and small supplements to a poor quality vegetarian diet may make the difference between long-term adequacy and deficiency. At the same time it must be stressed that nutritionists are not agreed about the comparative merits of animal and plant protein, since data that would determine the long-term viability of an exclusively vegetarian diet are not available (Young 1966). Lack of animal protein is not apparently a deterrent to human survival, but it is not the preferred situation, judging by the ethnographic record, where diets based exclusively on plant foods are exceedingly rare. At the other extreme, diets based exclusively or predominantly on animal meat may result in a protein intake vastly in excess of minimum requirements. There is no ill effect in this, but the excess cannot be stored for future use and is automatically converted to energy. Lack of protein is most serious among children; adults are less affected but may suffer weakened resistance to disease and a reduced life span from chronic shortages.

As far as vitamins are concerned, serious deficiencies are most likely to result from lack of vitamins A and C, while vitamin D is essential for bone formation in children. Of the minerals, iron and calcium are most variable as between different foods, and may be seriously lacking in some diets. Goitre, resulting from lack of iodine, may also occur where sea-foods are unavailable. The other minerals are widely distributed, and records of deficiencies are rare.

Nutritional Value of Molluscs

Table III.1 shows a detailed analysis of the nutritional value of the oyster, for which most information is available. Also shown are the minimum individual daily requirements for calories, proteins, minerals and vitamins

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TABLE III.1 - The Nutritional Value of the Oyster and the Quantities Needed for Daily Individual Requirements

Nutritional Constituent	Raw Value per 100 g [a]	Minimum Individual Daily Requirement [b]	Number of Oysters [c]
Protein	9.40 g	50.00 g	101
Calories	59.00 kcal	2 000.00 kcal	678
Vitamin A	350.00 I.U.	2 500.00 kcal	143
B1	0.14 mg	1.00 mg	143
B2	0.19 mg	1.50 mg	158
C	5.50 mg	20.00 mg	73
B12	0.28 mg	1.00 g	1
D	5.00 I.U.	400.00 I.U.	1 600
Nicotinic Acid	1.35 mg	12.00 mg	578
Sodium	311.00 mg	370.00 mg	24
Potassium	190.00 mg	1.00 mg	105
Calcium	124.00 mg	0.75 g	121
Magnesium	41.00 mg	300.00 mg	146
Manganese	0.30 mg	10.00 mg	667
Copper	3.70 mg	2.00 mg	11
Iron	6.40 mg	10.00 mg	31
Phosphorus	190.00 mg	1.30 mg	137
Chlorine	628.00 mg	-	-
Iodine	0.05 mg	0.10 mg	40
Zinc	trace	10.00 mg	-
Sulphur	215.00 mg	-	-

[a] Data from: Cole 1956b; Diem 1962; McCance & Widdowson 1960; Thomas & Corden 1970; Tressler & Lemon 1951; Watt & Merrill 1963

[b] Data from: Bender 1968; Diem 1962

[c] Data from: Table III.6, p.III:19

and the quantity of oysters that would be needed to satisfy those requirements. It is clear that oysters are a relatively poor source of calories, and far more would have to be consumed to satisfy this element of the diet than any other, apart from Vitamin D. A particularly graphic illustration of the limitations of shellfood as a source of energy is the number of oysters that would have to be consumed in a day to provide the calorie requirements of a single individual - 678, assuming no other food was eaten. This figure may help to put the numerical abundance of molluscs in its proper nutritional perspective. On the other hand, if eaten in sufficient quantity to satisfy calorie requirements, oysters would provide a more than adequate supply of all the other nutritional components, except possibly Vitamin D, which is only recorded as a trace in two dietary analyses (Tressler & Lemon 1951: Cole 1956b). From the nutritional point of view then it can be said that a diet based entirely on oysters would be a healthy one, except for growing children.

Table III.2 gives the major nutritional parameters for the other types of molluscs and for other major groups of resources. Although most of the analyses appear to be incomplete, certain comparisons can be made. Minor differences of protein and calorific value between the molluscs occur, the most worthy of comment being the high values for abalones, which may be an additional compensating factor for their relative inabundance and inaccessibility. Oysters also stand out with higher values for fat and carbohydrate content. This is especially the case in the months before spawning when the oyster also builds up reserves of glycogen. It is these features which give the oyster meat its "fatness" and appeal to the palate and they would appear to be the nutritional basis for the high regard in which oysters have been held as a food resource at all periods of human existence.

As a whole, however, shellfish are relatively poor sources of calories and protein. Only the abalone, and to a lesser extent the mussel, have values which approach the lowest of the other resources, such as the non-fatty fish like cod. The majority of the other foods are much more productive sources

TABLE III.2 - The Nutritional Value of Molluscs in comparison with Other Resources

Values per 100 g raw food weight

Resource	Water	Protein	Fat	Carbohydrate		Vit. A	Vit. C	Ca	Fe
	g	g	g	g	kcal	I.U.	mg	mg	mg
MOLLUSCS									
Abalone [g]	75.8	18.7	0.5	3.2	93	-	-	37	2.4
Clam [b, g]	82.9	10.7	1.2	2.7	68	110	-	96	7.0
Cockle [c]	78.9	11.0	0.3	3.4	48	-	-	127	2.6
Limpet [e]	-	13.0	-	-	70[h]	-	-	-	-
Mussel [c, f]	81.4	11.6	1.7	2.9	80	-	-	88	4.6
Oyster [g]	81.3	9.4	1.9	5.9	59	350	5.5	124	6.4
LAND ANIMALS									
Ox [b] Medium Fat	54.0	23.0	22.0	0.0	297	0	0.0	10	3.0
Deer [b]	73.0	22.8	1.4	0.0	139	-	-	11	3.0

TABLE III.2 - Continued

Resource	Water g	Protein g	Fat g	Carbohydrate g	kcal	Vit. A I.U.	Vit. C mg	Ca mg	Fe mg
FISH									
Cod [a, b]	81.2	16.7	0.5	0.0	76	0	1.0	18	0.6
Salmon [a]	-	20.0	10.0	-	180	100	0.0	40	1.2
PLANT FOODS									
Rice [b]	11.8	8.2	0.5	79.5	363	0	0.0	24	1.4
Wheat [a, b]	11.0	10.5	1.9	52.0	332	0	0.0	37	0.0
Dandelion [b]	85.8	2.7	0.7	10.6	44	13 650	30.0	187	3.1
Yam [d]	74.8	2.3	0.2	22.6	96	0	12.0	20	0.6
Hazelnut [b]	6.0	12.7	60.9	21.4	671	100	3.0	290	4.1

a. Bender 1968; b. Diem 1962; c. McCance & Widdowson 1960; d. Thomas & Corden 1970; e. Townsend 1967; f. Tressler & Lemon 1951; g. Table III.1; h. Interpolated from values for other molluscs.

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of calories; as for protein, only root crops have lower values. If shellfood can claim any general nutritional advantage over other food supplies, it is in its ability to supply the full range of mineral and vitamin requirements along with a modest supply of protein and calories.

2. Potential Food Output Per Unit Area

Potential shellfood output is, in practice, more difficult to assess than might at first sight seem the case, given the amount of biological and commercial interest that has been devoted to edible molluscs. Data are usually expressed in one of two extreme forms. In biological and ecological studies the main interest is the behaviour of the animal and its degree of aggregation, so that results tend to be expressed in terms of maximum quantities per square metre rather than as average quantities over a larger area and, in any case, rarely deal with the proportion of the population that could be removed as food without affecting its long-term stability. Ecological sampling has the further disadvantage that it reflects the situation at a single point in time and cannot express the range of fluctuations that may occur in the longer term.

At the other extreme there are commercial statistics which are usually expressed in terms of gross tonnages related only in the most general way to geographical area. On the credit side they do offer some guide to fluctuations in annual production over an extended period of time and to the potential surplus that can be safely removed for human consumption.

Even where data of an appropriate scale are available, there are further variables that may affect the picture. Apart from ecological factors, which vary widely in their effects from area to area, potential food output may also vary within certain limits as a function of the intensity of human exploitation. Even the simplest form of exploitation has the effect of thinning out the shell beds and thereby increasing the rate of turnover of successive generations.

On the other hand increases in intensity of exploitation beyond a certain point may result in declining yields by removing more of the population than can be replaced by the reproductive rate. Sophisticated techniques of exploitation have a more dramatic effect on potential outputs, especially where methods of cultivation are employed to extend by artificial means the molluscan habitat or to supplement the work of nature by distributing the spat more fully within the existing habitat. Technology also enters as an important variable into the equation between human exploitation and productive potential by giving access to molluscs in greater numbers, in deeper water, and at a greater distance from the shore. The interaction of these variables even in modern circumstances is a highly complex matter which has given rise to equally complex techniques of analysis (Nikolskii 1969), and, while it is reasonable to expect that certain general limits can be established at a large scale of focus, the complexity of the underlying situation urges caution in the extrapolation of modern figures to prehistoric circumstances.

A systematic attempt to assess the food output of an area in terms applicable to prehistoric subsistence is Shawcross's sampling of a New Zealand tidal flat. This yielded a figure for the potential annual production of cockles of about 111 t/km^2 of river estuary, equivalent to about 2 340 man/days of food (Shawcross 1967a, 1970). However, there are reasons for treating this figure with caution. In the first place the estuary chosen for sampling consists of almost continuous tidal mud flat, a general feature of New Zealand harbours but by no means typical of other coastlines. Secondly, the figure represents a point in time and does not take account of the possibility of long-term variations. Thirdly, and most important, only dense aggregations were sampled, and the figure stated above assumes a continuous distribution of shellfish in all parts of the estuary and in all other estuaries at similar densities. In practice the distribution of shellfish tends to be highly irregular, as Shawcross has subsequently pointed out (1972 p.597), and the areas of dense aggregation usually represent only a small proportion of the total area suitable for settlement. The figures from New Zealand are therefore

probably too high for general use.

A check on the New Zealand figures has been derived from fishery statistics for cockle (Cerastoderma) and oyster (Ostrea) in some of the major British centres. These are the Wash and the Thames estuary on the east coast, the Burry Inlet of South Wales, and the Fal estuary in Cornwall. Methods of cultivation aimed at substantially improving production have not been applied on a large scale, but advanced technology is used in the collection of the shellfish, and the yields are best treated as potential maxima for prehistoric circumstances. The commercial records have been converted to estimates of mean annual output and calculated in terms of live weight per unit area of estuary, per unit area of tidal mud flat and per unit area of densely settled mud flat. The data are taken from Franklin (1972) and Orton (1926). Areas were measured from the maps provided in these sources by graphic projection or by planimeter.

Table III.3 shows that the output of the British Cockle in densely concentrated beds is quite comparable to Shawcross's New Zealand estimates, but it also shows that, if the same output is expressed in terms of total area of tidal mud flat or total area of river estuary, much lower figures are obtained. In fact output per unit area of overall estuary amounts to 10% or less of the values for output per unit area of densely concentrated shell beds. The data also indicate a certain amount of variability as between different localities and different species, but there is broad agreement among the figures for estuarine molluscs in terms of general orders of magnitude.

Some data for the molluscs of exposed shorelines are presented in Table III.4. The data on limpets are based on an estimate of overall biomass made on the foreshore below the cliffs at Brighton, England, where a gently sloping shelf of rock provides an ideal and extensive habitat. The overall average density of limpets, including sparsely as well as densely populated areas of the intertidal zone, was about $12/m^2$. In terms of standing crop this was estimated to represent about 700 kg/hectare, equivalent to about 1 km of shoreline, or 140 kg/km of shoreline assuming a 25% cropping rate. For steeper

TABLE III.3 - Potential Annual Production of Estuarine Molluscs per Unit Area in terms of Live Weight and Man/Days of Food

Species	Locality	Quantity per km^2 Estuary		Quantity per km^2 Mud Flat		Quantity per km^2 Concentrated Shell Beds	
		t	m/d	t	m/d	t	m/d
Cockle	The Wash	3	64	8	169	70	1 483
Cockle	Burry Inlet	25	530	34	720	226	4 788
Cockle	Thames	4	85	16	339	89	1 886
Cockle	Whangateau	-	-	-	-	111	2 352
Oyster	Fal	7	303	11	476	50	2 165
	Means	10	246	17	426	109	3 169

coastlines where cliffs alternate with sand or gravel bays and the available limpets are confined to rocky headlands at either end of a bay, or in tideless basins such as the Mediterranean, this figure would be much lower.

The data on clams refer to the "toheroa" (Amphidesma ventricosum) of New Zealand, a species which inhabits exposed surf-beaten shores. The major sandy beaches of the North Island have been estimated to have a potential annual yield of about 544 t live weight (Rapson 1954) or an average of about 3 t/km of shoreline.

The data on estuarine molluscs have also been expressed in terms of live weight/km of shoreline and comparison with the exposed-shore molluscs in these terms brings out the much greater shellfood productivity of river estuaries.

Appropriate data for the other categories of molluscs are unavailable, but it may be supposed that their potential food output falls within the range of figures already available.

Since one of the factors in the formation of shell middens is the quantity of molluscs available within reach of a given site location, data on abundance can be used to assess the likelihood that shell middens could be formed simply

TABLE III.4 - Comparison of Potential Annual Production of Estuarine and Exposed-Shore Molluscs per Unit Length of Shoreline in terms of Number, Live Weight and Man/Days of Food

Species	Locality	Average Quantity per Kilometre			Average Quantity per Metre		
		N[a]	t	m/d	N	kg	m/d
Estuarine:							
Cockle	The Wash	840	28.0	593	840	28.0	0.60
Cockle	Burry Inlet	771	26.0	551	771	26.0	0.60
Cockle	Thames	1 155	39.0	826	1 155	39.0	0.60
Cockle	Whangateau	-	-	-	-	-	-
Oyster	Fal	204	7.0	303	204	7.0	0.30
	Means	747	25.0	568	747	25.0	0.60
Exposed Shore:							
Limpet	Brighton	6	0.2	35	6	0.2	0.04
Clam	New Zealand	90	3.0	113	90	3.0	0.10
	Means	48	1.6	74	48	1.6	0.07

a - Figures in thousands

in response to the concentrated distribution of the local shellfood supply. Table III.4 shows the data on food output expressed in terms of the quantity of molluscs per unit length of shoreline. While it seems plausible to suggest that the nature of the molluscan distribution could well be a contributory factor in the formation of substantial archaeological middens, at least as far as the estuarine bivalves are concerned, the data presented here do not allow us to say whether this would have been a sufficient factor, especially bearing in mind the large numbers of molluscs that are required to form archaeologically visible deposits - up to 100 000 shells per cubic metre of midden. But the data do suggest that exploitation of limpets would appear unlikely to give rise to concentrated middens unless other factors were operating.

In Table III.5 potential food outputs of molluscs are compared with data on other resources. Once again it must be emphasised that the data are by no means complete or comprehensive and are offered only as an approximate guide. In particular it is not always clear from published sources whether food densities refer to areas of maximum concentration or to overall densities which include unoccupied areas of the resource's habitat; data on cropping rates also seem to be somewhat variable. As far as possible, therefore, figures for each resource have been presented in terms of broad ranges rather than as single values. Food weights have been calculated from food weight to total live-weight ratios, converted to calorific yields and expressed in terms of man/days of food, assuming a minimum daily individual requirement of 2 000 kcal.

While molluscs in favourable circumstances appear to be capable of yields which overlap with those of other resources, the data presented here suggest that they are on the whole a relatively unproductive resource. A further depressing factor in the case of shellfood output, as Shawcross (1967a) has emphasised, is the relatively restricted extent of the molluscan habitat. As a general rule the area of molluscan habitat within reach of a given locus of human occupation is likely to be far less than the area of land, although one can envisage exceptional circumstances such as small islands and peninsulas where this position might be reversed. Clearly large variations in relative shellfood output may occur in response to varying local circumstances, but the overall figures in Table III.5 suggest that, where other resources are available, shellfood is unlikely to play a very prominent part in the total diet.

TABLE III.5 - Potential Annual Production of Molluscs per Unit Area in Comparison with Selected Terrestrial Resources in terms of Meat Weight and Man/Days of Food

Resource		Meat Weight per km^2 kg	Man/Days per km^2 m/d
Molluscs [a]	Min	300	10
	Max	10 000	250
Deer [b]	Min	100	100
	Max	3 300	2 250
African Game [c]	Min	250	200
	Max	1 200	850
Cattle [d]	Min	2 500	400
	Max	25 000	3 750
Wheat [e]		33 000	5 500

[a] Tables III.3 and III.4

[b] Darling 1957; Lowe 1966; Mitchell 1969; It is assumed that meat weight represents 50% of live carcase weight

[c] Bourlière 1964; Sachs & Glees, in Clark, 1970 p.36. It is assumed that meat weight represents 50% of live carcase weight and that calorific yield is similar to deer.

[d] Jarman et al 1968 p.189; Jarman 1972 p. 137. It is assumed that meat weight represents 50% of live carcase weight.

[e] Bennett 1935, in Clark, 1970 p. 152. Based on yields in early Mediaeval England.

3. Accessibility And The Time-Distance Factor

Although potential food output per unit area is a major directive of economic potential, of almost equal importance is the ability of the human population to extract that potential. A successful food supply must not only provide an abundant output of calories, it must also be accessible to human exploitation without the need for an excessive input of calories in terms of human energy expenditure. The less accessible a resource, the more effort or input is required in its exploitation.

The accessibility of resources is a function of three major variables: external factors such as the various physical and topographical obstacles that may stand between the consumer and his food supply; intrinsic features of the resource itself and, in particular, the time-distance factor for its exploitation; and the available technology, which may help to mitigate any limitations imposed by the other two factors.

The time-distance factor is especially important, since, as we have emphasised previously, the basic assumption of territorial analysis is that distance is a critical variable in economic exploitation. For hunting and gathering economies a figure of 10 km, usually expressed as 2 hours' walking time to accomodate variations in external limitations such as topography, is generally assumed to be the maximum radius of exploitation from a given site location (Lee 1968; Vita-Finzi & Higgs 1970). However, the time-distance factor is by no means a fixed quantity but may itself vary within certain limits, as is apparent from the adoption of a figure of 5 km or less for the study of agricultural sites based on plant cultivation (Vita-Finzi & Higgs 1970). The chief reason for this variability lies in the varying input-requirements of the resources exploited. Because of the preparatory stages of sowing, weeding and crop protection involved in plant husbandry, more work has to be expended than with simpler forms of economic exploitation. Consequently less time can be spared for the daily walk between source of supply and scene of consumption. Generally speaking the less accessible a

resource and the more effort that has to be expended in its extraction, the lower the time-distance factor.

Home-Base Exploitation

A second assumption of territorial analysis is that the sites to which it is applied are home-base sites from which people radiate out during the day, returning there each evening with the produce of their labours. This pattern of exploitation is based on studies of the ! Kung Bushmen (Lee 1968), and a similar pattern has been identified in Australia (Gould 1969; Peterson 1973). The resources involved are usually complementary staples, for example game and plant foods, which can be exploited by a division of labour, and which occur in sufficient abundance to justify transportation back to a strategically located central camp where the collective produce of the day's work can be shared out. Such an arrangement has a high selective advantage in promoting the survival of the human population by allowing everyone the benefits of a mixed diet and the security of alternative resources, as well as providing support for the non-productive part of the population.

Clearly such a pattern of centrally located base camps is only possible where the available resources are diverse and abundant and where they can be transported easily and in sufficient quantity by the individual so as to produce a daily surplus above his own requirements. Many of the common food supplies pose little problem in this respect. For example, according to Lee's (1968) data, a single bag load of mongongo nuts weighs $12\frac{1}{2}$ kg on the average, a weight sufficient to provide enough calories for at least five people. A joint of animal meat of the same weight likewise produces enough calories to support at least seven people (Table III.2). It is therefore perfectly logical to suppose that resources of this type would tend to be carried back to some central spot to be shared out. In fact this would not simply be a matter of expediency brought about to secure the advantages of food sharing but a matter of necessity if the surplus food were not to go to waste. Therefore the

logical basis for the existence of home-base sites would seem to be primarily an economic one, directed both by the food output of the available resources and their accessibility.

The archaeological consequences of such a pattern of exploitation are worth emphasising, for it is the repeated use of the same spot as a home-base which leads in time to the accumulation of imperishable debris in sufficient quantities to be visible to the observer of a later age. Without excluding other factors in confining archaeological material to restricted areas, it is possible to see that, without a home-base pattern of exploitation, the scope for archaeological investigation would be immeasurably reduced. A second consequence of importance in archaeological interpretation is the tendency of home-base sites to be situated at the junction between complementary resource zones, a strategically advantageous location which has been recognised for many archaeological sites (Vita-Finzi & Higgs 1970, p. 5).

Foraging

This radial pattern of daily exploitation, however, is by no means the only method of integrating resources for human consumption, as is implicitly recognised in existing territorial studies by the distinction drawn between home-base sites and transitory sites such as transit or kill sites (Vita-Finzi & Higgs 1970, p. 7).

Where a resource is sparsely distributed or excessively "expensive" to extract and transport over any distance, a situation may occur in which the effort of the individual in the course of the day's exploitation fails to produce more than enough to feed himself. In these circumstances it is logical to suppose that the food would be consumed by him on the nearest convenient spot to the scene of the collection, for there would be no point in carrying it back to some strategically located home-base site, unless this were situated conveniently close to the point of collection, since there would be no surplus to share with other people. In fact this type of individual exploitation appears to have been quite widespread and has been termed "foraging" (Steward [illegible] basis for the existence of [illegible] which would seem to be generally [illegible], although [illegible] by the [illegible] for the available resources and their accessibility.

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1968, p. 326); it is an activity which involves the consumption of food on the spot as it is collected and is especially applicable to resources such as fruit or small game which can be collected in small quantities suitable for individual consumption and which can be eaten raw or cooked over a small ad hoc camp fire. Some resources may promote a mixed response, being partly foraged for and partly collected for transportation back to the camp for the daily share-out. For example it is well known that the exploitation of large game often leads to ad hoc camp sites locally formed to consume some of the kill and to prepare the carcase for transportation - a logical response which has the double advantage of satisfying the immediate hunger of the hunters and reducing the weight of the food which has to be carried back to the central camp. Small items such as nuts or fruit may also be consumed locally in order to satisfy the immediate hunger of the individual collector as well as being taken back to camp. However, it is not difficult to perceive that foraging would be the only possible response for resources of intrinsically low economic potential.

The archaeological consequences of foraging are two-fold. In the first place, the evidence of diet found at home-base sites, however complete the circumstances of discovery, preservation and excavation, is quite likely to represent an incomplete sample of the total diet. Secondly, the scene of consumption has probably left less visible evidence than a home-base site, since it would have been used far less frequently - perhaps only once - and certainly by fewer people. At best the evidence stands a poorer chance of survival in the archaeological record; at worst it would be totally lost without trace. Even a few meals of molluscs consumed at random on a river bank are unlikely to have much chance of being preserved unless other factors in the situation ensure that the same spot is repeatedly used over time or by large numbers of people.

The Time-Distance Factor for Molluscs

Basic data on individual weights and weight ratios for the different

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TABLE III.6 - Weights of Selected Molluscs

Species	Locality	Sample Size	Total Live Weight	Shell Weight	Meat Weight	Mean Individual Live Weight	Mean Individual Meat Weight
			g	g	g	g	g
Limpet							
<u>Patella vulgata</u>	Brighton, England	33	454	213	241	14	7
Cockle							
<u>Anadara trapezia</u>	Sydney, Australia	59	2 030	1 161	177	34	3
Oyster							
<u>C. commerc.</u>	Port Stephens, Australia	200	6 735	5 525	1 060	34	5

TABLE III.7 - Ratios of Meat Weight to Shell Weight to Live Weight for the Major Molluscs

Category/Species	Meat Weight	:	Shell Weight	:	Live Weight
Abalone					
Haliotis (raw) [b]	1	:	1.0	:	2.0
Clam					
Tivela (raw) [e]	1	:	–	:	9.0
Macoma (raw) [c]	1	:	3.5	:	–
Cockle					
Chione (boiled) [j]	1	:	5.0	:	10.0
Chione (raw) [j]	1	:	6.0	:	9.0
Cerastoderma (boiled)[l]	1	:	5.0	:	10.0
Anadara (boiled)[m]	1	:	6.6	:	11.5
Mean	1	:	5.7	:	10.1
Limpet					
Patella (raw) [h]	1	:	1.4	:	2.0
Patella (raw) [k]	1	:	1.2	:	–
Patella (raw) [m]	1	:	0.9	:	1.9
Mean	1	:	1.2	:	2.0
Mussel					
Mytilus (raw) [a]	1	:	–	:	5.0
Mytilus (raw) [c]	1	:	2.4	:	–
Mytilus (raw) [d]	1	:	–	:	2.5
Mytilus (raw) [f]	1	:	–	:	3.0
Mean	1	:	2.4	:	3.4

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Category/Species	Meat Weight :	Shell Weight	: Live Weight
Oyster			
Crassostrea (raw) [m]	1 :	5.2	: 6.4
Ostrea (raw) [g]	1 :	5.0	: 6.0
Ostrea (raw) [f]	1 :	-	: 8.0
Mean	1 :	5.1	: 6.8

a. Bender 1968; b. Bonnot 1948; c. Cook 1946; d. Davies 1969;
e. Fitch 1950; f. McCance & Widdowson 1960; g. Orton 1926;
h. Patterson 1839; j. Shawcross 1967a; k. Townsend 1967;
l. Wright 1927; m. Table III.6.

types of molluscs are shown in Tables III.6 and III.7, and these have been used in the compilation of Tables III.8 and III.9, which present some data on the input-requirements of shellfood exploitation.

Table III.8 shows the number of individual molluscs which would have to be collected to provide the calorific equivalent of a single red-deer carcase - 22 600 in the case of the oyster, a particularly graphic illustration of the relatively labour intensive nature of shellfood exploitation.

TABLE III.8 - The Number of Molluscs Required to Provide the Calorific Equivalent of One Deer Carcase

Category	Meat Weight per Individual g	Calorific Value per Individual kcal	No. of Individuals per Deer Carcase [a]
Abalone [b]	750.0	667	100
Clam [c]	30.0	20	3 300
Limpet [d]	7.0	5	13 600
Oyster [d]	5.0	3	22 600
Mussel [c]	3.0	2	27 800
Cockle [d]	3.0	1	46 300

[a] The assumed weight of a deer carcase is 50 kg
(See Table III.9 for other notes)

Table III.9 shows the number of individual molluscs which would have to be collected to supply 1 man/day of kilocalories and the live weight involved. Most of the molluscan types follow the pattern of the oyster in requiring the collection of a large number for a day's food supply - as many as 1 389 in the case of the cockle. A more accurate and useful index of input-requirements is the ratio between live weight and kilocalories, for it is the weight of the food which sets a limit on transportability, and which is thus a major influence on the time-distance factor. In this respect there is considerable variation between the different types of molluscs. Abalone, limpet and mussel are relatively light-weight and would present no

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Table XIII shows the number of individual patients which would have to be admitted to provide the long-stay equivalent of a single [illegible] average [illegible] [illegible] [illegible] [illegible] [illegible].

TABLE XIII: [illegible]

Stratum	Mean [illegible]	No. of Individuals * per Long Stay [illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

* [illegible]

Table XIII shows the number of individual patients which would have [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

TABLE III.9 - The Quantity of Molluscs and Other Selected Resources per Man/Day Energy Requirement

Category	Live Weight per Individual g	Individuals per 2 000 kcal	Live Weight per 2 000 kcal kg
Abalone [b]	1 500	3.00	4.5
Clam [c]	270	98.00	26.5
Limpet [d]	14	408.00	5.7
Oyster [d]	34	678.00	23.1
Mussel [c]	8	833.00	6.7
Cockle [d]	34	1 389.00	47.2
Cod [e]	1 000	5.00	5.0
Deer [f]	100 000	0.03	3.0
Yam [e]	500	8.00	4.0
Mongongo Nut [g]	5	421.00	2.1

[b] Bonnot 1948; [c] Cook 1946; [d] Table III.6; [e] Approximation; [f] Bannerman & Blaxter 1969; [g] Lee 1968.

more of a weight problem in exploitation than the non-molluscan resources shown in Table III.9. On the other hand, clam, oyster and cockle require the collection of a quite considerable weight and would thus be relatively disadvantageous in this respect.

In Table III.10, these data on input requirements have been used to estimate the time-distance factors for various resources. Assuming that baskets or similar containers are available for transportation, and that the weight of a full bag load is 12½ kg, following Lee (1968), the number of man/days of food per bag load can be estimated. For example, a full bag of oysters provides only half a man/day of calories, so that the individual would have to collect two bag loads just to supply his own daily requirements, quite apart from anybody else's. If we assume that the time-distance factor is

TABLE III.10 - The Time-Distance Factor for Molluscs in comparison with Other Resources

Resource	Calories per $12\frac{1}{2}$ kg kcal	Man/Days per $12\frac{1}{2}$ kg	Bags per 1 M/D	T-D km	Bags per 2 M/D	T-D km	Bags per 6 M/D	T-D km
MOLLUSCS								
Abalone	6 125	3	$\frac{1}{3}$	10	1	10	2	5
Clam	944	$\frac{1}{2}$	2	5	4	$2\frac{1}{2}$	12	$\frac{1}{2}$
Cockle	606	$\frac{1}{3}$	3	$3\frac{1}{2}$	6	$1\frac{2}{3}$	18	0
Limpet	4 375	2	$\frac{1}{2}$	10	1	10	3	$3\frac{1}{2}$
Mussel	2 941	$1\frac{1}{2}$	$\frac{2}{3}$	10	$1\frac{1}{3}$	10	4	$2\frac{1}{2}$
Oyster	1 062	$\frac{1}{2}$	2	5	4	$2\frac{1}{2}$	12	$\frac{1}{2}$
OTHER RESOURCES								
Cod	8 750	4	$\frac{1}{4}$	10	$\frac{1}{2}$	10	$1\frac{1}{2}$	5
Deer	15 795	8	$\frac{1}{4}$	10	$\frac{1}{4}$	10	1	10
Yam	10 909	5	$\frac{1}{4}$	10	$\frac{1}{2}$	10	1+	10
Hazelnut	11 743	6	$\frac{1}{4}$	10	$\frac{1}{3}$	10	1	10

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inversely proportional to the number of basket loads, then the time-distance factor for transporting one man/day of oysters is 5 km; because two trips have to be made for its collection, the maximum radius of exploitation must be halved. Figures for the other categories of molluscs are also shown in Table III.10.

Clearly the accuracy of these figures is limited by the assumptions involved in their calculation as well as by the accuracy of the data in the preceding tables upon which they are based. However, certain general conclusions are admissible. In particular it is clear that the quantity of shellfood that a single person can collect and transport in one day drops steeply with increasing distance, much more so than for most other resources. Surplus production comparable to what can be achieved for plant and animal staples involves drastic reduction in the distance factor, especially for the bivalve species. Only limpets would be likely candidates for transportation in quantity over any significant distance from the shore, given their relative ease of collection close to the shore margin and their high time-distance factors. The same can be said of abalones and mussels collected from the intertidal zone, although not of the specimens found in deeper water, whose exploitation would absorb much of the time-distance component in transportation from the source of supply to the shore edge. It is thus particularly significant that limpets, and to a lesser extent mussels and abalones, are all found in some quantity in very early deposits which have escaped the destructive effects of changing land- and sea-levels, and their high time-distance factors may well be a contributing factor in their preferential preservation from early periods.

The generally low time-distance factors for shellfood have two other archaeological consequences. The first concerns the exploitation of shellfood at some distance from the shore. Inconveniently for the hungry Aborigine, the species most likely to live offshore are those with the lowest time-distance factors; the clam, the cockle and the oyster. Our data suggest that, where these types of mollusc occur more than about 5 km from the shore, their exploitation would cease to be viable, even for the individual forager, unless they

[illegible]

were eaten raw in the middle of the mud flat, or superior technology were available for their collection.

A second consequence of these low time-distance factors is the expectation that some prehistoric shellgathering would have been accomplished by foraging rather than by a home-base pattern of exploitation. Indeed, if relative outputs of shellfood were as low as we have suggested, then it is arguable that molluscs are unlikely to have had any significant influence on the occurrence or the location of home-base sites. In theory, therefore, large accumulations of shell are unlikely to have occurred on any one spot, unless complementary staples other than shellfood were available in close proximity to the shore and thereby made it strategically advantageous to form a home-base site close to the supply of molluscs. This leads quite logically to the paradoxical hypothesis that an economy based exclusively on shellfood consumption would leave almost no archaeologically visible traces at all since it would, of necessity, have been a foraging economy without home-base sites; conversely, archaeologically impressive mounds of shell would be associated with economies in which shellfood was of minimal importance. In the same way it follows that a home-base site located inland beyond the range of shellfood transportation but within foraging distance of the molluscan supply may represent a focus for a very thorough exploitation of the available shellfood yet totally lack archaeological evidence of discarded shells.

In practice, however, certain areas may come to be used as preferred sites over time in response to external restrictions on access, the concentrated distribution of the local shellfood supply (Table III.4), or conditions of shelter and water supply, even though used on a transitory basis in the course of foraging. This leads to the difficulty of distinguishing archaeologically between shell middens used as home-base sites from those which are preferred sites used on a transitory basis. On _a priori_ grounds we might suggest that home-base middens, being used by more people with greater frequency and regularity, would tend to be larger but cannot reject the possibility that foraging sites might also result in comparable accumulations of shell, and more

detailed archaeological criteria have been devised for this problem (see Chapter V).

Technology

The major variable affecting the time-distance factor for molluscs is technology. The figures already calculated are based on the assumption that baskets or similar portable containers would be available. Yet even this modest technological aid might be lacking, in which case a foraging pattern of exploitation would be almost inevitable. Water craft, whether boats, canoes or rafts, are also particularly important. They would provide a means of access to shellfish too far offshore or in too great a depth of water to be accessible to exploitation on foot; they would allow many types of shellfish to be collected when covered by water at high tide, especially important if it is remembered that soft-shore species such as cockles and clams are more easily collected by treading under water with the feet; and they would remove the limitation of transport by allowing a much larger number of shellfish to be taken back to some central point of consumption on the shore, or some distance inland along rivers or navigable streams and watercourses.

The extent to which boats would extend the distance factor is difficult to quantify and would depend on the type of boat and the method of propulsion. In the absence of more accurate data a limit of 10 km seems reasonable as a maximum radius for daily excursions, with the possibility of longer trips extending over several days.

All the major types of shellfish would be more efficiently exploited with boats, except possibly limpets, although, even with this species, boats might allow the exploitation of offshore rocks or parts of the shoreline too steep to be accessible on foot. Boating technology is therefore likely to be a significant factor in directing the extent of shellgathering as well as the location and formation of shell middens.

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4. Seasonal Directives

Seasonal fluctuations in the availability of resources play a major role in directing the total area over which a human group has to move and are therefore of importance in defining the annual territory and the degree of mobility involved in its exploitation.

Just as the integration of complementary resources from a home-base site has a high selective value in cushioning the occupants against fluctuations in daily individual food production and ensuring the most effective exploitation of resources within the site territory, so the use of seasonally complementary sites has a similar value in protecting the human group as a whole against seasonal and local fluctuations in the food supply and ensuring the most effective integration of the resources available within the annual territory. It allows the group to smooth oscillations in resource availability, taking full advantage of peaks in food production and minimising the detrimental effects of lean periods. There is also the subsidiary advantage of seasonal movement that it protects the resources to some extent from the threat of accidental overexploitation posed by a continuous human dependence on a single resource or a single locality.

Where staple resources are only seasonally available within the site territory, seasonal occupation is an obvious necessity, as in economies tied to herd animals which move over large areas in search of pasture in response to seasonal extremes of climatic variation. But, even in those many cases where some food is available throughout the year, seasonal variations in quantity are likely to be sufficiently marked to ensure the selection of a mobile economy as the more successful long-term policy, provided that seasonally complementary resources are available.

Shellfood is a good example of a resource which gives the appearance of being available throughout the year but which is nevertheless subject to a number of seasonal limitations. Rough seas and low water-temperatures, by their restriction on access, are an obvious limitation on some shorelines.

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But there are more subtle and widespread seasonal cycles of several kinds which may have a marked impact on human exploitation.

Seasonal flucuations in the phytoplankton supply are especially prevalent in temperate areas and affect the meat condition of some shellfish. For example, the meat yield of European cockles drops by as much as 50% in winter (Hancock & Simpson 1962). Although this would not necessarily prevent all exploitation, it would clearly require a doubling of input effort without any commensurate return of food. Given the already high input requirements of cockles even under favourable circumstances, this extra imposition would be a strong deterrent to winter exploitation. Similar seasonal changes affect the European mussel (Savage 1956), and most bivalve species are likely to suffer in the same way wherever there are seasonal fluctuations in their chief food supply.

Spawning behaviour can also affect the condition of the shellfish. The best known example is the oyster, which achieves peak nutritional condition in the spring or early summer immediately before spawning. Once spawning is over, the oyster meat becomes thin, watery and a negligible source of food energy and only begins to improve again during the winter. This cycle is found almost universally among oysters (Cole 1956b; Orton 1937; Shaw 1969) and would almost certainly have imposed a seasonal directive on exploitation. Other molluscs, including the gastropods, appear to have similar seasonal cycles in response to spawning behaviour, but little published information is available.

As a general statement the available data suggest that the possibility of effective shellfood exploitation throughout the year would have been the exception rather than the rule.

It must follow from this that, where shell middens are used primarily for the consumption of shellfood, seasonal occupation is most likely. It is arguable that food storage may be used as a substitute for seasonal movement. There are certainly many examples in the ethnographic literature of the application of simple techniques of smoking or drying to a range of resources, including molluscan meat (Best 1929, p. 60; Kroeber & Barrett 1960), and the

techniques are probably of considerable antiquity. However, the ethnographic record also suggests that these techniques were only used on a small scale and were commonly associated with population movement, representing an additional means of coping with fluctuations in food supply rather than an exclusive alternative.

In the case of molluscs, relatively low levels of food output may set a limit on the length of time over which they can be exploited long before seasonal directives come into play. Even where there is no seasonal variation in availability, a seasonal pattern of exploitation may be necessary in order to avoid depletion of the shellfish stocks, in a manner analogous to the operation of closed seasons in modern shellfisheries.

The major point to emerge from the foregoing analysis is the relatively low economic potential of molluscs, resulting from low levels of potential food output and their relative inaccessibility. These factors, combined with the prevalence of seasonal fluctuations, emphasise the probable dependence of shellfood exploitation on other resources and their ability to support human populations on a regular basis within reach of the shore. They suggest that the most successful long-term patterns of shellfood exploitation, and hence the largest and most abundantly concentrated middens are likely to occur where the shellfood supply can be conveniently integrated into a viable economic system incorporating other resources, and thus they direct our attention to the availability and distribution of complementary resources capable of supporting such a system as much as to the distribution of the molluscs. The data so far considered are by no means fool-proof or free from uncertainties, and we should not forget the essentially hypothetical nature of the conclusions drawn from them. Nevertheless they offer a powerful set of unifying expectations against which to test the actual record of human subsistence in different areas of the world and at different periods of time.

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[illegible] community. However, the [illegible] [illegible] [illegible]

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CHAPTER IV

THE ETHNOGRAPHIC RECORD

There are numerous descriptions of coastal peoples in the ethnographic literature which offer some insight into the economies associated with shell middens. It is not intended that examination of these ethnographies should provide direct analogies for archaeological use, nor should they be treated as necessarily superior to the archaeological record by virtue of their reference to intangible aspects of behaviour. They are more realistically treated as a complementary source of information, lacking the more obvious biases of archaeological data but subject to equally distorting effects of a different kind.

Not the least of the limitations of the ethnographic record is that it refers to a small sample of human behaviour from the recent past and for this reason alone arouses reservations about extrapolation to the remoter prehistoric past. Other potential biases arise from the synchronic limitations of the data, which may refer to temporary aberrations unlikely to persist in the long term; from the effects of colonial incursions or other distorting factors inherent in the local situation, which may obscure the operation of underlying principles; or from the perspective of the observer, who may record only what is of relevance to his particular interests or confine his observations to a limited and biased sample of the total behaviour pattern. But, if it is the case that economic directives exercise a universal influence on human behaviour, then we should expect to find these reflected in whatever circumstances, in whatever chronological period and through whatever filter of contextual distortion or observational bias, especially where locally derived conclusions are checked against the world picture as a whole. Figure II.1 shows the general location of the areas examined.

1. America

Tierra del Fuego

The Indians of Tierra del Fuego have been especially influential in forming archaeological opinion about shell middens. Not only were they described in detail by several early scientific expeditions (Bird 1938; Darwin 1845; Gusinde 1937; Hyades & Deniker 1891), but they appear to have pursued a strandlooping economy, moving from site to site along the shore margin throughout the year and living for the most part on marine resources (Bird 1946; Cooper 1946; Emperaire & Laming 1954). The sites which they used were often shell middens, sometimes mounds of very large size, and archaeological excavations of these have added a further dimension to the ethnographic picture (Lothrop 1928). There is no doubt that theirs was a harsh and unpleasant environment and Darwin's (1845) description of them seems to have contributed to their general image as miserable wretches on the very borderline of the human condition. These are the people who are primarily responsible for the persistence of the archaeological hypothesis that shell middens in general are to be associated with an impoverished and degraded existence, although the term "strandlooping" was originated by Dutch travellers in South Africa who thought, probably incorrectly, that the coastal natives spent most of their time wandering up and down the shoreline. In practice strandlooping does occur in several areas but appears to be a rather rare economic adaptation which arises in response to quite specific and unusual circumstances.

The people of this area, principally the Alacaluf and Yahgan - collectively known as the Canoe Indians - generally lived on shell middens, but had no permanent villages, moving from camp to camp along the shore and apparently never staying in one place for more than a few weeks. Staple foods were mainly littoral and marine resources. Shellfish were regularly collected by the women, and it is suggested that molluscs formed a major contribution

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The [illegible] have been especially [illegible] in [illegible]. [illegible] and they appear to have [illegible] along the [illegible] [illegible]

The people of this area, [illegible] – collectively [illegible] Indians – [illegible] villages, [illegible] and it is suggested that [illegible] a major contribution [illegible] to the diet amounting to a staple resource (Bird 1946; Cooper 1946). Other food supplies of importance were sea lions, seals and marine birds, especially cormorants. Fish, porpoises and crustacea were generally of lesser importance, while plant foods were of no more than casual or occasional significance. The evidence of terrestrial mammals is somewhat ambiguous although the environment is clearly one with a very poor terrestrial fauna. Deer and guanaco were available in some localities but their exploitation is not stressed in the ethnographic literature. On the other hand deer bones are described as fairly common in both prehistoric and modern middens (Bird 1946, p. 61). At any rate they were not of much importance in the area as a whole, and the predominant pattern of exploitation appears to have involved movement back and forth along the shore mainly in search of shellfish with the additional use of specialised sites for sealing and fishing.

The economy as described here has all the classic hallmarks associated with the concept of strandlooping, but, in order to place it in its proper perspective, some attention must be given to the nature of the environment, for the area is on the southernmost margins of the human habitat in conditions of extreme climatic severity and rugged topography. The overall situation and its effect on economic life is well summed up by Bird.

> In all this distance [12,000 miles] there is no place where one can walk along or near the shore without the greatest difficulty. The reason lies not only in the densely tangled forest that clings wherever it can secure a foothold but also in the rough nature of the country - mountains and hills that drop precipitously beneath the sea with little or no foreshore. Beaches are few and widely separated. Glaciers and swift flowing rivers offer further obstacles
> ....
>
> For food the natives on the Pacific side necessarily depended almost entirely on what the sea had to offer - a large variety of excellent shellfish, seals, otters, porpoises, and, occasionally, whales ...... On land it is a different story. Only isolated localities have anything to offer .... Pursuit is arduous and only where the topography favoured the hunters were any deer taken....
>
> (Bird 1938, p. 252)

It is clear that the hinterland, by reason of its inaccessibility and

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unproductive nature, was scarcely inhabitable even on an occasional or seasonal basis. Severity of climate added to the difficulties of terrain: summer and winter temperature means of 10°C and -2°C respectively, deep snow drifts in winter, snow falls at sea-level even in summer, frost sometimes persisting throughout the year and gale-force winds and heavy rain. Even the littoral resources were sometimes affected; bad weather could impede shellgathering and canoeing and in especially severe winters completely prevent these activities because of icy conditions (Bridges 1948).

These graphic descriptions leave one in little doubt that the shore-based economy was not a matter of choice but of strict necessity, although the molluscs appear to have been quite large and abundant in the more sheltered waters of this coastline and may well have been a contributing factor to the emphasis on littoral settlement.

The economy of the Alacaluf and the Yahgan is a model of what is possible under extreme conditions rather than of what one might expect to be typically associated with shell middens and is clearly unsuited to provide a direct analogy for shell middens in other circumstances. That it existed at all is a measure of the diversity and productivity of shore resources and of the capacity of the human species to survive in an unpleasant and unpromising environment aided by crucial technological devices - especially the canoe, whose importance in providing access to littoral resources has already been emphasised.

To the east of the Canoe Indians were found the Ona or Foot Indians. They lived in an area where topographical conditions are less limiting. Here the hinterland is characterised by tracts of open country supporting a seasonal abundance of game. The mainstay of the economy was guanaco, and in response to its seasonal movements the predominant pattern of exploitation was a mobile one with winter sites on the coast and summer encampments in the interior (Gallardo 1910; Gusinde 1931). At least some of these coastal dwellings were shell middens, and the Ona are supposed to have eaten shellfish in large quantities (Lothrop 1928). However, even if the superior attractions of an

abundant game resource had been lacking, dependence on shellfood would not have been possible to the same extent as among the Canoe Indians, for the coastline is more exposed, abundant concentrations of shellfish are fewer, and opportunities for canoe-transport are less frequent. Materials for the manufacture of canoes are also scarce, and lack of drinking water near the shore would have acted as a further disincentive to stay for long within easy access of the littoral zone (Bird 1938, p. 253).

As far as it is possible to reconstruct the situation from ethnographic sources the major contrasts between the economies of the Canoe and Foot Indians appear to have resulted primarily from topographic differences, with variations in the abundance of shore resources perhaps acting as a secondary directive. That these differences were not merely a matter of cultural choice is suggested by the practice of deer and guanaco hunting among the Canoe Indians wherever topographical conditions permitted, and by the exploitation of shellfood among the Ona wherever molluscs were accessible in quantity.

In general it appears to be the case that, where terrestrial resources were scarce, shellfood was capable of supporting a viable economy. However, the precise role of shellfood is difficult to assess. It is possible that, as a regular, daily beach activity, shellgathering had a larger visual impact on the observer than other economic activities, and the exploitation of aquatic mammals and birds shows that molluscs were by no means the exclusive support of the economy. Secondly, it is clear that shell middens were occupation sites associated with mobile economies, involving movement back and forth along the shore where hinterland resources were absent, or predominantly back and forth between shore and hinterland where the latter offered an accessible food supply. As to whether the shell middens were home-base sites or transitory sites, the data are not altogether clear, and both alternatives seem possible. It is of some interest that prolonged occupation is not recorded among the Canoe Indians and that all their sites appear to have been used on a fairly temporary basis, no more than a few weeks at a time according to Lothrop (1928), a feature which may be related to the lesser abundance and diversity of food

supplies in this area and in particular to the lack of a substantial complement of terrestrial resources.

California and the Northwest Coast

Many of the Indian coastal tribes along the Pacific coast of North America from Mexico in the south to British Columbia in the north have been directly observed to some extent. In some cases ethnographic studies have been supplemented by archaeological excavations to such a degree that it is difficult to detect where direct observation ceases and archaeological inference takes over. Numerous shell middens are found all along the Pacific coastline, among the largest being the mounds of San Francisco Bay. Shellfood usually receives a mention in most of the ethnographic records but quantitative studies of its contribution to the overall diet are non-existent, except for those based on archaeological excavation. Baumhoff's systematic studies have shown that the major staples in California were deer, salmon and acorns, but his data do not refer directly to areas with abundant shell middens, and he does not exclude the possibility that shellfood-dominated economies might have occurred in some places (Baumhoff 1963, p. 230). Most commentators recognise the potential importance of molluscs but it seems probable that opinions have been influenced to a large extent by the visual impact of the archaeological debris.

Among the Tolowa tribe, salmon and acorns were the dominant staples. Smelt, molluscs and sea-mammals are described as of secondary importance (Greengo 1952). Detailed study of the Point St. George area has shown that the major focus of settlement in such an economy was a home base situated near the shore and used at various times throughout the year (Gould 1966). Temporary camps geared to specific activities also occurred. There were coastal camps used during the smelt runs in late summer, autumn sites about 18 km inland used for the collection of the acorn crop and salmon-fishing sites used in early winter. However, the home base was rarely deserted completely, since much of the food exploited at these temporary camps was immediately transported back to the base camp for storage and consumption at

a later date. Both the smelt site and the home-base site are shell middens archaeologically speaking, but in both cases the molluscs seem to have been an incidental factor in the choice of site location, and precise data about their dietary role are lacking, although in view of the abundance of other resources they are unlikely to have been of great importance. Given that a single adult sea lion can provide as much as 500 kg of meat or more (Gould 1966), equivalent in calorific yield to some 100 000 mussels, shellfish may have been of quite marginal significance even in relation to the other marine resources, but further data to support this point are lacking.

The Tolowa pattern is typical of the area, and a somewhat similar seasonal round focused on coastal home bases with occasional movement along the shore to transitory sites or into the hinterland to exploit deer and acorns in what amounts to a mobile-sum-sedentary pattern is recorded for the Yurok, the Coast Yuki and the Coast Miwok among others (Greengo 1952; Kroeber 1925). A minor variant is found in some areas where the shoreline is too exposed or too inaccessible to favour prolonged settlement, in which case the major occupations are located further inland and the shore resources exploited from transitory camps, as, for example, among the Pomo.

Evidence of permanent settlement is rare. The Maidu are reputed to have stayed on the coast all year (Kroeber 1925, p. 396), but what this means in a territorial sense is ambiguous. Only the Costanoans have been associated to any extent with permanent littoral settlement or with shellfood-based economies. It is perhaps significant that this is one of the areas least well served by early observations of traditional life, since it became a mission centre from an early period (Kroeber 1939, p. 464). It is also an unfortunate coincidence that some of the largest shell mounds of the Pacific coast are found in this area, namely the San Francisco sites. Inevitably interpretations of economic life have been based less on ethnographic observation than on archaeological data and in particular the visual impact of mounds of shell and the bird remains obtained from excavation. The latter indicate both winter and summer occupation and when first studied were interpreted as evidence

of permanent, year-round occupation (Howard 1929). However, similar faunal evidence was subsequently found in a nearby mound and interpreted in the light of other data as evidence of permanent occupation during winter only, with occasional visits during the summer (McGeein & Mueller 1955). Greengo's suggestion (1925, p. 70) that the sheltered position of the mounds might allow the possibility of permanent occupation can hardly be taken as evidence that this was actually the case, since availability of food is likely to be a more critical directive on patterns of occupation than availability of shelter.

In any case, even if year-round occupation were the rule for these shell mounds, this would be in no way inconsistent with the practice of a mobile-cum-sedentary economy incorporating inland sites used on a transitory basis, as is demonstrated by the Tolowa example. Such direct observations as do exist show that the Costanoans were by no means fully dependent on shellfish but also exploited sea lions, small quantities of salmon and lamprey and the occasional stranded whale on the marine side, and seeds, acorns and rabbits on the terrestrial side (Kroeber 1925).

Another point worth noting is the evidence of occasional visits by inland tribes to the coast, where they were allowed by the local inhabitants to collect molluscs and other marine resources, some of which they took home with them (Greengo 1952; Kroeber & Barrett 1960). This is an interesting variant of seasonally mobile patterns for integrating resources and clearly needs to be taken into account when interpreting archaeological evidence of occasional molluscs found in inland sites - sometimes as much as 72 km from the coast according to evidence in Baja California (Hubbs & Roden 1964). Such evidence is neither proof of trade between independent communities each practising a sedentary economy, nor is it sufficient evidence of a seasonally mobile economy in which the people who deposit molluscs in the interior are the same group who are responsible for the accumulation of coastal occupation sites. More detailed parallels can be found in Australia.

Two other examples from the Pacific coast are worth examining. The first is the Seri Indians, who occupied a coastal strip on the Gulf of California

(Ascher 1962). They are of especial interest because they represent another case of strandlooping. The basis of subsistence for these people was aquatic resources, in particular the exploitation of the Pacific green turtle, which supplied up to 25% of the annual diet, and fish. Molluscs were collected by women and children. Of secondary importance were fruits and game. When observed in 1960 they spent the whole year moving back and forth along a coastal strip about 100 km long by 6 km wide with a permanent camp at one end and a temporary camp at the other. It is probable that both sites would appear archaeologically as shell middens although this is not confirmed.

A potential biasing factor is that population size at this time was only about 10% of the estimated maximum prehistoric population, a difference which may have altered the pattern of exploitation quite considerably. However, there is no difficulty in accepting that a strandlooping economy formed the traditional basis of exploitation, since the limitations of the local environment are not unlike those of Tierra del Fuego, namely an abundant supply of marine foods, especially turtle, and a hinterland almost barren of economic potential, in this case because of the encroachment of the desert almost to the shore.

The economies of the Northwest coast of North America provide a similar picture of littoral settlement supported mainly by marine resources, especially in the north (Drucker 1963). The area is best known for its great abundance of salmon, allowing the development of permanent villages. It seems likely, however, that these so-called "permanent" villages, while being home-base sites occupied by at least some of the people throughout the year, were not permanent, except in the sense of the Tolowa site of Point St. George, and incorporated a mobile element as well. Drucker (1943, p. 30) specifically notes that numerous sites would be included within the territory claimed by a single tribe. There were salmon sites, clam sites, sites for halibut fishing and sites for sea-mammal hunting, although villages occupied more or less permanently no doubt provided the focus of exploitation. Terrestrial resources are scarcely mentioned although deer appear to have been abundant in some areas. Molluscs

were consumed in quantity and have left their archaeological mark both as transitory camps and at village sites.

As in South America the environmental directives on such a pattern of exploitation are quite specific and one need look no further than these to explain the divergence in economy from the typical Californian pattern. The descriptions of the Northwest coastline are quite reminiscent of Tierra del Fuego, with rugged terrain, scarcity of landing places for boats, great mountains rising from the shore, dense tangles of forest and little soil. "One need not wonder that the natives were beach dwellers who penetrated the woods but rarely." (Drucker 1943, p. 29).

The North Atlantic Coast

Although there are numerous shell middens recorded along this side of North America the ethnographic evidence is much less detailed. The Indians of Nova Scotia had a pattern of coastal exploitation, including the consumption of molluscs and the formation of shell middens, broadly similar to the Californian pattern with a seasonal round integrating the resources of shore and hinterland (Erskine 1960). There is some suggestion that the coastal shell mounds of Florida were used by people who moved inland during the winter for shelter and game, or alternatively that they were the summer resorts of inland farmers (Douglas 1885), but the evidence on which this is based is not clear. In general such evidence as is available does little more than confirm the general picture presented by the Pacific tribes.

On the whole the ethnographic data from North America suggest somewhat similar principles for the operation of coastal economies to the evidence from Tierra del Fuego. Where hinterland resources were available these were incorporated into the coastal economy by a pattern of seasonal movement away from the shoreline. Where terrestrial resources were scarce, coastal economies based mainly on marine resources were able to operate, albeit with a greater degree of mobility, depending on the concentration, abundance and diversity of the available food supplies. Coastal shell middens of several kinds are

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recorded, including those which correspond to our categories of home-base and transitory sites, although it seems possible that even some of the latter were primarily used for non-molluscan resources. The role of molluscs in these coastal economies is difficult to assess from the available data, but there is little evidence to suggest that they normally made a major contribution to the diet.

2. Australia

There are three main sources of ethnographic observation relating to Aboriginal coastal exploitation. In the first place there are direct observations of traditional Aboriginal economies in northern Australia; secondly there is a mass of documents from early travellers and settlers in New South Wales, much of it highly misleading and unreliable; and thirdly some ethnographic records of rather better quality in Tasmania.

Cape York

The model for coastal economies in the monsoonal environment of northern Australia is described in Thomson's classic and often quoted paper about the Wik Monkan on the Gulf Coast of Cape York Peninsula (Thomson 1939). As might be expected in an environment with dramatic alternations of wet and dry seasons, there is marked evidence of seasonal variations in diet and settlement.

The primary staples were fish, obtained in greatest abundance in the wet season but available throughout the year, and plant foods, especially yams, available in greatest abundance in the early part of the dry season. Kangaroo and wallaby were also quite important as sources of animal protein. In addition there was a wide range of subsidiary resources such as birds, turtles, crabs, eggs, fruits and other plant foods, which, in aggregate, probably formed quite a substantial supplement. The dugong was important as a meat source in some areas, although never apparently a dominant staple (Thomson 1934, p. 241).

The evidence for shellfood is somewhat ambiguous. Shell middens are comparatively rare along the coasts of Cape York, apart from the dense concentration of mounds at Weipa (see Chapter VII). According to Thomson shellfish were important among the Wik Monkan during the wet season (Thomson 1939, p. 217), but shell middens in the area are scarce and of small size, and it seems probable that shellfood was an unimportant secondary resource in most areas.

As a general rule the overall pattern of economic exploitation was one integrating wet season home-base sites on the coast and numerous transitory sites of various kinds up to 30 km from the coast used mainly during the dry season.

Coastal economies of this type were the norm throughout western Cape York, and a similar pattern has been identified in Arnhem Land (White & Peterson 1969). There is little evidence of settlement confined exclusively to shore areas and marine resources except on the east coast of Cape York. Here the extensive shallow seas sheltered by the Barrier Reef and supporting large populations of fish and dugong combined with the relatively steep and inaccessible nature of the hinterland seem to have been primarily responsible for a pattern of exploitation based on permanently occupied coastal sites (Thomson 1934). However, economic activity was not exclusively confined to the shore, since Thomson reports that small groups of people sometimes went inland for a few days in search of yams and small game.

New South Wales and Tasmania

The pattern of coastal economies in New South Wales and Tasmania is less clear. The ethnographic records are much less complete and reliable than for the north, and the disruptions caused by European incursions are more marked. Secondly, the seasonal variations of climate and food supply become less dramatic as one moves southward out of the monsoonal zone of the north. Seasonal variations in resource availability certainly occur but their effects on economic life are less obvious. At any rate there are some records of coastal groups moving inland at certain periods of the annual cycle, particularly in

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northern New South Wales and in Tasmania (McBryde 1966; Hiatt, B. 1967). Even in the Sydney area, where the case for economies focused exclusively on the littoral is strongest, critical study of the early records in relation to environmental and archaeological evidence has shown that at least some people from the coastal community dispersed inland in the winter months (Poiner 1971), and there is nowhere any support for Meggitt's isolated assertion that the coastal peoples of Australia depended almost entirely on marine foods for their total supply, only occasionally obtaining 'bush' food by barter with inland people (Meggitt 1962, quoted in Hiatt, B. 1967, p. 119).

There are also records from several areas of overlapping movements in which people from inland tribes made occasional visits to the coast in order to take advantage of seasonally abundant supplies of fish and shellfish. Similar movements sometimes occurred in response to other resources which occasionally bloomed in sufficient abundance to exceed the requirements of the local population, notably the bogong moth of the Kosciusko Mountains in New South Wales (Jardine 1901) and the bunya pine nut of southern Queensland (Petrie 1932), attracting people from distances of 100 km or more.

It is clear that a certain amount of social flexibility existed both within each single annual territory and between one annual territory and the next. Whether the motivation was primarily economic or social, the value of such movements in smoothing irregular fluctuations of food supply and allowing the fullest possible utilisation of local and seasonal variations in resources is evident (Hiatt, L. 1968), and has been noted in America and Africa as well (Suttles 1968; Yellen & Harpending 1972).

As Hiatt has emphasised, the pattern of seasonal mobility need by no means be a simple one in which whole groups spend the summer on the coast and the winter inland or <u>vice versa</u>:

> I am not suggesting that the Aborigines who had largely coastal territories did not exploit the inland food resources nor that the natives from the inland did not visit the coast. The movement of most hunting-fishing-gathering peoples is usually designed to take advantage of seasonal and/or especially abundant food supplies . . . . Each group probably had a defined territory about which it moved according to food supply, weather and social obligations. It probably also utilised the resources of other groups according to established rules. Large gatherings containing several groups

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> probably clustered around food supplies at certain times of the year and at these gatherings no doubt, joint ceremonies were performed and quarrels settled as they were on the mainland . . .
>
> (Hiatt, B. 1967, p. 203)

These additional complexities need not detract from simple concepts of seasonal mobility which have been found adequate in extreme environments - although they should perhaps inspire caution in the interpretation of so-called seasonal indicators in archaeological deposits - but rather, by elaborating them in more complex circumstances, confirm the basic underlying principle, that patterns of economic exploitation are directed towards the integration of temporal and local fluctuations in resources in the manner most beneficial to the long-term support and survival of the consumer and the consumed alike.

3. Other Areas

Africa

The material from Australia and America represents by far the most comprehensive ethnographic record of coastal economies, and isolated accounts from other areas essentially confirm the major features already discussed. However, there are other examples which are worth a brief mention. They emphasise certain aspects of the use of shell middens and allow the general conclusions which have already been reached to be extended to other continents.

Ethnographic study of coastal groups in South Africa consists mostly of scattered observations by early travellers and, as such, provides a very highly biased picture of the indigenous economy. It is chiefly of historical interest as the source of the term "strandlooping", a word coined by early Dutch travellers to describe the native people they saw along the coasts and whom they believed to be beach dwellers who wandered along the coasts subsisting mainly on fish and shellfish (Van Riebeck Society 1954). So rooted was this concept that it gave rise to the idea of a distinct people with strandlooper physical characteristics and strandlooper pottery (Tooke 1908; Rudner 1968).

It seems almost certain, however, that this is a classic result of observational bias by travellers who only saw the native people during a small part of their annual cycle. The possibility that shell middens were formed by inland peoples who occasionally visited the coast seems to have been recognised from an early period (Leith 1898), and now seems to be the generally accepted archaeological opinion (Parkington 1972; Speed 1969). At least one Bushman group is known to have moved seasonally between coast and interior (Deacon 1969, 1970), and archaeological evidence of marine molluscs and strand-looper pottery in inland sites as well as cave paintings of boats which could only have been observed by people who had visited the coast all point towards movement of some sort between the coast and the hinterland.

The Andaman Islands

Important observations about the use of shell middens have been made among the Andaman Islanders, some of whom lived on shell mounds, the largest of which are archaeologically impressive deposits up to 5 m in thickness (Cipriani 1955, 1966). They are particularly important in providing a very clear ethnographic illustration of some of the hypotheses advanced in the examination of the economic directives of molluscan exploitation:

> Every kitchen-midden in the Andamans consists of the refuse of one particular group of thirty to forty persons who return to the same spot every year for a stay of forty to forty-five days or even less. Molluscs are not a favourite food of the Andamanese. They prefer wild fruits, honey, fish, turtle, dugong, and above all pig. Shells are eaten only when nothing else is available and nearly always only during halts at fixed localities, since it is rather cumbersome to carry around a sufficient amount of them. Even then shells are not thrown on the refuse heap every day.
>
> (Cipriani 1955, pp. 250-1)

Conversely, Cipriani notes that sites used only for the consumption of shellfood were "temporary resting places" where the molluscs were eaten in insufficient numbers to leave any lasting trace.

It seems clear enough that molluscs were relatively inaccessible and played a quite minor role in the economy. It is also clear that molluscs

were only accumulated in quantity at sites used primarily for other economic activities, and which therefore presumably served as home-base sites. Even these, though archaeologically among the largest of mounds, were only used for about two months in the year and were thus associated with a mobile economy. On the other hand, sites used only for shellgathering were archaeologically invisible foraging sites.

CHAPTER V

TECHNIQUES OF ARCHAEOLOGICAL ANALYSIS

The possibility that the numerical abundance of shells and the material impact of their archaeological remains may have exaggerated the importance of molluscs as a food supply and misrepresented the occupational significance of shell middens as a class of archaeological site is at least sufficiently strong to require the application of techniques which are sensitive to the presence of such a bias. Two major techniques are available for the analysis of shell-midden economies and have been developed in the light of this consideration. They are midden analysis concerned mainly with the "on-site" data, and site catchment analysis, concerned mainly with the "off-site" data. Both techniques are liable to limitations and uncertainties of varying severity and extent, but their combined application to a variety of case studies has been found to offer a useful measure of the biases inherent in any one technique or in the data available in a particular area.

1. Midden Analysis

The specialised nature of shell deposits has given rise to specialised techniques of excavation and interpretation, based largely on work carried out in California in the 1940's and 1950's and latterly in New Zealand (see Ambrose 1967; Heizer 1960; Meighan 1969 for reviews). The pioneering analysis, published in 1922, of C.G.J. Petersen, the Danish oyster biologist and co-author of the second report of the Kitchen Midden committee (Madsen et al. 1900), appears to have gone unnoticed outside Denmark. Yet it was found at a late stage of the present investigation that his work had anticipated

in several major respects the methods developed here, in particular the combination of on-site with off-site data. Had his paper had more impact on the English-speaking world, it is probable that some of the pitfalls which beset later developments in the analysis and interpretation of midden data would have been avoided. It is especially interesting to note his conclusion that oysters were of quite minor dietary value to the inhabitants of the Ertebølle shell mounds, a conclusion endorsed by our own analysis of the Danish evidence (Chapter VIII) as indeed in all the areas examined.

The California School

The development of midden analysis was first stimulated in the early years of this century by an interest in the age of the California shell mounds (Nelson 1909), and, although this initial objective was ultimately superseded, it had a strong influence on the direction of subsequent developments. The basis of the approach is the estimation of the total quantities of shell represented by the mounds, which are then converted into years of occupation by assuming figures for population size and daily shellfood intake (Nelson 1909). While the focus of interest later shifted from chronology to estimations of population size and diet as the primary objectives, the basic approach remained largely unchanged, and subsequent work was devoted to refining it by developing superior techniques of analysing midden composition and estimating population size and dietary intake (Ascher 1959; Cook 1946; Cook & Heizer 1951; 1965; Cook & Treganza 1947; 1950; Gifford 1916; Greenwood 1961; Treganza & Cook 1948), concerns which have been taken up more recently in New Zealand (Coutts 1971; Davidson 1964a; 1964b; Shawcross 1967b).

In spite of advances on these various fronts there remain inherent weaknesses in the California approach. The most serious of these is that in order to estimate any one of the three variables of chronology, population

size and diet, at least one of the remaining two variables, and sometimes both, have had to be assumed through lack of adequate controls on the data. Also, additional variables have been recognised in later work, most notably seasonality of occupation, which adds yet further uncertainties (Cook 1972). It is not surprising that results obtained from midden analysis have been subject to heavy criticism (Ambrose 1967; Glassow 1967).

While some of the objectives and techniques evolved in previous work have been rejected for the present purposes, in particular a concern with the minutiae of midden composition and with population size as an end in itself, it would be a mistake to reject all quantitative interpretations out-of-hand simply because of the criticisms which have been levelled. Dietary analysis of midden deposits has been found to offer useful results in the present investigation of economy, especially where non-excavational data of the type provided by site catchment analysis provide some independent control.

Dietary Analysis and the Site Economy

The standard technique of dietary analysis is the quantitative comparison of excavated food remains by conversion of bone and shell weights, or minimum individuals, to meat weights and nutritional units (Cook & Treganza 1947; Shawcross 1967b). The potential errors of this method should be clearly recognised and are of two main types: seasonality of occupation; and differential preservation, especially acute where plant foods are likely to be involved in any quantity.

Seasonal Occupation

The proposition that archaeological sites represent seasonal occupations has gained increasing favour in recent years, and various techniques have been developed to test it. Of particular relevance to the study of shell

middens is the analysis of shell structure (see p.V: 21). Similar methods of analysing fish bone (Shawcross 1967b; Ryder 1969) or other materials such as deer antler (Ryder 1968; Sturdy 1975) are also available.

However, seasonal identifications based on excavated data of this sort are unlikely to provide results of sufficient accuracy for dietary analysis. In the first place they reflect, at best, broad seasonal patterns in the collection of specific resources, which is not necessarily equivalent either to seasonality of diet or to seasonality of occupation. The potential disconformity between season of collection and season of consumption arises from the possible preservation and storage of food. Similarly, where a resource is of minor importance in the site economy, a situation which may well arise with molluscs, the season of exploitation can only provide a minimum estimate of the season of occupation.

In practice, quite apart from the technical problems involved, seasonal identifications rarely allow the limits of duration to be assessed with any precision. Evidence of occupation in summer, for example, would not in itself indicate whether the site was occupied at the beginning of the summer or the end, for three days or three months, and would leave open the possibility that the site was abandoned at intervals within the broad seasonal time bracket assigned to its occupation. A site used for six days and a site used for six months in the year might both be described as seasonal occupations, although the use of such a term would mask the very different type of occupation represented by each site and blur the contrast between the site economy and the annual economy in each case.

Equally, apparent evidence of year-round occupation should be viewed with scepticism. Given the diversity of resources available within reach of the shore, it is certainly possible that some people, at least, might stay by the shore thoughout the year. But, while excavated data might indicate a continuous human presence, this would not exclude the possibility that the numbers of people present in any one season might fluctuate considerably

in response to seasonal fluctuations in the economic potential of the local food supply, with movement of part of the population away from the site from time to time to exploit other resources in other areas from other sites in a mobile-cum-sedentary pattern of exploitation. Intermittent use of a site at different seasons of the year might also give the appearance of continuous year-round occupation.

Differential Preservation

It is usually assumed that mollusc shell and animal bone are not subject to large differential biases of preservation, although we shall have reason to question this assumption in the light of the results obtained in the archaeological case studies that follow. A more serious and more generally accepted potential bias is the under-representation of plant food. Sophisticated retrieval methods may at least establish whether or not plant resources were consumed, and specialised technology may sometimes allow a rough assessment of their importance in the diet. But, generally speaking, large uncertainties are likely to remain.

In view of all these qualifications, the contents of a single midden or group of middens cannot be assumed to represent more than a partial sample of the annual diet as a whole. Nevertheless, provided this limitation is kept in mind, conventional quantitative techniques for analysing excavated food remains can be of use as a guide to the site economy at least, if not to the annual economy.

<u>Mean Annual Shellfood Output and the Annual Economy</u>

As a means of complementing the information derived from the standard technique of dietary analysis, particular emphasis has been placed in the present investigation on the total duration of the shell middens in radiocarbon years and on the total quantities of shell contained within them, as

a guide to the mean annual output of shellfood, and on the use of data on the probable number of occupants. Given a knowledge of the nutritional value of the local shellfish supply and the size and nutritional requirements of the human population, it is clear that data of this type can be used to estimate the relative contribution of shellfood to the annual diet without reference to the time spent by the people on the middens, where they went at other periods of the year, or what they ate besides shellfood.

Potential Errors

The primary assumption involved in the use of such data is that the quantities of shell found in a midden represent more or less exactly the quantities actually consumed. The difficulty here is that unknown amounts of shell may have been lost to view because of transportation of molluscs away from the coast for consumption in the hinterland; scattering of shell in the course of daily individual foraging; or removal of midden deposit by natural and human agents of destruction. Archaeological evidence shows that shells were sometimes carried inland up to 50 km or more from the coast in Europe (Madariaga 1964), Africa (Parkington 1972), Australia (Ryder 1969), New Zealand (Davidson 1964c) and America (Hubbs & Roden 1964). But, at least in the areas we shall be concerned with, neither archaeological nor ethnographic data suggest long-distance transportation on any scale; the possibility of losses from foraging activity can be assessed by examining the accessibility of the local shellfood supply and its location in relation to the archaeological deposits; while, in Australia at any rate, post-occupational destruction is either not an issue, as at Weipa, or can be checked to a large extent by historical records, as at Ballina. Thus the effect of potential biasing factors can be assessed within certain limits, and ecological data on potential shellfood output can sometimes be used as a further control on the accuracy of the results.

A second assumption of the method is that the shell middens to which it

is applied accumulated on a regular annual basis. Yet it is arguable that a sequence of deposits spanning a period of 1 000 years may in fact have been used in, say, every 100 years or in some more irregular pattern, representing the accumulation of large quantities of shell on relatively few occasions rather than small quantities added to the mound each year. In order to minimise this potential source of error, the analyses have been applied as far as possible to all the sites serving a well defined area of shellfood abundance, such as a river estuary, on the assumption that the area as a whole would tend to have served as a regular focus of economic activity even if occupation of any one site within the area was infrequent. Stratigraphic features may sometimes throw some light on continuities of midden occupation and hence of shellfood exploitation. Aspects of shell analysis and site catchment analysis can also be brought to bear.

In practice the above assumption is thought not to be a serious limitation. In any case it must be admitted that a resource which provides a major supply of food once every 100 years and a resource which supplies a minor supply of food once every year both fill a similar role in the long-term support of the economies with which they are associated, that is as occasional resources of minor value. Since archaeological data, almost by definition, reflect smoothed trends over time rather than specific fluctuations at any given instant, the question of which of the above alternatives applied in the short term is largely irrelevant to archaeological considerations.

Population Size

Estimation of population size, if it is to be of any use in the assessment of the annual diet, must of course be arrived at independently of dietary data. The chief technique is the postulation of some mathematical relationship between population size and surface area of habitation, of which the most useful for our purposes is the logarithmic formula derived from a study of California mounds (Cook & Treganza 1950; Ascher 1959):-

$$\log. \text{population} = 0.361 \times \log. \text{base area} + 0.342$$

The logarithmic relationship arises from the fact that, as a mound grows in size, the base area increases at a faster rate than the living surface on the top of the mound, a principle which can be appreciated very clearly with steep-sided structures such as the large shell mounds at Weipa (see p. VII : 14).

However, the validity of the formula is open to some doubt, since the population data on which it is based are themselves subject to considerable uncertainty. That some sort of regular relationship exists between area and population size seems probable. That this relationship is a logarithmic one is suggested by observations of midden structure in several areas. The method can be systematically applied to a variety of sites and, in the absence of more accurate data, is better than guesswork. Where local ethnographic data on population size are available, as in Australia, they suggest that the logarithmic formula produces realistic and acceptable results, at least in terms of general orders of magnitude if not in more accurate terms.

Perhaps a more serious source of uncertainty may occur where two or more sites are closely grouped together. Determining whether all the sites were used simultaneously by a given group of people each year, or whether each individual site was used in succession by the same group either in alternate years or on some other rotational basis, is a problem which usually lies beyond the resolution of archaeological dating techniques.

An alternative formula is the conversion factor of 10 m^2/person established by Naroll (1962). Strictly speaking this refers only to internal floor area in structured settlements, although claims have been made for its successful application to Palaeolithic rock shelters (Binford 1968b, p. 247), and it is also subject to wide margins of error (Cook 1972; LeBlanc 1971).

Thus the estimation and application of mean annual output is liable to several uncertainties. But these can be resolved to some extent by the application of independent controls, and the results have been expressed as a range of possibilities in order to accomodate the margins of error inherent in the data.

Estimation of Midden Size

There are two main stages in the analysis of midden composition: measurement of midden volume; and sampling of the deposit in order to estimate the relative quantities of the different components. The basic methods for estimating volume are described by Cook and Treganza (1950) and have been adopted with minor modifications for the present investigation. They are most easily applied to middens which take the form of mounds. The base area of the middens is first measured by various geometrical methods or by graphic projection; height and profile are then established by excavation or core-sampling; and volume can then be estimated using the relevant geometric formulae:

Segment of sphere: $$V = \frac{\pi h}{6} \left[h^2 + 3R^2 \right]$$

Truncated cone: $$V = \frac{\pi h}{3} \left[R^2 + r^2 \sqrt{R^2(r^2)} \right]$$

where V = volume

R = radius of base area

r = radius of truncated surface parallel to the base

h = height

Not all middens approximate regular geometric forms of this type, and for irregular structures a different method is required, employing a modification of the standard surveying technique for estimating volumes of irregular solids. This involves the measurement of transverse profiles taken at equal intervals along the longitudinal axis of the structure and the application of Simpson's prismoidal formula (Clark 1957):

$$V = \frac{L}{6} \left[A_1 + 4A_2 + 2A_3 + 4A_4 + \ldots\ldots 2A_{n-2} + 4A_{n-1} + A_n \right]$$

where V = volume of prismoid

L = length of prismoid perpendicular to the parallel end planes

A = area of transverse profile

Transverse profiles are measured in the field using a clinometer and tape. Drawn to scale on graph paper their enclosed areas can be measured by planimeter or graphic projection.

The most extensive application of volumetric measurements was undertaken at Weipa, where a combination of these methods was used to obtain basic field data for more than 300 shell middens. A rapid method of field measurement was required in these circumstances, and surface dimensions were often measured by pacing, while height was estimated relative to eye-level height or with a clinometer and tape. For the irregular shaped mounds, only key cross-sections were measured, and longitudinal profiles were drawn in by eye, allowing additional cross-sectional profiles to be reconstructed on graph paper. Cook and Treganza (1950) estimated the expected error for volumetric calculations as ± 25%, and this has been accepted as an adequate margin of error for the present calculations.

Midden Composition and Sampling Procedure

Much discussion and experimentation has been devoted to the problem of sampling midden deposits. This emphasis arises from a reversal of the usual archaeological situation, where the potentially informative material forms a relatively small proportion of the total depositional matrix in which it occurs. With shell middens it is the depositional matrix itself, composed to a large extent as it is of mollusc shells, which is, or should be, one of the major features of archaeological interest and analysis. The nature of the sampling problem can be appreciated if it is realised that a single cubic metre of midden deposit contains about 1 t of material, representing up to 100 000 molluscs shells. Even a modest-sized midden may comprise several hundred cubic metres of deposit and the large mounds several thousand, so that even with a single site one is likely to be dealing with a potential population of hundreds of tonnes of material and tens of millions of molluscs.

The expense involved in sorting and analysis on this scale is normally beyond the scope of most investigations. Koloseike (1970), for example,

has estimated that excavation and sorting of all material from a single cubic metre of deposit alone would require about 1 000 man/hours of work, about 85% of that being spent on the post-excavational analysis. Not only is a rapid and reliable sampling procedure an imperative in these circumstances, but it must also be directed to quite specific objectives.

One method of overcoming these limitations is the use of column sampling, a technique pioneered in America by Gifford (1916), developed and tested by Cook & Treganza (1947, 1948), refined by Greenwood (1961), and adopted for use in New Zealand (Davidson 1964a, 1964b; Terrell 1967). The aim of the technique is to sample the midden deposit at random using the smallest possible number of samples of the smallest possible size in order to estimate the total mass of the various midden components. Treganza and Cook (1948) excavated and analysed a single midden in its entirety to assess the accuracy of various sampling measures and found that, for small and evenly distributed components occurring in large quantities, 15 to 30 samples, each about 1 to 2 kg in weight, were sufficient to represent the total composition of the mound with a standard error of the mean of about $\pm$ 5%. Later experiments showed that the sample size for such components could be reduced to about $\frac{1}{2}$ kg without significant statistical effect (Greenwood 1961).

This method has the virtue of reducing sample size to the minimum but it also poses certain difficulties. In the first place it may involve a disregard for internal variations of midden structure and stratigraphy, which may be of equal importance in the interpretation of the site (Ambrose 1967; Coutts 1971). Secondly it is geared primarily to the estimation of the total mass of the smaller components, such as molluscan shell, and is less suited to the analysis of large or sparsely distributed materials, such as stone artifacts or mammalian fauna. Where excavation is designed to recover large-scale features or details of stratigraphy, procedures may be incorporated for removing small samples from the trench walls after completion of the main excavation, but the samples so acquired are likely to be biased in ways which preclude reliable interpretation (Coutts 1971). A further difficulty is that

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the different components are normally expressed as percentages of the total mass of the sample. Not only does this require sorting and weighing of all materials in the sample, but it is also liable to statistical distortion, since changes in any one percentage may affect all the other percentages irrespective of their absolute values, a problem commonly encountered in other types of archaeological interpretation (Kerrich & Clarke 1967; Wilkinson 1971). With the exception of the "concentration index" of Willey and McGimsey (1954), aimed primarily at determining rates of accumulation, little use has been made of absolute quantities per unit volume in midden analysis.

Strictly speaking there can be no single, ideal sampling procedure since different objectives will require different types of samples and different degrees of accuracy in the results obtained. However, the following procedure has been found to offer some flexibility in the collection of samples suitable for a variety of purposes. All material from each excavated unit of a one metre square trench is placed in 50 cm x 20 cm plastic bags to a uniform level. As a general rule this involves about 12 bags for a 1 m^2 x 10 cm spit. A given proportion of these bags are selected at random and retained for detailed laboratory sorting. The remaining bags of material are sieved through 8 mm and 2 mm mesh on the spot for evidence of non-molluscan resources and artifacts, and the shells are discarded. The total quantities of shell represented by the spit are estimated by direct proportion from the laboratory samples and expressed in terms of kilogrammes per cubic metre using the formula: (total weight x 100) $\div$ mean depth of spit.

A minor disadvantage of this sampling method is that biases may be introduced by variations in the manner of excavating the spit. Since the deposit is loosened and disturbed in the process of excavation before being placed in bags rather than removed in a block from the trench wall as in column sampling, biasing factors affecting the proportion of components found in any one bag are more likely to occur. For example, one bag may contain a disproportionately large amount of soil and small shell fragments, another a predominance of large shell fragments or whole shells, even though the

representation of these different components in the deposit itself is perfectly homogeneous.

Normally a high level of sampling within each spit has been preferred, both to offset such sampling errors and to provide sufficient quantities of material for other aspects of shell analysis. For example, from a 10 cm spit filling 12 bags, 2 or 3 would be selected for detailed analysis, representing a total sample size of 12 to 20 kg. It is possible that experimentation with this technique, for example by the use of smaller bags, might allow smaller sample sizes without appreciable distortion, but this has not been developed, since large samples were consistent with the overall objectives of excavation.

This procedure is simple, flexible, easily geared to the other requirements of excavation method, applicable to excavated units of varying size and thickness, and has produced consistent results from a variety of sites. The sample size can be adjusted at any stage during the excavation to suit varying research objectives or practical limitations, and can be reduced after excavation by systematic sampling.

The data obtained in this way may reasonably be assumed to represent the excavated square. However, their relationship to the site as a whole is another matter. Since a single metre-square trench normally represents a very small fraction of the total deposit, additional squares should ideally be sampled to provide some control on the initial results. This was not possible with all the sites examined and other criteria have been resorted to in assessing the applicability of the excavated samples to the sites as a whole.

2. Site Catchment Analysis

The technique of site catchment analysis has been developed as a supplement to, and to some extent a substitute for, the use of broad environmental zones in the study of past human activity. It is founded on the proposition

that human occupation sites are often located with respect to features which are atypical of the general environmental zone in which they occur, or on the junction between two distinct zones, and that it is the characteristics of the immediate vicinity which are likely to have had most influence on the choice of location and the type of economy practised rather than the characteristics of the general zone with which the site is associated (Higgs & Vita-Finzi 1972; Jarman 1972; Jarman et al. 1972; Vita-Finza & Higgs 1970). Shell middens, being located on the junction between land and sea, are a classic illustration of this proposition.

The aim of the site catchment analysis is to relate the site and its excavated contents, particularly the food remains, to the area around the site. Examination of the economic potential of this area may help to supplement the information from excavated samples and to test the conclusions derived from them about diet and economy. Comparison of several such sites in these terms may provide a useful basis for generalisations.

Site Territory Analysis

The question naturally arises as to how large an area should be considered relevant to the site economy. Sometimes, where the reasources identified in excavation can be related to a quite specific location in the surrounding environment, the site catchment analysis itself may provide empirical evidence for an assessment. However, opportunities of this sort are rare, and in any case there is the further possibility that some items may have been carried back to the site as a result of occasional forays over exceptional distances. A distinction is therefore usually made between the site catchment, which is the total area from which the contents of the site have been derived, and which may include trips of several hundred kilometres to import raw materials for the manufacture of artifacts, as at Weipa, for example (Appendix B), and the site territory, which is the area habitually exploited from a

given site (Higgs & Vita-Finzi 1972 p. 30). Thus site catchment analysis is closely bound up with the concepts of territory examined in Chapter III.

The delimitation of the site territory, as we have seen, is based on assumptions about the time-distance factor in exploitation, and in the following studies the distance of 10 km, or 2 hours' walking time, has been adopted as a reasonable guide to the maximum radius of habitual exploitation around a site. In Australia cases have been recorded of hunters ranging up to 12 km from a site (Davidson 1928; McCarthy 1960), and daily trips of between 8 and 16 km for meat and vegetable staples seem to be quite common (Gould 1969), figures which suggest that the 2 hour radius is about right as a general order of magnitude.

The drawing of a 2 hour boundary around an archaeological site does not exclude the possibility of forays over larger distances. In a desert situation, for example, the scarcity of water supplies may necessitate longer trips, a possible factor in the relatively high figures quoted above from Australia. Conversely localised resources of great abundance may allow the population to meet its daily subsistence requirements from within a smaller area. Indeed in the short term the situation may fluctuate back and forth in response to temporary periods of scarcity or abundance. However, it seems reasonable to assume that the long-term trends reflected in the archaeological data represent some sort of stabilised optimum appropriate to the nature of the available resources and the level of technology.

Nor does the use of the 2 hour boundary necessarily imply a radial pattern of exploitation from a central locus, although this is often the initial assumption. Many sites may be transitory or specialised sites focused on a limited area of the potential site territory. However, mapping of the resources within the 2 hour boundary of such sites may show that they are incapable of supporting a home-base pattern of exploitation and thereby help to test hypotheses about the economic function of the site. Discrepancies between the resources identified in excavation and the resources potentially available within the site territory can throw further light on the nature of

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Thus the use of the 2 hour boundary is not intended as a rigid pre-judgement of the actual pattern of exploitation but rather as a measure of economic potential and as a convenient yardstick by which to judge the probabilities that, over the long term, resources within a given distance from a site will tend to have been exploited from that site.

Resource Potential

In assessing economic potential, attention has been largely confined to the staple resources, as far as this can be judged from the potential of the environment, the archaeological data and, where available, the ethnographic record. Borderline cases, where the resource may have been of supplementary rather than staple value, are included for consideration where necessary, as of course are the molluscs, which are our special object of interest.

Figures for potential food output per unit area are sometimes available, as with deer resources in Europe or fish and shellfish in Australia. More often analysis is limited to the consideration of general resource categories and the area of their representation within the site territory. Marine resources have been assessed at this level by projecting the 2 hour boundary of a coastal site out to sea (Figure V.I). This is an artificial device to the extent that there is some uncertainty about the time-distance factor for travel over water. The relationship between the area of enclosed water and the potential of the marine resources is also likely to be far more variable than on land. However, this method does allow assessment of the area of land that the site occupants were prepared to forego by living on the edge of the sea, as opposed to living at a site further inland, and it seems reasonable to accept this as a broad measure of the relative importance attached to marine resources while the site was in occupation. Where more detailed data about economic potential are available, whether on land or sea, these have been examined. But their absence does not entirely preclude analysis. By shifting the focus of investigation to a more general level of

investigation, even such simple measurements as the relative area of land and sea within a potential site territory can be used to some effect, especially where a number of sites from different areas are available for comparison.

The Factor of Size

The simplest measure of a site territory is its size, a variable which has important consequences for economic potential. Assuming a constant time-distance factor of 2 hours, three types of territory can be recognised (Figure V.1). The ideal territory is the situation which occurs on level terrain where the walking time of 2 hours coincides with a distance of 10 km. It is therefore a circle with a radius of 10 km and an area of 31 400 hectares. The distorted territory occurs where natural impediments to access such as hilly topography reduce the distance that can be travelled in 2 hours. Its major feature is its reduced area by comparison with the normal territory. In mountainous country such as northern Spain (Chapter IX) the distortions may be so severe as to reduce the area of a potential site territory to as little as 17% of the ideal size. A third type of territory recognised is the truncated terrestrial territory, where the area of available land is reduced by the proximity of the sea or of other large bodies of water such as lakes or broad rivers. Some coastal site territories are both distorted and truncated.

The analytical importance of these distinctions lies in their effects on economic potential, for it is logical to assume that, other things being equal, the larger the site territory the larger the potential supply of food. Therefore we should expect the ideal territory to be the preferentially selected form over time, and hence the type most commonly associated with archaeological sites, unless factors in the situation such as irregular topography make a distorted territory unavoidable, or unless the reduced area of land available within a truncated terrestrial territory is balanced by some compensating advantage such as the abundance of marine and aquatic resources. Sturdy (1972) has considered other, special circumstances where

the distorted or truncated form may be selected over time in preference to the ideal.

Inter-site Relationships

Clearly a truncated territory has rather less economic significance when it refers to a specialised site used on a transitory basis than when it refers to a home-base site. Adequate criteria are therefore necessary to distinguish the economic function of sites, and territorial analysis may be of use here by extending the range of investigation to the spatial relationship between sites. For it follows from the basic theory that home-base sites should be located not only with respect to their adjacent environment but with respect to each other. Where the distribution of resources is perfectly uniform, archaeological home-base sites should be evenly spaced across the landscape in accordance with the appropriate time-distance factor, a prediction which applies equally to complementary sites forming part of a single economic unit as to contemporaneous sites belonging to independent economic units. That many distributions fail to conform to this expectation may show that the record of sites is incomplete, that the known sites are not all home bases, that they belong to different chronological periods, or that the distribution of resources is irregular.

Thus a territorial approach offers a hypothesis about the distribution of archaeological sites. Where this hypothesis fits the known distribution, it should have important consequences in clarifying both the economic function of the individual sites - especially the question of whether or not they are associated with a home-base pattern of exploitation - and the problem of contemporaneity. Where it fails to fit the available data, the resulting discrepancies may open up further avenues of investigation.

Potential Errors

Problems of contemporaneity between sites and of potential gaps in the

known distribution of sites are an especially common source of potential errors, and while it may sometimes be possible to assess the limits of uncertainty by considering potential destructive agents, radiocarbon dates or other lines of evidence, certain assumptions have to be made, albeit assumptions which can be tested to some extent by reference to the territorial analysis itself.

Another major problem arises from the possibility of changes in the economic potential of an area over time, especially where the present-day situation is used as a guide to the prehistoric past. Assessment on land is often complicated by changes in vegetation or potential changes of soil cover and productivity. Detailed consideration of such possibilities lies beyond the scope of this work, and, while it is recognised that they may ultimately require some additions or alterations to the final picture, attention has been largely confined to gross differences, where it can be assumed with reasonable confidence that few changes have occurred since the period of prehistoric occupation, and such as may have occurred have not been sufficient to affect economic potential. Much more relevant to the central theme of the present investigation is the question of changes in the shoreline, especially those caused by changes in sea-level, which have considerably altered the relative proportions of land and water within the potential site territory of many prehistoric coastal sites. This applies most of all in Europe, and special attention has been focused on changes in this aspect of the biotope.

Methods of Measurement

The usual method of measuring territorial boundaries in the field is by walking one hour or two hour transects around a site. The reasons for making an assessment on foot are that it allows the degree of distortion imposed by topography or vegetation to be taken into account and that it allows on-the-spot observations about features of the environment such as land use, soils, water supply and so on. The major difficulty posed by this technique is that it is highly labour intensive and time consuming. Normally two transects per

site is the maximum daily practicable number that can be measured by one person on foot. Since four transects are considered to be a minimum for reliable assessment of a given site territory, analysis of a whole area with a large number of sites will clearly involve a considerable amount of time and effort. While this may not appear excessive in comparison with the requirements of excavation, a means of speeding up the process would seem to be desirable.

One technique which has been applied in the present investigation with some success is the measurement of territorial boundaries using a piece of string of scale length on a detailed contour map. The usual objection to this is that it does not take account of the effects of topography or other impediments to access (Jarman 1972 p. 712). However, this can be overcome to some extent by the application of Naismith's formula, commonly used by hill climbers, which states that the average time taken to walk 10 km on the flat is 2 hours and that for every variation in altitude of 300 m an extra ½ hour should be added (Poucher 1971 p. 70). Using this formula, it is a simple matter to measure any number of transects rapidly and consistently. In northern Spain, where the mountainous topography causes marked distortions of territorial size which are of great importance in economic interpretation, some 200 transects have been measured in this manner.

This method is not intended as a substitute for field observation, and it has only been applied in the present investigation in the light of first-hand walking experience of the areas under examination. But, by providing advance knowledge of the territorial boundary, it may help to identify problems which can be subsequently checked in the field and to concentrate attention on specific features of greatest relevance to the site economy. It also leaves the field observer free to choose alternative methods of transport or convenient vantage points as a means of assessing the economic potential of the site territory.

Resource zones have been identified according to criteria established in each of the individual case studies, and their distribution within each site territory has been mapped and measured with a planimeter.

3. Shell Analysis

Some interest has been focused in recent years on techniques of analysing shells for information about the age structure of molluscan populations and the season of their collection. These techniques are still very much in an experimental stage and some justification needs to be offered for not including them in the analysis of the archaeological case studies.

Seasonal Determinations

Certain species of molluscs, notably cockles, have well-defined growth rings on the shell surface, formed by winter recession of shell growth in response to decreased temperatures (Orton 1923), whence arises the possibility of assigning individual molluscs to age classes and of determining their season of death. Daily banding of shell growth is also visible using microscopic techniques (House & Farrow 1968; Koike 1973). The archaeological value of these techniques has yet to be fully explored, although some preliminary results have been reported from New Zealand (Coutts 1970; Coutts & Higham 1971; Swadling 1972). Analysis of oxygen isotopes has also been applied to seasonal determinations (Shackleton 1970, 1973).

A major limitation of the use of shell banding is that results of any kind can only be expected in temperate areas with well-defined seasonal variations of temperature. Even here, distortion of the growth pattern frequently occurs, with the absence of winter rings in some years and the presence of additional rings caused by disturbances occurring at any time of the year (Orton 1926; Cole 1956c). Microscopic analysis of shell sections may overcome some of these limitations, but the techniques involved are laborious and require expensive equipment. Given that a single midden may contain several million mollusc shells, even the most careful sampling programme will require a rapid technique of identification if general statements are to be made with any confidence. Isotope analysis is similarly limited

to rather restricted environmental conditions and depends on the skilled application of elaborate techniques and expensive equipment.

None of these problems is insuperable, and in time useful archaeological results of general applicability may be achieved by these techniques. However, even the most accurate seasonal analysis is likely to remain of limited value in the interpretation of economic behaviour in the absence of other data, for the reasons stated above (pp. V: 3-5), and, although some experimental work was carried out on seasonal dating in the course of the present investigation, the results were not found to be sufficiently satisfactory to justify further development of the technique as a major source of data.

Size and Age Analysis

Data on age and size variation may reflect variations in the intensity and regularity of human exploitation and the extent to which changes visible in the archaeological record are the result of changes in economic behaviour or of other factors in the biotope. Townsend (1967) attempted some preliminary interpretations of size change in prehistoric limpets in terms of pressure on resources, while Swadling (1972) has examined the archaeological implications more fully and demonstrated the results that can be achieved where detailed biological studies of modern mollusc populations have been carried out in circumstances comparable to those of the prehistoric period.

Ideally data on age as well as size should be obtained, since size changes in mollusc samples may reflect either environmental change or change in the intensity of human exploitation. The addition of information on age structure allows these two alternatives to be distinguished.

One difficulty with age analysis is that, as with seasonal determinations, it depends on the study of ring sequences. In the case of oysters, which are

the major molluscan species in two of our case studies, Ballina and Denmark, it has been established from studies of modern oysters of known age that growth rings are quite positively misleading as a guide to age (Massy 1914), whereas the cockles from the substantial Weipa mounds lack any visible signs of a ring sequence on the shell surface, presumably because they lived in a tropical environment where seasonal alterations of temperature are less marked than in more temperate latitudes, although sectioning and microscopic examination of the shells revealed what appeared to be evidence of daily banding.

Another difficulty is that age and size curves may be affected by fluctuations from year to year in spatfall, while variations in mortality from non-human causes may also distort the pattern. That high levels of exploitation intensity may be achieved by non-human predators is demonstrated by the behaviour of the oystercatcher on the cockle beds of South Wales (Davidson 1967), and crabs, fish, starfish and physical changes of the environment may all have a variable effect on shellfish mortality.

A third difficulty arises from the nature of archaeological samples. Apart from the usual difficulty that manageable quantities of molluscs represent a minute proportion of the available total, there is the problem of the time span represented by a single sample. All the samples available for analysis were collected from shell mounds with continuous sequences of deposit extending over at least several hundred years and with very little evidence of stratification, rather than from discrete layers representing a single year's occupation. Thus there is no way of telling whether a sample of shells removed from a 5 cm spit is an homogeneous sample referring to a single year's exploitation or a palimpsest of several different episodes of shellgathering extending over a period of years. It is thus possible that short-term oscillations in shellgathering activity might be masked or unrepresented altogether in samples of this type.

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In spite of these various difficulties, there is no reason why major trends in size and age should not be any less amenable to study than with other types of archaeological data. But, although some size differences were apparent in the excavated samples obtained from Australia and Denmark, the uncertainties involved in the nature of the samples, the lack of any modern biological control studies in the areas examined and the number of assumptions involved in the analysis rendered the results uninterpretable in ways which would have added significantly to our final conclusions about the use of prehistoric shell middens. It has thus been thought undesirable to burden further an already lengthy analysis with a battery of ineffective and possibly misleading statistical data.

CHAPTER VI

BALLINA AND NORTHERN NEW SOUTH WALES

1. Introduction And Archaeological Background

There are many hundreds of recorded shell middens throughout coastal New South Wales, ranging from small deposits with relatively few shells to quite substantial mounds. Many of these, however, are poorly preserved, and detailed investigations so far have been primarily focused on the coastline immediately south of Sydney and on the north coast in the region of the Clarence and Macleay Rivers.

In the Sydney area (Figure VI.1) a sequence of occupation extending from the last century back to 20 000 BP has been established (Lampert 1971a, 1971b; Megaw 1965, 1966, 1968). Three broad industrial stages are recognised, although there is some overlap of leading tool types, beginning with the Capertian from about 20 000 to 2 500 BP and followed by the Bondaian from about 2 500 to 1 000 BP, and the Eloueran, which takes the sequence up to the historical period. A similar sequence of industries has been identified in the hinterland (McCarthy 1948, 1964; Stockton 1970).

The key coastal sequences are at Curracurrang, dating from about 7 500 BP (Megaw 1965, 1968), and at Burrill Lake, dating from about 20 000 BP (Lampert 1971a). Yet in neither case do shell middens appear until the very top of the sequence, and organic remains generally are rather rare or completely absent from earlier levels. Dates from these and other sites in the area suggest that shell-midden deposits do not occur much before 1 000 BP. In the earliest deposits lowered sea-levels are most probably a factor in the lack of shell middens. As Lampert (1971b) has observed in connection with Burrill Lake, the coastline during the early Capertian would have been 13 to 16 km distant from the site - well out of range of shellgathering. Another

factor is the very acidic nature of the sandy deposits, compounded by the fact that all the dated sites are rock shelters where shells have been incorporated in the deposit in relatively small numbers. It is possible that large, open shell middens, where shells and other organic materials have accumulated in sufficient quantity to resist the corrosive effects of the underlying soil, may yield earlier dates. Sites of this character certainly used to exist around Botany Bay, but they have been badly damaged and offer few opportunities for excavation.

The sequence on the north coast (Figure VI.2) differs in several respects from the Sydney area. It is shorter, extending back only to about 6 500 BP according to evidence from the inland rock shelter of Seelands (McBryde, 1966). The stone industries also differ in their emphasis on unifacial pebble tools of Hoabinhian affinities, although the appearance of Bondi points at about 3 000 BP and the increased emphasis on bone and shell artifacts from about 1 000 BP show some similarities with the sequence of events to the south.

Shell middens are also more numerous, especially on the large river estuaries of the north. They are open sites, larger and better preserved than in the south, and make an earlier appearance in the prehistoric record. However, the chronological discontinuities in shellgathering are hardly less difficult to disentangle, on account of the active geomorphological changes which have gone on during the Postglacial period. The earliest dated shell middens occur at about 4 500 BP (Campbell 1969, 1972) and are situated on an old shoreline which is now over 10 km inland from the present coastline because of shoreline progradation by sedimentation in estuaries and coastal embayments (Hails & Hoyt 1969; Thom 1965). The earliest midden on the present shoreline is at Wombah on the Clarence River, dating from about 3 000 BP (McBryde 1965, 1966), while the Richmond River middens discussed below date from about 2 000 BP, a difference which probably reflects the different geomorphological history of the two rivers.

In view of the rather fragmentary nature of the available data along the New South Wales coastline, the relative lack of excavated samples and the factor is the very modest volume of the ready supplies, compounded by the fact that all the dates within the [illegible] where [illegible] have been incorporated in the ground in relatively small numbers. It is possible that large, open hall shelter, whose [illegible] materials have accumulated in sufficient quantity to [illegible] the effects of the [illegible] sand, may yield earlier dates. [illegible] important [illegible] that is which [illegible] but [illegible] for [illegible] in excavation.

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Shell middens [illegible], particularly on the large river-estuaries of the north. [illegible], [illegible] before [illegible] as the north, and east [illegible] sequences in the [illegible] region. However, the chronological characteristics of shell-midden sites are [illegible] less difficult to disentangle, on account of the [illegible] geomorphological changes that took place during the Holocene period. The earliest shell middens [illegible] about 6 500 BP (Campbell 1982, [illegible]) and are situated on [illegible] which is now some [illegible] km inland from the present coastline, as a result of shoreline progradation by sedimentation in estuaries and coastal wetlands (Hall & Hope 1985, Hope 1985). The earliest midden on the present coastline is at [illegible] on the Clarence River, dating from about 3 000 BP ([illegible]), while the Richmond River midden [illegible] dates from about 4 500 BP, a difference which probably reflects the different geomorphological history of the two rivers.

In view of the [illegible] of the [illegible] along the [illegible] coastline, the relative lack of excavated samples and the chronological irregularities in the record, a relatively restricted area has been chosen for detailed study.

The shell middens examined here are on the estuary of the Richmond River near the town of Ballina. The most important archaeological deposits are estuarine middens which occur in ten main groups, mostly in Chiciba Creek and North Creek (Figure VI.3). The largest are mounds up to 400 m long and 4 m thick which appear to have accumulated within the last 2 000 years and were still in use in the mid-19th century at the time of European contact. They are composed mostly of the Sydney rock oyster, Crassostrea commercialis, and their general character and stone industries appear closely comparable to the Wombah midden. There are also surface middens along the nearby open shores, containing mostly the sand-burrowing clam, Plebidonax, but the quantities of shell on these sites are relatively insignificant.

Although no detailed archaeological investigation has previously been carried out on the Richmond River, the oyster mounds are famous for the observations of E. J. Statham, a road engineer, who, in the course of digging away part of the largest mound in the late 19th century, perceived the possibility of dating the site by estimating the total quantities of oysters present and comparing the results with data on modern oyster yields (Statham 1892). His prediction of 1 770 years for the span of occupation compares favourably with the radiocarbon estimate of 1 650 years discussed below.

Since Statham's day much more of the midden deposits has been dug away, but Statham's figures, combined with other records, allow a reasonable estimate of the original size of the shell mounds. There are also data on the modern oyster output of the area in ecological circumstances which appear to have changed little since the time when the sites were occupied, and there are historical records of the number of Aborigines who used the shell mounds. Thus the area is well suited to the application of midden analysis and has incidentally provided an opportunity to salvage somthing useful from deposits threatened with total destruction by further commercial activity.

2. Environment, Resources And Exploitation

Climate and Topography

A major feature of the physical environment along much of the Australian east coast is the so-called Great Dividing Range. Strictly speaking this is not a mountain range on the European pattern, nor is it by any means continuous. It is more correctly viewed as a series of elevated plateaux, relatively few of which rise high enough - above about 600 m - to have an effect on the local climate (Taylor 1951). One such area is the New England plateau, which runs parallel with the stretch of coastline with which we shall be chiefly concerned. The plateau proper lies mostly above 1 000 m, rising to occasional peaks of 1 500 m. To the west it dips gently towards the arid interior of the continent; to the east it presents a steep scarp slope facing towards the sea and some 50 km or more inland from it. In places there are spurs of low foothills which provide a gentler transition between upland and coast. The plateau is thus an area of marked contrast to the coastal lowlands, although it is neither high enough nor close enough to the sea to have much effect on the lowland climate.

The climate of the coastal lowlands is subtropical, with mild winters, hot summers and high annual rainfall (Foley & Newman 1966). Temperature varies from a winter mean of about 13°C to a summer mean of about 24°C, and its influence on economic exploitation is in general relatively slight. Mean annual rainfall ranges between about 1 000 and 1 500 mm according to locality, (Bureau of Meteorology 1968). In an average year some rain falls in every month, reaching a peak during the summer from about October to March and declining during the winter. In bad years the winter may be without rain for as much as five months. But generally speaking lack of water is not likely to have been a serious limiting factor either locally or seasonally, for there are several large rivers draining the plateau with numerous perennial tributaries near the coast as well as swamps, small lakes and lagoons.

[illegible]

[illegible]

[illegible]

[illegible] rainfall [illegible] between about 2 000 and 7 000 mm according to locality [illegible]

Flooding of low-lying ground during the summer may have imposed some limitations on the movement of the human population and the location of sites.

Inland, in the vicinity of the plateau, conditions are somewhat different. The chief contrast with the coastal lowlands is the lower winter temperatures, with frost occurring at any time between April and October, and the lower annual rainfall. The seasonal distribution of the rainfall follows the pattern found at lower altitudes, with the result that the season of lowest rainfall coincides with the season of lowest temperatures, a combination which renders the plateau liable to marked seasonal variations in economic potential.

Vegetation

The present-day vegetation cover reflects the substantial interference of European activity. Tree cover has been cleared on a large scale to provide timber and pasture, and marshy ground has been drained for the cultivation of sugar cane. But much is known or can be reconstructed about the situation at the time of Aboriginal occupation.

Rainfall is the primary determinant of the vegetation cover in the Australian environment, while soil is a secondary factor of local importance (Williams 1955). In the north of our area the rich, basaltic soils and high annual rainfall supported a limited area of rainforest extending from about the Richmond River to just north of the Queensland border. Rainforest gives a dense, humid tree cover with little light penetration, sparse shrubs and scant herbaceous undergrowth. It is easily killed off by burning but is normally too damp to favour the spread of fire except in areas which are in any case marginal because of dry conditions. There is little doubt that the Aborigines would have attempted to convert rainforest to more productive open woodland by fire clearance if conditions had allowed, and there is some evidence of minor fire clearance in Queensland (Tindale 1959). But this does not appear to have been an important factor in the Ballina area. Indeed [illegible] of low-lying ground during the [illegible] and some [illegible] at the expense of the woody vegetation and the [illegible].

[illegible], in the vicinity of the [illegible], [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] rainfall. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

[illegible]

The [illegible] of European [illegible] [illegible] on a large scale to provide timber and pasture, [illegible] [illegible]. The [illegible] [illegible] [illegible] of the use of [illegible].

[illegible] [illegible].

one of the primary incentives to European settlement was the dense stands of cedar (_Cedrela toona_ var. _australis_), a typical rainforest species, and early accounts stress the impenetrable nature of the forest vegetation in the vicinity of the coast (Ainsworth 1922).

How far the rainforest extended inland is difficult to determine exactly, although it probably reached at least as far as Casino and possibly further inland too. What is clear is that it would have tended to grade into more open woodland with the progressive reduction of rainfall with increasing distance from the coast.

South of the Richmond River the rainforest appears to have given way to a predominantly wet-sclerophyll vegetation comprising dense, eucalypt woodland. Inland, on the eastern flanks of the plateau, dry sclerophyll vegetation, a more sparse eucalypt formation, was prevalent, grading into savannah and grassland to the west of the divide.

In the coastal areas the eucalypt woodland and rainforest were by no means continuous but were interspersed with extensive swampy areas of sedges and grasses and with heath-like formations on the sandy soils found along the coastal strip.

Terrestrial Resources: Animals

Rainforest and wet sclerophyll vegetation, with their rather sparse growth of grasses, generally support only the smaller types of marsupial animals (Marlow 1958). The most common species is _Thylogale thetis_, the pademelon, a small type of wallaby commonly taken in some numbers by the use of nets and communal drives (Ainsworth 1922 p. 17). A slightly larger animal, though not so abundant, is the swamp or black-tailed wallaby, _Wallabia bicolor_. Among the smaller creatures, _Perameles nasuta_, the bandicoot - about the size of a large rat - and _Trichosurus caninus_, the possum - about the size of a cat and important for its fur - are commonly found. Larger animals like kangaroos, _Macropus spp._, would rarely have penetrated into the coastal area,

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] (1973, p. 97). [illegible]

being confined to the dry sclerophyll and savannah woodlands of the plateau.

One other resource which may be mentioned under this heading is the flying fox, Pteropus spp., a bat-like creature, which congregates in large numbers at blossom time in spring and summer. It is emphasised in the local records of Aboriginal exploitation (Ainsworth 1922, p. 29) and could easily be caught in large numbers in wet weather when it would not stir from the trees (Bundock 1898). A single individual only provides about 200 g of meat so that it would be easy to overemphasise its importance in the diet, but it appears to have been of at least temporary importance especially in the summer wet season, probably as a supplementary resource.

Plant Resources

Of greatest importance among the plant foods are the various roots, tubers and rhizomes: the long yam, Dioscorea transversa, found on the edges of forest or woodland and widely distributed throughout northern New South Wales; the conjevoi lily, Colocasia macrorrhiza, which provides a poisonous root needing much preparation before it can be eaten and which is found on the edges of damp forests in the coastal district, and possibly the fern root, Pteris aquilina, a creeping rhizome found on rocks and tree trunks (Moore 1893). All three are mentioned to some extent in ethnographic records of the north coast and southern Queensland (Hodgkinson 1845; Dawson 1935; Petrie 1932), although they are not much emphasised. In the Ballina area only yams are mentioned, and even then are interpreted more as a delicacy than a staple (Ainsworth 1922, p. 29).

It is difficult to judge how far these observations are biased by the lesser impact of individual plant gathering on the casual observer in comparison with more dramatic economic activities such as spearing of fish or communal game-drives. But it seems likely that plant food was a staple in most areas, and that it would have been sought out wherever available as a rich source of carbohydrates to complement the abundant supply of fish and animal protein.

Other plant resources of probable importance are the various types of roots and tubers found in swamps. There are general references to such resources in the ethnohistorical records of New South Wales, but there is no mention of any specific plants (Hodgkinson 1845). One possible species is Eleocharis sphacelata, which is common in swamps all over New South Wales (Moore 1893). It was clearly a much favoured staple of great abundance at certain seasons in northern Queensland (Thompson 1939, p. 215), and it seems reasonable to infer that it was of comparable importance wherever there were extensive areas of suitable swampy conditions. Other swamp species, mentioned by Petrie (1932), are Typha augustifolia, a freshwater rush, and Blechnum serrulatum, a fern rhizome found in large quantities in swamps. At any rate it seems quite probable that swamps would have been a fairly prolific source of root-like plant foods of one type or another. Water lilies, Nymphaea gigantea, would also have been of some importance in areas with lagoons.

Nuts of various types, notably Castanospernum australe, the Moreton Bay chestnut, and Macrozamia spirilis, the Burrawang, would be found in the coastal areas, while the rainforests would produce various fruits, of which the cabbage tree palm, Livistona australis, and the bangalow palm, Ptychosperma elegans, may be mentioned. But these appear to have been of lesser value in the diet than the root plants and were probably no more than supplementary resources.

Marine Resources

Fish is a resource of great importance throughout New South Wales and was probably a major influence on the exploitation of the coastal area. The coastline has numerous bays, lagoons, inlets, estuaries and offshore grounds with favourable conditions for the support of a very large fish population which is of considerable commercial importance today. The major concentrations of fish rarely extend more than about 10 km offshore or to depths of more than about 70 m and most catches are taken close inshore or in rivers, especially

in the spawning season when the fish school in shallow water. It is therefore reasonable to assume that large quantities of fish would have been accessible to Aboriginal exploitation, and the wide range of tools and techniques employed by the Aborigines indicates the skill with which they adapted to this opportunity and the influence it had on their economic life. Boats and canoes were available in most areas, and spears, hooks and lines, nets, baskets, cages, traps, poisons, and weirs were all used (Roughley 1916; Tenison-Woods 1882). Sometimes communal drives were carried out to force the fish into shallow water where they could be more easily speared, and in one instance dolphins are supposed to have been encouraged to co-operate in these fish drives (Petrie 1932).

The most abundant fish on the north coast is the sea mullet, Mugil cephalus, individuals of which average about 1 kg with a maximum of about 5 kg. The spawning behaviour of this species has an important influence on patterns of economic exploitation. In about January or February the fish begin to shoal at the mouths of estuaries and from February or March onwards they migrate northwards in large shoals, keeping close inshore in shallow water until they reach another estuary or inlet, where they enter to spawn, a process which continues through to about June or July, after which the fish tend to disperse (Roughley 1966; Stead 1908). Throughout this period the fish are in their fattest condition and are easily accessible to exploitation in large quantities. The most important catches are generally taken within this period - late summer and autumn, roughly speaking - reaching a peak in about April. Although fishing for mullet is carried on throughout the rest of the year, the catches are smaller (Macdonald & Whibley 1966; Thomson 1953).

The next most important species after the mullet is the "salmon", Arripis trutta, more properly described as a perch. Like the mullet it is a large fish, reaching a weight of about 5 kg with migratory habits which determine the season of exploitation. The main spawning season is spring, when the fish shoal in large numbers in the shallow water along the open beaches (Stead 1908; Tenison-Woods 1882). Ainsworth (1922 p. 30) specifically notes that in the foraging system when the [illegible] from the [illegible] [illegible]. [illegible]

possible to ensure that large quantities of fish could have been [illegible]

[illegible] exploitation, and the wide range of [illegible] and [illegible] were exploited

[illegible] in which they adapted to [illegible]

[illegible]

[illegible]

[illegible]

The most [illegible] [illegible]

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[illegible]

The [illegible] [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

the Ballina Aborigines gathered on the beaches during the month of September to spear the salmon.

Between them the above two species probably account for the greater part of the fish intake. The snapper, Chrysophrys auratus, well known further south, also occurs in some abundance on the north coast, especially in the area of the Richmond River (Roughley 1966), although it is not mentioned in the ethnohistorical sources and seems unlikely to have produced much food by comparison with the salmon and the mullet. It is a smaller fish, not much above 2 kg, which is most easily caught by hook and line from rocks. Perhaps some further support for its unimportance in this area is the lack of archaeological or ethnohistorical evidence of fish hooks. Other species of minor importance are bream, Mylio sp., flathead, Platycephalus spp., and whiting, Sillago spp., all of which would be found in the Richmond River, the latter two especially in summer, the bream more in winter. Prawns, crabs and crayfish were probably of at least supplementary importance, although they are not given much emphasis in the historical sources.

Numerous species of shellfish occur in the area, both along the open shores and in the river estuary. Of these the rock oyster, Crassostrea commercialis, is undoubtedly the most important. It is exploited commercially at the present day, and is clearly rated highly as an item of diet in the ethnographic sources (Ainsworth 1922 p. 29), but its precise role in the economy is unclear. As is commonly the case with oysters, the local supply is most favourable for exploitation in the months before spawning, and oysters would therefore be most likely to be collected in the summer months from about November to January. The only other species to occur in any sort of quantity is the "pipi", Plebidonax deltoides, a burrowing clam found in the sand beaches of the open shore. Although almost certainly less abundant as food than the oyster, its shells were useful as scrapers for scaling fish and working wood (Petrie 1932 p. 72 and 101).

[illegible]

[illegible]

[illegible]

Exploitation

If we examine these resources from the point of view of seasonal complementarity, it is possible to distinguish three major geographical groupings or resource zones: the coastal zone, the area in the immediate vicinity of the sea-shore, which is dominated by marine resources; the low-lying coastal plain, varying in width from about 15 to 50 km; and the uplands, comprising the plateau and its eastern foothills. There is evidence of seasonal resource fluctuations in all three zones. On the coast, marine resources reach a peak of abundance during the summer, extending from early September, when the salmon begin to shoal, through to early winter, when the mullet runs slacken off, leaving a leaner period for several months of the winter during which marine foods would continue to be available but in much reduced quantities. Information on the resources of the coastal hinterland is less detailed, but it is recorded that extensive flooding limited human occupation to higher ground during the summer wet season (Bray 1922), and this would probably have restricted access to the animal resources to some extent. Root stocks also generally reach their best development as food plants in the drier season of the year. On this basis, the winter would have been the best period for exploitation of the low-lying hinterland. As for the plateau region, we have already argued on climatic grounds that this would have been most suited to summer exploitation.

Simplifying the picture, we have essentially a summer coastal zone, a winter hinterland and a summer upland. In considering how these three zones might be most effectively integrated into annual economic units, there is clearly a strong case to be made for relating the coastal zone and the coastal hinterland. The summer peak of marine resources in the former complements the winter abundance and accessibility of plants and animals in the latter, and it is highly probable that an optimum exploitation would have required some degree of movement between the two zones, with major concentrations of population on the coast in summer and a general shift of

people to the adjacent hinterland in winter.

The relationship of the plateau to patterns of exploitation is less easy to determine. Assuming that it was used primarily in summer, complementary winter exploitation could have been effected in two ways: either by movement of people westwards onto the rolling plains of the interior; or by movement eastwards into the coastal hinterland. The former pattern is feasible, at least south of a line drawn through Armidale, since both winter rainfall and winter temperatures on the western plains are slightly higher than on the plateau; conversely, in summer the plateau enjoys higher rainfall and less scorching temperatures. The difficulty with movement towards the coast is that it would have exposed the people who practised it to the risk of competition with coastal groups moving inland from the sea at the same season. However, there is no reason to suppose that winter resources would have been especially scarce in the coastal hinterland, and the problem of supporting two economic units would only have been a serious limitation where the proximity of rising ground to the sea-shore restricts the width of the coastal plain. It is also worth noting that summer movement towards the plateau, as an alternative to movement towards the sea-shore, would be a natural response for people wintering in the coastal hinterland, as a means of avoiding the summer flooding which tends to limit exploitation of low-lying ground.

Figure VI.4 illustrates these postulated patterns of economic integration. The reconstruction is essentially hypothetical, although existing archaeological and ethnographic data have been taken into account. The ethnohistorical record in particular is quite suggestive, although far from comprehensive or free from ambiguity. On the Clarence and Macleay Rivers it is recorded that large numbers of people lived on the coast in the fishing season and moved inland in the hunting season (Oakes 1842 p.665). The seasons of the year at which this took place are not mentioned, but the mobile nature of the annual economy is consistent with the pattern predicted above. Archaeological evidence also suggests some degree of movement between coast and hinterland, since small quantities of marine mollusc shells have been recovered from

excavations in the Seelands rock shelter some 40 km from the sea (Ryder 1969).

The historical records also indicate that there existed in the Grafton area groups with essentially inland territories. Whether they moved up onto the plateau in summer is not made clear. But it is recorded that they were allowed to send some of their number to the coast in winter (McFarlane 1934-5 quoted in Pierce 1971). From the nature of the available resources there is nothing implausible in occasional overlapping movements of this sort. As we have suggested previously, the marine resources would have offered a minor potential source of food throughout the winter, and it is possible that, although insufficient to maintain coastal groups near the shore throughout the year, this winter potential represented a supplementary resource of considerable value to inland groups who normally had no access to the coastal zone. The most spectacular case of long-distance overlapping movements on record refers to the exploitation of the bunya pine nut (Araucaria bidwilli). The bunya pine was formerly found in large numbers in the hill ranges west of Brisbane. About once in every three years the crop of nuts was so abundant that people from as far afield as the Clarence River would be invited to join in the feast (Petrie 1932).

On the Richmond River the evidence is more confused. Ainsworth (1922 p. 31) records that the chief Ballina group camped apart in separate divisions except at the oyster season when everyone congregated on the shell mounds, and that their overall territory extended inland as far as the "Big Scrub", which according to Pierce (1971) is about 10 km inland. If this was the case, then it implies an essentially sedentary economy in the territorial sense. On the other hand Ainsworth's estimates of the Ballina population are far higher than other records. His estimate is about 400 people, whereas Fry (1843) cites this figure as the size of the population on the Richmond River as a whole, including the area extending to Lismore and beyond, and records the size of the Ballina group as only about 100. While faulty observation may account for this discrepancy, an equally plausible hypothesis is that Ainsworth's figures refer to a period of population concentration, Fry's to a period of

dispersal. Certainly Ainsworth's estimates apply to the summer season, when population on the coast would have been largest, since they are based on the number of people present during the oyster season, and, as a Ballina resident, he may not have appreciated the full extent of dispersal at other periods of the year. In contrast, Fry, as Commissioner for Crown Lands, presumably travelled widely and was able to view the overall situation. There is certainly evidence of movement over relatively small distances, since Aborigines from the Lismore district are reported to have travelled to Ballina for the summer fishing season (Bray 1923), and the interpretation of the population data offered above suggests that movements over longer distances may also have occurred, possibly involving some overlap as in the Clarence River.

3. Midden Analysis

A total of at least 19 species of molluscs occurs in the shell middens generally. Eighteen of these are recorded in the estuarine middens (Table VI.1). The other species is *Dicathais orbita*, a rocky shore gastropod, which is exclusively confined to the open-shore sites. There is some overlap of shells from open-shore and estuarine biotopes in the middens. The most notable examples are the presence of *Plebidonax* in the estuarine mounds and of *Anadara*, *Pyrazus* and *Crassostrea* in the open-shore middens. In all these cases, though, the quantities represented are very small, and the *Plebidonax* shells in the estuarine sites appear to have been brought in as much for the use of scrapers as for their food value, since the shell edges show marks of utilisation. As regards quantities, *Plebidonax* is the dominant species in the open-shore middens, while excavated samples show that *Crassostrea commercialis*, the rock oyster, accounts for 98% by weight of all molluscan shell in the estuarine sites. In view of its overwhelming predominance, attention is confined to *Crassostrea* in the analysis that follows.

TABLE VI.1 - Molluscs Identified in Excavated Samples at Ballina (B1)

In order of frequency:

Crassostrea commercialis	Sydney Rock Oyster
Bembicium auratum	Estuarine Conniwink
Pyrazus ebeninus	Hercules Club Whelk
Velacumantus australis	Australian Mud Whelk
Plebidonax deltoides	Pipi
Austrocochlea sp.	Periwinkle
Anadara trapezia	Sydney Cockle
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Bedeva hanleyi	Common Oyster Borer
Monoplex australasiae	Hairy Oyster Borer
Tugali parmaphoidea	Narrow False Limpet
Notoacmaea petterdi	Petterd's Limpet
Trichomya hirsuta	Hairy Mussel
Venerupis crenata	Venus Shell
Periglypta sp.	Venus Shell
Parcanassa jonasi	Jonas's Dog Whelk
Cassidula sp.	Brackish Water Mussel
Subulinidae	Terrestrial snails
Nitoridae	Terrestrial snails

Species below the dotted line are represented by isolated individuals only.

Mean Annual Oyster Output

Mound Volumes

The main dimensions and estimated volumes of the oyster middens are

shown in Table VI.2. The volume of B2 was estimated as 11 000 m^3 (14 900 cu yd) when it was still largely intact in the 19th century (Statham 1892). Based on standard techniques of quantity surveying, this estimate may be accepted with some confidence as a fairly accurate approximation. Griffith Taylor visited B3 in 1924 and estimated its volume as 28 000 m^3 (Taylor 1924). Details of the method of estimation were not given, but the main dimensions of the mound appear somewhat less than at B2, although this does not necessarily imply a proportionately smaller volume. In fact it seems probable from Statham's comments (1892 p. 307) that B3 was the largest mound of all. A more modest estimate of 15 000 m^3 has therefore been assigned. Site B1 is the least disturbed of the large mounds, but even here much has been removed, and only about 500 m^3 of deposit remain. However, the surface area of the base of the mound is easily traced, and, using a surface area to volume ratio of 1 : 1, based on the data from B2, the original volume is estimated as 3 000 m^3. Four smaller mounds extend discontinuously to the west of the main B1 site. These are largely intact, and survey measurements indicate an overall volume of about 1 000 m^3. Additional oyster middens occur on the east bank of North Creek between B2 and Chiciba Creek and elsewhere on North Creek and the main arm of the river (Figure VI.3). Most of these have been damaged by ploughing or other means, and their original size is unclear, although they were almost certainly never as large as any of the main mounds, and their size has been estimated as 3 000 m^3, allowing for losses.

The total volume of the oyster middens throughout the whole river estuary in round figures then is 33 000 m^3. Margins of error apply to these figures as to all the other steps in the calculations which follow, but, apart from noting here that the estimates of mound volume probably err on the low side, detailed consideration of errors is deferred until the final discussion.

TABLE VI.2 - The Dimensions of the Ballina Oyster Mounds

Site	Length m	Breadth m	Height m	Area m^2	Volume m^3
B1	180	34	7	3 000	4 000
B2	417	40	4	12 000	11 000
B3 [a]	300	20	3	15 000	15 000
Others [b]	-	-	-	-	3 000
Total	-	-	-	30 000	35 000

[a] Minimum figures

[b] Rough Estimate

Excavation and Stratigraphy

Excavations were carried out at site B1 (Plate I). In its original state it formed a discrete mound about 180 m long by 30 m wide and between 4 and 7 m high (Figure VI.5). This site is of interest for three reasons. It is referred to quite specifically by observations made at the time of European contact, which record the numbers of people in occupation; it is the only large mound of the area with substantial portions of undisturbed deposit; and commercial working has left an exposed section through the middle of the mound which could be cut back to a vertical face to allow examination of the stratigraphy over a wide extent before commencing excavation. This section was cut back to a vertical face in the south-west corner for a distance of 8 m (Plate II), and a further section, 2 m wide, was exposed about 18 m north of this in order to examine the horizontal continuity of the layers. Systematic samples were obtained from a 1 m^2 x 2 m deep trench excavated into the north face of the main cutting, involving the removal

of deposit in thirteen units (Figure VI.6; Plates III & IV).

The most outstanding feature of the stratigraphy is the extensive dark layers of ash and reduced shell content which extend throughout the visible sections. Similar layers are also a regular feature on old drawings and photographs of the destroyed B2 mound (Statham 1892, plate XIV). Whatever their precise significance they appear to be co-extensive with the main area of these larger mounds and suggest that they are homogeneous structures occupied at any one time over the greater part of their surface, rather than composite structures built up in irregular fashion of a number of smaller mounds. A similar conclusion is indicated by the colour of the oyster shell at B1, which shows a progressive sequence of change from top to bottom, apparently as a function of age. At the base is a yellow deposit resting on alluvium, above this a grey deposit, and at the top of the sequence a dark brown deposit. The radiocarbon dates also indicate a uniform upward rate of accumulation as might be expected from this structural hypothesis.

Shell Quantities

Samples for shell analysis were collected using the standard procedure (Plate V). All material from a total of 31 bags was sieved, the 8 mm and 2 mm fractions were sorted and identified, the oyster shell was weighed, and minimum individuals were estimated by counting hinge fragments. The results are presented in Table VI.3. The figures for minimum individuals are shown in order to give some idea of the orders of magnitude involved, but only the shell weights have been used in the calculations, since there are reasons for supposing that the use of weight ratios provides a more reliable guide to the food output of rock oysters than the use of minimum individuals.

The usual objection to weight ratios is that prehistoric shell has probably lost weight through various leaching processes and is therefore likely to yield too low a figure for meat weight. In the present case, however, this effect is offset to some extent by the presence of "empty" oyster shells in the midden, that is shells which were empty when first [illegible] (Tables XII & IV).

[illegible]

[illegible]

[illegible]

TABLE VI.3 - Weights of Oyster Shell and Minimum Individuals/m^3 at B1

Layer	Mean Depth cm	Sampling Level %	Estimated Total kg	Mean Weight per m^3 kg/m^3	Minimum Indivs.	Mean Indivs. per m^3
1	27	16.7	220	820	18 060	67 640
2	11	16.7	72	660	5 510	50 130
3	9	20.0	63	740	2 250	26 160
4	10	14.3	81	840	6 640	68 410
5	11	12.5	85	790	4 600	42 990
6*	13	16.7	52	410	1 570	12 380
7	19	16.7	151	780	-	-
8*	6	25.0	23	390	1 210	20 200
9	14	20.0	125	880	7 070	49 750
10	20	16.7	152	760	8 690	44 970
11	12	20.0	74	640	-	-
12	11	20.0	74	690	5 580	52 100
13	12	20.0	94	790	7 230	60 250
			$\bar{x}$	700		45 000
			s	150		18 520
			$s_{\bar{x}}$	40		5 340

* Ash layers

collected from the river. These are identifiable by the presence of small barnacles still attached to the inner surface of the oyster shell and account for at least 10% of the prehistoric shell samples. The reason for their presence lies in the behaviour of the rock oyster, which requires a firm surface to live on and in natural conditions is commonly found attached to

mangrove stalks, stones or empty oyster shells. In much the same way clusters of stunted or juvenile oysters are often found attached to larger individuals, and it is probably for this reason that the archaeological deposits also contain an unusually high proportion of small oyster shells. Thus the biases involved in the use of minimum individuals as a guide to meat weight are likely to be exaggerated, while those involved in the use of shell weight to meat-weight ratios are likely to be minimised. If anything the latter method is likely to err on the low side.

The main variation in shell weights per unit volume occurs between two types of deposit, shell layers and ash layers, while the variability within each category is lower. In order to apply the figures from the excavated square to the mounds as a whole, the mean density for all layers, of 700 kg/m^3, has been used. Although this figure is based on an excavated sample which represents only about 0.01% of the total oyster midden deposits of the area, examination of extant sections at B1, B2 and B3, and of photographs of B2 taken in the 1930's before it was destroyed, strongly suggests that overall shell composition, both between and within mounds, including the regular recurrence of ash layers, is generally uniform throughout, and the B1 sample is accepted here as a basis for further calculation.

Chronology

Four radiocarbon determinations have been made on charcoal. The results are shown in Table VI.4. The three dates from B1 approximate a straight line when plotted against a depth scale, and indicate that the midden started to accumulate at about 1 720 BP and grew upwards at a more or less uniform average rate of 19 cm / 100 years. They further suggest that some one and a half metres of deposit have been removed from the top of the mound at this spot, confirming local reports about the extent of destruction of the site.

For the closest comparison with historical data the basal reading has been corrected to the new half-life and calibrated against the latest tree-

TABLE VI.4 - Radiocarbon Dates from Ballina

Lab. No.	Site	Provenance cm*	Date BP
SUA 122	B1	160	920 ± 80
SUA 123	B1	85	1 460 ± 90
SUA 124	B1	6	1 720 ± 80
SUA 125	B2	0-60	1 460 ± 105

* Distance above base of mound

ring sequences (Damon et al. 1972; Switsur 1973) to give a figure of 1 716 ± 130 BP - including uncertainty values for the calibration and the calculation of the half-life. Since the sample for this reading was not collected from the very base of the deposit, a further 30 years have been added by extrapolation from the sequence as a whole, so that the final estimate for the commencement of shell accumulation is 1 746 ± 130 BP. The current debate about calibration urges caution in the application of such a figure. But the very small difference between the calibrated reading and the original suggests that variations in this time range are too small to be of much significance for the purpose of the present calculations.

Historical records provide some data on the termination of shellgathering. According to Ainsworth (1922 p. 28) the traditional Aboriginal economy was in full operation in 1847 AD. How long Aboriginal oyster exploitation persisted unchanged until the first official records of European oyster exploitation in the 1880's is unclear, but the time range is in any case small and a terminal date of 100 BP (1850 AD) may be taken as a convenient figure.

The B2 sample was collected from a low bank of deposit about 1 m high - one of the few remnants of the original mound. This was cut back to a fresh

vertical face which revealed a lower shell deposit of yellow colour resting on alluvial clay and stratified above it a dark brown shell deposit. Dispersed fragments of charcoal were collected from the vertical section of the yellow deposit through a vertical distance of about 60 cm. Bearing in mind the imprecision of this method and the higher risk of contamination, the result is sufficiently similar to the dating of the lower levels at B1 to suggest broad contemporaneity between the two sites, a conclusion which is supported by stratigraphic resemblances. Traces of yellow deposit resting on alluvium and stratified beneath grey and brown deposits are also visible at B3.

Therefore it seems reasonable on the basis of stratigraphy and radiocarbon to assume that all the major concentrations of oyster midden have accumulated within the period 1 750 BP to 100 BP, indicating a total duration of 1 650 years. The question of the relative dating of the shell middens within this period is less easy to determine. The historical records suggest that all the people of the area gathered together on one mound, although they do not indicate whether or not this was a regular occurrence. If all the mounds are broadly contemporaneous, then it is improbable that only one site was used by all the people in every year, but impossible to say what was the precise pattern of variation in site-usage within this overall time span, and the calculations which follow are based on the oyster output for the area as a whole rather than for any single site.

Results and Crosscheck

Accepting the total volume of oyster midden as 33 000 m^3, the total quantity of oyster shell can be estimated as 23 100 t. Using a shell to meat weight-ratio of 5 : 1 (Table III.7), a calorific value of 59 kcal per 100 g of oyster meat (Table III.2), and applying the radiocarbon sequence, the mean annual output of oysters can be expressed as 17t/year live weight, equivalent to 2.8 t meat weight, or 165 x 10^4 kcal. Clearly this final figure should be treated as an approximation since various uncertainties and

potential errors are involved at each stage of the calculation. In general terms it should be regarded as erring, if at all, on the low side. It would be possible to assess these various potential errors in detail and to arrive at a grand margin of error, but such considerations have been delayed until the discussion of relative oyster output, where it is shown that data of this sort can be used to some advantage even within rather wide limits of error. The availability of modern data on oyster output also allows much of the discussion of potential errors to be circumvented by providing an independent control on the archaeological estimates.

Oyster farming has always been a seasonal activity in this area, so that intensive methods of cultivation leading to much increased yields have not been introduced on any scale. Much of the oyster output is derived from oyster beds permanently submerged in 2 to 3 m of water, but there is no reason to suppose that these would have been any less accessible to Aboriginal exploitation, for they are in that part of the river where the large mounds occur, and there are also historical records which suggest that diving for oysters was a regular practice (Henderson 1851 p. 137). Modern figures should at least provide a broad guide to the potential oyster output of the river in precontact times.

A mean annual output of 576 bags (1 759 bushels), based on a six-year record is quoted for the late 19th century (Statham 1892 p. 307), while Department of Fisheries statistics for a period of 26 years between 1944 and 1970 indicate a mean annual output of 364 bags. Assuming that an average "bag" contains some 1 200 oysters (P. Wolf _pers. comm._) with a live weight of 40 kg, the mean annual output is 23 t and 15 t live weight respectively per year, and the overall mean for the two sets of figures 17 t live weight per year.

Although this is the same figure as the archaeological result, this is no certain guarantee of its accuracy. Uncertainties and potential errors attach to the modern figures as to the archaeological estimates. In particular there is the possibility of long-term changes in the potential

oyster output of the river. There is some reason to suppose that oyster yields have declined slightly since the 19th century because of the silting over of some of the large natural oyster beds and the introduction of a worm disease. On the other hand this has been offset to some extent by the formation of artificial oyster beds in other parts of the river. Nevertheless the overall similarities of the various results suggest that a figure of 17 t live weight per year may be used with some confidence as a convenient measure of mean annual oyster output.

Relative Oyster Output

Population Data and the Annual Economy

According to the historical sources discussed above, some 400 to 500 people were regularly involved in the consumption of oysters in the Ballina area, with the possibility that a lower figure of 100 may apply. The possibility that both estimates are exaggerations seems unlikely, since figures of this order are typical throughout northern New South Wales (Pierce 1971) and are consistent with Birdsell's (1953) findings for Australia as a whole. It is possible that prehistoric population size was lower than that observed at the time of European contact or that the presence of Europeans attracted a larger number of Aborigines to the area than was normally the case. However, the latter bias can be discounted, since any such increase would probably have been a temporary occurrence, whereas the historical observations span a period of at least four years. Major changes in technology, the other possible factor in large population increases, can also be discounted during at least the last 2 000 years. Thus it seems reasonable to take 100 and 500 as minima and maxima for population size in the calculations which follow.

Turning to archaeological evidence, the base area of the B1 middens is about 4 000 m^2, and of B2 about 11 000 m^2, while the area of B3 can be reconstructed as about 15 000 m^2 (Table VI.2). Using the Cook and Treganza formula, this would give maximum population figures of 60, 100 and 120

respectively. However, it is not possible to say whether there was simultaneous occupation of all the mounds in a single year, although the general indications are that this is unlikely. Thus these figures might refer to a total population size anywhere between about 50 and 300. In the same way Naroll's formula suggests a total between about 400 and 3 000. These results are subject to considerable uncertainty, but at least they can be argued to favour a general order of magnitude of population size numbered in hundreds rather than tens and as such show a broad consistency with the historical data.

Assuming a population size of 100 and an individual daily calorie requirement of 2 000 kcal, total calorie requirements would be 2×10^5 kcal/day and 73×10^6 kcal/year. At this level the calories provided by 17 t live weight of oysters would be sufficient to supply about 2% of the annual diet.

Given this strikingly low result, the possibility of an underestimate requires examination. Two sorts of potential errors are relevant here: the possibility of a higher value for mean annual output and of lower values for population size and for calorie requirements. Making the generous assumption that mean annual output over the prehistoric time span was as high as the maximum annual output achieved in any one year by European exploitation, namely 26 t live weight, a maximum increase of about 50% for the value of mean annual output seems acceptable. The effect of this adjustment and of varying population and calorific levels is shown in Table VI.5. An acceptable minimum for population size is thought to be about 100, but the Table shows that even assuming a population size of 25, minimum calorie requirements, and maximum oyster output, the contribution of oyster food to the annual diet would not have been greater than about 17%. In practice the most likely figure is thought to be less than 5%, and less than 1% if the highest population estimates are accepted.

The Site Economy

Unless we make the unlikely assumption that the shell middens were permanently occupied throughout the year, the relative contribution of oysters

TABLE VI.5 - The Calorific Contribution of Oysters to the Annual Diet

Mean Annual Oyster Output	Mean Individual Calorie Requirements	Population Size		
		25	100	500
165×10^4 kcal	2 000 kcal	9.0%	2.3%	0.5%
248×10^4 kcal	1 625 kcal	16.7%	4.2%	0.8%

to the site economy should be higher than to the annual economy. Also the degree of difference between these two figures should throw some light on the duration of occupation of the shell mounds in an average year.

The resources identified from the excavation are listed in Table VI.6 and represent for the most part small marsupial game and fish. The remains were too fragmentary to allow detailed assessment of their relative representation, but bones of fish and land animals could be distinguished and a breakdown of their relative weights in Table VI.7 shows that land-animal bone is about twice as abundant as fish bone. Table VI.7 also shows the total weights of bone at different levels of the deposit and their mean value for the excavated square as a whole. The relative importance of all the resources as a unit in relation to oysters can be estimated using a standard bone weight to meat-weight ratio of 1 : 25 (Cook & Treganza 1947). If all the bone is treated together, the mean weight is 100 g / m^3, which represents 2.5 kg / m^3 of meat, or 5 kg / m^3 if the figure is doubled to allow for various losses according to the recommendation of Cook & Treganza. The mean weight of oyster meat represented in the deposits is 145 kg / m^3. Taken at face value therefore these figures suggest that oysters represent about 97% of the total food supply in terms of meat weight or 94% in terms of calories, assuming that the calorific value of fish and mammalian meat is about twice that of oysters.

TABLE VI.6 - Non-molluscan Resources Represented at B1

Scientific Name	Common Name
Terrestrial: in order of frequency	
Thylogale sp.	Pademelon
Wallabia spp.	Wallaby
Trichosurus sp.	Possum
Perameles sp.	Bandicoot
Unspecified	Lizard
Marine: in order of frequency	
Platycephalidae	Flathead
Mylio sp.	Bream
Unspecified	Crab

However, the weaknesses of this technique have already been emphasised. Bone material is notoriously susceptible to uncertainties of differential preservation and differential distribution in comparison with shell and may be heavily under-represented, especially bearing in mind the small percentage of the deposit excavated. But, if oysters are assumed to represent only 50% of the total calorie intake, this would require that the quantity of bone per unit volume of deposit found in excavation represent only 4% of the bone originally collected in the course of economic exploitation from the site, which is at least an indication of the scale of losses that would have to be invoked to allow reduction in the percentage contribution of oyster food. A more serious potential bias is the under-representation of plant foods, for which excavated evidence is lacking, although ethnographic and ecological data suggest that they may have been important at some stage in the annual

TABLE VI.7 - Weights of Bone Found in Excavation at Site B1 *

Layer	Land Animals g	Fish g	Total g	Density g/m^3
1	63	19	82	310
2	7	3	10	90
3	8	2	10	110
4	11	3	14	140
5	4	2	6	50
6	3	2	5	40
7	10	3	13	70
8	-	-	-	-
9	5	2	7	50
10	5	5	10	50
11	1	2	3	20
12	3	2	5	50
13	11	10	21	180
	131	55	186	
			$\bar{x}$	100
			s	80
			$s\bar{x}$	22

* Weights based on all excavated bone

economy. Artifactual evidence may be of some use here. Occasional large, hand-held chopping tools occur which might have been used in the preparation of root vegetables, but they might equally have been used for other purposes. Specialised pounding and grinding equipment such as might be expected to be associated with large-scale preparation of plant food is absent.

The representation of species in the excavated sample may be of some

relevance here. Of particular note is the absence of either mullet or salmon from the fish remains, in spite of the fact that they appear to have been the most prolific and sought after of the fish species according to ethnographic and ecological data. Only bream and flathead are represented, species of lesser abundance which could have been caught in the immediate vicinity of the site. It is possible that identifiable remains of salmon and mullet happen to be unrepresented in the excavated sample. Identifiable parts of the fish skeleton are usually confined to parts of the jaw or skull, precisely those parts which are absolutely rare in excavation, whereas the more numerous vertebrae and spines are rarely identifiable to species. The size of the vertebrae may, however, offer some clues, and in this respect it is worth noting that only one specimen is large enough to be commensurate with a large fish such as an adult salmon or mullet, whereas the great majority are of quite small size, and as such are generally consistent with the existing species identifications. Another fact of possibly greater significance is the quantity of fish bone, which is less than half that of mammalian bone. If the site were in any way representative of the economy practised on the coast with its heavy emphasis on fishing, we would expect fish bone to be the dominant category in terms of weight, even if identifiable specimens were lacking. But this is not the case, at least as far as the excavated sample is concerned.

The species of fish represented in the site, the quantity of fish bone represented, and the relative food supply represented by oysters in relation to the other resources all suggest an interpretation of the shell mound as a specialised site used primarily for the consumption of oysters. The difference between the site economy and the annual economy with respect to oyster consumption is therefore quite dramatic. But the excavated data pose sufficient uncertainties to keep open the possibility of alternative interpretations. We can best clarify the situation in the following way. An oyster output of 165×10^4 kcal can be expressed as 825 man/days of food – enough that is to feed 100 people for just over one week if they ate nothing

[illegible]

[illegible]

[illegible]

but oysters. Using this figure as a base, the duration of occupation of the shell mounds at different levels of oyster consumption can be worked out theoretically. The results are shown in Table VI.8, and, as before, are based on the assumption that the calorific value per unit food weight of other resources is about twice that of oysters. The figures bring out very clearly the alternative extremes. If the oyster mounds were used exclusively or predominantly for oyster consumption, then occupation could not have lasted for more than a matter of days at the population levels postulated above. Even at the 50% level of oyster consumption, occupation would scarcely have lasted more than two weeks. Conversely, if the shell mounds were occupied for a substantial part of each year, then it must follow that oysters were a minor contribution to the site dietary and that the middens served as foci for a diversity of economic activities. Where the true situation falls along this spectrum of possibilities is difficult to define exactly, but the excavated evidence strongly favours an interpretation towards the former extreme, in which case we are dealing with sites which were occupied on the average for no more than a matter of days in the year.

TABLE VI.8 - Occupation of the Ballina Oyster Mounds in Days/Year at Different Dietary Levels*

Percentage Contribution of Oysters in terms of Calories	Population Size		
	25	100	500
5%	>1 year	165	33
20%	165	41	8
50%	66	17	3
100%	33	8	2

* Assuming 165 x 10^4 kcal oyster output and 2 000 kcal requirement

At least there can be little doubt about the relative value of oysters in the overall economy, whatever the precise function of the oyster mounds. In this respect the analysis shows that even large margins of error need not inhibit the application of quantitative data for some purposes. Much depends on the level of inaccuracy that can be tolerated by the problem under investigation. The results obtained above are at least sufficiently accurate to reject the proposition that these large oyster mounds were formed as a result of prolonged dependence on shellfood as a staple resource. Even if modern data on oyster output were not available as a control on the archaeological estimates, and the figures for mean annual output were increased by 200% to make the most generous allowance for the uncertainties involved in the use of archaeological data, this would not increase the relative contribution of oysters to the annual economy, within the range of population sizes thought to apply in this area, to more than about 10%.

4. Site Catchment Analysis

Sites

Sites used in the analysis are shown in Figure VI.2. Sources of evidence are published data, unpublished site records on file in the Department of Prehistory and Anthropology, University of New England, and field surveys compiled by the National Parks and Wildlife Service of New South Wales.

The sites fall into five basic categories. By far the most common are the open-shore middens. These are usually shallow deposits in the dunes immediately behind the open beaches and are identifiable by the scatters of Plebidonax shells and stone tools. Sometimes they cover quite an extensive area. Commercial sand mining is a possible cause of destruction. But since this is a fairly recent activity, local information can usually establish where sites used to exist, even if little deposit now remains, and it is probable that the overall distribution is reasonably representative, except

possibly in the Brunswick River area, where rarity of sites appears to be due to lack of exploration.

The second category of sites is the oyster mounds situated on river estuaries. Apart from the sites on the Clarence and Richmond Rivers already discussed, there are two other oyster mounds, the Brunswick site, mentioned by Statham (1892 p. 308), and the Evans River site, which is reported in local records. Although these sites have been badly damaged or even destroyed, their general distribution appears reasonably complete, at least to the extent that it broadly coincides with the distribution of river estuaries, where oysters would be found in greatest abundance.

Inland sites are rare. Apart from the Seelands rock shelter, which falls outside the area considered here, the only other known site is at Tucki near Lismore. Although no excavations have been carried out, large grinding stones have been found on the surface (I. McBryde pers. comm.), which suggests that processing of plant foods was probably of some importance. The absence of other inland sites probably reflects lack of exploration or lack of archaeological visibility.

The other two types of site are workshops and bora rings. Although neither are directly concerned with economic exploitation, the latter, in particular, are relevant to distributional problems. Bora rings are low, stone or earthen mounds encircling an area some 10 m or more in diameter and sometimes connected to a smaller circle of similar construction. Their main purpose is ceremonial, but they have the great virtue of archaeological visibility, and it seems reasonable to assume that they would tend to occur within fairly close proximity to major foci of occupation. The fact that they are closely associated with occupation sites lends some support to this.

Only the oyster mounds at Wombah and Chiciba Creek have radiocarbon dates. The other sites lack dates of any sort, although, as surface sites, it could be argued that they are likely to belong to the latter part of the prehistoric sequence. But this is conjecture, and the analysis has had to proceed on the assumption of broad contemporaneity between all the sites.

Resource Potential

Five categories have been used in the mapping of resources: rainforest, seasonal marsh, swamp, heath and "marine". By seasonal marsh is meant low-lying areas liable to flooding in the wet season but relatively accessible on foot during the dry season. Swamp, on the other hand, refers to areas more or less permanently under water. The distinction between these two categories is not always easy to make, since extensive artificial drainage in recent years has altered the situation, and the areas of swamp marked on the accompanying maps probably represent a minimum.

The economic potential of these different categories is open to some uncertainty. For, while some information is available for the marine sector, the situation on land is less clear. However, some general comments can be made. Seasonal marsh was probably the most productive area for animal resources, especially during the drier part of the year, swamps for plant foods. Rainforest was probably a secondary source of both animals and plants, although this is difficult to judge with certainty. Heath would almost certainly have been the least productive category of all, given the poor quality of the soil and the sparse vegetation.

Coastal Site Territories

Quite apart from lack of exploration and lack of dates, there is the further difficulty of distinguishing home-base sites from transitory sites. The most impressive archaeological deposits are the oyster mounds. But, although these are preferred sites, excavation has suggested that they are not home bases. It is possible that the excavated data, and in particular the food remains, are grossly biased. But the sparsity of stone tools in the deposits both at Chiciba Creek and at Wombah (McBryde 1965) is consistent with transitory occupation. In order to disentangle the problem of site function, and in particular the relationship between the oyster mounds and

the open shore middens, attention is first focused on the local situation at Ballina, where most evidence is available, before looking at the broader picture.

(i) Local Distribution: Ballina

There is a total of 17 sites, or groups of sites, in the Ballina area (Figure VI.3). Apart from one bora ring, they are all shell middens. The two northernmost sites are on an old beach line. By analogy with the situation described in the Macleay River area, they are presumably of some antiquity and most probably precede the sequence of occupation identified in the oyster mounds. They are therefore excluded from the analysis. Also excluded from the initial discussion are the two sites south of the Richmond River. Their relationship to the other sites is unclear, since it seems arguable that the mouth of the river forms something of a barrier to a radial pattern of daily exploitation.

Territorial Evidence of Transitory Occupation

The site territory of the Ballina oyster mounds is shown in Figure VI.7. For the purposes of analysis it is assumed that the three mounds were effectively one site, since the site territories for each mound considered separately are so close as to be almost identical. For comparison the site territory of the open-shore middens at Lennox Head is shown in Figure VI.8. Of the three open-shore sites shown in Figure VI.3, Lennox Head appears to have had the most extensive surface material, although sand mining in the area has caused much destruction. The nearby presence of a bora ring also favours this area as a potentially important focus of occupation.

Comparison of the Ballina territory, which refers to the oyster mounds and the Lennox Head territory in Table VI.9 (p. VI:41) shows that, in terms of size and economic potential, both sites are closely comparable. They appear equally well placed strategically for the exploitation of the major staple resources in the general vicinity of the coast and in particular the fish, [illegible] VI 2 [illegible]

[illegible], although it [illegible] the inner dyke [illegible]

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The site [illegible] is shown in Figure 6.1. [illegible] the [illegible] [illegible] as shown in Figure 6.1, [illegible] the most extensive [illegible], although most [illegible] in the [illegible] period [illegible]. The [illegible] presence of a [illegible] ring [illegible] as a potentially important focus of occupation.

[illegible] of the [illegible], which [illegible] in the [illegible] in Table VI.3 (p. [illegible]) shows that, in terms of [illegible], both sites are [illegible] comparable. They appear [illegible] for the [illegible] of the major [illegible] in the general [illegible] of the [illegible] in particular [illegible], which would be found in greatest abundance along the open shore during the summer.

The application of site catchment analysis to the oyster mounds, however, shows major discrepancies between the excavated evidence of diet at B1 and the economic potential of the site territory. Mullet and salmon are completely absent, as already emphasised, even though the site catchment analysis shows that both are potentially within easy access of the site, while the terrestrial resources occur in small quantities and are such as could have been found in the immediate vicinity. This evidence, although based on a small sample, is certainly consistent with the quantitative analysis of the midden deposits and provides some confirmation for the hypothesis that the oyster mounds were used on a transitory basis primarily for the exploitation of oysters and whatever else might have occurred nearby. This in turn renders the Lennox Head site the more likely candidate for use as a home base, but a direct test of this hypothesis cannot be made, since excavated data are not available. If the hypothesis is correct, however, we should expect to find a simple answer to two questions. Why were the oyster mounds preferred sites, if they were not home bases? Secondly, if they were used as preferred sites, why were they not used as home bases, given their apparently favourable location with respect to the major staple resources?

Preferred Sites: Distribution of the Oyster Supply

A possible answer lies in the study of the distribution of oysters. Small quantities of oysters can be found in most parts of the river, but the best and most abundant occur in North Creek (Plate VI), and the high figures for oyster output achieved by European exploitation in the late 19th century are based entirely on the North Creek beds (Statham 1892). Conditions are especially favourable in this part of the river, because the salinities are lower, because the spatfall is less dense, so that oysters are not too overcrowded, and because many of the shell beds remain permanently submerged, thereby allowing optimum feeding conditions for the oysters. All these [illegible] would be found in [illegible] assemblages from the same [illegible] during the [illegible].

The explanation of [illegible] however, [illegible] of [illegible] and [illegible] that [illegible] in [illegible] while the [illegible] found as [illegible] the [illegible] were [illegible] of oysters and [illegible] the [illegible] but a [illegible] of [illegible] and [illegible] if [illegible] to find a single [illegible] if [illegible] or [illegible] to the major [illegible]?

Regional Sites: Characteristics of the Oyster Supply

A [illegible] place in the study of the distribution of oysters. Dense concentrations of oysters can be found in most parts of the river, but the [illegible] most abundant occur in North Creek (Figure VI), and the high figures [illegible] oyster output achieved by European exploitation in the late 19th century [illegible] entirely in the North Creek beds (Stevens 1893). Conditions are [illegible] favorable in this part of the river, because the salinities are [illegible], because the rainfall is less heavy, so that oysters are not [illegible], and because many of the small beds remain permanently submerged, [illegible] allowing optimum feeding conditions for the oysters. All [illegible] factors result in a concentrated distribution of the oyster supply as is shown in Figure VI.9.

Figure VI.9 also allows a more detailed examination of the location of the oyster mounds and shows that in a general way they are closely related to the oyster supply. However, certain irregularities call for comment, in particular the fact that both B1 and B3 are nearly 1 km from the nearest oyster beds, and that in the former case there is a thick intervening barrier of mangroves. Such asymmetry would not necessarily impede shellgathering, since the use of canoes would have allowed easy access from B3 at least. Even B1 could usually have been reached through the mangroves by boat at high tide. But there are other factors that should be considered.

Changes in the Estuarine Environment

One explanation of the distribution is change in the estuarine environment. A factor of probable significance is the increased rate of freshwater run-off and siltation which has occurred since the end of the last century as a result of widespread forest clearance and which would tend to inhibit the survival of oysters near the upper limit of their distribution in North Creek. A further detrimental factor for oysters in a marginal situation is infestation by the mudworm parasite, Polydora websteri. This pest is thought to have been introduced from New Zealand at the end of the 19th century - the characteristic blistering of the shell is certainly absent from any of the prehistoric shells we have examined - and tends to be most troublesome on the oyster beds in the upper part of North Creek (P. Wolf pers. comm.). Increased siltation might also be invoked to account for the recent development of mangroves at the mouth of Chiciba Creek since the time when the B1 mounds were last used.

Accessibility and Mound Formation

Another factor brought out in Figure VI.9 is the restriction of access between dry ground and the river. The creek banks are lined almost continuously [illegible] a representative distribution of the [illegible] of the [illegible]

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with thick barriers of mangroves or extensive areas of seasonal marsh. Dry land rarely approaches close enough to come within convenient shellgathering distance. Bearing in mind the rather critical time-distance factor for oysters, as low as ½ km (Table III.10), just an additional few hundred metres might be sufficient to deter exploitation. Even where higher ground does adjoin the river bank, as at the junction of North Creek and Chiciba Creek, it would have been covered with dense rainforest vegetation unfavourable for occupation, and it is suggestive that, although some middens occur on this spur of land, the main mound at B1 is actually situated about 50 m away from rising ground right on the junction between marsh and mangroves (Plates VII and VIII). B2 and B3 are similarly located, although rising ground is not so close (Plates IX and X).

Given that the most favourable season for the exploitation of oysters is the summer, and that this is also the wettest period of the year, the surroundings of the site would have been especially liable to flooding, and it seems plausible to invoke Peterson's (1973) "effect" as a further reinforcing factor in accounting for the location of all three large mounds and their repeated use over time as preferred sites. For the accumulation of shells on a given spot as the incidental by-product of oyster consumption would in time form a dry surface, and, with every annual increment of discarded shells, become that much more favourable as a camping place elevated above the level of the surrounding marsh. If we assume that in a given year about one quarter of the total oyster output of the river would tend to be brought back to be consumed on Chiciba Creek, this would involve about 4 t live weight, or some 100 000 individual oysters. With quantities such as these it is easy to see how the process of accumulation could "take-off" within a very short space of time, and, once begun, become self-perpetuating.

Quite apart from the convenience of having an artifical platform that much nearer the oyster supply, a shell midden is in fact a rather favourable surface to live on, being relatively dry and a good heat insulator, and it would certainly be an improvement on a muddy slope with damp, overhanging

[illegible]

[illegible]

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vegetation, which is the best that could be offered by the rising ground in the immediate vicinity. These additional factors in the location of the shell mounds may also provide part of the explanation for the apparent irregularities in the distribution of B1 and B3 and in particular the location of B1 behind a thick barrier of mangroves.

Thus the formation of the oyster mounds as preferred sites can be accounted for by the concentrated distribution of the oyster supply and the difficulties of access imposed by the surrounding terrain, without the need to invoke a home-base pattern of exploitation.

Home-Base Exploitation

The nature of the local environment also suggests a hypothesis to explain why the oyster mounds were not used as home-base sites. Although conveniently placed for the exploitation of oysters, they are thus situated in a position, which, for all the mitigating factors introduced by living on shell mounds, is still a relatively insalubrious one - low-lying, damp and, by its proximity to the mangroves, especially mosquito-ridden. Access to the open shore and the mouth of the river estuary, where the great majority of the fish could be most easily obtained, would also involve walking back and forth through rainforest or waterlogged ground, not an impossible task, but hardly a profitable one when more convenient locations could be found nearer the fish supply.

By contrast, Lennox Head is situated amongst relatively dry and mosquito-free heath vegetation, as are the other open-shore middens. It offers easy access to the long sweep of sandy bay to the north and the rocky headlands and river estuary to the south. It also provides access to the swamps and seasonal marsh on the landward side without the inconvenience of the intervening barrier of water and mangroves which impedes wide-ranging access from any of the oyster mounds. While excavated evidence is not available as a test, the nature of its position in relation to the available resources suggests that, of all the sites in the Ballina area, Lennox Head has the best claim

to be considered as a home base. That oysters were not incorporated in any numbers in the site economy can easily be accounted for by the fact that Lennox Head is some 4 km from the nearest oyster beds, well beyond the range of profitable shellfood transportation. If correct, this hypothesis provides a good illustration of a case where a strategic location for a generalised home-base site fails to coincide with a convenient location for the exploitation of shellfood.

The site catchment data support the conclusion derived from excavation that the oyster mounds were specialised transitory sites rather than generalised home bases and suggest that the latter pattern occurred, if anywhere, at Lennox Head. However, a third hypothesis is that none of the sites were home bases. For it is arguable, especially in view of the lack of excavated evidence from all but the oyster mounds, that the open-shore middens were specialised sites used primarily for the exploitation of local supplies of fish and shellfish, and that, rather than isolating any one site as pre-eminent and treating the others as subsidiary, the whole group of Ballina sites should be viewed in aggregate as forming a loosely defined home-base cluster, without any single central focus. Such a pattern of site-usage would seem to be quite plausible in an area where the difficulties of the local terrain accentuate the problem of gaining access to the available resources. Whether this hypothesis is preferred to that of the single home base or not, the conclusion still stands that the oyster mounds, although archaeologically the most impressive sites in the area, may well have been the least significant in terms of occupation and economic activity, being transitory sites used for no more than a week or so for the exploitation of a minor resource.

(ii) Regional Distribution

The distribution of seven site territories along about 100 km of coastline is shown in Figure VI.10. Apart from the inland site of Tucki, the territories all refer to open-shore middens comparable in general character to the Lennox Head site. In several cases the site focus of each territory

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is a loose cluster or scatter of sites, comparable to the distribution of open-shore sites around Ballina, rather than a specific locus, and the extent of the cluster is indicated by the dotted lines. The choice of any particular point within the cluster as the centre of the site territory is to some extend arbitrary, and there is therefore some scope for varying the position of the territorial boundaries within certain limits. But it is clear that these clusters are spaced apart in a way which approximates fairly closely the expected distribution for home-base sites in a uniform environment. The fact that four of these site clusters are associated with a bora ring is some additional support for the view that they represent a generalised focus for home-base exploitation.

The major irregularity in this distribution occurs on the Richmond River, where the South Ballina site has a potential site territory with an unusually large degree of overlap with its neighbours, especially Lennox Head. But, if it is correct to assume that the river would have served to some degree as a barrier to regular, daily movements in a north-south direction, then the distortion in the site pattern can be related to distortions in the pattern of access to resources, and the South Ballina site can be viewed as an outlier to the Lennox Head or Woodburn sites, located to take advantage of the abundant fish resources which are available on the south bank of the river and the adjacent stretch of open shore-line, but which are out of convenient reach of the major home-base clusters on either side.

Conversely the distribution of the oyster mounds suggests that they are symmetrically located with respect to the distribution of oysters rather than with respect to each other. All appear to be situated well upstream in their respective rivers, where the optimum conditions of oyster growth would be found. The Clarence sites, in particular, are certainly close to the upper limit of the oyster distribution, if not above it, since Statham (1892 p. 307) notes that the present distribution of oysters extends about 8 km inland from the sea. The position of the Evans River and Brunswick mounds suggests that their location is directed by similar considerations. By being

so placed, all these sites would tend to be located away from the open shore, and, given the limitations on access imposed by extensive areas of swamp and marsh in all these areas, it is not surprising that the site pattern should show similarities with the situation at Ballina. Furthermore, at Wombah on the Clarence River, excavated evidence shows that non-molluscan faunal remains, and in particular fish bone, are very sparse (I. McBryde, pers. comm.), which is particularly useful confirmation of the conclusions drawn from the Chiciba Creek excavation since it is based on a much larger excavated sample.

Economic Potential of the Coastal Site Territories

The territories of the Ballina and Lennox Head sites have already been briefly introduced above. Here we consider their economic potential in greater detail (see Figures VI.7 and VI.8), and compare them with four other site territories (Figures VI.11 to VI.14). The representation of the different resource categories for each site is shown in Table VI.9.

TABLE VI.9 - The Economic Potential of Site Territories in the Ballina Area

Site	Total hectares	Marine %	Rain-forest %	Seasonal Marsh %	Swamp %	Heath %
Coastal Sites:						
Byron Bay	26 800	70	17	2	7	4
Lennox Head	26 400	50	23	12	10	5
Ballina	24 500	52	16	20	7	5
Woodburn	27 800	53	15	5	13	14
Evans Head	25 600	50	33	0	16	1
Clarence	24 800	50	28	0	22	0
Inland Sites:						
Tucki	23 600	4	31	45	20	0

The most obvious feature in common between all the coastal sites is the high values for the marine sector - at least 50% of the potential site territory in every case. If it is correct to assume that these sites are home bases used as a major focus of occupation, then it must follow from the nature of the territorial data that marine resources played a major role in the site economy.

A quantitative assessment of this marine sector is possible by reference to records of annual production in the modern mullet fishery. Since mullet was a resource of great importance to the Aborigines according to ethnographic data, it may be expected to provide a useful guide to the overall value of marine resources.

Before these figures can be used in the interpretation of the prehistoric economy, two difficulties must be dealt with. Firstly, it is possible that modern methods of exploitation are able to take advantage of a higher proportion of the potential supply than Aboriginal methods. But, while it is probable that modern fishing is more productive in terms of output per man/hour, the modern fishery is predominantly an estuarine and inshore one. Also the mullet is an anadromous species which shoals in shallow water where it can easily be taken, and simple techniques were available to the local Aborigines for its exploitation, as emphasised above. Any inability to achieve levels of European output would also have been offset to some extent by the exploitation of other species of fish as well. The salmon in particular would presumably have been quite prolific, although it is no longer found on the north coast, so that commercial figures are unavailable.

A second difficulty is that the modern figures, although primarily based on the Richmond River, may refer to a total catchment area which extends along the coast into the neighbouring territories of the Byron Bay, South Ballina and Woodburn sites, some of which appear to have been used by different groups of people (Pierce 1971). At any rate it seems reasonable to suppose that the Ballina group would have had a large share in the mullet catch, and the total figure for the annual output has been accepted as a convenient

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starting point for assessing the potential value of all fish resources in the area.

Mean annual output for mullet in the Richmond River area over a ten-year period from 1941 to 1950 was 386 323 lb live weight (Thomson 1953), equivalent to 175 t. Assuming that gutted weight is about 70% of live weight (Shawcross 1967b p. 119), and that 100 g of mullet flesh yields 137 kcal (Thomas & Corden 1970), this represents about 168 x 10^6 kcal. This in turn represents about 84 000 man/days of food, assuming a daily individual calorie requirement of 2 000 kcal - that is enough to feed 200 people for the whole year, or 400 people for 6 months in the wet season.

Even allowing for the uncertainties involved in the use of modern commercial data, these figures show that there is nothing unacceptable about the population size of 400 quoted in the historical sources. They further suggest that fish must have been a major factor in supporting such a population, and possibly a sufficient factor for 6 months of the year. Given that the local fish supply is liable to marked seasonal fluctuations in availability, a quite substantial complement of terrestrial resources would have been required to maintain this population throughout the year. Although comparable quantitative data for plants and mammals are not available to show whether this could have been achieved without some movement away from the coastal sites to the interior, the fact that the coastal home bases are located right on the shore margin means that they would, by definition, have had access to a much smaller area of land within the site territory than sites situated further inland, and thus the possibility of seasonal movement is certainly raised by the data.

One further conclusion that can be drawn from the mullet data concerns the question of relative oyster output. A comparison of mean annual oyster output and mean annual mullet output is presented in Table VI.10. This shows that, even if only 10% of the total mullet catch were available to the Ballina people, oysters would still be worth less than 10% of this fish supply in terms of kilocalories. Thus the data on fish output provide rather convincing support for the minor dietary role assigned to oysters on the basis of the

midden analysis.

TABLE VI.10 - Oyster Output Expressed as Percentage of Mullet Output

Mean Annual Mullet Output kcal	Percentage Oyster Output *
168×10^6	0.9%
84×10^6	1.9%
42×10^6	3.7%
17×10^6	9.3%

* Assuming mean annual oyster output of 165×10^4 kcal

Economic Potential of the Hinterland

Only one inland site territory is available for comparison with the coastal site territories, that is the site of Tucki (Figure VI.15; Table VI.9). One general feature common to both inland and coastal sites which is worth commenting on is the relatively low representation of rainforest within the site territories, consistently accounting for less than one third of the total area. This would seem to bear out the view expressed above that rainforest is a relatively unproductive zone for human subsistence. It also provides a useful illustration of the value of site catchment analysis in discriminating between the zonal characteristics of a region, which in this case would be labelled according to the dominant vegetational type as rain-forest, and local differences of detail which may have a crucial effect on the site economy.

At Tucki the dominant resource zone is seasonal marsh, accounting for about 45% of the total. If the swamp category is included, some 65% of the site territory would have been waterlogged or flooded during the summer, compared with an average of less than 20% for the coastal sites, rendering

much of the territory unsuitable for effective exploitation for a part of the year. Conversely, the drying out of the seasonal marsh during the winter would have attracted animals to the area and made exploitation easier. The water level in the swamp would also probably have been lower. By analogy with the situation in northern Australia (Peterson 1973) this would have been a factor of some importance in making the collection of swamp plants an easier task and at least an additional reinforcement in boosting the economic potential of the site during drier periods. The surface material found on the site suggests an emphasis on plant food, although we cannot be certain what type of plants were involved, nor is there excavated evidence to show whether animal resources were taken in quantity.

Thus a strong case can be made for a complementary relationship between inland and coastal sites. The former, by its emphasis on seasonal marsh and swamp would have been most favourable in terms of economic potential during dry periods, and hence mostly during the winter, while the latter, by their emphasis on marine resources would have been most favourable during the summer. This does not exclude the possibility that a permanent population was supported in both areas throughout the year, for the available resources would appear to have allowed this up to a point, especially given the fairly high values for swamp at some of the coastal sites, nor does it exclude more complex movements in response to varying seasonal fluctuations of rainfall and resources. But the main outlines of the pattern are clear enough, and some degree of population movement would most probably have been essential to take fullest advantage of seasonal peaks in food supplies.

The question of which coastal site or sites were complementary to the Tucki site is left open, as is the question of additional complementary sites situated further inland from Tucki. Both questions must await the results of more intensive archaeological exploration for inland sites. But the data presented here should be sufficient to show the nature of the directives on seasonal movement in this area and the potential of site catchment analysis in identifying their operation.

5. Conclusions

One conclusion that can be drawn with some confidence from the preceding analysis concerns the role of shellfood in the coastal economies of this area. The results of both the midden analysis and the site catchment analysis are quite explicit in showing that oysters were a resource of quite minor importance not only in the annual economy as a whole but most probably during the season when the human population was concentrated in the coastal zone.

This result emphasises the misleading visual effect of the archaeological data as well as the biases inherent in the ethnohistorical record, which ranks oysters alongside fish and marsupial game as a major resource. If it is the case that oysters were eaten by a large number of people for a short period of time rather than by a small group of people for a longer period, it is easy to imagine that such an event would have had a disproportionate impact on the casual observer, resulting in an overemphasis on oysters as an item of diet at the expense of other less dramatic and less easily observed economic activities, especially when reinforced by the impressive and tangible by-products of oyster consumption provided by the shell mounds. This appears to be a case where the biases of archaeological data coincide with those of the ethnohistorical record.

The result also raises in an acute form the problem of the value of the oysters to the economy. For, in spite of their negligible calorific contribution to the diet, they were exploited over a period of nearly 2 000 years, and it is axiomatic that behavioural traits which persist in the archaeological record have some long-term adaptive significance.

The nature of the prehistoric shellfood exploitation can be brought into sharper focus by reference to the quantitative data on mean annual output. A useful standard of reference is the modern data, which are known to refer to regular and intensive exploitation on an annual basis. Both the modern figures and the archaeological results are subject to margins of error of

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uncertain extent, so that comparison of the two should be treated with caution. But, although the data do not allow us to assert categorically that the pattern of Aboriginal exploitation was exactly similar to that practised today, they do allow us to say that the results of prehistoric exploitation, expressed in terms of mean annual output, do not differ significantly, within the limitations of the quantitative data available, from the results of modern exploitation. There is thus nothing in the data to contradict the hypothesis that prehistoric oyster collection was a regular, annual activity, representing an intensive exploitation of the available supply, and indeed there is considerable positive support for the view that there is a significant element of long-term continuity in the exploitation of oysters, not only throughout the 1 650 year time-span represented by the shell mounds, but a continuity persisting through the radical changes of race and culture which accompanied the replacement of the traditional economy by European settlement.

Among the various factors which may have been responsible for the persistent and intensive exploitation of such a minor resource, three are worth detailed comment. First of all there are nutritional factors. Although of little significance as a source of calories, it is arguable that oysters may have been of considerable value as a source of some other nutritional element. Protein can be eliminated, since the protein value of oysters is generally less than that of the other animal resources locally available, and there is no evidence to suggest that small but essential quantities of minerals or vitamins, such as iodine, are present in oysters, which cannot be found in other marine resources. However, some importance may lie in the seasonal accumulation of fats and glycogen, which contribute to the palatibility of the oyster, even if they do not provide any unique nutritional element lacking in other foods. In this respect it is worth noting that the shell mounds were probably occupied during the wet season, which is when the local oyster supply is in best condition.

A second factor is the seasonal fluctuations in the major staples, which may have brought occasional pressure to bear on resources of lesser importance [illegible] areas, so that comparisons of this sort should be regarded with caution, [illegible] although the data do not allow us to [illegible] categorically that the process of ecological specialization was already [illegible] in this particular region, they [illegible] [illegible] specialization, [illegible] [illegible] [illegible] [illegible] [illegible] within the limitations [illegible] [illegible]

[illegible] Although of little significance as a source of calories, it is arguable that fish may have been of considerable value as a source of some other nutritional element. Protein can be eliminated, since the protein value of fish is generally less than that of the other animal resources locally available, and there is no evidence to suggest that small but essential [illegible] of minerals or vitamins, such as iodine, are present in [illegible], which cannot be found in other normal resources. However, some importance may lie in the seasonal accumulation of fish and shellfish, which contribute to the reliability of the economy even if they do not provide any unique nutritional element lacking in other foods. In this respect it is worth noting that the shell middens were probably occupied during the wet season, [illegible] when the local cereal supply is at its lowest [illegible].

A second factor in the seasonal [illegible] of the major [illegible], which [illegible] brought [illegible] [illegible] [illegible] [illegible] as temporary stop-gaps. There is some evidence to suggest that part of the summer wet season may have been a slack period for fishing, falling between a spring abundance of salmon and a late summer/early winter peak of mullet. If this were so, alternative coastal resources would have been of high selective value in maintaining the human population on the coast in the relatively short interval between the two periods of maximum fish abundance. However, it must be admitted that, if this was the primary stimulus to shellfood exploitation, the potential of the oysters is such that it can have filled only a very small gap in the availability of the fish resources.

A third factor may be the incidental proximity of the oyster supply to resources of much greater abundance, in this case fish, capable of supporting large numbers of people on the coast for considerable periods at a time, such that casual exploitation by the occasional individual would have been repeated often enough to ensure utilisation of the full oyster potential without any organised strategy of shellgathering on the part of the coastal population as a whole.

Whatever the immediate motivation for shellfood exploitation, the above discussion of the various alternatives emphasises two important points: the effectiveness with which even minor resources may be incorporated into the economy; and the over-riding effect of the staple resources in directing where and in what manner such resources are exploited.

The broader aspects of economic organisation can be conveniently introduced by discussing the role of the shell mounds in the economy. If the calorific contribution of the oysters was as low as the data suggest, then one is left with two major alternatives: either the shell mounds were transitory sites used mainly for shellfood consumption; or they were home-base sites, in which case the surviving evidence of food remains is heavily biased in favour of the oysters. All the various lines of evidence examined in detail appear to point to the former as the more likely alternative in this area, although they do not positively exclude the latter.

In a sense, however, the distinction between these two hypotheses is less

important than might first appear to be the case. For it is clear that, even if the oyster mounds were transitory sites, they were nevertheless closely associated with a home-base pattern of exploitation, so much so that it is more appropriate to treat them as a specific element within a generalised home-base cluster. Thus, although the distribution of the oyster supply and the problems of gaining access to it were probably of some importance in the location and growth of the shell mounds, the ultimate directives on their occurrence and pattern of use are more likely to be found through examination of the staple resources which supported the home-base pattern of exploitation.

Almost certainly the major attraction of coastal occupation, the major factor in the large coastal populations that are reported to have existed, and, by extension, the major factor in the large numbers of prehistoric shell middens dotted all along the coastline, is the abundance of fish resources. Given that this abundance was only available for certain seasons of the year, it follows that exploitation of the full potential would have required seasonally complementary dependence on plant foods and terrestrial mammals, and both archaeological and ethnographic data are in agreement in suggesting that this was achieved by population movement away from the coast to hinterland sites during the winter.

In summary, the large shell mounds of this area were most probably associated with seasonal home-base clusters focused primarily on fish and to a much lesser extent on molluscs and complemented by inland sites focused primarily on marsupial game and plant foods. This pattern is probably of great antiquity; it appears to have offered an effective integration of seasonal and local variations in food supply; and it probably contributed, in its turn, to the effective exploitation of the oyster supply and the persistent accumulation of their shells over time to form the large mounds which are all that is left to-day.

CHAPTER VII

WEIPA AND THE CAPE YORK PENINSULA

1. Introduction And Archaeological Background

Few archaeological sites are known in northern Australia, resulting from poor conditions of preservation and relative lack of exploration. The major sites are shown in Figure VIII.1, together with other places mentioned in the text. Rock shelter excavations near Oenpelli in Arnhem Land (White 1971) and Laura in northern Queensland (Wright 1971) indicate a broadly similar archaeological sequence with a heavy flake industry dating from as early as 23 000 BP, replaced after about 6 000 BP by a smaller industry with points and scrapers which bears a general resemblance to the later stone industries in the south-east of the continent. An important technological continuity is the presence of edge-ground axes from the earliest period up to the ethnographic present.

The chief concentration of shell middens is at Weipa in the Cape York Peninsula, where large mounds date from about 1 000 BP (Mulvaney 1969; Wright 1971). The Weipa middens are not only large and numerous, but they are also almost completely intact, something which can no longer be said of any other major group of shell mounds in Australia. They are therefore particularly suitable for the application of techniques of midden analysis. Plates XIb to XV show some of the large sites of this area.

Sites of a similar character have been recorded on Milingimbi Island and in Castlereagh Bay in Arnhem Land, which also date from the last 1 000 years or so of the prehistoric record (Mulvaney 1969; Peterson 1973). Otherwise, the only other known shell middens are surface scatters of shell associated with stone artifacts which have been reported in the vicinity of the Escape River (A.H. White _pers. comm._), and the small middens dating

CHAPTER VII

MENA AND [illegible]

1. Introduction [illegible]

The archaeological [illegible] resulting from investigations of [illegible]. The major sites are [illegible] in the Cape. Each [illegible] and [illegible] [illegible] [illegible] as [illegible] and [illegible] [illegible] [illegible] in the [illegible].

The major concentrations of shell middens of [illegible] in the [illegible] Province, where large middens date from around 1 000 BP (Deacon, 1984; [illegible] 1972). The Cape middens are not only large and numerous, but they are also almost completely [illegible], which can be compared to those of the other major group of shell middens in Australia. They are therefore particularly suitable for the application of principles of [illegible] archaeology [illegible] of the larger middens of this area.

Sites of a similar character [illegible] found on the [illegible] coast in [illegible], which date from more than 1 000 [illegible] of the [illegible] (Parkington 1972). However, the only other known shell middens [illegible] complex middens of small [illegible] with stone artifacts [illegible] by the vicinity of [illegible] River [illegible], and the [illegible] from about 6 000 BP which were found in the upper part of the Oenpelli rock- shelter sequence.

It is possible that the rarity of middens around the coastline as a whole simply reflects lack of exploration. But sufficient is known from general surveys and air photographs to render it highly unlikely that mounds like those at Weipa and Milingimbi have been overlooked elsewhere. Thus a major problem posed in this area is the geographical discontinuity of the shell middens, together with the dramatic mound-like formation of many of the sites in the two main centres of occurrence.

The Weipa shell mounds were first recorded by Roth (1901), who observed the remains of fires and huts on the tops of the large sites at the junction of the Embley and Hey Rivers (Plate XV). The same sites were also noted by Jackson (1902). But it was not until the discovery of bauxite in 1955 that a thorough aerial survey revealed the full extent of sites along both banks of the three main rivers flowing into Albatross Bay. The steep sides of the mounds, some as high as 10 m or more, the lack of stone artifacts on their surfaces and the massive quantities of shell involved suggested to Stanner (1961) that they were natural accumulations, possibly created by changes in Postglacial sea-level. However, geomorphological studies directed to this very problem had already shown the implausibility of a natural origin (Valentin 1959), and subsequent excavation by Wright (1963, 1971) established the presence of Bipointed bone artifacts, food remains of fish and land mammals and charcoal lenses throughout the shell deposits. Since the possibility of a natural origin has remained a live issue locally, a detailed discussion of the criteria for distinguishing natural and artificial shell deposits is set out in Appendix B, where details of the artifacts recovered by the writer and the sources of the raw materials from which they were made will also be found.

In order to provide some control on the interpretation of the Weipa middens, brief surveys were carried out on foot, by boat and by air on the

Archer, Edward and Mitchell Rivers, in addition to the main investigations at Weipa itself.

2. Environment, Resources And Exploitation

Climate and Topography

There is relatively little topographic contrast in the Peninsula. Such high ground as exists is confined to a narrow series of hill ranges which represent the northernmost outliers of the Great Dividing Range. They lie close to the east coast and 100 km or more from the Gulf of Carpentaria, and they rarely exceed 600 m in height. The western part of the Peninsula is a broad and fairly level area mainly composed in the south of alluvial plains and in the north of a low plateau of Cretaceous sandstone capped by Tertiary laterite. In the Weipa area bauxite pisolites occur near the surface of the laterite and are the object of extensive, open-cast mining today. The general effect is a uniform, undulating landscape sloping gently towards the sea.

The lower parts of the rivers which cut into the edge of the plateau have been drowned by the later phases of the eustatic rise in sea-level and have been subsequently silted up along their shallow margins by marine deposits associated with mangrove and salt-marsh formations. This phase of infilling has been interpreted as the result of marine regression after a period of high sea-level during the Holocene, an interpretation based on the evidence of raised beaches which can be traced along much of the open coastline, and which may be as high as 8 m above present sea-level (Valentin 1959, 1961). Some of these beach ridges are certainly of Holocene date since radiocarbon dates ranging from 470 to 5 360 BP have been obtained, suggesting a *terminus ante quem* of 5 600 BP for the period of maximum submergence (F. Doutch *pers. comm.*). But whether this is the result of eustatic transgression or of tectonic instability remains unclear.

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[illegible] of the Peninsula, [illegible] [illegible] [illegible]. [illegible] the surface [illegible]

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Along the major rivers draining into Albatross Bay, the rising ground alongside the marine fill takes the form of ridges parallel with the river bank, which give the appearance of an old shoreline (Plates XVI and XVII). Valentin (1959), on the basis of aerial observation, suggested that these might represent a raised beach formed during the period of maximum transgression. From the fact that many of the shell mounds are situated on these ridges, he further suggested that the sites were contemporaneous with the period of high sea-level and might indeed be used to date it. However, these conclusions are probably erroneous, since the ridges are in fact composed of red loamy earths; they are therefore of terrestrial origin and are in no way related to the raised beaches along the open coast, which are composed of fine sand and marine mollusc shells and which are therefore genuine marine deposits (see Plates XVIII and XIX). Furthermore the earliest radiocarbon dates for the mounds are about 1 000 BP, which is rather late in comparison with the postulated date of 6 000 BP for the period of maximum transgression. In any case some of the larger mounds are situated directly on the surface of the marine fill (Plate XX), and, as Wright (1963) has demonstrated by boring of cores, even some of the loamy ridges are themselves stratified above marine deposits. So far from being used as a means of dating high sea-levels, the Weipa shell mounds can do no more than provide a terminus ante quem for the formation of the marine fill.

In terms of its limiting effect on economic behaviour, the climate is not unlike that described for the Ballina area, differing mainly in the more extreme seasonal variations of rainfall. The climate is monsoonal with hot, humid summers and warm, dry winters. Temperature ranges from a winter mean of 15°C to a summer mean of 32°C and is generally of less influence on economic behaviour than rainfall except in so far as it contributes to the scarcity of surface water by high rates of evaporation during the dry season. Mean annual rainfall invariably exceeds 1 000 mm. The figures vary slightly from year to year and from place to place, but the most striking contrasts in rainfall occurrence are seasonal. More than 90% of the total falls within

the five months from November to March, and the heaviest falls occur in January and February, a pattern which is maintained consistently and regularly throughout the region.

During the wet season extensive areas of low-lying ground are flooded, and seasonal streams and pools of water spring up across the land, ensuring an adequate supply of fresh drinking water for several months after the rains have ceased. As the dry season progresses, many springs and water courses run dry, and water becomes increasingly difficult to find except in permanent swamps and inland lagoons. Thus the pattern of rainfall imposes a double limitation on subsistence behaviour, providing too much water in the wet season, when flooding makes many areas difficult of access, and too little at the height of the dry season, when exploitation is confined to those resources which lie within convenient access of a permanent water supply.

<u>Vegetation</u>

The present day vegetation cover is a stable, fire-adapted one which appears to have changed little since the time of European entry into the area in the late 19th century (Pedley 1971). Extensive firing of the undergrowth in the dry season was clearly a traditional Aboriginal practice and probably one of quite considerable antiquity. Numerous plumes of smoke continue to cloud the horizon today, whether initiated by Aborigines from the local reserves when they go out into the bush or by the European cattle ranchers. In either case the effect is an improvement of the available grazing resources. For burning off the rank growth of wet season vegetation which chokes the landscape makes the hinterland more easily accessible for man and beast alike and clears the ground for a new growth of fresh herbage.

The major new variables in the European situation are the introduction of cattle and feral pig, but the former has not so far imposed any pressure on the natural grazing resources (Pedley 1971), whereas the latter has taken over one of the roles of the Aborigine in the local ecosystem by grubbing

around in the swamps and mangroves for roots and shellfish, items which were formerly of importance in the traditional diet. Except in the relatively restricted area of mining operations near Weipa, European interference with the existing tree cover is not a factor of any significance. As with the exploitation of oysters at Ballina, a recognisable theme in the relationship of man to vegetation with the transition from Aboriginal to European patterns of economy is one of continuity. Such variations as do occur in the pattern of vegetation can be related to local edaphic factors.

The two commonest vegetational communities are open forest of sclerophyll type and savannah woodland. The former provides a uniform, tall and fairly dense tree cover in which the main species is the stringybark (_Eucalyptus tetradonta_), and it is found on slightly elevated, well drained ground. The latter is dominated by _E. polycarpa_, has a more open formation with a richer herb layer and appears to be characteristic of lower ground where the soil is more moist. Broadly speaking the open forest is more common in coastal areas, except on the sandy beach ridges, which support low eucalypts and grasses, whereas the savannah woodland becomes more prevalent as one moves inland. South of Edward River extensive grasslands are found. Although the open forest is most probably a less productive source of food, its importance as a source of raw materials should not be overlooked, for the stringybark tree is an ideal source of the bark sheeting used to make canoes during the wet season (Thomson 1939 p. 212).

The margins of the river estuaries support a complex and variable pattern of vegetation which can be divided into three zones of some importance to the human economy. The outermost zone, nearest the river, consists of oozing mud clothed with mangrove trees, which often presents an almost continuous barrier and, in the Weipa area, attains a maximum width of nearly 3 km. There is a further gradation within this zone, ranging from the outer edge, where the vegetation is tallest and densest, through successively drier and less thickly populated zones, which ultimately grade into a zone of salt flats or salt pans. These are a distinctive feature of the region and may vary in [illegible] for study and [illegible], local groups were [illegible] ... [illegible]. [illegible] of the [illegible] [illegible] ... [illegible] with [illegible] ... [illegible]. In [illegible] the [illegible] ... of the relationship [illegible] ... in the [illegible] ... in the [illegible] ...

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[illegible] of the [illegible] ... [illegible] (January 1936 to 1937).

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width from several metres to several kilometres. During the dry season they are bare, arid expanses of sand or hard-baked clay, largely devoid of vegetation except for occasional patches of salt-tolerant plants such as Salicornia (Plate XIa). But with the onset of the wet season they are frequently covered by the unusually high tides, known as "king tides", which occur at this time, and they are transformed into extensive sheets of shallow salt water. This zone in turn grades into a "marsh" zone, a flattish expanse with a covering of tall grasses, which is marginally higher than the salt pans and is liable to a certain amount of waterlogging in the wet season.

The gradation from aquatic to terrestrial conditions across these three zones, combined with the effects of seasonal flooding, make this a true ecotonal situation of great food abundance, especially in the wet season.

One other natural feature of importance to the human economy is the oval, swampy depressions, as much as 400 m in diameter, which are dotted irregularly across the landscape. The character of the vegetation varies according to the level of the water table, but it may include root-bearing plants of various types and tea-trees (Melaleuca spp.). Apart from the plants, which are important sources of food, water can also be obtained during the dry season by digging wells or by piercing the water-filled bulges which are sometimes found in the trunk of the Melaleuca tree.

Terrestrial Resources : Animals

Both the stringybark forest and the savannah woodland support large marsupials, the latter probably more so, given its richer herb layer. The chief species are wallaby, Macropus agilis, and kangaroo, M. rufus and M. giganteus. Peak availability appears to have occurred during the wet season, when restrictions on animal movement, concentrations of fresh undergrowth and the noise of wind and rain all favoured the success of the hunter, but organised drives associated with the firing of the vegetation were carried on to some extent, especially at the end of the dry season (Roth 1901; Thomson 1939).

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Bird life figures in accounts of Aboriginal exploitation, notably emu, scrub turkey, scrub hen, flying fox and various aquatic species. But these seem to have rated of lesser importance as meat sources than the marsupial game.

"Sugar bag", the honey of the native bee, which is found in hollow trunks of eucalypt trees, is emphasised as a dry season staple.

Plant Resources

A total of 47 species of plant foods has been recorded on the west coast of Cape York Peninsula (Golson 1971), and it is clear from all the early accounts of this area (McConnell 1930; Roth 1901; Thomson 1939) that plant foods as a whole played a substantial role in the economy. The most important type of plant resource is the root stocks and the season of greatest abundance the months following the cessation of rain from about March to July. Yams, *Dioscorea bulbifera* var. *sativa* and *D. bulbifera* var. *rotunda*, appear to have been taken in greatest quantity over the longest period of time. Judging by the evidence from Arnhem Land (Peterson 1973; Specht 1958), the most favoured areas are the edge of swamps or soils with good moisture retention, which suggests the savannah woodland of the Weipa area as the most likely source of supply. Leguminous roots such as *Eriosema chinense*, *Vigna vexillata* and *V. canescens* were important staples of a similar kind. The swamp corm, *Eleocharis sphacelata*, reaches its maximum development at a late stage of the dry season, at which time it is capable of sustaining large groups of people for several months of the year (Thomson 1939 p. 216). The tubers and seeds of the water lily, *Nymphaea spp.*, are found in swamps with permanent water and become important in the latter part of the dry season when the vegetative parts of other root stocks have withered away and are no longer easily located.

Fruit is of less importance, although a variety of species were exploited during the wet season, including apples, *Eugenia suborbicularis*, currants,

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Flueggea microcarpa, figs, Ficus spp., and mangroves, Avicennia marina. The only species with any claim to staple importance in the diet is the nonda plum, Parinari nonda, which becomes available for consumption in the dry season.

Marine Resources

These are of great potential abundance, especially in the Weipa area, where the confluence of several major river estuaries offers extensive areas of muddy shallows rich in aquatic life. The importance attached to the exploitation of fish may be judged from the range of technological devices described by Roth (1901; 1904), which include the use of hook and line, spears, harpoons, hand-held nets, poisons and the construction of bush fences for use as weirs. There is every reason to suppose that fish resources played at least as large a role in the economy as at Ballina.

A species which may be singled out for special mention is the perch, Lates calcarifer, locally known as barramundi. Individuals may weigh as much as 50 kg, and their normal habitat is river estuaries (Roughley 1966). Although available throughout the year, perch are most abundant during the wet season when the king tides carry them in large numbers up the rivers and onto the flooded salt pans. The shallow water that is found in the latter situation greatly facilitates netting and spearing of fish, and, as the water level recedes in the early dry season, they become trapped in isolated pools or can be caught with artificial weirs.

Dugong, Halicore dugong, were harpooned from bark canoes in the open waters of Albatross Bay, although the people of this area were far less dependent on this resource than those groups living on the east coast of the Peninsula (Thomson 1939 p. 212), and sea turtle, Chelonia sp., were taken with similar techniques. It is, however, probable that the exploitation of these animals was relatively ineffective in the absence of outrigger canoes, which do not appear to have been in use on the Gulf of Carpentaria south of the Pennefather

River until a very recent period (Thomson 1939 p. 212).

The most abundant species of shellfish is the cockle, Anadara granosa, especially in the extensive, shallow, tidal mud flats around Weipa (Plate XXI). Other common species are rock oysters, which cluster on mangrove roots near the river, large bivalves called mud shells, and whelk-like gastropods, all of which are found buried in the mud of the mangrove zone. A complete list is shown in Table VII.3 (p. VII : 15). Thomson (1939 p. 215) noted the importance of shellfish during the wet season, and from the writer's own enquiries at Weipa, Archer River, Edward River and Mitchell River, it is clear that shellfish are recognised by the Aborigines throughout this area as being primarily, although not exclusively, a wet-season resource.

Exploitation

From the preceding discussion, two factors stand out as of primary importance in directing patterns of economic integration. The first is the seasonal complementarity between the marine resources of the coastal zone, which reach their peak of economic potential in the wet season, and the plant resources of the coastal hinterland, which are mainly dry season staples. The hunting of wallabies, associated with the burning of the vegetation, would have been a further draw to the hinterland in the dry season. There are thus close parallels with the northern coast of New South Wales, and it is predictable that some degree of seasonal movement would have been an essential element in the optimum exploitation of the coastal zone, as indeed is clearly emphasised in Thomson's (1939) account of the Wik Monkan.

The second factor is the water supply. The parched landscape of the late dry season not only limits the availability of drinking water but also contributes to the scarcity of some of the major food staples. Fish become progressively restricted in distribution or inaccessible to exploitation as the dry season advances, and plant foods also become scarce or difficult to locate except in the vicinity of water. Kangaroos and limited quantities of

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plant food become available for exploitation with the onset of the wet season, but there is some evidence to suggest that this is also a season of comparative scarcity. Peterson (1973 p. 182) observed that wind and rain made it difficult to see into the water and catch fish, and Thomson (1939 p. 215) noted that numerous casual foods were collected in small quantities at this season. Of particular interest is the matchbox bean, Entada scandens, which, although available throughout the year, was only resorted to at this time. Small quantities of yams and swamp corms were also stored up from earlier periods of abundance, which implies some anticipation of seasonal dearth. It is also worth noting that the stringybark does not strip freely until after the rains have commenced (Thomson 1939 p. 217), so that effective water transport would not have been immediately available with the onset of flooding.

The seasonally limiting effects of excessive or insufficient water supply would thus have been an important factor in determining the degree and direction of movement, depending on the local availability of such crucial resources as water holes and swamps. Indeed the ethnographic record suggests that the most appropriate way to simplify an understanding of human exploitation in such circumstances is to view it as an oscillating pattern of population dispersal and concentration - dispersal during the early part of the dry season, when water is freely available, and movement across the landscape on foot or by canoe is unimpeded, and contraction and concentration in response to the limiting effects of water supply.

The extent to which the remoter hinterland was incorporated into the coastal system of exploitation is far from clear. The hinterland is certainly of considerable extent, and a year-round supply of marsupial game, some fish, and plant foods would have been available to support independent, inland economies. On the other hand, two further factors are brought into sharp relief by comparison with New South Wales. The first is the comparable seasonal abundance of marine resources, which may be expected to have exercised a comparable attraction for hinterland peoples; the second is the absence

of a comparable complementary upland which might have served as an alternative wet season/early dry season resource-zone. The hill ranges that do exist are of limited extent and are partially covered in unproductive and impenetrable rainforest. Any potential they may have had as a seasonally complementary zone is more likely to have been tapped by peoples occupying the relatively narrow coastal strip on the east of the Peninsula. However, some degree of interconnecting movement between the highland and the west coast is demonstrated by the identification of raw materials in Appendix B. Of 39 stone artifacts recovered from surface collections or excavation at Weipa, 11 are made on material whose source is in the vicinity of Iron Range, over 100 km to the east. Thomson (1939), in his discussion of the Wik Monkan on the Archer River, implies that there were several economic units, corresponding to local clan groups, which extended from the Gulf of Carpentaria to the highlands. At the same time he suggests that there was some degree of interdependence between them as well. On the other hand, Roth (1910), speaking of the Pennefather River, suggested that people did not penetrate very far inland. Further assessment of the way in which annual territories were aligned to take advantage of hinterland resources would require more detailed and extensive data on the seasonal and local distribution of water resources than is available here.

3. Midden Analysis

There is an estimated total of about 500 shell middens on all four major rivers which flow into Albatross Bay (Figure VII.2). The sites on the east bank of the Hey River, the north and south banks of the Embley River, and a small group on the north bank of the Mission River, amounting to 304 sites in all, have been surveyed in detail. A complete schedule with details of dimensions, locations and estimated population sizes is set out in Appendix C. The remaining sites shown in Figure VII.2 have been located by air surveys and by examination of commercial air photographs taken at a height of 7 600 m

(25 000 ft), on which the larger mounds are clearly visible.

The middens show a wide range of shapes and sizes, from low mounds (Plate XVI) or surface scatters (Plate XXII) of limited extent to steep-sided mounds containing nearly 10 000 m^3 of deposit and standing up to 13 m above the level of the surrounding plain (Plate XIb). Some details about heights and volumes are summarised in Tables VII.1 and VII.2. These show that the large mounds for which the area is famous are in fact relatively few, and that the majority of the middens are less than 1 m in height and less than 100 m^3 in volume.

TABLE VII.1 - Frequency Distribution of Maximum Midden Heights at Weipa

Height m	Mission	North Embley	South Embley	East Hey	Total	%
<1	7	59	39	66	171	56
1 - 1.9	-	17	15	42	74	24
2 - 2.9	-	2	2	11	15	5
3 - 3.9	-	2	2	12	16	5
4 - 4.9	-	1	3	7	11	4
5 - 5.9	-	-	1	2	3	1
6 - 6.9	-	1	-	2	3	1
7 - 7.9	-	-	-	5	5	2
8 - 8.9	-	-	1	1	2	0.6
9 - 9.9	-	-	-	-	-	0
10 - 10.9	-	-	-	2	2	0.6
11 - 11.9	-	-	-	-	-	0
12 - 12.9	-	-	-	1	1	0.3
13 - 13.9	-	-	-	1	1	0.3
Total	7	82	63	152	304	99.8

The larger mounds are invariably grouped with smaller middens in isolated clusters (Plate XXIII). The larger mounds are also often irregular in form with tops of restricted area in comparison with the surface area of the base (Plates XIII and XIV), providing an extreme example of the logarithmic principle which underlies the relationship between the base area and the living area on the top of a mound (see p. V : 8). The simplest explanation of these structural and distributional features is to suppose that the basic unit of occupation is relatively small, perhaps a single family group occupying a hut of the type illustrated by Thomson (1939 p. 218) or Peterson (1973 p. 178). Thus the small middens would represent isolated occupations used relatively infrequently, the long low mounds multiple occupations, or preferred locations representing the accretion of single occupations over time by a process of horizontal extension, and the tall, steep-sided mounds preferred locations where the accumulation of smaller units has proceeded upwards rather than outwards. Plate XV is a good illustration of the composite structure associated with the growth of the larger sites.

As a further consequence of the composite structure of the tall mounds, it is usually the case that low mounds, representing earlier stages of accumulation, project outwards from the base of the main structure, offering a fairly easy means of ascent (Plates XIV and XV). Thus, although the mounds sometimes present an almost unscalable scarp slope of loose shell scree on some sides, there is usually a relatively easy means of access and therefore nothing implausible in the idea of regular occupation on the summit.

Table VIII.3 shows that a total of 15 species of molluscs has been identified in midden deposits. Only six of these recur with any regularity. Anadara granosa, the cockle, is the predominant species throughout, accounting for 95% by weight of all molluscan shell according to the analysis of excavated samples. As far as can be judged from superficial examination, all the middens appear to be quite uniform in terms of species composition, and attention is confined to Anadara in the following analysis.

TABLE VII.2 - Frequency Distribution of Mound Volumes at Weipa

Volume m^3	Mission	North Embley	South Embley	East Hey	Total	%
<100	3	64	39	87	193	65
100 - 490	2	9	13	34	58	19
500 - 990	1	5	2	8	16	5
1000 - 1990	1	2	7	12	22	7
2000 - 2990	-	2	-	2	4	1
3000 - 3990	-	-	-	2	2	0.6
4000 - 4990	-	-	1	-	1	0.3
5000 - 5990	-	-	1	3	4	1
6000 - 6990	-	-	-	1	1	0.3
7000 - 7990	-	-	-	1	1	0.3
8000 - 8990	-	-	-	1	1	0.3
9000 - 9990	-	-	-	1	1	0.3
Total	7	82	63	152	304	99.9

TABLE VII.3 - Molluscs Identified in Excavated Samples from Kwamter

In order of frequency:

Anadara granosa	Ellobium cf. aurisjudae
Batissa cf. violacea	Trigonostoma scalarina
Volegalea wardiana	Melo sp.
Telescopium telescopium	Corbulis sp.
Crassostrea sp.	Cassidula sp.
Tapes sp.	Cerithium sp.
Zeuxis dorsatus	Nerita lineata
Placamen sp.	

Species in the right hand column are represented by isolated individuals only.

Mean Annual Output

Mound Volumes

Data were collected using the methods described in Chapter V, with the addition of a minor correction factor applied to mounds situated on narrow ridges with convex upper surfaces. Full details of dimensions and volumes for each site are presented in Appendix C, and the data are summarised by mound cluster in Table VII.6 (p. VII : 22).

Excavation and Stratigraphy

The site chosen for excavation is Kwamter (site number 298) on the north bank of the Embley River near its junction with the Hey River (Figure VII.2). It is the same site excavated by Wright (1963, 1971) and has the advantage of being easily accessible and of having an existing section from which samples could be removed with a minimum of excavation. The site is a mound 110 m x 45 m in plan (Figure VII.3) with a maximum thickness of 3 m and an estimated volume of 2 250 m^3. It sits on a low ridge about 1½ m high at the very edge of the open forest and separated from the mangroves by a strip of flattish low-lying ground about 50 m wide; it is one of the largest of a cluster of nine sites (Figure VII.4).

Surface marks suggest that the mound has gone through at least two major phases of growth (Figure VII.3), an earlier stage, in which shells appear to have been scattered to form low mounds or surface deposits, and a later stage, in which shells were confined to a more restricted area and during which the main upward growth of the mound took place. The earlier stage is distinguishable by the more brittle, worn appearance of the surface shell and can be traced at the very base of the excavated section. This growth pattern is visible at many of the other larger mounds as well.

A bulldozed trench through the highest part of the mound already existed, and one face of this was cut back to undisturbed deposit. No attempt was made to clean this back to a vertical section because of the loose structure

of the deposit and the danger of slumping, and excavation was confined to the removal of a 1 m^2 x 3 m deep trench in 21 units (Plate XXIV). The deposit was composed almost exclusively of Anadara shells with very little surrounding soil matrix apart from occasional lenses of ash and fine charcoal (Plate XXV). No clear traces of structure or stratification were visible, so that excavation proceeded by the removal of horizontal spits.

Shell Quantities

Samples were collected using the standard procedure as described for the Ballina excavation (p. VI : 18). The results are shown in Table VII.4. The mean of 880 $\pm$ 110 kg/m^3 is slightly higher than the Ballina mean of 700 $\pm$ 150 kg/m^3, which is consistent with the more compact nature of the cockle shells and the lower quantities of non-molluscan material in the Weipa deposits. However, the size of the standard deviations is such that no statistical significance can be attached to the difference between the two means.

Meat weight has been estimated using both shell weight and minimum individuals. The latter method may be expected to give more reliable results than at Ballina, since the size range of the molluscs is narrower and the number of minimum individuals/m^3 more consistent. Using the mean individual meat weight of 3 g of Table III.6 and the meat weight to shell weight ratio of Table III.7 gives mean meat weights of 125 $\pm$ 6 kg/m^3 and 134 $\pm$ 17 kg/m^3 respectively. There is thus no statistically significant difference between the results of the two methods of estimation, which supports the assumption that potential weight losses resulting from leaching processes since the time of deposition can be disregarded in the application of weight ratios to shells of this age.

Chronology

Seven samples of charcoal were collected at various levels, of which three have been analysed. The results are shown in Table VII.5 (SUA dates) alongside the two results obtained by Wright (1971) from the same site (I dates).

TABLE VII.4 - Weights of Anadara Shell and Minimum Individuals/m^3 at Kwamter

Layer	Mean Depth cm	Sampling Level %	Estimated Total kg	Mean Weight kg/m^3	Minimum Indivs.	Mean Indivs. No./m^3
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	10	20	92	920	4 910	49 060
4	11	20	95	870	3 610	32 800
5	-	-	-	-	-	-
6	12	20	97	840	5 040	43 810
7	11	20	83	790	3 740	35 620
8	9	20	86	950	4 870	54 140
9	8	20	80	1 000	3 140	39 250
10	8	20	83	1 040	3 880	48 500
11	12	18	91	760	3 940	32 820
12	-	-	-	-	-	-
13	9	20	93	1 030	4 480	49 740
14	14	14	120	860	5 390	38 500
15	17	14	120	690	5 800	34 090
16	10	20	80	800	3 680	36 800
17	-	-	-	-	-	-
18	-	-	-	-	-	-
19	10	20	86	860	4 830	48 300
			$\bar{x}$	880		41 800
			s	110		7 420
			$s_{\bar{x}}$	30		2 060

The SUA dates show a uniform upward rate of growth of about 45 cm/100 years when plotted against a depth scale.

TABLE VII.5 - Radiocarbon Dates from Weipa (Kwamter)

Lab No.	Provenance cm*	Date BP
I-1737	Near the top	235 ± 110
SUA-147	265	725 ± 90
SUA-148	150	870 ± 70
I-1738	At the base	810 ± 65
SUA-149	5	1 195 ± 75

* Distance above base of mound

However, comparison with the I dates raises doubts, although these are difficult to assess, since the dates in either sequence are few in number, and their relative provenance is not established with any precision. I-1738 is significantly younger statistically than SUA-149, although their respective horizontal positions in the deposit cannot be greatly different, and a similar comment applies to I-1737 in relation to SUA-147.

Two types of explanation can be offered for this anomaly. Either inaccuracies of the dating method or contamination of samples are responsible, or the dates reflect major stratigraphic discontinuities. The latter possibility is not at all implausible in view of the model of mound growth elaborated above on the basis of the shape and size of the middens and the surface condition of the shells. But more data would be required to justify further interpretation of the existing dates.

If the SUA sequence of dates is used to estimate the commencement of shell accumulation at Kwamter, the result is 1 200 BP, allowing for calibration and correction to the new half-life. Assuming that intensive shellfood

exploitation ceased in about 1900 AD (50 BP), the approximate breakdown of the traditional subsistence system following European entry into the area, the total duration of shell accumulation works out at 1 150 years.

Two sources of uncertainty are involved in the use of such a figure, the one deriving from the potential inaccuracy of the Kwamter radiocarbon dates, the other from extrapolation of the Kwamter figures to the area as a whole. The possibility of gross bias arising from contamination of radiocarbon samples seems improbable, given the internal consistency of the dates. However, the statistical uncertainties are such that the true date to which the SUA-149 sample refers may range anywhere between 970 BP and 1 420 BP, giving minimum and maximum figures for total duration of 920 and 1 370 years respectively. Since our main interest is in the possibility of invalidating the hypothesis that shellfood is a major food supply, the minimum figure should be preferred in the analysis of mean annual output.

On the other hand, an accurate assessment of the earliest shell deposition at Kwamter is not necessarily a reliable guide to the commencement of shell accumulation in the area as a whole. As we have noted previously, any given shell midden may span only a fraction of the total period postulated for occupation of the area as a whole. All the major midden clusters of the Weipa area contain quantities of shell comparable to those represented by the Kwamter cluster. They also usually include large sites with low subsidiary mounds of worn shell passing into the base of the main structure as at Kwamter. At least 28 sites throughout the area are substantially taller than the Kwamter site, including site 291 in the Kwamter cluster itself, and, although height is almost certainly not a simple function of age, it is probably a related factor. Thus the question is whether shell accumulation in general began earlier than at the Kwamter site rather than later. Clearly more radiocarbon dates would allow more confidence to be placed in any assessment, but, in their absence, a figure of 1 000 years for total midden duration has been accepted as a reasonable working basis for the assessment of mean annual output. This is not intended as a precise estimate, rather as a convenient indicator

of an order of magnitude. As with many of the figures used throughout this investigation, it represents the best possible estimate in the light of the data presently available and the writer's assessment of the potential sources of error.

Results and Cross-check

Table VII.6 sets out the details of midden volume, shell weight and mean annual output, by midden cluster, for the area as a whole. The most reliable data are from the Embley and East Hey, where detailed survey was carried out. But gross figures are also included for the West Hey and Mission Rivers, based on an earlier, geological survey, and for the Pine River, where an admittedly crude estimate has been made simply by averaging the results of the other three rivers. The total quantity of shell is thus estimated as about 200 000 t. Assuming a mean meat weight of 134 kg/m^3, a calorific yield of 50 kcal/100 g and a total duration of 1 000 years, mean annual output can be estimated as 345 t live weight, 30 t meat weight or 15 x 10^6 kcal.

There are no data on modern yields of Anadara in this area, but mean annual output both at Weipa and at Ballina can be expressed in terms of unit area and compared for consistency. Although the data refer to different species of molluscs, comparison may at least show whether similar orders of magnitude are involved. The results are shown in Table VII.7. Areas refer to the total area of river within the maximum limits of distribution of the living molluscs or alternatively, where such information is unavailable, as at Weipa, the area within the maximum limits of distribution of the prehistoric shell middens. The method is liable to some inaccuracy since the ratio between the area potentially suitable for molluscs and the total area of river may vary according to the particular character of any given estuary and the extent of its tidal mud flats. Nevertheless, the Weipa mean of 0.346 t/km^2 is very close to the Ballina figure of 0.350 t/km^2, and there is nothing in these figures to justify the assumption that the Weipa calculations involve any gross underestimate of shell quantities.

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TABLE VII.6 - Volume, Shell Weight and Mean Annual Output of the Weipa Shell Mounds

Mound Cluster	Volume	Shell Weight	Mean Annual Output of Meat		
	m^3	t	kg	kcal	m/d
East Hey:					
1 - 19	21 440	18 870	2 873	1 436 500	718
20 - 60	35 240	31 010	4 722	2 361 000	1 181
61 - 80	7 830	6 890	1 049	524 500	262
81 - 92	3 030	2 670	406	203 000	102
93 - 109	3 590	3 160	481	240 500	120
110 - 128	8 860	7 800	1 187	593 500	297
129 - 146	2 440	2 150	327	163 500	82
147 - 152	10 390	9 140	1 392	696 000	348
Sub-total	92 820	81 690	12 437	6 218 500	3 110
South Embley:					
153 - 194	15 960	14 040	2 139	1 069 500	535
195 - 201	3 470	3 050	465	232 500	116
202 - 217	6 460	5 680	866	433 000	217
Sub-total	14 380	12 650	1 926	963 000	482
North Embley:					
218 - 227	50	40	7	3 500	2
228 - 264	1 630	1 430	218	109 000	55
265 - 268	1 690	1 490	226	113 000	57
269 - 289	4 150	3 650	556	278 000	139
290 - 299	6 860	6 040	919	404 500	202
Sub-total	14 380	12 650	1 926	963 000	482

TABLE VII.6 - Continued

Mound Cluster	Volume m^3	Shell Weight t	Mean Annual Output of Meat kg	kcal	m/d
West Hey:					
Sub-total	14 550	12 800	1 950	975 000	488
North Mission:					
Sub-total	910	800	122	61 000	31
South Mission:					
Sub-total	22 730	20 000	3 046	1 523 000	762
Pine River:					
Sub-total	51 550	43 360	6 908	3 454 000	1 727
Grand Total	222 830	194 070	29 859	14 929 500	7 468

Also shown in Table VII.7 for comparison are the data from the British shellfisheries previously referred to in Table III.3 (p. III : 11). The range of figures overlaps with the Australian results, although the overall mean is more than twice as high. This may reflect the more intensive exploitation of shellfood possible with an advanced technology; ecological factors and uncertainties inherent in the method of estimation may also be involved. Taken as a whole, however, the figures suggest that an index of shellfood output per unit area can be established within limits of accuracy and applied to estuarine conditions in a wide variety of areas.

TABLE VII.7 - Comparison of Shellfood Output per Unit Area in Australia and Britain

Location	Species	Area of Estuary km^2		Meat Weight t/km^2
Australia:				
Mission	Anadara	68		0.466
Embley	Anadara	16		0.334
Hey	Anadara	60		0.239
			$\bar{x}$	0.346
Richmond	Crassostrea	8		0.350
			$\bar{x}$	0.348
Britain:				
The Wash	Cerastoderma	1 000		0.298
Burry Inlet	Cerastoderma	90		2.475
Thames	Cerastoderma	700		0.396
Fal	Ostrea	21		1.029
			$\bar{x}$	0.910

Relative Shellfood Output

Population Data and the Annual Economy

The population size of all the middens examined in detail has been assessed using the Cook and Treganza formula, and the results are tabulated in Appendix C. This shows that on the East Hey alone maximum population size was 2 453, on the Embley River a further 2 421, figures which, by extrapolation to all four major rivers, would bring the total population of the area to some 10 000.

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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[illegible]

[illegible]

Clearly this figure is far too high, most probably because it is based on the assumption that the many middens which cluster closely together in this area were occupied simultaneously in any one year. Examination of this clustering effect in the following section on site catchment analysis suggests that such an assumption is invalid. Although no precise estimate can be made of the proportion of sites which were used simultaneously, it seems probable that we should think in terms of a population numbered in hundreds, as at Ballina.

There are no detailed ethnographic records of Aboriginal population size in the Weipa area, but it is generally accepted that coastal population densities in the monsoonal zone of northern Australia were comparable to those in New South Wales, where a variety of sources suggest that some 1 000 km of coastline supported about 25 000 people (Yengoyan 1968 p. 190). Assuming that all these people had access to the marine resources of the coastal zone, it follows that the average density was 25 people/km of coast. On this basis, the total population of the Weipa area would be 1 250 people, given a straight-line distance from the northern bank of the Pine River to the southern limit of the Hey River of 50 km. Relative annual output at this level would be about 6%.

Comparisons with New South Wales

Another method of assessing the reliability of figures for relative annual output at Weipa is to use the index of shellfood output per unit area based on mean annual output at Weipa and Ballina and to apply it to other areas where the population figures are more secure, notably in New South Wales.

Table VII.8 lists all the major estuarine areas of New South Wales and shows that the total area is some 1 041 km^2. Species of cockles (Anadara trapezia and A. granosa) and oysters (Crassostrea commercialis and Ostrea angasi) predominate throughout, so that it seems reasonable to apply the mean figure

[illegible]

usually been higher in the [illegible], which probably because it is based on the assumption that the [illegible] roughly [illegible] so this year were averaged [illegible] the period. [illegible] of [illegible] effect in [illegible] suggests that such an assumption [illegible] to be made of the proportion of [illegible], if [illegible] methods [illegible] in particular, [illegible] at present.

There are no [illegible] populations with [illegible] area, but [illegible] to the [illegible] in [illegible] of [illegible] than [illegible] [illegible] c. 1950. [illegible] of the [illegible] of [illegible] of [illegible] 250 people, [illegible] in [illegible] at that [illegible] about [illegible]

Comparison with New South Wales

Another method of assessing the reliability of figures for [illegible] is to use the index of [illegible] output per unit area [illegible] output of [illegible] and to apply it to other [illegible] where the [illegible] are [illegible], notably in the South [illegible]

[illegible] the major [illegible] areas of New South Wales and [illegible] that the total area is about [illegible]. Figures of [illegible] ([illegible]) and ([illegible]) [illegible], so that it [illegible] to apply the same figure.

TABLE VII.8 – The Area of the Major Estuarine Inlets of New South Wales

Location	Area km^2
Tweed River	10
Richmond River	8
Clarence River	60
Bellingen and Nambucca Rivers	5
Macleay River	10
Hastings River	8
Manning River	8
Wallis and Smith Lakes	88
Myall Lake	66
Port Stephens	135
Hunter River	21
Lake Macquarie and Munmorah	130
Tuggerah Lake	57
Brisbane Water	31
Broken Bay and Hawkesbury River	78
Pitt Water	23
Port Jackson	55
Georges and Cooks River	15
Botany Bay	50
Port Hacking	10
Lake Illawarra	31
Shoalhaven River	9
Crookhaven River	10
Lake Wollumboola	5
St. Georges Basin	40
Cudmirra Lake	3
Cunjurong Lake	3
Burrill Lake	3
Durras Water	3
Buckenbowra River	10
Moruya River	4
Tuross Inlet	10
Lake Birroul	3
Lake Mummuga	2
Wagonga River	5
Bermagui River	2
Bithry Inlet	4
Mogareka Inlet	4
Lake Wallagoo	6
Lake Meribula	4
Lake Pambula	5
Wonboyn River	7
Total	1 041

for shellfood output of 0.35 t/km^2 of Table VII.7. Open-shore molluscs are not included in the calculation on the assumption that their potential is relatively slight in comparison with the estuarine species. The results are set out in Table VII.9

TABLE VII.9 - Comparison of Relative Shellfood Outputs from Weipa and New South Wales

Location		Population Size	Mean Annual Output m/d	Days/Year of Occupation	Relative Output %
New South Wales:					
Total Coastline		25 000	91 000	4	1.1
Botany Bay to Broken Head	(1)	3 000	17 500	6	1.6
	(2)	1 500	17 500	12	3.3
Richmond River	(1)	500	825	2	0.5
	(2)	100	825	8	2.2
Weipa					
Total Area	(1)	1 250	7 464	6	1.6
	(2)	500	7 464	15	4.1
South Embley and East Hey	(1)	500	3 978	8	2.2
	(2)	250	3 978	16	4.4
	(3)	100	3 978	40	11.0

The first set of calculations refers to the whole New South Wales coastline and is based on the figure of 25 000 quoted above.

The second set of calculations refers to the coastline from Botany Bay to Broken Head inclusive, in the Sydney Region, with a total estimated estuarine area of 200 km^2, chosen because it seems fairly well established that population size was between 1 500 and 3 000 (Yengoyan 1968 p. 190).

[illegible]

[illegible]

[illegible]

[illegible]

Commercial records of oyster output are available from the Georges and Hawkesbury Rivers. The estuarine area of these two is considerably less than the area under consideration. But stick-and-tray cultivation is extensively employed and has almost certainly raised output to a large degree in comparison with natural conditions. A total annual output of 12 240 bags has been recorded (Rochford 1951). Using the conversion factors applied to the Ballina data, one arrives at a figure of 22 440 man/days of shellfood output. This cannot be taken as an exact parallel for the prehistoric situation, but it does suggest that the estimate of 17 500 man/days for the Broken Head to Botany Bay area is of the right order of magnitude.

The third set of calculations refers to the previously discussed results from the Richmond River, Ballina, which are included here for comparison.

The results for relative annual shellfood output are very low in every case, scarcely above 3%, whichever set of calculations is preferred. Although it is possible that occasional areas of great shellfood abundance may have been obscured by averaging out the data in this way, it seems unlikely that much higher figures will be obtained in New South Wales without a drastic downward revision of population estimates.

Turning to Weipa, the population size of 1 250 used in the first set of calculations in Table VII.9 is the figure estimated by analogy with coastal population densities in New South Wales, and the second figure of 500 is an arbitrary number chosen to assess the effect of lower population size on relative shellfood output.

The second set of calculations is limited to the area bounded by the South Embley and East Hey, an area which, judging by the shell quantities, appears to have been the most productive for shellfood within the Weipa area as a whole. The numbers of shell middens in this area and the numbers of people that could have been supported on their surfaces is such that a population figure lower than 100 is considered highly unlikely, although the possibility of lower population numbers cannot definitely be excluded.

Thus the highest figure for relative annual shellfood output which seems

Reasonable records of [illegible] output are available from the [illegible] and [illegible]. The [illegible] area of these [illegible] is considerably less than [illegible] other [illegible]. But [illegible] is [illegible] applied and had almost [illegible] values [illegible] to a [illegible] degree in comparison with [illegible] conditions. [illegible] output of [illegible] has been [illegible] ([illegible]). [illegible] applied to the [illegible], [illegible] output. [illegible] should be [illegible], but it [illegible] that [illegible] to [illegible] of the [illegible].

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The [illegible] for [illegible] very [illegible] [illegible], [illegible] is [illegible]. Although it is possible that [illegible] may have been [illegible] by [illegible] this way, it seems unlikely that such higher figures will be [illegible] in the [illegible] without a [illegible] of population estimates.

Turning to [illegible], the population size of [illegible] used in the first set of calculations in Table [illegible] is the figure estimated by analogy with modern population densities in the [illegible] valley, and the second figure of [illegible] is an arbitrary number chosen to assess the effect of lower population size on relative [illegible] output.

The second set of calculations is limited to the area occupied by the [illegible] and [illegible], an area which, judging by the small quantities, appears to have been the most productive for [illegible] within the [illegible] area as a whole. The evidence of small [illegible] in this area and the numbers of [illegible] that could have been supported on their [illegible] is such that a population [illegible] lower than [illegible] is considered highly unlikely, although the possibility of lower population densities cannot definitely be excluded.

Thus the highest figure for relative annual [illegible] output which seems acceptable within the limits of the data is 11%. However, uncertainties remain, as in previous calculations of this type. In this case the major source of uncertainty is population size, although Urquhart (1897 p. 44) observed "large numbers of natives" in the vicinity of the junction of the Embley and Hey Rivers, and Boyd (1895 p. 48) recorded the presence of several hundreds of natives on the Pennefather River, figures which support the general order of magnitude favoured in the above calculations.

What our data do allow us to say with some confidence is that, if population densities in coastal Cape York can be assumed to have been comparable to those of New South Wales - and the general similarity of the coastal economies in the two areas is consistent with such an assumption, then comparable levels of relative annual shellfood output may be expected to apply to the Weipa area.

The Site Economy

Table VII.10 shows the resources identified in excavation, and Table VII.11 the total weight of bone found in the 3 m^3 of excavated deposit. The general character of the sample is similar to the Ballina material, and it differs, if at all, in being more exiguous and fragmentary. Insufficient fragments could be assigned to fish or mammal, so that all the bone has been lumped together in the estimation of meat weight. Using the conversion factors applied to the Ballina sample, it is found that the bone represents a mean of 3.8 kg/m^3, which compares with a mean of 125 kg/m^3 of shellfood. On this basis shellfood would have represented some 94% of the site economy. As at Ballina there is a heavy under-representation of the other resources known to have been of importance in the coastal zone. However, the small fraction of deposit excavated, the possibility of mechanical destruction or removal of bone and the probable under-representation of plant foods all preclude a definite interpretation. Bipointed bone artifacts, used as barbs for spears, are scattered throughout the deposit and suggest that the site was used at least as an intermittent focus for the exploitation of fish or marsupials.

TABLE VII.10 - Non-molluscan Resources Represented at Kwamter

Terrestrial, in order of frequency:	
Macropus agilis	Agile Wallaby
Isoodon macrourus	Short-nosed Bandicoot
Isoodon sp.	Bandicoot
Marine:	
Mylio sp.	Bream
Scylla serrata	Crab

TABLE VII.11 - Weights of Bone Found in Excavation at Kwamter

Layer	Total Weight g	Density g/m^3	Layer	Total Weight g	Density g/m^3
1	-	-	11	13	108
2	11	110	12	9	72
3	4	40	13	2	22
4	3	27	14	9	64
5	7	70	15	8	47
6	12	104	16	12	120
7	10	95	17	13	92
8	8	84	18	-	-
9	6	75	19	3	30
10	10	125	20	-	-

$$\bar{x} = 76\ g/m^3$$

$$s = 33\ g/m^3$$

$$s_m = 8\ g/m^3$$

but they cannot be used to quantify further the role of these activities in the site economy. All the data allow at this stage is the statement of alternatives: either large quantities of non-molluscan food consumed at the site have left no archaeological trace; or else the shell mound was used as a transitory site for little other activity than the consumption of shellfood.

4. Site Catchment Analysis

Sites

Apart from shell middens, material traces of occupation sites are almost unknown in the Weipa area, although it seems highly probable from the ethnographic record that such sites must have existed. This is partly due to lack of exploration but also to the local scarcity of stone materials for making tools and the consequent dependence of the traditional technology on perishable materials, a point which is emphasised by the relatively few stone artifacts found within the shell midden deposits or on their surfaces and by the fact that many of these are made from rock types which must have been imported over distances of 100 km or more (see Appendix B). Other factors are the acidity of the soil and the lack of rock shelters which might give some archaeological visibility to otherwise scanty traces of occupation. Indeed it is a common experience to be shown traditional camping grounds which completely lack any surface signs of occupation except perhaps for a rusting can abandoned on a recent visit.

Only one possible inland site can be identified, at the Old Mission on the Embley River about 20 km upstream from its junction with the Hey River. According to local information this used to be a traditional Aboriginal meeting place for people from a wide area, which seems plausible, given the favourable position of the site on the river and the presence nearby of swamps and permanent water holes, although archaeological corroboration of its use before

European contact is lacking.

In spite of this dearth of sites, a study of the economic potential of the areas within reach of the shell middens allows some assessment of the degree to which seasonal movement would have been necessary and the probable location of complementary sites.

Resource Potential

Six categories have been recognised in the mapping of economic potential: salt pans, mangroves and the open river, referring to the marine sector; and open forest, savannah woodland and seasonal swamp, referring to the terrestrial sector. All of these categories can easily be distinguished on the ground and on aerial photographs. The chief uncertainty lies in the identification of water supplies, which may have been of crucial importance in determining the degree of exploitation of local food resources. Only patchy information is available on this point.

Quantitative data on economic potential are not available for any of the categories, excepting the figures for shellfish. But some general statements can be made about relative potential. The mangroves and salt pans, considered in isolation, are probably of least importance as sources of food. The former offer little more than a small quantity of fruit and shellfish; the latter are virtually barren during the dry season. However, for at least part of the year, these two zones are more properly treated as an extension of the open river. The zone of salt pans in particular would most probably have supplied a potential abundance of fish in the wet season. On land, swamps are often of limited size but of potential food abundance. Of the other two terrestrial categories, open forest is probably the less productive overall, although the lower moisture retention of the soil which is primarily responsible for this would have offered compensating advantages at the height of the wet season by providing a well-drained refuge for men and animals. Potentially the most productive zone of all is the marine zone, although there is an

element of uncertainty as to how far this potential would have been actually realised within the limitations of the prehistoric technology.

Coastal Site Territories

Figure VII.5 shows the distribution of potential site territories on the Embley and Hey Rivers. The map is introduced at this stage in order to illustrate the tightly packed distribution of sites and site territories along the large rivers. The territories refer only to major groupings of middens, each one of which in its turn comprises a varying number of individual sites. Thus the overall distribution of sites in this area is quite exceptional and presents an extreme form of the clustering which we have already observed in a more localised and less dramatic form at Ballina.

(i) Local Distribution

In order to understand the factors which contribute to this pattern, attention is first focused on a single cluster. The group of sites selected is on the East Hey, where the clustering effect is most prevalent and the underlying principles of site location most easily understood. It is illustrated in Figure VII.6 and comprises sites 110 to 128, a total of 19 shell middens, all of them encompassed within a circle of about ½ km radius. They range in size from the largest (116), 5 100 m^3 in volume and 7 m high, to the smallest (120), a surface scatter representing about 1 m^3 of shell deposit. The various resource zones have been mapped in. Also shown are the mud banks from which the great majority of the molluscs would have been collected, and the strip of flat, low-lying, grassy plain which separates the salt pans from the open forest.

The Importance of Boats

The first point to emphasise concerns the location of the cluster as a whole, and that is its distance from the river, about 2 km as the crow flies.

We have previously established that the maximum time-distance factor for the transportation of cockles is about 3 km and the optimum 1 km or less (Table III.10). In terms of distance alone, leaving aside the intrinsic difficulty of forcing a path through mangrove vegetation, shellgathering on foot would have been scarcely viable, if not totally impossible. That the group of sites under consideration here represents a total quantity of shell of 7 800 t (Table VII.6), equivalent to more than 300 million cockles, is a measure of the regularity with which shells were collected and underlines the importance of water transport in overcoming the restrictive limitations of the time-distance factor in circumstances of difficult access such as these. Especially significant in this connection is the location of the site cluster close to a stream which would provide a ready means of access for a small boat or canoe through the mangrove barrier to the shell beds and the open river beyond.

The example described above is an extreme one, since the mangroves are rarely as wide elsewhere along the river banks. In other areas it is probable that some shellgathering on foot would be feasible. But even where the mangrove zone was thin enough to allow this, the use of boats at high tide would offer a significant saving of effort, since personal experience shows that it is difficult to walk very far at low tide on the exposed tidal flats without sinking to one's knees in soft mud. Absence of boats would thus have rendered the exploitation of shellfood less effective in this area, and the archaeological evidence of shell middens less substantial.

Seasonal Factors

Generally speaking the over-riding principle in the selection of a given spot for the consumption of shellfood, or at least for the removal of the shells, would be to camp as close as possible to the source of supply, or the nearest point of access to it, in this case the point where the stream comes closest to emerging from the mangroves. Given the highly restrictive limitation of the time-distance factor for transportation on foot of shellfood in general and cockles in particular, we might expect the formation of shell deposits to

be confined to one or two major locations as near as possible to the most convenient access point. Instead we find a marked tendency for the distribution of shell middens to scatter in a way which bears little apparent relation to problems of access to the shellfood supply, as if some additional factor were distorting the effect of the time-distance constraint.

The simplest explanation of this tendency for individual sites to proliferate within each major cluster is a seasonal one. As is apparent in Figure VII.6, sites occur in several different types of location: some are situated within the open forest; some on the low grassy plain; and one on the salt pan. The full range of positions in which shell middens are characteristically found in the area generally is illustrated schematically in Figure VII.7. Each position has features which confer certain advantages on it as a focus of occupation in some seasons and certain disadvantages at other seasons. For example, flooding of low ground would be expected to force occupation off the salt pans and low grassy plains onto the higher ground within the open forest in the wet season. In this respect ethnographic observations are quite explicit about the importance of dry ground not simply as a refuge from the floods but for the shelter from bad weather provided by the tree cover (Peterson 1973 p. 189; Thomson 1939 p 215). Another factor emphasised in the ethnographic record is the effect of mosquitoes and sandflies, which are sufficiently troublesome immediately after the rains have ceased to promote a shift of camp onto open, windswept ground on the edges of plains and salt pans. The location of water supplies may also have been of sufficiently critical importance in the drier part of the year to influence changes of site location over small distances.

The seasonal shift of location within a given cluster might be plausibly reconstructed along the following lines. At the height of the wet season, stormy weather and wet ground would concentrate occupation within the forest, mainly in position G. This location away from the river would be tolerable in economic terms to the extent that it coincides with a period when exploitation of land animals appears to have been a more important source of protein than [illegible] one of the major [illegible] as potential [illegible] the upper [illegible]. [illegible] for the [illegible] [illegible]

[illegible]

[illegible] and [illegible] [illegible]

[illegible]

[illegible] and the [illegible] [illegible] marine foods. At the end of the wet season, the need to escape from insect pests, combined with the desirability of moving closer to the marine resources, which become abundantly available at this time, would promote a move to positions F, E, and D. Finally, with the drying out of the salt pans, movement to positions C, B and A would be possible, followed perhaps by a reversion to some of the earlier positions as the emphasis of the economy shifted back from marine to terrestrial resources with the progress of the dry season. This reconstruction is simplified to the extent that it does not take account of mound formation, which would have allowed occupation of the low-lying positions without regard to the state of flooding. But this is a matter of sufficient importance to require separate comment in a following section and does not invalidate the hypothesis of a general seasonal drift of occupation from sheltered high ground to exposed low ground with the progress of the seasons.

The Time-Distance Factor

Although seasonal directives appear to be uppermost in the location of the individual shell middens, analysis of shell quantities reveals the underlying influence of the ever-present time-distance factor. In view of the critical effect of short distances on shellfood exploitation, we might expect the largest quantities of shell to occur in position A, nearest the river, and the smallest quantities in position G, furthest away, with a progressive decline in the intervening positions.

Table VII.12 shows the shell quantities represented by all the shell middens of the East Hey, arranged according to site position. Positions B and C have been amalgamated to form a single group since both are effectively salt-pan locations. Positions D and E have been amalgamated for similar reasons. The data are taken from Appendix C.

Contrary to expectation, the largest quantities of shell do not appear to be found in the positions nearest the river. However, the rarity of shells in position A is easily explicable, since the mangrove zone is an intrinsically unpleasant place to live, and such few sites as do occur are found on the very

TABLE VII.12 - The Distribution of Shell Quantities on the East Hey According to Type of Location

Position	Shell Quantities m^3	%
A	110	0.1
B/C	13 940	15.0
D/E	57 250	62.0
F	13 040	14.0
G	8 480	9.0
Total	92 820	100.1

edge. The relative rarity of shells in positions B/C is less obviously explained, but can nevertheless be accounted for quite simply by the fact that the largest salt pans on the East Hey are usually found behind a wide zone of mangroves and are thus at some distance from the river. Conversely, where the mangrove barrier is quite thin, the zone of salt pans is also thin or non-existent. The point may be more clearly appreciated from Figure VII.6, which shows that, in relation to the local access point provided by the stream, the salt pans are no more conveniently situated than the grassy plain. Reverting to Table VII.12, it will be seen that, beyond the salt pans, the expected pattern reasserts itself, with the maximum quantities of shell in positions D/E and a progressive reduction in positions F and G.

Mound Formation

It is appropriate here to examine the problem of mound formation more closely. The mounds take an extreme form in this area, which is not only of intrinsic archaeological interest but is also a major stumbling block to the acceptance of the artificial nature of the shell mounds by the non-archaeologist

(see Appendix B).

The simplest explanation at present available is Peterson's (1973) hypothesis, already mentioned in connection with the Ballina shell mounds (p. VI : 37). It is of special relevance here, since it was designed to explain the closely similar character of the earth and shell mounds of coastal Arnhem Land. The Weipa mounds thus form an important test case for the validity of the hypothesis.

The shell middens of Castlereagh Bay and Milingimbi Island range from small middens to large mounds, as at Weipa. The composition of all the sites is closely similar throughout, with Anadara granosa the dominant shell species. The largest mounds are usually located on extensive areas of salt pans behind the mangroves, which are liable to flooding by rain and king tides throughout the wet season and at the very end of the dry season. The area is therefore muddy or flooded at the period of the year when marine resources are most abundant and occupation close to the marine zone most desirable. Any small accumulation of shells on the salt pans would represent a low, dry area above the level of the surrounding waters. It would thus be an obvious spot to camp on in subsequent visits and, with each year's accumulation of shells, would become increasingly favoured as a dry location, resulting in time in the tall, steep-sided structures which are visible today. Conversely, middens situated on sandy ridges or in dry woodland, where the constraints on the area over which shells are discarded would be less rigid, are lower and more extensive.

Parallels for all these features can be found at Weipa, although there are also some local differences of detail. Figure VII.8 presents a series of frequency distributions of maximum mound heights in order to illustrate their relationship to locational position. From this it is obvious that there is a very clear trend, with the tallest mounds showing an almost exclusive correlation with position D, the low strip of grassy plain. The rarity of large mounds on the salt pans, in contrast to Arnhem Land, can be accounted for by the fact noted above, that areas where the mangroves are thinnest and

the river most easily accessible are also those areas where the salt pans are narrow or non-existent. Since first hand observations of the area were only made during the dry season, an exact assessment of the degree of flooding of the grassy plain cannot be offered. But it is generally flat and low-lying and in many places only a few inches above the level of the salt pan. It is thus probably liable to at least some degree of waterlogging during the wet season and presumably remains waterlogged for some period after the rains have ceased, as water continues to drain off the higher ground nearby, providing an analogous set of circumstances to those found on the Arnhem Land salt flats. It is worth adding in this context the comments of two independent witnesses from the local Aboriginal settlement, who remembered camping on the top of shell mounds in the Mission River area when spear fishing during the wet season, because they were the only dry places available.

Two further points should be made about the Weipa sites. The first concerns the relationship of mound formation to the time-distance factor. The critical effect of short distances on the exploitation of shellfood, which we have emphasised above, allows us to resolve a discrepancy noted by Wright (1971) in discussing the application of the above hypothesis to the Weipa area, and that is the fact that the rising ground of the open forest does exist quite close by many of the shell mounds and might therefore seem to obviate the advantages of living on their surfaces. However, by offering artificial islands close to the river, the shell mounds would have allowed people to live as close as possible to the marine resources whenever necessary without having to wait for the flood waters to recede and the low ground to dry out. In view of the probable importance of marine resources during the wet season and early dry season and the critical effect of the time-distance factor in their exploitation, the selective advantage of movement close to the river, even over quite small distances, is likely to have exercised a powerful directive on the use of shell mounds, ensuring their upward growth from year to year over many hundreds of years. A reinforcing factor in their use, emphasised by Peterson, would have been the need to move out of tree cover

in order to escape insect pests at a time when exposed ground would still have been wet under foot.

A second point to emphasise is that flooded locations are not an essential prerequisite for the formation of archaeologically visible shell mounds, although they are quite clearly an accentuating factor in the formation of the larger structures. Shell middens also occur in the drier locations of the open forest. Although generally smaller, they are not insubstantial, as is demonstrated by site 23 on the East Hey, which is 4 m high (Appendix C). The cause of concentrated shell dumping in this sort of position is less obvious, although it is probably related to the use of wet-season huts and the advantages of dryness and heat insulation involved in living on a shell surface. At any rate this point is important to bear in mind when discussing the absence of shell mounds from other parts of the Cape York coastline.

Home-Base Exploitation

If the seasonal interpretation of variations in site location offered above is correct, it implies that the site cluster as a whole was used for a substantial period of the year, at least on an intermittent basis and was not merely the focus of transitory occupation lasting for a few days per year.

The economic potential of the surrounding area throws some light on the nature of occupation. From the territorial point of view the shell middens in Figure VII.6 are so close that they represent in effect a single site focus. Only a small portion of the potential 2 hour site territory is illustrated, but it is sufficient to show that all the major resource zones are within easy reach, including the open river, mangroves, salt pans, open forest and a relatively extensive area of seasonal swamp in which corms were observed to be growing at the time of survey. The impassable nature of the mangrove vegetation is such that the territorial boundary would probably be confined to a narrow access corridor following the stream which traverses the mangrove barrier, as is illustrated in Figure VII.6. The stream is thus not only of specific importance in allowing access to the shell beds, but of general

importance in linking together the marine and terrestrial sectors of the site territory. The shell middens are therefore strategically located with respect to all the major food staples of the coastal area, and this, together with the number of sites involved, strongly suggests that we are dealing with a home-base cluster of the type identified at Ballina, with different sites serving different aspects of the overall exploitation pattern.

The precise economic role of any single shell midden cannot be assessed with certainty. Some may have been transitory sites used primarily for shell-food consumption or as shell dumps; others for more general activity. The available archaeological evidence from other site clusters of a similar character is of little help here, although the presence of spear barbs at Kwamter and of two pounding stones, probably used in the processing of plant foods, found on site 80 (Appendix B), add a little to the picture of economic diversity, and suggest that at least some of the middens were used as occupation sites by family groups.

Nor is it certain that other sites, no longer archaeologically visible, did not form part of the cluster. The site marked in Figure VII.6, about 1 km north of the main group of shell middens, was pointed out by an Aboriginal guide as a camping place used by as many as 100 people from the Old Mission during the early part of the dry season for the exploitation of fish and swamp plants. However, careful examination of the area failed to reveal any surface evidence of occupation. Other sites of this type may also have existed. But, as at Ballina, the clustered distribution of the shell middens appears to indicate a home-base focus, even if the archaeologically visible sites represent only a partial element of the total pattern.

(ii) Area Distribution

In contrast to northern New South Wales, the home-base clusters of the Weipa area are much closer together than one would normally expect (Figure VII.5). A possible explanation is that the clusters were not occupied contemporaneously,

and that one group of sites was used in one year, another in the following year, and so on in a rotating pattern. If this were the case, however, it would still leave us with the task of explaining the existence of alternative foci of exploitation.

The Problem of Accessibility

A major factor in the Weipa distribution appears to be the local limitations on accessibility. If we are correct in assuming that the resources of the marine zone were a major element in the coastal economy, then the pattern of access to the river is likely to have been a major directive in the location of the coastal home bases. In this respect the chief limiting factor is the mangroves, which represent an almost continuous zone along the river banks. Their distorting effect on territorial boundaries is well illustrated by the extreme situation of Figure VII.6 already discussed.

The importance of access points is illustrated on a larger scale in Figure VII.9, which is a general map of sites and resource zones around the Embley and Hey Rivers. It is clear from this that the major site clusters are closely related either to streams which provide an access route through the mangroves or to stretches of the river bank where the mangrove barrier is quite thin.

It is also apparent that, in contrast to shorelines with unimpeded access, where it is possible to radiate out from some central location at any angle along a marine frontage of as much as 20 km, the pattern of access to the marine zone at Weipa is predominantly at right angles to the river bank, so that any given site location is necessarily confined to a relatively limited frontage of river. The consequent distortion of territorial boundaries and reduction in territorial size are closely analogous to the effects of hilly terrain, except that in this case the impediment to access is not topography but vegetation. These limiting effects would presumably have been less marked where the mangrove barrier is thin. But even here initial access to the river would probably have been confined to the shortest distance through the [illegible] the group of [illegible] in the [illegible] or the following year, [illegible] in a [illegible] pattern. If [illegible], it would [illegible] of [illegible].

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mangroves at some point where a pathway could be cut through the vegetation and maintained without too much difficulty. At any rate the pattern of access to marine resources along shorelines with mangroves is likely to have been more variable, and the distortions of territorial size and site distribution more marked, than is normally the case elsewhere.

A second factor of probable importance is the abundance and concentrated distribution of the marine resources and the numbers of people which they are capable of supporting. This factor is difficult to assess because of the lack of precise data about either potential food outputs or population size in this area. But it is not difficult to appreciate as a general principle the asymmetrical relationship which may occur between coastal occupation sites and the marine resources which support them. For a major limitation in the economic exploitation of the sea generally is that, in the absence of a high-powered technology which might allow them to adopt a semi-aquatic existence, human populations are essentially terrestrial beings, incapable of distributing themselves across the marine environment in the same way that is possible in the exploitation of terrestrial resources. Thus the area of land within reach of the sea may be of relatively restricted extent in relation to the numbers of people who can live off its produce, resulting in the clustering of occupation sites along the shore edge.

We might expect this clustering tendency to be further exaggerated where local limitations restrict the length of shoreline suitable for occupation, or where the marine resources are very abundant. In the Weipa area both these conditions are present. The extensive, shallow, tidal estuaries support a great richness of marine resources in circumstances where they can be exploited with relative ease by populations with a simple technology; and parts of the shoreline are unsuitable for occupation because of the mangrove barrier. The distribution of sites on the East Hey is suggestive in this respect, and particular attention is directed to the major clusters at the southern end of the distribution and at the junction of the Embley River (Figure VII.9). In both areas the open forest approaches close to the river, and the mangrove

[illegible]

[illegible] along the north edge.

[illegible]

barrier is at its thinnest; both also face a relatively broad expanse of river estuary. Conversely, the intervening 8 km of shoreline is less suitable for occupation because of the exceptional width of the mangroves, and , if shell quantities are any indicator, occupation is correspondingly less dense along this stretch.

Thus we might suggest that the coastal population would tend to have been funnelled by this peculiar combination of circumstances into two concentrated areas of distribution at either end of the river bank, instead of being more evenly spaced out along its full length. In contrast, the west bank of the Hey River, where the mangrove barrier is uniformly thin, shows much less evidence of densely clustered occupation.

Clearly the factors which contribute to the distribution of sites in this area are quite complex; some of them may lie beyond the scope of this analysis or the resolution of the available data. The question of which of the two types of hypothesis offered above is the correct one is a matter for further investigation. In a sense, however, these are not so much mutually exclusive alternatives as slightly differing reflections of a common theme, and that is the theme of accessibility. With the first hypothesis the emphasis is on the difficulties of access to the river imposed by the impassable nature of the mangrove barrier and the consequent contraction of the time-distance factor; with the second hypothesis the emphasis is on the difficulties of access imposed by the concentrated abundance of the marine resources available in the river and the number of people they are capable of supporting. An overall view of the data available in this area suggests that both hypotheses may be applicable. In any case, between them they serve to clarify a principle of considerable importance in the understanding of coastal economies in general, arising from the fundamental problem of access which confronts a terrestrial species in the exploitation of marine resources.

Complementary Areas and the Annual Territory

Table VII.13 shows the relative representation of the various resource

categories in five potential site territories, four coastal and one hinterland. A visual presentation of the distribution of resources is shown in Figure VII.9 and VII.10. The coastal territories have been selected as being sufficiently representative of the general situation to obviate the need for additional examples; the choice of the hinterland territory is limited by the known sites. Mangroves and salt pans have been grouped together for the purposes of assessment, since, taken separately, they are of quite restricted extent, and it is uncertain to what degree their area is any reflection of economic potential. Seasonal swamps have been omitted altogether since they are of such small size that they scarcely register at this scale of measurement, although the few that do occur may have an economic potential quite high in relation to their limited size. A further complicating factor in the assessment of economic potential is the degree of overlap between neighbouring territories. In estimating the figures in Table VII.13, this overlap has been ignored, and the potential within the full 2 hour radius has been measured, since the main objective is to assess the maximum economic potential of a coastal location for general comparative purposes. Only one concession has been made to the overlap effect in order to simplify measurement, and that is where the territories of sites on opposite river banks overlap in the centre of the river.

Coastal Economic Potential

Because of the relatively restricted width of the rivers and the consequent degree of overlap of site territories projected out from sites on opposite river banks, not to mention the distortions imposed by the pattern of access to the river, the representation of the marine zone as a whole, including mangroves and salt pans, is much lower than that of the terrestrial zones. On the face of it this might be taken as evidence of a greater economic emphasis on land resources. However, area in itself is a poor guide to comparative economic potential when such widely divergent types of resources are under scrutiny, as we have noted already in the case of seasonal swamps. A more realistic measure integrated in this potential with experiment. Their results and ours [illegible] interpretation of the discrepancies of resistivity as shown in Figure VIII.9 [illegible]. The several theories have been presented as being satisfactorily [illegible] of the general [illegible] the nonthermal [illegible]. The choice of the [illegible] to be limited by the basis given. [illegible]

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[illegible] of the relatively restricted width of the [illegible] of a range of high temperature [illegible] [illegible]

TABLE VII.13 - The Economic Potential of the Weipa Site Territories

Site	Zone 1 %	Zone 2 %	Zone 3 %	Zone 4 %	Total Hectares	Land as Percentage of Ideal %
Old Mission (Inland)	31	64	5	0	27 290	83
S. Mission	77	3	7	3	17 230	44
Kwamter	42	15	24	19	11 020	20
S. Embley	54	19	15	12	16 100	28
S. Hey	41	25	16	18	16 240	34

Zone 1 - Open Forest; Zone 2 - Savannah Woodland; Zone 3 - Mangroves and Salt Pans; Zone 4 - Open River

of the relative economic value of land and sea is the amount of land lost to a shore location in comparison with a location further inland. In order to assess this, the terrestrial zones in each territory have been expressed as a percentage of the total ideal territory of 31 400 hectares. The results are presented in the final column of Table VII.13 and show that, whereas in the coastal site territories the area of available land is not more than 44% and may be as low as 20%, at the hinterland site of the Old Mission the figure is 83%, nearly twice as high as the highest coastal figure and more than three times the lowest. Furthermore the terrestrial resources that are available for exploitation on the coast are dominated by the less productive category of the open forest, which accounts for between 62% and 96% of the total available land resources. These figures support the evidence of site distribution discussed above, that marine resources were the major factor in the site economies of the coastal zone.

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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Seasonal Variations

The resources of the marine zone and of the open forest are ones which we have previously identified as being of greatest potential abundance and accessibility during the wet season and the early dry season. Since these two resource zones account for between 75% and 87% of the total territory of the coastal sites, it seems highly likely that effective exploitation would have depended to quite a large extent on seasonal movement away from the coastal zone to complementary areas situated in the hinterland during the dry season.

Support for this view comes from an examination of the dry season resources available within the coastal site territories, especially drinking water. Since the area was surveyed during September, when the dry season is well advanced, it was possible to make some general observations about the limiting effects of water supply. The assessment probably errs, if at all, on the generous side, since continued dessication of the landscape proceeds with increasing severity in October and November.

No surface water at all was observed anywhere along the east bank of the Hey River, and none on the South Embley except for some puddles in a small patch of swamp at the eastern end of the site distribution. The small creeks which drain the plateau had run dry by this time. Occasional small swamps were observed, but in all cases the surface was baked to a hard clay, although the possibility that water could have been obtained from them by sinking wells cannot be excluded. On the North Embley, fresh water was observed in several small streams draining the plateau, and surface water was still present in the swamp at Kwamter, so that this area appears to be slightly better off. In general, however, the relative lack of water, at least on the South Embley and East Hey, would most probably have been a major limiting factor if not a total deterrent to occupation in the latter part of the dry season.

The Economic Potential of the Hinterland

If attention is confined principally to shell middens on the Embley and

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Growth-Potential of the Settlement [illegible]

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Hey Rivers, there are two areas which qualify for consideration as potentially productive zones of complementary dry-season resources. Their relationship to the coastal zone is illustrated in Figure VII.10. The first area is in the vicinity of the Old Mission on the upper reaches of the Embley River. Reference to Table VII.13 shows that the potential territory of this site has all the advantages for dry season occupation which the coastal sites lack, in particular a very high representation of savannah woodland, a zone which, by virtue of its higher moisture retention and richer herb layer, maintains its potential as a source of food for a longer period in the dry season than the open forest, and which accounts for some 64% of the total territory. At least one permanent water hole exists nearby, and there is a zone of swamps about 2 km to the north-east which contained water when visited at the end of September. Conversely, the territory is poorly served by the wet-season resources of the marine sector and the open forest, which figure so prominently nearer the coast. It is also worth noting that the 2 hour boundary of the site is almost contiguous with that of the nearest shell-midden cluster (Figure VII.5), so that in terms of distance, at any rate, it is optimally located to function as a complementary home base.

A second area of importance to the maintenance of the annual economy lies about 15 km south-east of the southernmost shell-midden clusters of the East Hey. As at the Old Mission, the dominant resource category is savannah woodland. But the most important feature of the area, which is much less marked or absent both at the Old Mission and on the coast, is the extensive zone of swamps. There are at least 20 closely scattered over a distance of about 7 km. No survey has been carried out in this area, but it is doubtful whether much archaeological evidence would have survived on the surface to corroborate its importance as a seasonal focus of occupation. What is certain is that these swamps lie outside the range of daily movement from any of the shell middens and would thus have required a shift of camp site for effective exploitation. Nor is there any information about the water supply, although the size and number of the swamps renders it probable that water would have been

available on the surface or close below until well into the dry season. The greatest importance of this area would have been as a potential source of plant foods in quite considerable abundance.

There is thus a very obvious and clearly defined complementary relationship between the resources of the immediate hinterland and those of the coastal zone, and it is highly probable that seasonal population movements would have been a regular feature of the annual economy. The arrows in Figure VII.10 are a hypothetical reconstruction of the way in which such movements might have been organised to integrate the resources of the three major complementary areas.

Archer River and the Regional Distribution

Now that we have examined the various factors which contribute to the formation of shell mounds at Weipa, we are in a position to examine the reasons for their absence elsewhere. The test area is the Archer River, which of all the river estuaries in the Peninsula is the one most closely similar in its general ecology and economic potential to the Weipa area. Figure VII.11 shows the distribution of sites and resource zones.

One general feature that can be established about the west coast of the Peninsula as a whole is that prehistoric occupation was not by any means confined to the Weipa area. This can be deduced from the accounts of the 16th century Dutch explorers who sailed down most of this coastline and observed evidence of habitation throughout (Heeres 1899; Wright 1971).

Two further facts can be established about the Archer River in particular. One is that shellfish were collected as part of the traditional exploitation pattern of the area; the other is that, although shell mounds of the Weipa type are absent, surface scatters of shell are quite common.

Three alternative hypotheses can be put forward to explain the lack of shell mounds. Either molluscs were not available in the same quantities as at Weipa; or large quantities were available, but severe limitations of

access or lack of the appropriate technology prevented their effective exploitation; or molluscs were collected in large quantities, but their shells were scattered over a wide area in such a way as to leave disproportionately scanty archaeological evidence.

Topographically the area around the estuary is quite similar to the conditions found on the Embley and Hey Rivers. This is especially noticeable on the north arm of the Archer River, where mangroves and salt pans extend back from the river and are separated by a more or less narrow strip of low, grassy plain from rising ground covered with open forest. As at Weipa, the edge of the forest and the open ground in front of it are favoured camping spots today, especially during the wet season and early dry season, when fish are an important food supply. The mangrove barrier is generally quite thin and imposes no more severe limitations on access than at Weipa. The stringybark is locally abundant; it is known that bark canoes were made locally (Roth 1910); and it is clear from Thomson's (1939) account that they played a vital role in the economy. Therefore all the factors which promoted the dumping of shells in restricted areas to form mounds at Weipa are present here too, and neither technology nor accessibility can be invoked as factors in the comparative lack of shell remains. Thus by elimination of the second and third hypotheses attention is focused on the first.

The species of shell in the Archer River sites are of some interest, since they include all those commonly found at Weipa except Anadara granosa, an absence which appears to be related to ecological conditions. For extensive examination of shells washed up along beaches and river banks failed to produce more than six individual valves of Anadara granosa. A far more common species is Anadara maculosa, a closely related species, whose predominance appears to be related to the more sandy conditions of the Archer estuary. But this shell too is rare or absent on camp sites.

Closer comparison of the Archer River with the Weipa rivers shows that the estuaries of the two areas are in fact quite dissimilar in certain respects. The former is relatively short and narrow, and the most extensive mud banks are

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close to the river mouth and are composed of relatively sandy sediments. If one were to seek an exact analogy in the Weipa area, it would be the mouths of the Pine, Mission and Embley Rivers close to the point where they merge into Albatross Bay, rather than the conditions further upstream where the most extensive cockle beds and the great majority of the shell middens occur.

There is thus some evidence to suggest that the ecological conditions which support large quantities of cockles are lacking on the Archer River. Conditions on the Mitchell and Edward Rivers are even less suitable, given the narrowness of the rivers, although small quantities of Anadara maculosa can be collected. There is the additional limitation in these two areas that suitable bark for making canoes is relatively scarce, a point confirmed by the ethnographic record, according to which bark canoes were absent south of the Archer River (Roth 1910). In view of the lack of any evidence to support the alternative hypotheses, it seems highly probable that the discontinuity in the distribution of shell mounds along the Cape York coastline is related quite simply to differences in the quantity and type of shellfish locally available.

5. Conclusions

The evidence for the role of molluscs in the Weipa area is less specific than at Ballina, because of the larger uncertainties in the available population data, and it is possible that relative annual shellfood output may have been somewhat higher in this case. But, in spite of the concentration of shell middens and the massive quantities of shell represented, analysis of the data offers no support for the view that shellfish were anything more than a supplementary resource, intensively exploited on a regular, annual basis, where available, but of relatively minor dietary importance in comparison with the non-molluscan resources available for exploitation on the coast.

As at Ballina, the shell middens in aggregate, whatever the precise role of individual sites, appear to have been associated with seasonal home-base

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[illegible] appears to have been [illegible]

clusters used mainly during the wetter part of the year, focused primarily on the exploitation of fish and dependent for their long term viability on a seasonally mobile exploitation of a hinterland rich in complementary dry-season resources. It is possible that dugong and turtle were additional attractions to coastal settlement, but there are insufficient data to allow a full examination of these resources, except to note that they were probably of greater importance in the open waters near the mouths of the river estuaries than further upstream where the majority of the shell middens occur. One might go further and suggest that the open waters of Albatross Bay represented a fourth area of complementary resources in addition to the three already identified as of major importance in the annual economies of the Embley and Hey shell middens. But lack of archaeologically visible sites and of detailed information about economic potential do not allow more than a recognition of the possibility.

Two further features about the operation of coastal economies are thrown into sharp relief by the Weipa evidence. The first is the all-pervasive influence of accessibility in general and of the time-distance factor in particular, which have left their mark on almost every aspect of the data, whether it be the exploitation of shellfood and of the marine zone in general, the tendency to mound formation or the distribution of sites in densely packed clusters along the river banks.

The clustered site distribution and the overlapping of site territories is of particular interest and seems to be especially prevalent around the river estuaries of the Weipa area. Two sorts of clustering have been noted: the grouping of individual sites to form home-base clusters, which we have related primarily to seasonal factors; and the grouping of home-base clusters to form closely spaced area distributions, which we have related primarily to the pattern of access to the marine zone. It seems possible that the small-scale clustering of individual sites within home-base clusters may also be related in part to similar problems of access.

Although this clustering effect is less prevalent in northern New South

Wales, it is interesting to note that it is best developed around the estuary of the Richmond River, whereas the sites along the open coast are spaced out much more in accordance with the expected distribution pattern for home-base sites. The evidence from the two areas thus suggests that there is a consistent correlation between the clustering effect and the presence of river estuaries.

There are three characteristics of river estuaries which seem to be of general importance in promoting this pattern. In the first place estuaries are usually zones of shallow water washed by extensive tidal movement. They are therefore nutrient-rich environments offering excellent feeding and breeding conditions for fish and other forms of aquatic life, and they are thus areas of concentrated food abundance potentially capable of supporting large numbers of people, foci for the attraction of dense settlement within a limited area.

Secondly, the shallow, sheltered waters are easily traversed by simple forms of water transport, so that the potential abundance of marine food is accessible for exploitation with relative ease by peoples with a simple technology and rudimentary boats. A related factor is the ease of access to the hinterland afforded by river estuaries for people with boats. Where seasonally complementary exploitation of hinterland resources is an integral part of the coastal economy, this is likely to be a further factor in concentrating occupation sites along the banks of the estuary.

A third factor is the impediments to access between land and water which may occur along river banks. Whether or not this is a factor of general importance or a local factor arising from the extensive development of mangrove vegetation which is typical in tropical areas, it would appear from the Weipa evidence to be a potentially reinforcing factor in reducing the distance between occupation sites, through its contracting effect on the time-distance factor for the exploitation of the marine zone.

The second feature emphasised by the Weipa example is the disparity which may occur between the quantities of food available in the marine and terrestrial

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sectors respectively of a coastal site territory, a feature which is also apparent at Ballina. In a sense, this too is partly a reflection of the limiting effects of the time-distance factor, although directives of potential food output per unit area also loom large. Any site concerned with the exploitation of terrestrial resources is normally limited to the resources available within a maximum radius of 2 hours' walking distance. For sites situated on the shore margin, the area of land, and hence the quantity of terrestrial resources available, is normally reduced by about 50%. Where the resources of the marine sector are available in great seasonal abundance, it is highly improbable that a sufficiently large complement of terrestrial resources could be secured within such an area without movement to the hinterland, especially where, as at Weipa, the ideal shore location with respect to the marine zone is adjacent to terrestrial resources of relatively low economic productivity. The greater the disparity between the marine and terrestrial sectors, the more wide-ranging will be the seasonal movements required to allow full exploitation of the coastal potential. A more detailed application of this principle to the Australian data is not possible in the absence of precise figures for potential food outputs per unit area, but even the relatively crude data available suggest that this type of disparity is a marked feature of the coastal zone and hence a powerful incentive to the adoption of a mobile economy by coastal peoples.

Logical extension of the principle suggests that the converse situation, a sedentary coastal economy, is unlikely to occur except where the marine resources are evenly distributed throughout the year; where the seasonal abundance of marine resources can be complemented by a comparable abundance on land within a 2 hour radius of the shore; or where it is feasible to practise large-scale food preservation and storage. In the Cape York Peninsula, for example, an extensive zone of swamps adjacent to the sea-shore might provide the sort of combination of resources capable of maintaining a relatively sedentary economy, and it is conceivable that variations in the relative disposition of complementary resources from area to area may account for the [illegible] of a product with [illegible], a feature which is also [illegible]. In a sense, this can be partly a reflection of the [illegible] of the [illegible] although [illegible] of potential [illegible] with the [illegible] to the [illegible]. The other [illegible] of [illegible]. These [illegible] of [illegible] the [illegible] presence of [illegible] and [illegible] the [illegible]. A more detailed [illegible] to the [illegible] and each [illegible], but also [illegible] suggest that each type of [illegible] is [illegible] of people.

[illegible] suggests that the [illegible] of [illegible], [illegible] the [illegible] [illegible] varied patterns of economy recorded in the ethnographic literature. Figure VII.12 shows the resource zones in the vicinity of the Pennefather River. Here a very extensive zone of swamps does occur close to the coastline, and the arrows indicate a possible means of integrating seasonal resources to support a viable annual economy. It is apparent from this that the direction of movement would be essentially parallel to the coastline rather than at right angles to it, and it is thus particularly interesting to recall Roth's (1910) statement noted above (p. VII : 12), that the inhabitants of this area travelled up and down the coastline but did not normally travel very far inland.

However, there is no evidence for sedentary economies in the territorial sense. Even in those apparently rare circumstances where the seasonal and local distribution of resources might appear capable of supporting such a pattern of exploitation, it seems improbable that seasonal scarcity further inland would not have promoted some intrusion of hinterland peoples into such a well endowed coastal zone, or that an accessible source of untapped seasonal abundance in the hinterland would not have been incorporated by seasonal movement into the coastal economy.

CHAPTER VIII

DENMARK AND THE ERTEBØLLE

1. Introduction And Archaeological Background

If the principles which we have identified in the preceding investigation of Australian shell middens are not simply of local importance but have an underlying significance for the understanding of human behaviour, then we should expect to find them reflected with equal clarity in the palaeoeconomic record of Europe, and it is the purpose of this part of the investigation to see with what success the conclusions reached so far can be applied to the different circumstances and the different data of prehistoric Denmark.

Specifically the Australian results suggest that two factors are of major importance in determining the prominence of shell middens in the archaeological landscape: the presence of marine resources, other than molluscs, sufficiently abundant and sufficiently accessible to attract regular settlement close to the sea-shore; and the presence of seasonally complementary resources in the adjacent hinterland.

Denmark is in some respects an exceptionally favourable area for such a study by any standards and certainly by the standards of the data available elsewhere in Europe. Flint is an abundant source of raw material for artifact manufacture, so that many archaeological sites have been identified; there is a tradition of systematic archaeological investigation extending over a century and a quarter, combined with a chronological framework provided by pollen analysis and radiocarbon; and isostatic recovery has ensured the preservation of large numbers of shell middens which would otherwise have been submerged by the eustatic rise of sea-level.

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There is thus a wide range of data available to test existing hypotheses, although the advantages are offset to some extent by environmental changes which have occurred since the period of prehistoric occupation and by the incomplete recording and subsequent destruction of many of the shell middens.

There is also evidence of major discontinuities in the record of shellgathering, in particular chronological ones, which challenge the explanatory power of our existing theoretical framework, and which have been variously explained in the past by invoking population pressure, with or without the added stimulus of land loss caused by the rise of sea-level, on the one side, or by the extension of a dense and uninhabitable forest in the hinterland, on the other side (Clark 1952; Evans 1969; Smith 1972, p. 11). But, if the data concerning the Danish prehistoric coastal economy follow the Australian pattern, then we should expect to find evidence of discontinuities in the availability of shellfood as the simplest explanation, with the effects of rising sea-level on the time-distance factor for shellfood transportation as an additional possibility to be considered.

The investigation will be confined primarily to the Ertebølle period and primarily to Jutland, although the available data from Zealand are also incorporated. Table VIII.1 sets out the main features of the archaeological sequence, and Figures VIII.1 and VIII.2 provide general location maps of places and archaeological sites mentioned in the text.

Shell middens are most numerous in the Ertebølle period, and the history of their study has been inextricably bound up with the prevailing conception of this entity. The question of what constitutes the Ertebølle culture and how it is related to the occurrence of shell middens can best be considered by a process of elimination.

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TABLE VIII.1 -- Some Key Events in the Danish Archaeological Sequence

Archaeological Period	Economy		Climate	Litorina Trans-gression	Date
	Shell Middens	Agriculture			BP
Neolithic (TRB)	x	x	Sub-Boreal	4	5 200
Erteb⌀lle	x	-	Atlantic	3	5 800
Kongemosen	x	-	Atlantic	2	6 500
Kongemosen	-	-	Atlantic	1	7 000
Maglemosean	-	-	Atlantic/ Boreal	-	9 300

In the first place, the Erteb⌀lle, although it was first defined on the basis of excavations of shell mounds, is not exclusively a shell-midden culture, nor are Danish shell middens exclusively associated with the Erteb⌀lle. Erteb⌀lle coastal sites which are not shell middens have long been known, notably at Brabrand (Thomsen & Jessen 1906), and Dyrholm (Mathiassen et al. 1942). A more recently excavated example is Ølby Lyng (Brinch Petersen 1971). It is also well established that shell middens persisted into the Neolithic period, particularly in Zealand, as recent

analysis of the classic site of Sølager has shown (Skaarup 1973, Tauber 1971), and Bronze Age examples also have been recorded (Grantzau 1953, Zinck 1871). Equally, occasional shell middens have been identified from the preceding Kongemosen period (Andersen 1969).

A second point of considerable importance is that the Ertebølle can no longer be considered as an exclusively coastal grouping any more than its predecessor, the so-called Early Coastal Culture. The characteristic artifact-types of both entities have recently been identified in stratified inland sites, notably at Ringkloster (Andersen & Sterum 1971, Tauber 1973) and at Kongemosen (Jørgensen 1956), respectively. Vester Ulslev and Godsted in Zealand are also reported to have yielded substantial quantities of Ertebølle artifacts and fauna (Brinch Petersen 1973). Similarly, a long sequence of stratified finds of classic Ertebølle material from Storelyng in the Aamosen basin has been dated by pollen analysis to the late Atlantic period (Troels-Smith 1966).

That the concept of a coastal culture persisted for so long in the literature can be attributed to two main sources of confusion. The first lies in Mathiassen's (1937) definition of the "Gudenaa" culture. This is based on the analysis of over 300 sites in the Jutland interior which, almost without exception, are surface finds without evidence of stratification or dating, and which present a mixture of typological characteristics unparalleled in coastal sites. It was thus accepted that this represented evidence of an inland people quite distinct from those who lived on the coast. However, recent analysis of this material has shown that the Gudenaa is not an homogeneous grouping at all but a palimpsest of occupations typical of several different periods of the prehistoric sequence (Andersen & Sterum 1971). As Clark (1975) has emphasised, typical Ertebølle artifact-types, not to mention those of earlier and later periods, are present in abundance on Gudenaa sites, and it seems highly probable that many of these inland sites were repeatedly visited over a considerable period

of time by people who made the same types of artifacts as those found in the better stratified coastal middens.

A second source of confusion is the high percentages of tree pollen in the pollen diagrams of the late Atlantic period. These have been interpreted as evidence of a dense, continuous forest, which, with "dangerous swamps as the only openings, covered the entire country". (Iversen 1941, p.31). That this forest would have been sufficiently impenetrable to deter exploitation of the hinterland by animals or men is a view which has probably been overexaggerated, and one which is rendered increasingly improbable not only by the more recent discovery of inland sites with mammalian fauna but by the biases which have been shown to exist in pollen data and to render them highly unreliable as an accurate guide to the regional vegetation pattern (Tauber 1965, Wilkinson 1971). Furthermore, our investigations in the rainforest areas of Australia (Chapter VI) show that dense forest interspersed with swamps is no deterrent to human occupation nor to the practice of a mobile economy incorporating sites on the coast and in the hinterland.

With the weakening of the two main props to the concept of a coastal culture, the one based on supposed evidence of a separate inland culture, the other on supposed evidence of no hinterland occupation at all, the conventional interpretation of the Mesolithic shell middens as an isolated and relatively temporary episode in European prehistory, during which human populations were compelled to adopt a sedentary coastal or strandlooping existence based on shellfish by the pincer-like encroachment of rising sea-levels on the one hand and the expansion of the Postglacial forest cover on the other, appears increasingly suspect.

It is true that some gaps remain in the inland sequence, notably the one spanning the late Kongemosen (Vedbaek) and early Ertebølle (Dyrholm 1) periods, a subdivision of the main archaeological sequence which can be identified by artifact analysis on some coastal sites (Brinch Petersen

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1973, p.98). Whether the absence of these subdivisions in the interior is due to discontinuities of archaeological investigation, of stratigraphy or of prehistoric occupation is hard to judge, and it may reflect no more than the greater ease with which the artifactual material from the longer and, as yet, more numerous and better studied coastal sequences can be classified. In any case, the periods in question are not well represented by coastal sites either, and the existing data do not invalidate the proposition that the main phases of coastal occupation were associated with broadly contemporaneous occupation in some areas of the hinterland.

Whether coastal and hinterland were occupied by discrete and largely independent human groups or whether they were integrated by mobile groups into a single economic unit is thus a problem of major interest in this area, and a matter for further investigation, although recent opinions show a preference for the latter hypothesis (Clark 1975, Noe-Nygaard 1971). Noe-Nygaard in particular has raised the possibility that artifactual similarity between coast and hinterland might be construed as evidence for mobile economies. This in turn raises the further possibility that examination of artifact distributions might be used to define the alignment of annual territories. However, artifactual similarity is not, in itself, necessarily evidence of seasonal complementarity,nor is artifactual dissimilarity necessarily evidence of discrete social groupings. In either case the chief stumbling block is the problem of distinguishing the functional elements in an artifact assemblage from those which are imposed by cultural tradition. One might rather advocate the study of annual territories through the analysis of economy as a means of resolving this perennial taxonomic dilemma. Although the problem of the relationship between artifact distributions and annual territories opens up a potentially fruitful avenue of investigation, it is not one which we propose to examine further here.

A third point to emphasise about the Ertebølle culture is that it is not, for the most part, a farming culture. Troels-Smith (1953, 1966) was able to show from his detailed investigations in the inland bog of Aamosen on Zealand that Ertebølle artifacts were associated with sherds of Neolithic beaker pottery and evidence of cereal husbandry. Similar industries have been found in the uppermost levels of some of the Jutland sites also. Whether this is a genuine transitional industry or the product of stratigraphic mixing at the interface between discrete entities remains a matter of uncertainty. What is more important for the immediate discussion is that this development refers only to a very late phase of the Ertebølle culture at about 5 200 BP. It is thus incorrect to refer to the Ertebølle culture as a whole as a "farming culture", and it is quite clear from the available radiocarbon dates that the transitional period associated with the introduction of cereal husbandry postdates a long period of shell-gathering. The problem of the introduction of agriculture into Denmark is thus not of direct concern in the analysis of shell middens, although the possibility of economic interactions between shellgathering and cereal husbandry is one of some interest and one on which the data considered here have a bearing.

A minimal view of the Ertebølle culture, then, is a clustering of artifact types, among which flake axes, transverse arrowheads and thick-walled pots are prominent, made by people who lived in the hinterland and on the coast, who sometimes lived on shell middens, and who rarely, if ever, practised cereal husbandry. Whatever the validity of the Ertebølle culture as a behavioural entity, it is at any rate acceptable as a chronological marker, and it is mainly in this sense that the term "Ertebølle" is used in the rest of the discussion. The main point to underline here is that there is no necessary or exclusive relationship between this grouping and the presence of shell middens.

Turning to the broader aspects of the shell-midden distribution, the main occurrences are in the Limfjord area, on the east coast of Jutland and around the major inlets of northern Zealand, areas where the Litorina shoreline is still exposed.

The absence of mollusc shells from some coastal sites, and of coastal sites from some stretches of coastline, has been explained in the past either by reduced salinities or by submergence of the Litorina shoreline, and there is no reason to question either of these explanations, since they seem to account satisfactorily for the major gaps in the distribution. Geographical discontinuities in the occurrence of shell middens can be accounted for in terms of discontinuities in the availability of shellfood without recourse to more complex hypotheses. In this respect the Danish data parallel our findings in northern Queensland (p. VII.49). Also, as in Queensland, the presence of a shellfood supply is not a necessary condition for the occupation of coastal sites, although it is a common concomitant.

Rather the problems posed by the Danish data centre on chronological continuities. Although we have emphasised above that shell middens are not exclusively confined to the Ertebølle period, they nevertheless appear larger and more numerous during this period than at any other time, and some chronological trends are evident in the data, including unexpected gaps in the earlier part of the sequence.

Logically we might expect the causes of geographical discontinuity to apply on the chronological axis too, or, failing that, resort to preservational factors. The absence of shell middens before about 7 000 BP can be explained in these terms, since the shorelines of this early period are now submerged. Lower temperatures at this time would, in any case, probably have inhibited the survival of intertidal molluscs. However, as Clark (1975, p.193) has observed, there is a complete gap from about 7 000 to 6 500 BP, during the early period of the Litorina transgression,

when one might reasonably expect some evidence of shell middens to have survived, given that the contemporaneous shorelines are still exposed to-day, and this is a discrepancy which cannot be resolved by invoking salinity or temperature, since neither of these would have been unfavourable for molluscs at this period. Even after 6 500 BP, shell middens are quite rare until the Ertebølle period, during which shellgathering reached its apogee. Thereafter there appears to be something of a decline in the quantities of shell collected, especially in Jutland. Thus chronological discontinuities are a prominent feature of the Danish evidence, which it will be one of the objectives of the following analysis to explain.

2. Environment, Resources And Exploitation

Climate

The Danish climate is transitional between the moist, temperate oceanic conditions of the Atlantic coasts of Europe and the drier, continental conditions found on the main European land mass. Because of the small size of the country and its lack of altitudinal variation, climatic conditions are broadly uniform throughout the whole area. Rainfall is distributed fairly evenly throughout the year with an annual mean of 500 to 700 mm and is unlikely to have exerted either seasonal or geographical limitations on economic activity. Temperature probably had a more direct influence on economy, especially during winter. With temperatures as low as $-8^{\circ}C$ and appreciable snow cover from about December to February (Davies 1944), this would have been the leanest period for terrestrial resources.

There is considerable evidence, based on changes in the distribution of several plant and animal species, that both winter and summer temperatures were higher during the Atlantic period than those which prevail to-day (Iversen 1960). Hence the above figure for winter temperature should be regarded as a minimum.

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What effect this upward revision should have on our interpretation of the prehistoric economy is a matter of uncertainty. But it should not be supposed that temperature change per se necessarily promotes corresponding changes in economic behaviour, especially where quite small differences are involved. Very often, climatic or geological changes may affect features of the biotope which have no direct influence on the human economy and which can thus be ignored from an economic point of view. The above changes in temperature would probably not have been sufficient to mitigate the severity of the winter lean season on land. But one resource that certainly would have gained from higher winter temperatures is the oyster, which cannot survive in Danish coastal waters to-day except where permanently submerged in 5 m or more of water, because of the freezing winter temperatures, and is only capable of supporting a viable fishery at all by the annual importation of spat from the Netherlands (Spärck 1924).

Topography

The landscape has been heavily moulded by the last glaciation, when much of the country was covered by thick ice sheets, and thus presents an undulating surface with low rounded hills rarely exceeding 100 m in height, shallow lakes and small sluggish rivers. In the area covered by ice, deep and fertile clays and loams have been laid down, especially on the islands and along the east coast of Jutland. Broadly speaking these glacial deposits become less fertile as one moves westwards, giving way to glacial sandy loams in central Jutland and ultimately to outwash sands and gravels in west Jutland beyond the maximum extent of the ice sheets, interspersed with "hill islands" representing the outcropping of heavily eroded sandy deposits formed during the Penultimate Glaciation (Davies 1944; Jensen 1937). These variations in soil cover are closely related to

differences of soil fertility and are likely to have had a major influence on potential economic productivity throughout the period of prehistoric occupation.

The coastline is mostly low and easily accessible with shallow, offshore waters, and this is likely to have been much the case during the Ertebølle period. Certain changes, however, require discussion. Several cycles of emergence and submergence of the land have occurred during the Postglacial period in response to the uneven rates of isostatic recovery, on the one hand, and the eustatic rise of sea-level on the other. The most recent and best known is the period of the Litorina submergence, which has been shown to consist of four transgressions of the sea in all, each one slightly higher than the preceding (Iversen 1937, Troels-Smith 1939), and together extending from about 7 000 to 5 000 BP (Berglund 1971). This was followed by a final period of isostatic emergence, a major effect of which was to extend some of the north Jutland shorelines seawards by several kilometres (see Figure VIII.3). In the Limfjord area this severely narrowed the channel which connects the Kattegat with the North Sea, restricting the inflow of saltwater and, thereby, reducing the tidal range and the salinities in the inner waters of the Danish archipelago. Precisely when after 5 000 BP these various changes began to take effect is uncertain. But it is clear that their influence at the present day, combined with the colder winters, is sufficient to deter the growth of the major edible molluscs except in the Limfjord (Petersen 1907). Thus several changes of the coastal environment have occurred since the shell mounds were occupied, and need to be taken into account when reconstructing coastal site territories of the prehistoric period. Also associated with the Litorina transgressions were rises in the water level of inland lakes and rivers (Iversen 1973), which are relevant to the assessment of economic potential in the hinterland.

Vegetation

Although the picture of continuous forest seems somewhat exaggerated in the light of the recent discoveries mentioned above, it is probable that the better soils would have been well wooded, and pollen analysis combined with soil data can provide a reconstruction of some general vegetational features which are relevant to the human economy.

According to Iversen (1960), the immigration of the various warmth-demanding species and the establishment of a stable climax forest were completed by the beginning of the Atlantic period. The major species were lime, *Tilia sp.*, elm, *Ulmus sp.*, oak, *Quercus sp.* and ash, *Fraxinus sp.* On the rich low-lying glacial soils, ash and elm would have been dominant with lime more frequent on high ground. On the poorer soils of the western peninsula oak would have been the commonest tree species, and it is probable that the tree cover in general would have been much thinner with heath as the dominant vegetational association.

Both ash and elm are favoured sources of winter fodder for the large ungulates, and fluctuations in the pollen curve of these tree species at about 5 000 BP have been interpreted as evidence of human fodder collection (Troels-Smith 1960), although alternative climatic and edaphic hypotheses have also been proposed (Iversen 1960, Tauber 1965). A more general point, which applies equally to earlier periods, is that the prevalence of these trees on the fertile soils would have contributed to their value as potential foci for the exploitation of the large ungulates.

Terrestrial Resources: Animals

Twenty species of terrestrial mammals have been identified in prehistoric sites (Brinch Petersen 1973, appendix IV; Clark 1975, appendix E). The major potential sources of meat were primarily red deer,

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Cervus elaphus, roe deer, Capreolus capreolus, and pig, Sus scrofa. Aurochs, Bos primigenius, and elk, Alces alces, were also quite prominent in the earlier periods but had largely disappeared by late Atlantic times, most probably as a result of changes in habitat brought on by the full extension of the climax forest.

Data on the relative proportions of these species are shown in Table VIII.2 and refer mainly to sites of the Ertebølle period. Figures for minimum individuals have been extracted from the original reports and converted to meat weights using the conversion ratios in Clark (1972, figure 7). In terms of individual numbers there is no clear dominance of one species, and roe, red deer and pig all reach occasional predominance, although roe deer is clearly overshadowed by the other two as a meat source.

Table VIII.3 shows similar data for some inland sites, referring mainly to the Maglemosean or Kongemosen periods. Although the total figures in each site are probably not exactly comparable, because of variations in the percentage of deposit excavated and of the time span represented in each case, nevertheless, comparison of the figures in Table VIII.3 with those in Table VIII.2 suggests that mammalian meat provided a considerable element of the diet of the Ertebølle coastal sites and one not substantially less in absolute terms than at the earlier, inland sites.

Aurochs and, to a lesser extent, elk were clearly of major importance in the earlier sites, but there is no reason to suppose that their replacement by the smaller woodland species would necessarily have occasioned a contraction of the meat supply. However, allowing for the fact that some of the figures for the coastal sites include seal, there is some evidence for a decline in the total contribution of terrestrial mammals. On the other hand, the coastal sites, by virtue of their shore location, would have had a smaller area of land available for exploitation. If this additional factor is taken into account, then the data presented here offer

TABLE VIII.2 -- Minimum Individuals and Meat Weights of Mammalian and Avian Resources in some Late Atlantic Coastal Sites

Site		Terrestrial					Marine		Avian	Total
		Sus	Capreolus	Cervus	Alces	Bos	Phoca	Halichoerus	Major Species	Mind/Kg
		%	%	%	%	%	%	%	%	
1.	Mind	25	31	12	*	*	*	7	25	107
	Kg	31	11	30	-	-	-	25	3	4 370
5.	Mind	17	33	33	-	-	-	17	-	6
	Kg	11	7	45	-	-	-	36	-	440
6.	Mind	16	37	26	-	-	-	5	16	19
	Kg	16	11	54	-	-	-	17	2	930
8.	Mind	33	25	34	2	5	2	-	-	67
	Kg	20	4	45	3	25	2	-	-	5 080
9.	Mind	18	11	15	-	-	4	8	44	61
	Kg	21	4	34	-	-	5	31	5	2 610
22.	Mind	40	50	10	-	-	-	-	-	20
	Kg	54	19	27	-	-	-	-	-	740
23.	Mind	10	23	10	-	-	3	5	49	61
	Kg	16	11	32	-	-	7	26	8	1 850
29.	Mind	17	29	48	-	-	4	2	-	96
	Kg	13	6	72	-	-	4	5	-	6 350

* Trace

For key to sites see Figure VIII.1 and VIII.2

Sources: Degerbøl 1942; Madsen *et al.* 1900; Petersen *et al.* 1888; Westerby 1927; Winge 1903.

TABLE VIII.3 -- Minimum Individuals and Meat Weights of Mammalian and Avian Resources in some Inland Sites of the Atlantic Period

Site		Sus %	Capreolus %	Cervus %	Alces %	Bos %	Avian %	Total Mind/ Kg
33.	Mind	19	14	52	1	13	*	142
	Kg	8	2	43	1	46	-	17 250
35.	Mind	26	18	8	7	5	36	73
	Kg	23	4	14	14	41	3	4 010
36.	Mind	26	19	24	5	6	20	84
	Kg	18	4	33	8	35	2	5 990
37.	Mind	35	28	11	11	6	8	109
	Kg	24	5	15	18	37	1	7 960

Sources: Degerbøl, in Mathiassen 1943, pp.165-206; Winge, in Broholm 1924, pp.28-30; Winge, in Friis Johansen 1919, pp.128-33; Winge, in Sarauw 1903, pp.194-8.

little support for the hypothesis that numbers of terrestrial mammals as a whole were drastically reduced by the extension of the forest in late Atlantic times, although the data admittedly allow only a crude assessment.

The other mammalian species recorded in archaeological deposits are mostly small animals present in small quantities, which would have added little to the meat supply, and some, such as the fox and the badger, may have been sought after as much for their fur as for their value as food.

The regular presence of the domestic dog from at least as early as about 10 000 BP is worth emphasising, not only for the evidence it affords of the existence of close man-animal relationships at this time but as a potential destructor of bone remains on middens, a point which has been traditionally emphasised in studies of the Danish prehistoric fauna.

Plant Resources

As far as actual archaeological evidence goes, seeds of water lily, Nuphar luteum, and hazelnut shells, Coryllus avellana, have been found in inland Maglemosean and Ertebølle sites in small quantities (Andersen 1951; Brinch Petersen 1973), and occasional seeds, nuts and fruits of various kinds have been identified in Mesolithic sites elsehwere in north-west Europe (Clark 1972; Newell 1973). However, the role of plant foods generally in prehistoric Europe is a controversial issue and can only be approached indirectly. For it is arguable that, just as molluscs, although archaeologically highly visible resources, may have been of relative dietary insignificance, so plant foods may suffer from exactly the reverse type of bias, having been of considerable dietary importance, but in terms of archaeological remains almost totally destroyed.

From what is reported in the ethnographic record, simple economies in which plant foods play a major role are usually found in areas which abound in plant species with large storage organs in the form of tuberous roots and corms or seed capsules, features which, by definition, tend to be best developed in the warmer parts of the world, where they have a high selective value in maintaining a supply of nutrients to the organism during periods of aridity. The Australian case studies examined in preceding chapters provide examples of this, and Lee's (1968) ethnographic survey of the world demonstrates the point by showing that there is a clear tendency for the relative importance of plant foods to increase with decreasing latitude.

Actual quantitative data are, however, exceedingly rare. The only evidence the present writer has found in the literature is Meggitt's (1957) assertion that plant foods provided some 80% of the diet of the Aborigines living in the central Australian desert, although there is no indication whether this figure was arrived at in terms of total weight, edible food weight, calorific value or some other criterion, and Lee's (1968) figure

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of 67% for the calorific contribution of plant foods to the diet of the !Kung Bushmen, also in a desert situation, and also based on observations made over a period of only four weeks of the year. In view of the potential biases of ethnographic observation, on the one hand, and of the methods of estimating economic potential, on the other hand, which we have emphasised in Chapter IV and Chapter III respectively, some caution is required in generalising from figures of this sort. Baumhoff's (1963) analysis of the California Indians has an indirect bearing on relative dietary importance and suggests that acorns were at least of staple importance alongside deer and salmon. On this basis one might assign some local or seasonal significance to hazel nuts in Europe, especially in view of their high calorific yield (Table III.2, p. III: 7). However, it is the writer's opinion that, in the cool temperate areas under discussion here, namely Denmark, and, in the following chapter, northern Spain, plant foods as a whole were probably of no more than supplementary importance in the total diet before the introduction of cereal husbandry. The possibility that they were staple foods is not definitely excluded. But the possibility that they were of greater importance than the terrestrial mammals is considered highly improbable.

Marine Resources

Fish spears, fish hooks, netting equipment and harpoons are well established features of the Danish archaeological record, and at least one example of a fish trap has been recovered (Kapel 1969). The archaeological evidence of water transport, by its very nature, is likely to be at best sporadic. But mention may be made of the boat from Pesse in Holland, dated to about 8 000 BP (van Zeist 1957) and of the wooden paddles found on Maglemosean sites in central Zealand (Andersen 1951; Broholm 1924).

There would thus seem to be sufficient evidence to justify the view that the level of technology available in Mesolithic Denmark was generally comparable to that used by the Australian Aborigines. The presence of boats in particular should be emphasised, in view of the importance placed on them in preceding pages as a means of gaining access to the marine zone.

Seal is probably a resource of considerable importance and is represented on 17 out of the 18 Mesolithic coastal sites for which reasonably complete faunal assemblages are available (Møhl 1971b). By far the commonest species is the grey seal, Halichoerus grypus, present on 16 sites, while the harp seal, Phoca groenlandica, and the ringed seal, Phoco hispida, occur in lower frequencies. Table VIII.2 (p. VIII.13) shows that, although seals are not apparently present in large numbers, they would have provided a considerable quantity of meat of high calorific value amounting to as much as 37% of the meat supply by comparison with the large ungulates. The figures in Table VIII.2 have been estimated using individual weights for species of Phoca of about 100 kg and of Halichoerus of about 270 kg (Scheffer 1958) and assuming that meat weight is about 60% of live weight. Allowing for the high content of fats and oils in the seal carcase, it seems probable that, on some coastal sites at least, sealing, supplemented by occasional supplies of other aquatic mammals such as porpoises, Phocaena phocaena, and dolphins, Tursiops truncatus, Delphinus delphis and Lagenorhynchus albirostris, which are represented in small quantities in archaeological deposits, would have provided as much food in the site economy as the exploitation of the terrestrial fauna.

Fish make a frequent if rather sporadic appearance in prehistoric sites, especially cod, Gadus morrhua, flounder, Pleuronectes sp. and eel, Anguilla anguilla. The spur dog, Squalus acanthias, is also quite common, although it may have been sought after for the use of its spines as a raw material as much as for food (Noe-Nygaard 1971). Pike, Esox lucius, and

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sheatfish, Silurus glanis, would have been available in inland lakes. Early reports stressed the small quantities of fish bone in middens (Madsen et al. 1900), but more recently Møhl (1971a) has shown that at Ølby Lyng fish bone, mainly cod, accounts for some 70% of all bone in terms of fragments. The method of counting fragments is hardly satisfactory since the figures cannot be converted to a common scale of meat or calorific yields, but the results seem to suggest that in some cases fish may have been of greater importance than previously supposed. At the same time it seems unlikely that a fish such as cod with its rather low calorific yield (Table III.2, p. III: 7) would have equalled the mammalian meat sources.

Molluscs, of course, are present in large numbers. The most common species in midden deposits is the oyster, Ostrea edulis, which is also the most common species in Danish waters to-day, although its distribution is now confined by changes in the configuration of the shoreline and the reduction of water temperatures and salinities which have occurred since the prehistoric period. Cockles, Cerastoderma edule, mussels, Mytilus edulis, periwinkles, Littorina littorea, and dog whelks, Nassarius reticulatus. are commonly found in small quantities too.

Bird Resources

Some mention should be made of these, since they are prominent in archaeological deposits. Some 55 species of birds have been identified in prehistoric deposits of the Atlantic period, mainly swans, ducks, scoters, and gulls of various types. Ignoring the many species represented only by isolated fragments of bone, a rough estimate of minimum individuals and of meat weights is shown in Table VIII.2 (p. VIII: 13). An individual meat yield of 5 kg has been assumed. The results emphasise the minor role of these resources, amounting to little more than 8% of the meat supply.

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As with molluscs, numerical abundance in archaeological deposits is a poor guide to dietary value, and it is unlikely that bird resources had a major influence on patterns of economic organisation.

Exploitation

In assessing the ways in which these various resources might have been integrated into economic units, it is convenient first to consider the seasonal availability of the major resources and then their distribution in potentially complementary zones. Attention is focused mainly on the resources of the marine zone and the terrestrial mammals.

On the marine side, the grey seal in particular would probably have been a seasonal resource. For, although it is potentially available throughout the year, it is most easily accessible during the breeding season in January and February, when the adults congregate close inshore and are most easily harpooned (Møhl 1971b). Another favoured method of exploitation is the clubbing of seal pups in spring, for which there is archaeological evidence from the small island of Hesselø off the coast of Zealand (Møhl 1971b). It is true that this find refers to the Neolithic period, but it seems reasonable to suppose that the possibility of visiting offshore seal rookeries would have been an additional attraction to coastal settlement in earlier archaeological periods too, given the availability of water transport. A further incentive to winter sealing is the high fat-content of the meat, which would have been especially valuable in the colder part of the year. Another relevant point is the use of the blubber to provide lighting during the long winter nights, a use suggested by the similarities between some of the pottery found on Ertebølle coastal middens and Eskimo blubber lamps (Mathiassen 1935).

More specific evidence of winter exploitation is provided by the harp seal, which only penetrates southwards into Danish waters in winter (Møhl 1971b). Thus its presence, albeit sporadic, in some coastal deposits

is positive evidence of winter occupation. Similarly, porpoises would have been most easily harpooned during the schooling migrations which take place between November and February.

Of the fish, the only marine species for which there is any evidence of exploitation in quantity is the cod, and this too is most easily accessible during the spawning migrations of late winter and spring, when the fish shoal in shallow water, although the cod fry may be found in shallow water throughout the summer also (Graham 1924, Smitt 1893).

As far as terrestrial mammals are concerned, the most detailed information relates to deer behaviour. Since the evidence indicates that deer account for a major part of the meat diet at Ertebølle sites, it may be expected that their behaviour would have had some effect on patterns of economy. Both red deer (Cameron 1923, Darling 1957) and roe deer (Tegner 1951) regularly move over distances of up to 50 km between summer and winter pastures. In the Scottish Highlands climatic factors reinforce the pattern of red-deer movement. Winter snow on high ground generally drives the animals down to low valleys or coastal plains below about 500 m, while the exposure of fresh feed and browse by the retreating snows, combined with the affliction of insect pests, encourages the deer to disperse onto higher ground again during spring and summer.

Modern Scottish deer are not an entirely appropriate analogy for prehistoric Denmark, not only because of the different topographic and climatic features of the two areas but because of the restrictions imposed on their pre-existing habitat by the clearances of the 18th and 19th centuries (Cameron 1923).

However, the underlying factor in deer movement, whether in Scotland or elsewhere, is seasonal and local inequalities in the distribution of grazing resources. There is the additional factor that feeding within a given place results in a depletion of the local supply and a consequent increase in the costs of its exploitation which are most easily mitigated

by movement to another area. The time-distance factor is limiting for animals as for man, and a mobile way of life a highly advantageous means of overcoming its limiting effect. It is thus reasonable to suppose that the nature of the distribution of the plant cover would have influenced the behaviour of herbivorous animals such as deer and, by extension, the human economies dependent on them, irrespective of local differences in other features of the biotope.

In Denmark the topographic and climatic factors which influence deer movement in mountainous areas are lacking. There are no seasonal variations of climate or local differences of altitude of sufficient magnitude to render some areas unsuitable for exploitation at certain seasons of the year. However, there are other factors which have a comparable influence on the seasonal availability of grazing resources. The primary one is variations in the quality of the soil cover, which can be most clearly appreciated in Jutland. Here the distinction between the glacial loams of the eastern part of the peninsula and the eroded sandy loams and outwash gravels in the west are of particular importance. A general map of their distribution is shown in Figure VIII.3. Indeed although the western part of the peninsula is not an upland area in any topographic sense, it is not unlike the upland areas of Europe in a vegetational sense, with a predominant natural cover of heath vegetation, interspersed with patches of marsh and oak scrub along the edges of water courses and scatters of small, peat-filled depressions. Much of the area is given over to animal grazing to-day, and where cereal cultivation is practised, yields are among the lowest in Denmark (Jensen 1937).

It is therefore logical to suppose that this area would have served mainly as a temporary reservoir of summer grazing. During winter the sparse tree cover and the consequent lack of browse and lack of shelter from the westerly winds which prevail at this time of year would have reinforced the inherently poor quality of the soil, rendering the area

highly unsuitable for use by comparison with the more heavily wooded zone to the east, and it is thus likely that the dominant trend of any animal movements would have been between winter areas on the east ooast and summer areas on the west.

If we consider the distribution of resources in the Jutland peninsula in terms of complementary zones, it is possible to divide the area, as in Australia, into three major zones: a coastal zone, confined mainly to the area of the Limfjord and the east coast, with an emphasis on marine resources; a coastal hinterland, coterminous with the loams and clays deposited during the Last Glacial, with a high potential animal biomass; and a zone represented by the western half of the peninsula which, for convenience, we shall refer to as the inland zone, with a considerably lower economic potential.

Given the seasonal variations in the abundance of resources available in each zone, clearly one possible method of optimum exploitation would be a mobile economy traversing all three zones in the course of the year. For the peak availability of marine resources in the coastal zone in winter and spring coincides with a period when the terrestrial animals would be most likely to be concentrated near the coast, while the lean period for marine resources in the summer would coincide with a period when it would be most advantageous for the animal resources to move into the hinterland.

Two alternative patterns of integration should also be examined, although they appear to offer a less advantageous economic basis. The first is of a type which we have had occasion to consider in Australia, namely one in which the coastal hinterland serves as a complementary resource zone for two largely independent mobile economies, the one based in the coastal zone, the other focused on a complementary zone further inland.

In the Danish context such a pattern would presumably have involved movement into the coastal hinterland by peoples of the coastal zone in summer, and by peoples of the inland zone in winter, in alternating fashion. If we are correct in assuming a major role for animal resources in general and for deer in particular in the coastal hinterland, the critical question

is whether the plant cover of this zone could have tolerated continuous cropping by alternating groups of animals. It seems likely that such a pattern of grazing would have imposed considerable pressure on the vegetation, which would have been deleterious in the long term for both economies.

A second alternative is the existence of two mobile economies, one focused on the coastal zone and the coastal hinterland, the other incorporating the inland zone and the marine resources along the west coast of the peninsula. The advantage of this pattern over the former one is that it does not involve any geographical overlap of the two economies. The disadvantage is that the marine zone of the west coast is exposed to strong winds and sea currents; it is not noted for its abundance of seal, fish or shellfish; and it is less easily accessible than the sheltered waters of the Limfjord and the Kattegat. The scarcity of winter resources for animal populations would be a further deterrent to a mobile economy confined to the western peninsula. Thus this pattern of integration is considered the least likely of the three alternatives.

In Zealand similar considerations apply. The chief difference from Jutland is the lack of an inland zone comparable to west Jutland, since most of the island is covered with deposits of the Last Glacial. Thus there are only two major zones: the coastal zone, comprising most of the island's coastline; and the coastal hinterland, comprising the interior. As in Jutland, it is probable that these two would have been economically complementary.

Archaeological Data

Existing archaeological data are available in some quantity to test the above hypothesis, and it is appropriate to consider them here before moving on to the more detailed analysis in subsequent sections.

An essential prerequisite for the hypothesis of a mobile economy is the existence of contemporaneous archaeological sites in the various complementary zones, and this is something which can be examined in far greater

[illegible]

detail here than in Australia.

Figure VIII.3 shows all the sites known or presumed to belong to the Ertebølle period of late Atlantic times in Jutland in relation to the major complementary zones defined above. Before commenting on the distribution, some further justification should be offered for the view that the hinterland sites can be treated as archaeologically contemporaneous with the coastal sites, especially since the former are known almost exclusively from surface finds. In the absence of pollen analytical or radiocarbon dating for all but a very few sites, one is compelled to fall back on typological criteria.

Clark (1975, p.191) has drawn attention to the large numbers of transverse arrowheads found on the large Gudenaa sites. This artifact type is as appropriate a chronological indicator as any, for it is found in abundance in dated sites of the Ertebølle period in coastal and inland situations; it is easily identified; and it has as short a chronological time span as any other common Mesolithic artifact type (Clark 1975, p.172). It is not an exclusive chronological marker, since it may occur in assemblages from as early as the Kongemosen period, but it is usually found in smaller numbers in this earlier period and is invariably overshadowed by the equally distinctive rhombic microlith.

Some caution is required in comparing assemblages since the artifacts recovered from inland sites are mostly surface finds whereas the coastal finds are mostly derived from careful excavation, although sampling biases are probably a factor here too. Two further qualifications apply to the inland sites. In that they are surface sites which probably include a mixture of material from several archaeological periods, artifact types diagnostic of only one period might be expected to show a lower representation than is the case with stratified assemblages. Their location in zones economically and environmentally complementary to the coastal zone might have a further effect on the relative representation of artifact types. On these grounds the absence or relative rarity of transverse arrowheads from the hinterland would not be sufficient evidence to reject the possibility

of occupation during the Ertebølle period; conversely, their presence in quantity might be accepted with all the more confidence as positive support for such a proposition.

Table VIII.4 shows the large Gudenaa sites quoted by Clark. The number of transverse arrowheads has been expressed as a percentage of the total number of worked artifacts and compared with similar data from stratified coastal assemblages of known Ertebølle date. It is clear that the figures from the inland sites fall well within the range of the Ertebølle data. Against the objection that they might refer exclusively to earlier periods is the further evidence that in all the cases cited transverse arrowheads are more numerous than rhombic microliths (Mathiassen 1937, pp.96-7). In short there is no typological evidence to reject the proposition that occupation of the hinterland occurred during a period which is archaeologically contemporaneous with occupation of the coastal middens, and considerable evidence to support it.

The further question arises as to whether the extensive scatter of sites in what we have referred to as the inland zone can also be related to the Ertebølle period. It is true that transverse arrowheads are less common on these sites, but so also are the total numbers of artifacts. The relevant consideration is the percentage representation. Table VIII.5 compares the sites of the coastal hinterland with those of the inland zone in these terms. Transverse arrowheads are a regular occurrence in the latter area, and, although the percentages are lower, they are still within the range of well established Ertebølle sites. Figures for rhombic microliths are not generally available to support the point except in the case of some of the individual sites, among which may be mentioned Praestkaer, just inland from the south west coast of Jutland, which has yielded 84 transverse arrowheads & 30 rhombic pieces (Mathiassen 1937, pp.96-7). Thus similar conclusions apply to the chronology of settlement in the inland zone as to the coastal hinterland.

TABLE VIII.4 -- Comparison of Artifact Quantities in Coastal and Inland Sites

Site	Archaeological Period	Worked Artifacts Total	Transverse Arrowheads Total	%	Area Excavated m^2		Artifacts $/m^2$
Shell Middens:-							
Ertebølle	Ertebølle	3 022	401	13	314		10
Aamølle	Ertebølle	649	83	13	88		7
Norslund 3-4	Ertebølle (early)	701	86	12	85		16
Norslund 0-2	Ertebølle	477	178	37			
						$\bar{x}$	11
Coastal Sites:-							
Dyrholm I	Ertebølle (early)	354	16	5			
Dyrholm II	Ertebølle	2 215	198	9	1 980		2
Dyrholm III	Ertebølle (late)	944	71	8			
Brabrand	Ertebølle	1 062	129	12	94		11
Vedbaek Boldbaner	Kongemosen	1 500	127	8	113		13
Bloksbjerg D-E	Ertebølle (early)	782	251	32	250		6
Bloksbjerg A-C	Ertebølle	781	419	54			
Ølby Lyng	Ertebølle	796	382	48	43		19
						$\bar{x}$	10
Inland Sites:-							
Klosterlund	-	1 070	157	15	200		5
Havstrup Sø	-	2 639	620	23	-		-
Rye Bro	-	2 803	734	26	-		-
Salten Sø	-	818	186	23	-		-
Skygge	-	860	497	58	-		-
Siimholm	-	179	122	68	-		-
Melhede	-	474	102	22	-		-

Sources: Andersen & Malmros 1965; Brinch Petersen 1971; Madsen et al. 1900; Mathiassen 1937, 1946; Mathiassen et al. 1942; Thomsen & Jessen 1906; Troels Smith 1966; Westerby 1927.

Table VIII:5 -- A Comparison of Artifact Quantities in Sites of the Coastal Hinterland and the Inland Zone

Site Numbers *	Total Sites	Total Artifacts	Transverse Arrowheads Total	%	Artifacts /Site
Coastal Hinterland:-					
1 - 134	135	10 164	2 179	22	74
212 - 223; 232 - 233	14	1 609	748	46	115
283 - 310	28	1 040	674	65	37
	177	12 813	3 601	$\bar{x}$ 44	$\bar{x}$ 75
Inland Zone:-					
125 - 180; 281	47	625	108	13	13
181 - 211; 282	32	370	86	23	12
224 - 231; 234	9	50	7	14	6
235 - 240	6	29	5	17	5
241 - 280	40	781	114	15	20
	134	1 855	320	$\bar{x}$ 16	$\bar{x}$ 13

* Mathiassen 1937.

One other aspect of the data calls for comment and that is the density of occupation represented by the various categories of sites, as reflected in the numbers of worked artifacts recorded. Table VIII.4 shows the density of worked artifacts in shell middens, coastal sites without shells and sites of the coastal hinterland. Data from the latter are limited and there is the further qualification for all the sites that the time span of occupation is not certainly comparable. But within these limitations it is clear that there is little substantial difference between the types of site.

If the shell middens represent specialised sites used primarily for shellgathering, we might expect not only a lower density of artifacts but a

Table XIII.4 — A Comparison of [illegible] in Wales and the [illegible]

[illegible]

The other aspect of the data [illegible] and that is the density [illegible] represented by the various subcategories of sites, as indicated by the number of [illegible]. Table XIII.4 shows the [illegible] small [illegible], central sites [illegible]. Note that the ratios are limited and [illegible] qualification for all the sites [illegible] but within these limitations it is clear [illegible] appreciable [illegible] differences between the types of site.

In the small [illegible] we might expect not only a lower density of [illegible] narrower range of artifact types. But neither of these expectations is fulfilled, at least in the case of the larger shell mounds. There is thus no more reason to doubt that they represent home-base sites than the other categories of site. Nor is there any reason to doubt that the shell middens represent the actual scene of occupation. The alternative possibility, that the midden deposits as such might represent the rubbish dump of people who lived close by, is not excluded, but on the evidence of artifact quantities there is no reason to suppose that this hypothesis should apply to the shell middens any more than to the other sites, and it is significant that, although this hypothesis has been recognised (e.g. Troels-Smith 1966), no substantial evidence has yet been recovered to support it.

Table VIII.5 shows the average number of artifacts per site in the coastal hinterland and the inland zone, 75 and 13 respectively. Indeed the number of artifacts on sites of the inland zone is so low as to render a hypothesis of transitory occupation most likely, although it should not be forgotten in this context that the site of Ringkloster in the coastal hinterland was originally represented by only 27 artifacts (Mathiassen 1937) but has since proved on excavation to represent a quite substantial occupation. Taking all the sites together, however, the data support our previous suggestion above that the inland zone probably had a lower economic potential than the coastal hinterland or the coastal zone.

Turning to the overall distribution in Figure VIII.3, the first point to emphasise is the presence of sites in all three major complementary zones. It is also worth noting the absence of sites from the western shores of Jutland. Much of this coastline consists of shifting sand dunes, and in the south a substantial area of the Litorina coastline has been submerged, so that the possibilities for the preservation of archaeological sites are poor. But the absence of sites is consistent with our previous assessment of the relatively low economic potential of marine resources in this area.

The second point to note is the large number of coastal sites around the more sheltered shores of the Limfjord and the Kattegat. Of particular interest in the light of the Australian results is the marked clustering effect that is apparent in the vicinity of river estuaries, especially on Randers Fjord and Mariager Fjord and the major inlets of the Limfjord. Too little is known about the character of many of the sites to assess whether they are home-base sites or individual components of home-base clusters, but in any case the general effect is clear enough and supports the emphasis that we have placed on the marine resources of this area.

A similar clustering is also apparent in the lake region of east-central Jutland and raises the possibility that the aquatic resources of this inland region may have exercised a similar attraction for human settlement as the marine resources of the coastal zone. It is also significant from the point of view of complementary exploitation that these major clusterings in the hinterland and on the coast are linked by the Gudenaa, Skive and Karup Rivers, which would have provided a convenient means of access between the coast and the hinterland for people with boats, especially if it is remembered that the inland waterways of Jutland would have been broader, more extensive and more easily navigable during the latter part of the Atlantic period in response to the general rise of the water table occasioned by the Litorina transgressions.

Figure VIII.4 presents similar data for Zealand. The dense clustering of coastal sites around Roskilde Fjord and the smaller clustering of inland sites around the former lake of Aamosen in the hinterland suggest a similar pattern of exploitation to Jutland.

Seasonal Indicators

The two major sources of seasonal information are the bones of migratory birds and the remains of deer antler. Both are subject to all the uncertainties of interpretation that we have emphasised in Chapter V, but the data are

The second point to note is [illegible]

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Figure VIII.4 presents similar data for Scotland. [illegible]

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extensive and worth some examination, especially since finds from both coastal and inland sites are available. A major difficulty is that most coastal deposits are confined to the Ertebølle period, while most inland deposits from which data are available belong to the Maglemosean period and are found only in Zealand. Thus comparison between the two types of situation inevitably assumes a large measure of continuity in seasonal factors between Zealand and Jutland throughout the Atlantic period.

Table VIII.6 shows the representation of probable summer and winter bird-migrants on coastal and inland sites for which some quantitative data are available. Out of a total of 4 376 identifiable specimens in coastal deposits, only 4 bones (0.09%) can be assigned to summer visitors, whereas 67% of the total represents probable winter migrants, or species most easily accessible in winter and spring, while 31% is composed of *Cygnus musicus*, which is certainly an exclusively winter visitor to Denmark to-day arriving in November and leaving in March (Madsen *et al.* 1900, p.185). The presence of so few summer indicators is hardly significant and might represent the occasional early arrival taken just before the coastal groups abandoned their winter quarters or odd bones carried from the hinterland. Only one site has provided substantial evidence of summer migrant birds and that is Villingebaek in Zealand (Kapel 1969), where remains of *Grus grus* and *Ciconia negra* have been recorded. However the location of the site, as shown in Figure VIII.2 is such that it might represent a complementary site used at various times of the year by people whose predominant pattern of exploitation was based on winter sites around Roskilde Fjord or along the east coast and on summer sites in the hinterland. A further possibility, given the relatively short distances between coast and hinterland in Zealand, is that occasional movements for specific purposes were undertaken against the general trend of seasonal mobility.

Only 253 bones are available from inland sites, so that the results are somewhat equivocal, but in spite of the small sample summer migrants

[illegible]

[illegible] mainly early contact [illegible] the several groups, throughout their [illegible] the surface of all bones derived from the Highlands. Only one site has positive provisional evidence of summer migrant birds and that is [illegible] (Appendix [illegible]), where presence of both [illegible] and [illegible] were [illegible]. However the location of the site, as shown in Figure VIII.[illegible], suggests that it might represent a complementary site used to exploit those [illegible] by people whose predominant pattern of exploitation was based [illegible] along the east coast and in eastern [illegible]. A further possibility, given the relatively short distance between [illegible] and [illegible] in Iceland, is that occasional [illegible] [illegible] were undertaken against the general trend of [illegible].

Only 132 bones are available from [illegible] sites, so that the result [illegible] applicable, but in spite of the small sample [illegible]

TABLE VIII.6 -- The Representation of Seasonally Migrant Birds in Sites of the Atlantic period

	Coastal											Inland			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Winter:-															
Anas penelops	3	-	-	-	-	-	-	-	1	-	2	1?	-	-	-
Cygnus musicus	74	3	62	66	339	21	-	14	750	17	3	-	-	-	-
Cygnus minor	2	-	4	-	72	1	-	-	29	7	-	-	-	-	-
Fuligula marila	-	-	2	-	1	-	-	6	11	2	-	-	-	-	-
Clangula glaucion	-	-	-	1	3	-	-	6	193	11	1	-	-	-	-
Pagonetta glacialis	2	-	1	-	-	-	1	1	-	-	-	-	-	2	-
Oedemia nigra	11	-	17	-	2	-	-	9	38	1	-	-	-	-	-
Oedemia fusca	188	3	67	25	17	4	-	2	281	4	-	-	-	-	-
Anser torquatus	1	-	4	-	5	-	-	-	1	29	-	-	-	-	-
Colymbus arcticus	7	-	-	-	9	1	-	4	-	-	-	-	-	-	-
Colymbus septentrionalis	24	-	5	2	2	-	-	1	3	2	-	-	-	-	-
Sula bassana	2	-	-	-	-	1	-	-	-	-	23	-	-	-	-
Uria troile	-	1	-	1	2	3	-	4	1	-	209	-	-	-	-
Mergus albellus	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-

TABLE VIII.6 Continued

Species	Coastal											Inland			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Summer:-															
<u>Pelecanus crispus</u>	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–
<u>Grus grus</u>	–	–	–	–	–	–	–	–	–	1	–	6	–	2	6
<u>Ciconia negra</u>	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
<u>Pernis apivorus</u> (wasp)	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Others:-	285	10	11	33	221	12	–	17	860	28	62	89	5	103	33
Total	599	18	173	127	673	43	1	164	2168	106	303	95	9	109	40
Winter:- Total	314	7	162	94	452	31	1	47	1308	77	240	1	4	4	0
%	52	39	94	74	67	72	100	29	63	73	79	0	44	4	0
Summer:- Total	0	1	1	0	0	0	0	0	0	1	1	6	0	2	7
%	0	6	<1	0	0	0	0	0	0	1	<1	6	0	2	18

Sites:- 1. Ertebølle; 2 Aamølle; 3 Havnø; 4 Gudumlund; 5 Meilgaard; 6 Fannerup; 7 Faareveile; 8 Klintesø; 9 Sølager; 10 Havelse; 11 Ølby Lyng; 12 Svaerdborg; 13 Vinde Helsinge; 14 Mullerup; 15 Holmegaard.

Sources: Degerbøl, in Mathiassen 1943, pp.165-206; Madsen <u>et al</u>. 1900; Møhl 1971a; Petersen <u>et al</u>. 1888; Winge 1903; Winge, in Broholm 1924, pp.28-30; Winge, in Friis Johansen 1919, pp.128-33; Winge, in Sarauw 1903, pp.194-8.

account for a relatively high percentage of the total (about 7%). Bones of nestlings also indicate summer occupation. Mention may also be made of the late Ertebølle site of Muldbjerg in the Aamosen bog, where the bird remains are said to indicate summer occupation (Troels-Smith 1966). However, some

winter species are present, but, of these, the four bones of _Colymbus arcticus_ found at Vinge Helsinge in the Aamosen bog do not necessarily refer to winter occupation since some non-breeding individuals of this species may remain in Denmark throughout the summer (Mathiassen 1943, p.169), while the identification of a single bone of _Anas penelops_ at Svaerdborg is uncertain. This leaves a total of only four bones which can be certainly referred to winter visitors.

In assessing these results it should be emphasised that the exact timing of migration or accessibility is not certainly established for all the species cited and may in any case vary slightly from year to year. There is the further possibility that the pattern of migration has changed since the prehistoric period. Another factor in the differences between coast and hinterland may be the different nature of coastal and inland habitats. Nevertheless there is a marked contrast between the two zones and one which is consistent with the hypothesis of seasonal complementarity, although it is not well enough established to exclude altogether alternative hypotheses.

Deer antlers undergo a characteristic cycle of growth during the year, which allows the possibility of seasonal interpretation. Red deer generally shed their antlers in April and remain in velvet until September to October (Darling 1957, Ryder 1968), whereas roe antlers are shed in the autumn and harden in the spring (Tegner 1951).

Shed antlers are usually regarded as the most specific seasonal indicators, since they are chewed by the deer or lost in the undergrowth unless collected immediately after being cast. However, the times of shedding are such that the presence of cast antlers may refer equally to the end of a winter occupation or the beginning of a summer one in the case of red deer and _vice versa_ with roe, especially in view of the fact that the exact moment of shedding may vary by up to a month or more on either side of the average dates commonly cited. It is hardly to be expected that stages of antler growth will neatly coincide with seasonal stages of the human economy.

Another potential bias is the importance of both roe and red deer antler in the production of artifacts (Andersen 1972), so that material may be transported some distance from the source of supply to the scene of manufacture.

Table VIII.7 presents some data on antler material. Of particular note are the high figures for unshed roe deer antler on the inland sites, which is consistent with the hypothesis of a predominantly summer occupation.

TABLE VIII.7 -- Deer Antler Data from Sites of the Atlantic Period

Site	Red Deer			Roe Deer		
	Shed	Unshed	Unspecified Fragments	Shed	Unshed	Unspecified Fragments
Coastal:-						
Ertebølle	34	3	P	A	A	–
Aamølle	–	2	A	–	–	–
Havnø	2	–	A	–	–	–
Dyrholm	–	–	A	–	8	–
Faareveile	–	–	P	–	2	–
Klintesø	2	–	P	1	7	P
Inland:-						
Mullerup	P	P	A	1	19	P
Svaerdborg	P	P	A	2	45	–
Holmegaard	–	–	–	–	12	–

P = present; A = present in abundance.

Sources as in Tables VIII.2 and VIII.3.

On the coast large numbers of cast red deer antlers have been found at Ertebølle as well as numerous shed and unshed roe deer antlers. Clearly there is a considerable overlap of seasonal indicators. But there is nothing

in the data which cannot be reconciled with a hypothesis of seasonal mobility between mainly winter occupation on the coast and mainly summer occupation in the hinterland, although the quality of the data is such that they might be considered consistent with alternative hypotheses.

Other evidence of mainly summer occupation in the hinterland is the low-lying lake-side position of many of the inland sites, which is thought likely to have exposed them to flooding in winter (Friis Johansen 1919); the presence of large numbers of bones of pike and sheatfish, which would have been most easily accessible in quantity in the warmer part of the year when they are found near the surface; and the hazel-nut shells, which were presumably collected in the autumn.

The only evidence that has been quoted as possible support for winter occupation of the hinterland comes from Holmegaard V in Zealand (Brinch Petersen 1973, p.96). But this evidence is largely negative, namely the lack of fish remains and the location of the site in a position protected from winter flooding, neither of which necessarily excludes summer occupation or requires winter occupation.

The occurrence of seal bones on the inland sites of Svaerdborg (Degerbøl 1933, p.376) and Øgaarde (Mathiassen 1943) has long been recognised as evidence of some sort of contact with the coast from an early period, evidence expanded more recently by a further find of a seal bone from Salpetermosen (Møhl 1971b), a whale bone from Ringkloster (Clark 1975, p.195) and a spur-dog spine at Praestelyngen (Noe-Nygaard 1971). That this contact took the form of seasonal movement between predominantly winter occupations on the coast and summer occupations in the hinterland seems highly probable in the light of the various lines of evidence that have so far been examined.

3. Midden Analysis

The total number of prehistoric shell middens which used to exist in Denmark is not easy to establish. Some were already being destroyed in the mid-19th century when archaeological interest was first aroused; at least 50 shell middens were examined by the Kitchen-Midden Committees, although relatively few of these were published in detail; others have been damaged or destroyed since that time. Thus, although the total number of middens probably runs to several hundreds, relatively few have yielded adequately detailed data or are still available for analysis. Inevitably this has involved the selection of data from widely scattered sites rather than the comprehensive analysis of narrowly defined areas undertaken in Australia, a disadvantage considerably offset by the opportunity to compare published data from extensive excavations with specially collected samples.

Excavation

Excavations were carried out at Brovst, Meilgaard and Norsminde (Figure VIII.1), sites which together span a period of about 2 500 years from the late Kongemosen to the Neolithic.

Brovst is located on what would formerly have been a small island in the Limfjord, and preliminary archaeological and dating results have already been published (Andersen 1969; Tauber 1973). The midden is of limited extent and consists of two major layers, neither of which much exceeds ½ m in thickness. The lower layer dates to about 6 500 BP and contains artifacts assigned to the Vedbaek phase of the Kongemosen period; the upper layer is dated to about 5 500 BP in association with typical Ertebølle artifacts. Three separate metre-squares were opened up in different parts of the site and a total of about 1 m^3 of shell midden was removed.

Meilgaard is one of the classic mounds extensively excavated in the last century (Madsen 1888) and was originally some 3 m in thickness

with a sequence of deposits belonging primarily to the Ertebølle period. It is one of the few large mounds with any extensive portions of undisturbed deposit. Two metre-squares were examined and about 2 m^3 of deposit removed.

Norsminde is a recently discovered site with a continuous sequence of shell deposits more than 1 m thick which include a lower level belonging to the Ertebølle period and an upper level with Neolithic ceramics and carbonised grain seeds. The full extent of the midden is yet to be established in detail since it is covered by a thick overburden of soil, but it is probably smaller than the nearby and now destroyed middens of Norslund and Flynderhage. Two metre-squares were sampled here too, involving the removal of about 2 m^3 of deposit.

Table VIII.8 shows that a total of 19 species of molluscs have been identified from previous excavations.

TABLE VIII.8 -- The Representation of Molluscan Species in Ertebølle Shell Middens

In order of frequency:-

Ostrea edulis	Venerupis aurea
Cerastoderma edule	Littorina saxatilis
Mytilus edulis	Buccinum undatum
Littorina littorea	Gibbula cineraria
Nassarius reticulatus	Tectura virginea
Venerupis decussata	Chlamys varia
Venerupis pullastra	Bittium reticulatum
	Littorina littoralis
	Macoma balthica
	Parvicardium exiguum
	Scrobicularia plana
	Montacuta sp.

Source:- Madsen et al. 1900.

Species in the right hand column are represented by isolated specimens only.

A quantitative analysis of the major species of molluscs found in the sampling excavations described above is shown in Table VIII.9 and emphasises the overall predominance of oysters except in the Neolithic levels of Norsminde, where cockles are most common.

TABLE VIII.9 -- The Relative Representation of the Major Molluscan Species at Brovst, Meilgaard and Norsminde

Provenance	Oyster		Cockle		Mussel		Peri-winkle		Total	
	g	%	g	%	g	%	g	%	g	%
Brovst:-										
Layer 11	1 195	96	40	3	1	0	5	1	1 241	100
Layer 11	865	96	25	3	1	0	10	1	900	100
Layer 4	950	97	1	0	10	1	15	1	976	100
Layer 4	1 425	94	5	1	15	1	70	4	1 505	100
Meilgaard:-										
N/Spit 10	6 035	94	130	2	205	3	35	1	6 405	100
N/Spit 6	4 830	88	385	7	275	4	20	1	5 510	100
N/Spit 2	17 350	88	1 045	6	1 020	5	105	1	19 520	100
Norsminde:-										
Ertebølle	1 908	60	1 155	37	58	2	45	1	3 166	100
Neolithic	80	4	1 938	93	35	2	33	1	2 086	100

Mean Annual Shellfood Output

Midden Size and Structure

Table VIII.10 presents some data on midden volumes. Since only maximum dimensions are available in most cases, it has been assumed that the base area of each site is 73% of the rectangular area enclosed by maximum length and breadth, based on analysis of 30 of the larger Australian shell middens selected from Table VI. 2 (p.VI: 17) and Appendix C. It has been further

assumed that the shape of each site approximates a segment of a sphere. Two existing estimates of mound volume are also available, but their accuracy cannot be assessed since the methods of estimation are not given in detail. If anything, they suggest that the methods adopted here err on the high side, which may well be correct in view of the relatively generous assumption about base area.

TABLE VIII.10 -- The Dimensions of some Danish Shell Middens

Site	L m	B m	H m	Base Area m^2	Vol. m^3
Ertebølle	141	22	1.75	2 260	1 970 [a]
Bjørnsholm	250	35	1.50	6 390	4 790
Sebber	40	25	0.50	730	180
Aamølle	65	10	1.20	480	290
Havnø	100	25	0.74	1 840	690
Meilgaard	125	25	3.00	2 280	3 660 [b]
Nederst	60	25	0.60	1 100	330
Faareveile	56	11	1.00	450	230
Klintesø	60	18	0.35	710	140
Brovst 11	28	10	0.50	130	30
Brovst 4	26	11	0.50	120	30

Sources:- Andersen pers. comm.; Brøndsted 1957; Madsen 1888; Madsen et al. 1900; Mathiassen et al. 1942.

a. Compare 1 500 m^3 (Clark 1975, p.193); b. Compare 2 000 m^3 (Petersen 1922).

What does clearly emerge from Table VIII.10 is the wide variation in midden size, ranging from a minimum of 60 m^3 at Brovst to a maximum of 4 790 m^3 at Bjørnsholm, a range which is comparable to the Weipa results. What can be inferred about stratigraphy from recently excavated sections and

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from the photographs and section drawings of the 19th century excavations at Erteb⁄lle and Meilgaard also suggests that the type of midden structure tends towards the Weipa pattern, in which the large mounds are built up from smaller accumulations in an irregular manner.

Shell Quantities

Excavation proceeded as far as possible by the removal of 10 cm spits, and samples of shell were collected using the standard procedure. The mean weights of shell/m^3 are shown in Table VIII.11. The shells were noticeably lighter than their modern counterparts, and it was expected that shell weights would be on the low side. As a measure of this effect it may be noted that the mean of 430 $\pm$ 40 kg/m^3 of the oyster midden of Meilgaard is significantly lower than the figure of 700 $\pm$ 150 kg/m^3 obtained from the oyster midden at Ballina (p. VI: 19), and the mean of 588 $\pm$ 70 kg/m^3 from the cockle midden at Norsminde significantly lower than the figure of 880 $\pm$ 110 kg/m^3 at Weipa (p.VII: 18). That the figures for deposits of cockle midden in both continents are higher than for oyster middens, presumably in response to the smaller size and more compact shape of the cockle shell, is at least a measure of internal consistency in the data, even if the absolute figures are subject to some uncertainty.

Both weight ratios and minimum individuals have been used in the estimate of meat weight, and the results are shown in Tables VIII.11 and VIII.12 respectively. As expected the latter method yields a higher figure than the former. The result of about 150 $\pm$ 27 kg/m^3 is closely comparable to the Australian results of 145 $\pm$ 30 kg/m^3 and 125 $\pm$ 16 kg/m^3 and seems acceptable as a basis for the calculations which follow.

Chronology and Results

Only the site of Erteb⁄lle has so far yielded a sequence of radiocarbon dates (Tauber 1973). Six samples collected through a depth of deposit of about 1 m suggest that the greater part of the mound accumulated within a

[illegible]

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TABLE VIII.11 -- Weights of Mollusc Shell at Meilgaard and Norsminde

Provenance		Sampling Level %	Mean Weight/m^3 Oyster kg/m^3	Cockle kg/m^3	Mussel kg/m^3	Litt. kg/m^3	Total kg/m^3
Meilgaard:-							
N/Spit 2		100	413	28	14	20	475
N/Spit 6		22	326	47	17	21	411
N/Spit 10		25	439	11	15	5	470
S/Spit 5		28	329	24	1	18	372
	$\bar{x}$	-	377	28	12	16	432
	s	-	-	-	-	-	40
	s_m	-	-	-	-	-	23
Meat Wt.[a]	$\bar{x}$	-	75	4	20	5	104
Norsminde:-							
Neolithic		17	9	643	4	4	660
Neolithic		18	25	461	27	2	515
	$\bar{x}$	-	17	552	16	3	588
	s	-	-	-	-	-	72
	s_m	-	-	-	-	-	51
Meat Wt.[a]	$\bar{x}$	-	3	92	7	-	102

a. Shell weight to meat-weight ratios are based on Table III.7 (p.III: 20). The ratio for periwinkles (Litt.) is 1 : 12, based on measurement of modern samples.

[illegible]

TABLE VIII.12 -- Minimum Individual Molluscs at Meilgaard and Norsminde

Provenance		Sampling Level %	Mind/m^3 Oyster	Cockle	Mussel	Litt.	Total
Meilgaard:-							
N/Spit 2		100	18 270	3 350	2 920	8 310	32 850
N/Spit 6		22	24 920	7 090	3 030	8 850	43 890
N/Spit 10		25	23 640	2 190	2 730	2 430	30 990
S/Spit 5		28	15 510	3 670	400	7 260	26 830
	$\bar{x}$	-	20 590	4 080	2 270	6 710	33 640
	s	-	-	-	-	-	6 310
	s_m	-	-	-	-	-	3 160
Meat Wt.[a] (kg/m^3)	$\bar{x}$	-	124	8	11	7	150
Norsminde:-							
Neolithic		17	2 640	60 780	4 020	2 640	70 080
Neolithic		18	3 190	37 680	7 750	990	49 610
	$\bar{x}$	-	2 920	49 230	5 890	1 820	59 850
	s	-	-	-	-	-	10 240
	s_m	-	-	-	-	-	7 240
Meat Wt.[a] (kg/m^3)	$\bar{x}$	-	17	98	29	2	146

a. Individual meat weights of 6 g, 2 g, 5 g and 1 g have been assumed for oysters, cockles, mussels and periwinkles respectively.

period of about 200 years. A seventh sample from the topmost part of the deposit suggests that there was some further accumulation extending over an additional 400 years, but this date is suspect since it may be contaminated with younger material (Tauber 1972). At any rate the great majority of radiocarbon dates of the Ertebølle period from other Danish sites cluster between about 5 600 and 5 200 BP (Tauber 1967, 1971,1973), so that 600 years is a reasonable maximum for the total duration of the period. Assuming that the large Jutland shell mounds were repeatedly visited throughout the Ertebølle period, the radiocarbon dates as a whole suggest that 600 and 200 years may be taken as acceptable maximum and minimum limits for total duration of mound use.

In assessing mean annual output only three sites have been considered: Ertebølle, Bjørnsholm and Meilgaard. These are all large and relatively isolated mounds and are therefore likely to have been repeatedly visited on a regular basis. There is no evidence to suggest that other shell middens may have existed in the near vicinity, except for some small and quantitatively insignificant deposits. But Ertebølle and Bjørnsholm are sufficiently close - about 7 km - to require consideration of the possibility that they may have been used as alternative foci of exploitation. Another potential bias is that some foraging was carried out. But, given that seasonal concentrations of population occupying coastal home bases would have been present, this is not thought likely to be a major factor.

The results are set out in Table VIII.13 and have been arrived at using a meat weight of 150 kg/m^3 and a calorific yield of shellfood of 60 kcal/100 g. This gives a total yield of 90 000 kcal/m^3, which has been rounded to 100 000 kcal/m^3.

TABLE VIII.13. -- Mean Annual Shellfood Output at Ertebølle, Bjørnsholm and Meilgaard

Site	Total Output kcal	Mean Annual Output kcal Min	Mean Annual Output kcal Max	Man/Days Min	Man/Days Max
Ertebølle	197×10^6	328 000	985 000	140	430
Bjørnsholm	479×10^6	828 000	2 485 000	350	1 040
Ertebølle + Bjørnsholm	676×10^6	1 127 000	3 380 000	490	1 470
Meilgaard	366×10^6	610 000	1 830 000	270	800

Relative Shellfood Output

Population Data and the Annual Economy

Population size has been estimated using the Cook and Treganza formula, and the results are shown in Table VIII.14. Also shown are the estimates of relative annual shellfood output. In view of the uncertainties of the Cook and Treganza formula, the results have been expressed in terms of population sizes of 25, 50 and 100, in order to give a range of possibilities for consideration. Maxima and minima refer to the alternative chronologies discussed above.

The results show a relatively low calorific contribution of shellfood to the annual diet, ranging between a maximum of 16% and a minimum of 0.4% with a probable value of less than 6%, figures which compare closely with the Ballina results, which were found to range between 0.5% and 16.7% with a probable value of less than 5% (p.VI: 26). There is little scope for increasing the Danish figures by assuming a reduced chronology or a smaller population size, since the minima already incorporated in the calculations

TABLE VIII.14.-- Relative Annual Shellfood Output at Ertebølle, Bjørnsholm, and Meilgaard at Different Population Levels

Site	Population Size	Relative Annual Output					
		25		50		100	
		Max %	Min %	Max %	Min %	Max %	Min %
Ertebølle	48	4.6	1.5	2.3	0.8	1.2	0.4
Bjørnsholm	76	11.4	3.8	5.7	1.9	2.9	0.9
Ertebølle + Bjørnsholm	124	16.0	5.3	8.0	2.7	4.0	1.4
Meilgaard	48	8.7	3.0	4.4	1.5	2.2	0.8

for these variables are as low as the available data will tolerate. The major remaining possibility is that total shell quantities have been underestimated, and this is a possibility which we shall examine further in the discussion of site catchment analysis.

The Site Economy

This section will be concerned chiefly with the site of Meilgaard, for, although considerable data on bone quantities are available from the extensive shell-midden excavations of the last century, only at this site can they be related to a specific volume of deposit in such a way as to allow a direct comparison with shell quantities.

The minimum numbers of individual animals quoted in Table VIII.2 for Meilgaard are known to have come from 50 m^3 of deposit (Petersen 1922). Their calorific values are shown in Table VIII.15 alongside the calorific value of the shellfish represented by 50 m^3 of midden. Conversion factors for most species are based on Table III.2 (p. III:6-7) or the sources quoted therein, except for seal. For this species an overall figure of 4 000 kcal/kg has been assumed, which seems reasonable in comparison with

TABLE VIII.[illegible] — Relative Annual [illegible] Values of [illegible] and [illegible]

[illegible]	Population Size	Relative Annual [illegible]				
[illegible]	22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	131	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] variables are [illegible] with relatively [illegible]. The [illegible] possibility [illegible] been [illegible], and this is a [illegible] as many [illegible] of this [illegible] analysis.

[illegible]

The species will be discussed [illegible] with the size of [illegible]. Although considerable data on [illegible] quantities are available from [illegible] shell-midden excavations of the last century, only as they may be related to a specific volume of deposit in such a way [illegible] allow a direct comparison with shell quantities.

[illegible] numbers of individual animals counted in Table VIII.2 [illegible] are taken to have come from 50 m³ of deposit (Greenwood 1987). [illegible] values are shown in Table VIII.3 [illegible] the population represented by 50 m³ of midden. Conversion factors [illegible] species are based on Table III.1 (p. III:6-7) or the sources [illegible], except for seal. For this species an overall figure of [illegible] has been assumed, which seems reasonable in comparison with the meat of terrestrial mammals of high fat-content such as pig, which has a calorific value of about 3 500 kcal/kg. The results show that shellfish is the largest individual item in the site dietary, accounting for 40% of the total yield.

TABLE VIII.15. -- The Relative Calorific Output of Resources at Meilgaard

Resource	Meat Weight kg	Conversion Factor kcal/kg	Total 2 kcal	%
Pig	550	3 500	193×10^4	15
Roe Deer	100	1 400	14×10^4	1
Red Deer	900	1 400	126×10^4	10
Seal	920	4 000	368×10^4	29
Fish	30	760	2×10^4	0
Fowl	140	3 500	47×10^4	4
Shellfish	7 500	600	500×10^4	40
Total	10 140	-	125×10^5	99

As a check on this result, Table VIII.16 shows the weights of bone recovered from the small sampling excavation carried out at Meilgaard. Treating all bone as a single unit, assuming an average quantity of bone of 1 100 g/m^3 and a bone weight to meat weight ratio of 1 : 25, the average yield of non-molluscan meat is 27½ kg/m^3, or 55 kg/m^3 if the figure is doubled to allow for losses according to the procedure advocated previously. Assuming an average calorific yield of 2 860 kcal/kg, based on the relative representation of the different species and their appropriate conversion factors in Table VIII.15, 1 m^3 of shell midden represents about 157 300 kcal of non-molluscan meat as compared with 100 000 kcal of shellfood. Thus, according to this method, the molluscs represent some 39% of the total supply.

TABLE VIII.16.-- Weights of Bone at Meilgaard

Level		Total g	Mean Weight/m^3 g/m^3
S/Spit 1		10	100
S/Spit 2		40	400
S/Spit 3		100	1 000
S/Spit 5		145	1 450
S/Spit 6		330	3 300
N/Spit 2		50	560
N/Spit 6		45	500
N/Spit 7		110	1 100
N/Spit 10		120	1 200
	Total	950	9 610
	$\bar{x}$	-	1 070
	s	-	890
	s_m	-	300

The close similarity of these two calculations strongly suggests that small samples of bone excavated from a minute percentage of the total deposit and converted to food values using weight ratios are just as valid a guide to relative food output as large samples of bone recovered from more extensive excavations and converted to food values using the method of minimum individuals. It would certainly appear from this example that sampling errors of differential distribution of bone within midden deposits are probably not a major bias in the assessment of relative food outputs from excavated data, a point which is very relevant to the interpretation of the Australian data, where only small samples were available for analysis.

According to Table VIII.14, the relative annual shellfood output of Meilgaard lies between about 1.5% and 8.7%. Thus if 40% is the relative

contribution of shellfood to the site economy, then it must follow that the site was occupied for not more than 3 months in the year and for as little as 2 weeks. Taken at face value, therefore, these figures provide powerful confirmation of the hypothesis that large shell middens such as Meilgaard were used on a seasonal basis.

However, confidence in this conclusion is weakened to some extent by the possibility that bone quantities are heavily and systematically under-represented in comparison with the shells, because of off-site butchering of carcases, mechanical destruction of bone or chewing by dogs. If Meilgaard had been occupied on the average for 6 months/year, then it follows from the above data that between 70% and 95% of the bones of the animals required to support a population for this length of time must have been destroyed or lost to archaeological view. But no precise quantification of this destruction factor is possible.

Thus the midden analysis as a whole is highly suggestive but by no means fully conclusive. Assuming that Meilgaard is representative of the other large shell middens, two points seem to be generally acceptable. In the first place the sites were probably home-base sites or foci of home-base clusters, dependent on the exploitation of a diversity of resources, both marine and terrestrial, and by no means exclusively or even predominantly focused on shellgathering. In this respect it is worth noting that the relative value of shellfood in the site economy, although quite high, is nevertheless considerably lower than the figures from Australia and in particular from Ballina, where other lines of evidence suggest that the oyster mounds might well have been used primarily for shellfood consumption. The second point is the calorific contribution of seal meat, which is clearly comparable to, if not greater than, that of the terrestrial mammals, a result which supports our earlier conclusions about the role of sealing in the coastal economy.

4. Site Catchment Analysis

Sites

Attention is confined in this analysis primarily to Jutland and specifically to the major coastal sites. As far as the hinterland is concerned, no detailed examination has been made of sites on the outwash gravels and sands of the western peninsula since there appears to be little doubt about the relatively low economic potential of the area, and the sparse nature of the archaeological finds themselves strongly supports the idea of transitory occupation. The critical problem in assessing the hypothesis of a mobile economy is the economic potential and probable season of use of sites in the coastal hinterland. Hence interest is mainly focused on the large sites of this zone.

Resource Categories

Five categories of economic potential have been used. On the landward side there is good grazing and rough grazing. Good grazing occurs mainly on the glacial clays and loams in areas which to-day are given over to cultivation or use as meadows. Rough grazing refers to areas where the soil cover is thinner because of local variations in topography, often with relict woodland vegetation, or where the soil cover is of poor quality because of the high sand-content.

On the aquatic side the categories are marine, lacustrine and "Litorina inlets". Areas identified as lakes probably represent a minimum since some of the lakes of the Litorina period have become filled with marshy deposits following the lowering of the water table, and it is not always possible to identify with confidence which areas of marshy ground were formerly lakes. "Litorina inlets" are coastal areas which are now dry or marshy ground but which would have formed areas of shallow water

belonging to the marine zone during the Litorina period. They are easily identifiable and of considerable importance in the study of shellfood potential.

Coastal Site Territories

(1) Local Distribution: The Site Economy of Meilgaard

A detailed study is presented here of the site of Meilgaard, combining the results of the midden analysis with an examination of the economic potential of the site territory (Figure VIII.5). The approach adopted here is not unlike that used by Petersen (1922), who perceived the possibility of using data on potential numbers of deer and oysters within a specified area of the site and relating them to the faunal material recovered from excavation.

Potential Deer Output

The total area of land potentially within reach of Meilgaard is 14 580 hectares. A small part of this is rough grazing, but for the purposes of the present calculation it has been assumed that potential deer densities would have been uniform throughout the territory. Figures for deer densities may range from a maximum of 1/6 hectares (Mitchell 1969) to a minimum of 1/200 hectares (de Nahlik 1959). However, figures at the upper end of the range invariably refer to the atypical conditions of the Scottish Highlands. In lowland forest densities rarely exceed 1/40 hectares (Matthews & Crooke 1969). A comprehensive scheme for assessing densities in relation to variations of vegetation and soil is von Ueckerman's (quoted in de Nahlik 1959). Applied to the glacial soils and mixed forest conditions of Denmark, this method yields a figure of 1/50 hectares. If there is any truth in the pollen analysts' reconstruction growing in the region only during the [illegible] period. They are mostly [illegible] and of considerable importance in the study of [illegible] [illegible].

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[illegible] [illegible]

The total mass of [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible]. A small part of this is [illegible] [illegible], but for the [illegible] of the present calculation it has been assumed that [illegible] [illegible] would have been uniform throughout the territory. Figures for [illegible] production may range from a minimum of [illegible] [illegible] [illegible] to a maximum of [illegible] [illegible] ([illegible] [illegible]). However, figures at the upper end of the range [illegible] [illegible] to the original [illegible] of the [illegible] [illegible]. In [illegible] forest [illegible] [illegible] [illegible] ([illegible] & [illegible] [illegible]). A comprehensive scheme for [illegible] quantities in relation to variations of vegetation and soil is [illegible] (quoted in [illegible] [illegible]). Applied to the [illegible] [illegible] [illegible] conditions of [illegible], this method yields a figure of [illegible]. If there is any truth in the pollen analysts' representation of a dense forest with little herbaceous undergrowth, then this figure is most probably a maximum, but it has been accepted as a basis for calculation.

Cropping rates are likewise variable, ranging between 10% (Cameron 1923) and 20% (Darling 1957), depending on the incidence of natural mortality. Wolf and lynx both make a sporadic appearance in Ertebølle deposits, so that it seems reasonable to assume some element of non-human predation. Another factor is the efficiency of human cropping techniques. In this respect it is worth noting the evidence of healed spear wounds in some of the deer and pig bones recovered from Danish prehistoric sites, which may be interpreted as a measure of cropping inefficiency (Noe-Nygaard 1974). In view of these possibilities the lower figure of 10% seems preferable.

Using Clark's (1972) figure of 114 kg for individual meat weight and a calorific yield of 1 400 kcal/kg, the potential annual deer output of the Meilgaard territory in man/days can be calculated as follows:

$$\frac{1\ 400 \times 14\ 580 \times 114}{50 \times 10 \times 2\ 500} = 1\ 861 \text{ man/days}$$

Total Potential Food Output (Excluding Shellfood)

According to the data on minimum individuals recovered from excavation, red deer represents 10% of the total in terms of calories (Table VIII.15) or 17% if the figures for shellfood are excluded. Assuming that the relative potential food output of the various resources within the site territory is proportional to the relative percentages represented by the excavated faunal remains, then total food output can be estimated by reference to the data on potential deer output as follows:

$$\frac{100 \times 1\ 861}{17} = 10\ 947 \text{ man/days}$$

Potential Shellfood Output

There are 1 490 hectares of silted inlet within the Meilgaard site territory, which would formerly have provided suitable conditions for the settlement of oysters. In assessing potential oyster output, the mean figure obtained from the Australian data of 0.35 t/km^2 (Table VII.7, p.VII: 24) has been used. The uncertainties involved in extrapolating this figure from a different context are recognised, but, as emphasised in our previous discussions of potential shellfood output (p. III: 10 and VII: 23), figures for estuarine species are probably constrained within limits which are narrow enough to be tolerable in archaeological calculations, irrespective of context.

As a check, the higher figure of 1 t/km^2 (Table VII.7) has also been applied. This figure is derived from the Fal oyster beds of south-west England, which probably provide a closer parallel to prehistoric Denmark in terms of temperature and general environment than Australia, but it also refers to exploitation based on methods of cultivation and advanced technology, so that it is probably too high.

Assuming that oysters form 83% of the total shellfood supply (Table VIII.12) with a mean calorific yield of 500 kcal/kg, minimum and maximum potential shellfood output can be assessed as follows, with a probability that the minimum is closer to the correct figure:-

minimum (0.35 t/km^2)

$$\frac{3\,500 \times 14.9 \times 500 \times 100}{2\,500 \times 83} = 1\,208 \text{ man/days}$$

maximum (1 t/km^2)

$$\frac{1\,000 \times 14.9 \times 500 \times 100}{2\,500 \times 83} = 3\,590 \text{ man/days}$$

These figures should be compared with the results based on excavation, which yielded a minimum of 270 man/days and a maximum of 800 (Table VIII.13). The latter figure falls some way short of the minimum estimate above of

1 208 man/days, a discrepancy which may be accounted for by supposing either that the archaeological representation of oysters is too low or that the territorial estimate of potential output is too high.

Taking the former point first, reference to Figure VIII.5 shows that the site of Meilgaard and the two smaller middens nearby are only optimally located for the exploitation of a limited portion of the total potential. Large areas of inlet within the site territory would have been marginal for shellfood exploitation on foot, although boats may have been used. It is thus possible that other shell middens, now destroyed, were formerly used to exploit these areas or that extensive foraging was carried out without leaving any archaeologically visible traces.

Turning to the second point, it would be possible to invoke regional variations of growth rate, incidence of natural mortality or regularity of spatfall, all of which might affect the total potential output. For example, it is relevant to note that the oysters of the Richmond River in Australia reach a marketable size in 2½ years (P. Wolf pers. comm.); on the Fal estuary the figure is 3 to 4 years (Orton 1926); and in modern Denmark 4 to 6 years (Spärck 1924). Thus differences in growth rate alone might be sufficient to account for differences in oyster output of as much as 100%.

At any rate the figures for shellfood output derived respectively from excavation and territorial analysis are close enough to be acceptable within the limits of uncertainty which apply to both types of estimation.

Relative Shellfood Output

If one refers to the minimum figure for potential shellfood output of 1 208 man/days, then the total food output of all resources including molluscs is 12 155 man/days, and relative shellfood output is thus 9.9%. Taking the maximum figure of 3 590 man/days, total food output is 14 537 man/days, and relative shellfood output is thus 24.8%.

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If we are correct in preferring the lower figure, relative shellfood output would have been less than 10%, which is substantially lower than the excavation estimate of 40% (Table VIII.15). It is possible that the lower figure is the result of using an excessively high figure for potential deer output, on which the whole territorial calculation depends. Thus it might be argued that deer densities were much lower, because of the encroachment of the forest, and that the minimum number of individuals found in excavation is a more realistic guide to mean annual output. However, if we estimate the mean annual output of the non-molluscan resources in the same manner as for the molluscs, projecting the total number of individuals estimated to be present in the whole mound onto a time scale, we arrive at maximum figures of 3 minimum individuals for red deer, 4 pig, 3 roe deer, 3 seal, 11 fish and 10 fowl. Using the longer chronology for mound duration of 600 years, mean annual output is 1 red deer, 1 pig, 1 roe deer, 1 seal, 4 fish and 3 fowl. In either case the figures look surprisingly low and unrealistic as a measure of regular economic activity. The discrepancies between the midden analysis and the territorial analysis are more simply resolved by assuming that, whereas the oyster shells in the midden are a reasonably close approximation to the quantity originally collected, the animal bone has been subject to more severe processes of destruction and archaeological under-representation. On this basis 10% is accepted as a more realistic figure for relative shellfood output in the site economy of Meilgaard.

The combined results of the midden analysis and the territorial analysis of relative food outputs are summarised in Table VIII.17. This shows that marine and terrestrial resources were of about equal importance in the site economy and that on the marine side seal accounted for some 81% of the food supply. Also shown are the areas of land and sea within the potential site territory, and it will be seen that there is a satisfactorily close correspondence between these figures and the relative representation of marine and terrestrial resources.

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TABLE VIII.17. -- The Relative Representation of Resources at Meilgaard: Summary and Comparison of Midden Analytical and Territorial Results

Resources		Territorial Category	
Species	%	Hectares	%
Terrestrial			
Pig	23	-	-
Red Deer	15	-	-
Roe Deer	2	-	-
Fowl	6	-	-
Total	46	14 580	52
Marine			
Seal	44	-	-
Fish	0	-	-
Shellfish	10	-	-
Total	54	13 450	48

Table VIII.18 shows the probable duration of occupation at different population levels. The higher figure for total food output includes the maximum figure of 3 590 man/days for potential shellfood output. This is probably on the high side but is included in order to provide a range of results for consideration. As in all the preceding calculations, the results are probably subject to quite wide margins of potential error, and too much emphasis should not be placed on specific figures.

As with so much quantitative data, the results are not fully conclusive. They certainly admit the possibility of seasonal occupation, although equally they do not exclude the possibility of permanent occupation. The extent to which we favour one hypothesis at the expense of the other depends on our assumptions about population size. Taken at its face value, the Cook and Treganza formula suggests a figure of 48 people, and at this level occupation would probably have lasted for about 8½ months/year.

TABLE VIII.18.-- Duration of Occupation at Meilgaard in Days/Year at Different Population Levels

Total Food Output Man/Days	Population Size 25	50	100
12 155	486	243	122
14 537	581	291	145

Stated another way, the data presented here suggest that some 33 people could have been supported throughout the year on a permanent basis, and 66 people for a 6 month season.

One conclusion that can be drawn with confidence from these results is that, if the site was occupied on a seasonal basis, then the season must have been a prolonged one lasting for a considerable part of the year, probably not less than 4 months/year. It is interesting to compare this conclusion with the results of the antler analysis considered above (Table VIII.7, p. VIII: 34), which show that both shed roe-deer antler, indicating autumn occupation, and shed red-deer antler, indicating spring occupation, have been found in coastal deposits. If we are correct in our view that these sites were used during the winter, then a seasonal duration of at least 6 months is indicated.

(ii) Regional Distribution

Eleven coastal site territories in Jutland in addition to Meilgaard have been selected for analysis (Figures VIII.5 to 10). It is probable that most of these sites represent home-base sites or components of home-base clusters, although excavated data are inadequate to establish this in every case. Comparison with the Meilgaard territory may help to clarify this problem by showing up similarities or significant differences.

In assessing economic potential, overlapping of neighbouring territories, as, for example, between Ertebølle and Bjørnsholm, has been ignored, except where the overlap is due to projection out into the river of territorial boundaries of sites situated on opposite shores, following the method adopted at Weipa (p. VII: 45). At Ertebølle and Bjørnsholm, for example, it has been assumed that the land on the opposite side of the fjord would have been too far away to be worth exploiting on a regular basis from these sites and that it would probably have formed part of an independent exploitation territory including the marine zone immediately adjacent. In some cases, notably Brovst, Havnø and Kolind, the channel in front of the site is so narrow that this assumption may be unjustified, so that a second estimate of economic potential for these three sites has been made to include the land on the opposite shore.

Table VIII.19 shows the relative representation of economic categories. The figures for the marine zone include areas of Litorina inlet and show considerable variation, ranging from a minimum of 9% of the total territory to a maximum of 99%. Some of this variation reflects distortion of territorial boundaries in the marine sector. As a more consistent guide to the relative importance of the marine categories, the area of land within each site territory has been expressed as a percentage of the total ideal territory. Using this method, one arrives at a figure for Meilgaard of 46%. If this is taken as a reference standard, 7 other sites have figures close to or less than this, ranging as low as 0.1% and 3% at Havnø and Brovst respectively, or 48% and 19% if the maximum area of land is included. Thus, according to the logic of territorial analysis, it follows that marine resources played at least as important a role in the site economy as at Meilgaard.

Conversely, four sites give higher percentages. Dyrholm, with a figure of 54%, is scarcely significantly different from Meilgaard. But the high figures for Gjessingaard and Norslund suggest a considerably lower emphasis on the marine sector.

TABLE VIII.19.-- The Economic Potential of Coastal Site Territories of the Ertebølle Period

Site		GG %	RG %	Lake %	Marine %	GG+RG[a] %	Total Hectares
Ertebølle		42	7	0	51	27	17 640
Bjørnsholm		50	4	0	46	41	23 350
Sebber		66	8	0	26	38	16 260
Brovst	Min	4	1	0	95	3	17 465
	Max	18	8	0	74	19	22 615
Aamølle		58	11	0	31	34	15 450
Havnø	Min	1	0	0	99	0.1	9 590
	Max	52	2	0	46	48	20 590
Gjessingaard		85	6	0	9	66	22 760
Dyrholm		83	0	0	17	54	20 630
Meilgaard		44	8	1	47	46	28 030
Kolind	Min	79	0	0	21	36	14 160
	Max	79	2	0	19	74	23 110
Braband		79	4	0	17	68	25 750
Norslund		68	1	1	30	59	26 690

a. Expressed as a percentage of 31 400 hectares

There are few quantitative indicators about relative density of occupation at these different sites, but what little is available (Table VIII.4, p.VIII: 26) does not suggest any substantial difference between sites with a high representation of the marine category, such as Ertebølle and Aamølle, and sites at which the terrestrial categories are predominant, such as Braband and Norslund. Thus the territorial data are weighted towards an emphasis on marine resources, but at the same time they indicate that the terrestrial fauna formed a substantial and sometimes a pre-eminent focus of exploitation within the coastal zone.

The degree of overlap between neighbouring site territories is variable. In some cases this may be due to the fact that we are dealing with sites which form part of the same home-base cluster. This is possibly the case with Aamølle and Havnø. Clearer examples of probable home-base clusters are provided by Sebber and the unspecified site on the opposite bank of the river estuary; the group of sites at Gjessingaard; the two small middens near Meilgaard, already mentioned; the group of sites comprising Kolind, Nederst and Fannerup; and the Norslund-Norsminde-Flynderhage group.

An example of territorial overlap between neighbouring home-base sites is provided by Ertebølle and Bjørnsholm. If midden size is any guide (Table VIII.10, p. VIII: 39), both sites represent very substantial occupations, and they would appear to be too far apart to represent alternative foci of a single home-base cluster, although this possibility is not excluded. In any case, the important point is that the territorial overlap coincides with a heavy emphasis at both sites, and particularly at Ertebølle, on the marine zone. It is thus possible that this represents a case of large-scale clustering in response to the concentrated potential of marine resources in the Limfjord, comparable to the examples examined in Australia. Conversely, the neighbouring home-base sites of Norslund and Brabrand are spaced apart in a manner which much more closely approximates the expected pattern for the exploitation of terrestrial resources, a feature which gains significance from the fact that the site territory in both cases is focused more on the terrestrial than the marine sector. These examples of site spacing are highly suggestive and are consistent with the principles of coastal site location elaborated in preceding chapters. But the sample of sites is too small to allow a more conclusive interpretation.

A more convincing illustration of site clustering is provided by the shell middens in Roskilde Fjord (Figure VIII.11). This is a long, shallow and relatively broad inlet in northern Zealand not unlike the inlet of the

Hey River at Weipa (compare Figure VII.5). Mathiassen's (1919) survey provides enough data on relative size to allow some distinction between larger and smaller sites. As at Weipa there is a marked clustering of individual sites and site clusters around the shores of the fjord, forming a tightly packed distribution of territories focused on the marine zone. In contrast to Weipa there are no mangroves or equivalent restrictions on access to the marine zone. It is thus possible to eliminate one of the hypotheses advanced at Weipa, that the concentrated distribution of sites resulted from a contraction of the time-distance factor (see p.VII: 42). Correspondingly greater emphasis can therefore be placed on the restricted distribution of marine resources of high economic potential as the underlying factor in site distributions of this type.

<u>Inland Sites and Seasonal Complementarity</u>

Six site territories, referring to the major known sites of the coastal hinterland, have been analysed (Figures VIII.10 and VIII.12 to 14). Measurement of territorial boundaries in this inland region is relatively straightforward, although occasional variations of topography and the complex pattern of waterways and lakes impose some distortions. Table VIII.20 shows the relative representation of the various resource categories within each territory.

The first point to emphasise is the relatively high representation of terrestrial categories. Expressed as a percentage of the total ideal territory, the figures range from 49% to 92%. An interesting point is that the lower end of the range overlaps with the upper range of the coastal sites. Particular attention is directed to the sites of Salten Sø and Siimholm with figures of 65% and 49% respectively, results which reflect the relatively high representation of the lacustrine category in both cases. Indeed the lacustrine category is a prominent feature of all the inland sites, ranging from 4% to 22%. The major economic potential of these inland

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TABLE VIII.20. -- The Economic Potential of Inland Site Territories of the Ertebølle Period

Site	GG %	RG %	Lake %	Lake + RG %	GG+RG[a.] %	Total Hectares
Ringkloster	93	0	7	7	80	27 070
Havstrup/ Melhede	91	5	4	9	92	29 900
Salten Sø/ Rye Brø	58	27	15	42	65	23 850
Siimholm	57	21	22	53	49	15 475
Klosterlund	39	58	3	61	88	27 500
Skygge	14	80	6	86	85	28 240

a. Expressed as a percentage of 31 400 hectares.

lakes would have been as a source of fish, which are most easily accessible in the summer months when they are found near the surface. Hence high values for the lacustrine category would be a useful seasonal indicator. In absolute terms the figures are not especially high, but their significance is increased by comparison with the coastal site territories, where lake resources never exceed 1%.

Furthermore, the fact that most of the inland sites are situated on lake edges requires us to consider the possibility that the lake zone represents an area of concentrated food abundance out of proportion to its relatively limited extent. As a more sensitive indicator of this possibility, the percentage area of lake within 1 km and 5 km radii of each site has been measured and compared with the figure for the 2 hour territory, on the assumption that resources in the immediate vicinity of a site are likely to have been of particular importance in the site economy. The results are shown in Table VIII.21. For most sites there is little significant variation. Only Ringkloster and Siimholm have substantially

higher percentages of lake within the immediate vicinity than within the site territory as a whole. It would therefore appear that lake resources played a variable role in the hinterland but were probably not as important an element in the site economy as the marine resources on the coast.

TABLE VIII.21. -- The Economic Potential of Lake Resources in Site Territories of the Coastal Hinterland: Comparison of Data from 1 km, 5 km and 2 hour Territories

Site	1 km %	5 km %	2 hour %
Ringkloster	32	11	7
Havstrup/Melhede	9	6	4
Salten Sø/Rye Brø	16	13	15
Siimholm	38	21	22
Klosterlund	8	2	3
Skygge	8	4	6

Another significant difference between the hinterland and coastal site territories is the high percentages of rough grazing in the former. Again the figures for the hinterland are highly variable, ranging from 0% to 80%, but they are generally higher than on the coast, where the highest figure is 11%. Extensive areas of rough grazing, especially when combined with a relatively treeless vegetation - most probably the case at Skygge and Klosterlund - would presumably have been a major deterrent to occupation in winter, given that extensive areas of more fertile and better sheltered good grazing would have been available elsewhere. Therefore it seems reasonable to combine the rough grazing and lacustrine categories as joint indicators of mainly summer exploitation-potential. The combined figures for these two categories are presented in Table VIII.20 (p.VIII: 61)

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and show that the likelihood of summer occupation increases as one moves inland. Only the sites of Havstrup/Melhede and, to a lesser extent, Ringkloster would be feasible winter sites.

There is thus a considerable degree of seasonal complementarity in terms of economic potential between site territories in the coastal zone and the coastal hinterland, and the question arises as to the bearing of these results on the alternative hypotheses of mobile exploitation proposed in the Introduction to this chapter.

Specifically, what evidence do we have to support the hypothesis that the coastal hinterland might have served both as a winter zone for human groups who spent the summer in the western peninsula, and as a summer zone for human groups who spent the winter on the coast? If our seasonal interpretation of resource categories is correct, then there is very little supporting evidence for this hypothesis. The only sites that might possibly have been used in winter are Havstrup/Melhede and Ringkloster. Yet both are situated immediately adjacent to coastal sites, and, in the case of Ringkloster at any rate, there is a significant degree of overlap with the neighbouring coastal site territory.

The hypothesis that these sites were used by human groups who were economically independent of those who occupied the coastal sites would require us to imagine that people regularly spent the winter lean season within 15 km of the coast without ever seeking to take advantage of the high winter potential of marine resources available. It is a far simpler interpretation to suppose that Ringkloster and Havstrup/Melhede were related to their neighbouring coastal sites in a complementary pattern of exploitation, which also included sites further inland as well. In this respect it is worth emphasising the distribution of the major sites of the coastal hinterland around the interconnecting network of rivers and lakes, which would have offered convenient access routes for seasonal population movements between complementary zones (Figure VIII.15).

It is of course true that the number of inland sites with evidence of substantial occupation is limited and in any case is based mainly on surface data of questionable reliability. It might be argued that other major sites await discovery in the coastal hinterland in locations optimally placed for winter occupation. The fact remains that the majority of known sites are not so located; those that are so placed are so close to the coast as to render it highly improbable that they were not related in some way to exploitation of the coastal zone. On the available data, then, a hypothesis of seasonally mobile patterns of exploitation, incorporating sites of the coastal zone, the coastal hinterland and, by extension, the inland zone of the western peninsula, appears the most likely of the proposed alternatives.

Discontinuities of Shellgathering

The territorial data also provide a solution to the problem of chronological discontinuities in the occurrence of shell middens. The clue to this problem lies in examination of the figures for the area of "Litorina inlet". As we have emphasised previously, these areas would have represented shallow bays and inlets during the period of the maximum Litorina transgression, but were subsequently transformed into dry land by the process of isostatic uplift. The data presented in Table VIII.22 illustrate the extent of changes which have occurred in the marine sector of many of the coastal site territories since the Ertebølle period.

The effect of these coastal changes on shellfood exploitation can best be appreciated in the case of Meilgaard (Figure VIII.5). Here the Litorina inlets would have represented the major areas for the growth of intertidal oysters during the period when the site was occupied. However, it will be seen that the process of isostatic uplift did not simply have the effect of shifting the intertidal zone further away from the site, but also changed the whole character of the coast, transforming it from a series

TABLE VIII.22 -- The Economic Potential of Marine Resources in Coastal Site Territories of the Ertebølle Period

Site	Total Marine Hectares	Litorina Inlet Hectares	%
Ertebølle	8 940	1 550	18
Bjørnsholm	10 605	2 250	22
Sebber	4 230	1 430	35
Brovst	16 615	9 110	55
Aamølle	4 820	2 280	48
Havnø	9 530	6 420	67
Gjessingaard	2 160	1 800	83
Dyrholm	3 595	3 535	98
Meilgaard	13 150	1 490	11
Kolind	2 930	2 930	100
Brabrand	4 500	1 310	29
Norsminde	8 000	460	7
Sølager	11 300	1 000	9

of protected bays and shallow inlets into a uniformly exposed shoreline much less suitable for the settlement of oysters. Indeed Figure VIII.3 shows that isostatic uplift had a general effect throughout northern Jutland of "smoothing" the contours of the coastline.

Given that isostatic uplift began to take effect immediately after the fourth Litorina transgression, that is to say at about the time of transition from the Ertebølle to the Neolithic period, it is not difficult to appreciate that many areas of former shellfood abundance would have undergone progressive deterioration as a focus for shellgathering after the Ertebølle period, especially in view of the drop in winter temperatures

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[illegible]	[illegible]	[illegible]	[illegible]

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which is known to have been associated with the areas where isostatic uplift was most severe (Iversen 1973).

Clearly the effects of isostatic uplift would have varied according to the nature of the local shoreline topography. Comparison of Brabrand and the Norslund group of sites (Figure VIII.10) illustrates this point. During the Ertebølle period both sites were situated on estuarine inlets. However, the Brabrand inlet was completely transformed into a land-locked lake, presumably because of the shallower depth of water in the former estuary, whereas the latter, although somewhat narrowed, maintained its essentially estuarine character, a difference which is reflected in the figures in Table VIII.22. It is thus no surprise to find that occupation of Brabrand ceased after the Ertebølle period, whereas at Norsminde there is evidence of continuity of occupation in the form of a Neolithic shell midden. Similarly, the site of Sølager in Zealand (Figure VIII.16), where shell accumulation persisted well into the Neolithic period, underwent relatively little change in the marine sector of its territory.

A further point to emphasise is that these coastal changes did not only affect the shellfood supply but the exploitation of marine resources generally. If we are correct in assigning a relatively minor role to shellfood, then its disappearance should have had relatively little impact on continuity of occupation. However, Table VIII.22 shows that many of the coastal sites in Jutland would have had a substantial part of their marine territory transformed into dry land, with dramatic effects on the immediate availability of marine resources and on the pattern of access to the marine zone in general. It is probably as much for this reason as because of the disappearance of shellfish that discontinuities of occupation occur.

What of the rarity of shell middens before the Ertebølle period? The important clue here is the difference in height between the earliest and latest Litorina shoreline. The figures vary slightly from area to area

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and are not always complete, but according to data from Amager in Zealand (Troels-Smith 1939), the fourth transgression was 5.2 m higher than the first. At Brabrand, the difference in height between the first and third is 3.5 m (Troels-Smith 1937).

If we compare these figures with the difference in height between the maximum level of the Litorina shoreline and the present day sea-level in those areas where isostatic uplift is most marked, we find a close similarity. At Meilgaard, for example, the Litorina shoreline is 5 m above sea-level, at Ertebølle 4.5 m, and so on (Mertz 1924).

Now, if a 5 m rise of land relative to a stable sea-level is sufficient to transform a series of shallow inlets and estuaries into an exposed shoreline unsuitable for shellfish, then it is logical to suppose that a 5 m drop in sea-level relative to a stable land surface will have precisely the same effect. Given that the earliest Litorina transgression was some 5 m lower than the latest, it seems reasonable to suggest that the shellfish potential during the earliest transgression would have been as poor as in the period after the onset of isostatic uplift. An exact parallel between the shorelines of the two periods cannot be established since presumably some deposition of sediment occurred in the intervening period, and other variables such as minor differences of local topography are also probably involved. But some degree of similarity is suggested.

At any rate there is sufficient evidence to promote this hypothesis as a plausible one, and, while it may be said that more data are required to establish it in detail, it is a hypothesis which would have to be eliminated before one could fall back on alternative explanations. There is the additional factor for the earliest phases of the Litorina period, that any contemporaneous shore sites would have been vulnerable to erosion or burying in sediment by the subsequent rises of sea-level. Paradoxically,

it seems that the factor of isostatic uplift, which has ensured the preservation of so much data on prehistoric coastal economies, has also served to obscure the course of their development.

5. Conclusions

The relatively minor role of shellfood in the coastal economy; the grouping of shell middens in home-base clusters focused on the integration of marine and terrestrial resources, in this case mainly seal, deer and pig; the clustering of home-base sites around access points to the marine zone; the seasonal exploitation of the hinterland; the relationship of discontinuities in the occurrence of shell middens to discontinuities in the distribution of the shellfood supply; all of these provide obvious parallels with Australia and suggest that the principles of coastal exploitation which were apparent there can also be applied to the coastal economies of prehistoric Europe.

With the advantage of our comparative perspective, it is also possible to consider more closely the essentially European concept of the Mesolithic as an economic entity. The equation of the Mesolithic, as an artifactual clustering, with an intensification of economic behaviour, as reflected in the more abundant archaeological evidence for aquatic resources, and with the climatic changes of the Postglacial period is based in part on the fallacious assumption that changes in all three phenomena are somehow necessarily linked in a synchronous pattern. It is also based in part on the apparent restriction of shell middens, as the most visible archaeological indicator of aquatic exploitation, to the Postglacial period.

Although we have cast doubt on this interpretation of shell middens, in view of the potential biases of the record, it does appear to be the case in Denmark, interestingly enough, that shellfood exploitation was

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probably an episode of relatively limited duration, which reached its culmination at the very end of the Mesolithic period immediately before the introduction of cereal husbandry.

However, our analysis further suggests that the development and decline of shellgathering was probably not influenced in any way by other economic developments occurring at this time, nor was it much affected by those other two features which are commonly invoked as potentially disruptive elements in the development of the Postglacial economy: the extension of the late Atlantic forest and the loss of land caused by the eustatic rise of sea-levels. Nor is there any evidence to justify the introduction of currently popular theories of population pressure. Rather the important factors appear to be a combination of climatic and geomorphological changes which happened to coincide for a limited period to render the otherwise marginal conditions of the Danish coastline unusually favourable for the extensive development of intertidal oyster beds.

If we had to select one change above all others as a potentially disruptive factor in the long-term development of the Danish economy, it would be the effects of isostatic uplift from about 5 000 BP onwards. Whether this paved the way for the introduction of agriculture is a matter which lies beyond the scope of this investigation and is a possibility which we can do no more than mention in passing.

Thus it would seem justified to refer to the Danish shell middens as a "Postglacial" or "Mesolithic" phenomenon, if only because of local circumstances which happened to bring shellgathering to prominence at this period. That this idea should have been applied on such an extensive scale elsewhere represents a generalisation from local conditions which probably owes more to the pre-eminence of Danish archaeology in the history of the subject than to a correct understanding of the underlying principles of economic behaviour.

CHAPTER IX

NORTHERN SPAIN AND THE ASTURIAN

1. Introduction And Archaeological Background

Shell middens are found in several parts of the Iberian peninsula, notably in southern Portugal, on the Mediterranean coast of Spain, and on the northern coastline from about the French border to central Asturias. We shall deal mainly with the latter area, for it has not only one of the largest groupings of early shell middens in Europe but one of the longest sequences of coastal occupation, with a record of shellgathering extending back at least as far as the Mousterian period some 40 000 years ago. Figure IX.1 is a general location map of the area.

Compared to the situation in the previous case studies there are relatively few opportunities for detailed quantitative analysis of midden deposits, since the largest shell middens are comparatively small and have been badly damaged by erosion and excavation. Such quantitative observations as can be made are necessarily of a general nature. On the other hand a century of archaeological investigation has yielded the location of numerous sites, both coastal and inland. There is also a general uniformity of environment along the Cantabrian coastline. These factors have thus encouraged the adoption of a broader geographical perspective to complement the long time-span of the archaeological record, and greater emphasis has been placed on distributional and territorial studies. In any case, the greater gaps and uncertainties of the data are ones which we can grapple with all the more effectively, armed with the body of hypotheses established in the preceding investigations.

Table IX.1 illustrates a broad chronological framework for the prehistory of Cantabria. This is based to some extent on radiocarbon dates but mainly on

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[illegible] has yielded the location of numerous sites, both excavated and [illegible] with a general uniformity of environment along the [illegible] have been suggested the adoption of a [illegible] geographical [illegible] to supplement the long time-span of the archaeological record, and [illegible] has been placed on [illegible] and territorial studies. [illegible] the greater part and concentration of the data [illegible] which we [illegible] all the more effectively, [illegible] with the help of [illegible] of the preceding [illegible].

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TABLE IX.1 - The Chronology of Prehistoric Settlement in Cantabria

Industry		Date BP
Neolithic		5 000
Post-Asturian		6 000
Asturian		9 000
Azilian		10 000
Magdalenian VI	Upper	11 500
Magdalenian V		13 000
Magdalenian IV	Middle	15 000
Magdalenian III	Lower	17 000
Solutrean		18 000
Gravettian		26 000
Aurignacian		30 000
Chatelperronian		32 000
Mousterian		70 000
Acheulean		<70 000

After González Echegaray 1966

the sequence of stone industries of the Cantabrian Palaeolithic and Mesolithic, which are broadly similar to the various stages of the better dated French sequence and are usually named after them (Jordá 1963). There are certain differences of detail between the artifact assemblages of the two areas in particular the absence from northern Spain of the French Lower and Middle Solutrean and Magdalenian I and II. But in other respects there is broad agreement, and such radiocarbon dates that are available from Spain support the establishment of broad synchronisms with France established on the basis of artifactual similarity.

The major oddity of the Spanish sequence is the Asturian industry, which

has no close parallel in France. It is especially well represented in the province of Asturias, whence the name, where it is associated with an important group of shell middens. The exclusive artifact is a flaked pebble, shaped rather like a small, elongated handaxe. The earliest finds of this primitive looking "pic" were dated to the Acheulean period (Vega del Sella 1914). But similar specimens were subsequently found in shell middens stratified above an Azilian industry. Hence Vega del Sella (1923) made them the type-specimen for a new industry, assigned them to a "Pre-Neolithic" period and explained their primitive appearance as a functional characteristic suited to knocking limpets off rocks.

More recently there has been a revival of the early dating. The Asturian shell middens originally filled the entrances of small caves, but at some stage in antiquity the shells were cemented together and then eroded away, leaving only cornices of shell midden cemented to the walls and ceiling and cemented shell material lying on the floor surface. This unusual phenomenon has suggested the hypothesis that, if the underlying Palaeolithic deposits predate the Asturian, then they too should show signs of erosion; since they do not, it follows that they were accumulated after the formation and erosion of the shell middens, in which case the Asturian is probably older than 70 000 years and dates to the Riss-Würm Interglacial or earlier (Jordá 1958; 1959). Other evidence invoked in support of this hypothesis is the primitive appearance of the Asturian pics and their association with typical Lower and Middle Palaeolithic artifacts on surface sites throughout the coastlines of Portugal and northern Spain (González 1968).

If this dating were correct, it would be quite important for interpreting the long-term record of shellgathering, providing a unique example of concentrated shell deposits from a fairly remote Pleistocene context. However, there are powerful objections to this view. In the first place "primitive" typology is a notoriously misleading guide to chronology. The evidence of surface sites must also be ruled out, since, in the absence of stratigraphy, it may refer to a mixture from many different periods. Secondly, if the shell middens were [illegible] to Mousterian. It is apparently well represented in the [illegible], where the other, where it is associated with an important [illegible]. The [illegible] according to a [illegible], [illegible] [illegible] [illegible] [illegible] [illegible]

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[illegible], and they were contemporaneous or [illegible] the formation and erosion of the [illegible], in which case the [illegible] is probably older than [illegible] the [illegible] (Bordes, 1953). [illegible] evidence in support of this hypothesis is the [illegible] appearance of [illegible] and their correlation with typical Lower and Middle Palaeolithic [illegible] throughout the [illegible] of Portugal and northern [illegible].

If this scheme were correct, it would be quite important for interpreting [illegible] of stratigraphy, providing a unique example of [illegible] from a [illegible] Palaeolithic [illegible]. However, there are [illegible] objections to this view. In the first place "primitive" typology is [illegible] misleading guide to chronology. The evidence of surface sites [illegible] and, in the absence of stratigraphy, it may refer to very different periods. Secondly, if the small [illegible] were of an early date, cornices of midden attached to the cave walls should extend below the level of the Upper Palaeolithic deposits, and loose, cemented shell material should be stratigraphically interleaved with them. But there is no evidence of this. The most important objection is a series of radiocarbon dates recently obtained from existing in situ shell midden, which give internally consistent results of 9 000 BP and later (Clark, G.A. 1971). The balance of evidence is therefore heavily in favour of a Postglacial date.

The Asturian pic has a wide distribution along the Atlantic seaboard of the Iberian peninsula, from Biarritz in southern France to southern Portugal, and throughout this area it is confined almost exclusively to coastal sites on or very near the shore. With the exception of the shell-midden deposits of eastern Asturias and Santander, the majority of these sites are surface finds, so that nothing certain can be said about the nature of the associated industry or its relationship to other types of assemblage. Even in the stratified midden deposits other artifact types are rare, and the impression is given of an industry composed almost exclusively of pics.

Clearly if the Asturian pic is a functional adaptation to the collection of limpets, then its coastal distribution cannot be taken as evidence of a coastal people permanently confined to the exploitation of resources within the immediate vicinity of the shore. Conversely, if it represents a particular cultural tradition, its presence on surface sites is not necessarily evidence of a shellgathering economy. In short the economic significance of the artifact distribution is a matter of considerable uncertainty, even more so than with the Ertebølle in Denmark, and the pursuit of typological studies is unlikely to throw further light on economic interpretation.

Whatever the significance of artifact distributions, the distribution of shell middens is of a much more restricted nature. Indeed it reveals major discontinuities, both chronological and geographical, and thus presents a combination of features which, in previous case studies, we have considered mainly in isolation.

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[illegible] of the Lebanon gun is a functional adaptation to the collection [illegible] that the general distribution cannot be taken as evidence of a [illegible] presumably confined to the exploitation of resources within the [illegible] of the above. Conversely, if it represents a particular [illegible] tradition, the presence or absence which is not necessarily evidence of [illegible] contact. In short the economic significance of the sickles [illegible] is a matter of considerable uncertainty, even more so than with the [illegible], and the pursuit of typological studies is unlikely to [illegible] light on economic interpretation.

[illegible] the significance of artifact distributions, the distribution of [illegible] is of a much more restricted nature. Indeed it reveals major [illegible], both chronological and geographical, and thus presents a [illegible] of features which, in previous site studies, we have considered [illegible].

The chronological discontinuity is of the type that we have noted generally, namely a relative scarcity of mollusc shells in archaeological deposits before the Postglacial period. An important point about the chronological distribution is that, although there is a major break in shell quantities between the Postglacial and the preceding periods, there is a marked element of continuity in the location of the shell middens and the preceding Palaeolithic occupations. Of the total of 25 known shell middens in Cantabrian Spain, 15 are stratified above deposits containing Upper Palaeolithic material, and this number includes the great majority of the larger shell middens. The remaining 10 shell middens are all Asturian sites, mostly with minor deposits of shell, and in any case within a kilometre or so of Upper Palaeolithic sites.

The geographical discontinuity is illustrated in Figure IX.2. Of the 25 known middens, 20 are situated within the 60 km of coastline between Ribadesella and Unquera in eastern Asturias. The remaining 300 km or so of coastline adjacent to centres of prehistoric occupation have yielded only 5 further shell middens, three of which are in western Santander close to the Asturian border and thus represent outliers of the main Asturian distribution.

One possible explanation of the geographical irregularities in the distribution of shell middens is differential preservation. Vega del Sella (1923) observed that the people who used the Asturian shell middens must have lived in the open in front of the cave, using the entrance literally as a rubbish dump. From this he supposed that other open-air sites of the same period might have existed elsewhere, only to be covered by vegetation and escape discovery, or else to be eroded away without trace. However, open sites are not unknown in this region. The Mousterian site at Unquera is an example (Alcalde del Rio 1911), and the beach at Ciriego in Santander is supposed to have yielded finds of Acheulean and Asturian (Obermaier 1925), although little else is known about the character of the site. Furthermore, the most important of the Asturian shell middens were originally quite substantial mounds, and it is reasonable to expect that open-air sites of comparable importance would have accumulated equally substantial deposits unlikely to escape detection. There is no reason to

[illegible] morphological discontinuity of [illegible] the type that we have called generally [illegible]
[illegible] pattern of [illegible] to morphological [illegible] before [illegible] period. An important point about the [illegible] industries [illegible] there is a [illegible] between the [illegible] and the preceding period [illegible] element of [illegible] portion of the small [illegible] [illegible] of [illegible] [illegible]

[illegible]

[illegible] in numbers of [illegible] [illegible] of which are [illegible] further [illegible] of the [illegible] [illegible].

The possible explanation of the [illegible] interpretation of the [illegible] and their changes in [illegible] characteristics. This [illegible] likely [illegible] that the people who used the [illegible] might [illegible] of the area, [illegible] so [illegible] that it is argued that these [illegible] sites of the same period might have [illegible], used to be affected by [illegible], and [illegible]. [illegible] without [illegible]. However, these sites are not [illegible]. The [illegible] site at [illegible] [illegible] is [illegible] to have [illegible] [illegible], although little [illegible] of the site. Furthermore, [illegible] of the [illegible] with [illegible], and it is [illegible] [illegible] would have [illegible] [illegible]. There is no reason to suppose that such sites would have eroded away either, although destruction by human agency is a possibility, for shell mounds of comparable size and age have survived intact elsewhere in Europe in comparable climatic and environmental conditions, and erosion of the known Asturian shell middens seems to be due precisely to the fact that they are situated in cave entrances, where they would be particularly exposed to the erosive action of water washing down from the walls or roof of the cave entrance, rather than in the open.

Another possible explanation, and one which might seem plausible in view of its successful application in Denmark and Australia, is irregularities in the distribution of the molluscs. It might be postulated, for example, that during the early Postglacial period there was an unusual concentration of molluscs along the shoreline of eastern Asturias, which rendered this area particularly favourable to shellgathering. However, in contrast to our previous case studies, where we were concerned primarily with estuarine molluscs and their sensitive requirements of shelter, salinity, temperature and sediment, the major mollusc in the Asturian middens is the sturdy and ubiquitous limpet, the inhabitant of exposed rocky shores. This is commonly found in quantity throughout the length of Cantabria at the present day and is likely to have been present in similar quantities throughout the Last Glacial period too.

The alternative possibility, and one which follows from the underlying principles established in the preceding investigations, is that the exploitation of molluscs in quantity and their accumulation as middens was influenced by over-riding directives imposed by the non-molluscan resources which formed the basis of the economy. An hypothesis of this type was first put forward after the completion of the field investigations in Spain (Bailey 1973), and it is of considerable importance to the validity of the underlying theory to see how well the hypothesis fares in the light of the subsequent investigations in Australia and Denmark.

An essential prerequisite for the acceptance of this hypothesis is the

demonstration that the Asturian shell middens were seasonal home-base sites focused on an economy in which shellfood played a relatively minor role. This is something that we have found to be generally the case elsewhere, and it would be surprising if it were not also reflected in the Spanish data. It remains to examine in greater detail the nature of the chronological, geographical and quantitative discontinuities of the evidence for shellfood exploitation and the extent to which the elements of the hypothesis outlined above can be elaborated to account for these discontinuities within a unified scheme of interpretation.

In order to provide an effective framework for such an analysis, which offers sufficient time depth and an adequate sample of shell middens as well as of coastal occupations lacking shells to serve as a control, the Upper Palaeolithic and Mesolithic deposits of Asturias and Santander have been included for examination. Occasional reference has also been made to sites in the neighbouring provinces of Vizcaya and Guipúzcoa, in particular the shell midden of Santimamiñe. But no detailed analysis of these areas has been undertaken since the situation is generally similar to that in Asturias and Santander, and any comprehensive study would have added much to the bulk of the investigation but little to the final interpretation.

2. Environment, Resources And Exploitation

Climate

Two factors dominate the climate on the north coast of Spain and probably have done so throughout prehistory: the Gulf Stream, whose temperate influence is thought to have persisted through the period of the Last Glaciation (Vega del Sella 1921, p. 140); and the mountain range of the Cantabrian cordillera, which runs more or less parallel with the coastline and not more than 50 km distant from it. The close proximity of these mountains to the shoreline has several important climatic effects which are

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of direct relevance to economic exploitation. It ensures a high level of precipitation throughout the coastal region; and it causes a rapid decline in average temperature as one moves inland from the coast, a factor which would have been especially marked during the late Pleistocene, when the mountains were an important centre of glaciation.

Generally speaking the climate of the present day may be described as Oceanic Temperate, with cool winters, warm summers and ample rainfall in all seasons. Given the combined influence of the Gulf Stream and the Cantabrian mountain system, this remains a broadly accurate description of the climate at most periods with which we shall be concerned, although there are some differences of potential economic significance between the Last Glacial and the Postglacial period which require examination.

The Present-Day Climate

Mean annual temperature on the coast is about 12 to 13°C, with mean temperatures of 8 to 9°C in January and 19 to 21°C in August. Minima of -4°C and maxima of 39°C have been recorded, but generally temperatures rarely fall below freezing or exceed 30°C (Solé Sabarís 1952; Gilbert & Beckinsale 1941). High levels of humidity prevail on the coast during the summer, which may aggravate the effect of temperature. Major geographical variation in temperature occurs from north to south, chiefly as a result of changes in altitude. As a rough guide it may be assumed that mean temperature declines by about ½°C for every increase in altitude of 100 m (Vega del Sella 1921).

Annual rainfall is everywhere in excess of 1 000 mm, being slightly higher in the east than in the west - 1 397 mm at San Sebastian compared with 1 034 mm at Gijon - and markedly higher with increasing altitude - more than 2 000 mm above 1 000 m for example (Solé Sabarís 1952; de Terán 1952). Distribution throughout the year is fairly even, with some rain every other day on average. But there is a peak in the winter months, from about October to January, when monthly rainfall is up to 130 mm, and a trough in [illegible]. It requires a high level of [illegible] throughout the [illegible] and [illegible] a rapid [illegible]

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The mean temperature [illegible]

[illegible] to 2°C [illegible]. Minima of [illegible]

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[illegible] High levels of humidity prevail on the coast during the [illegible] which may aggravate the effect of temperatures. [illegible] of temperature [illegible] from south to north [illegible]. As a rough guide it may be assumed that mean temperatures [illegible] by about 1°C for every increase in altitude of 150 m [illegible]

Mean rainfall is [illegible] of 1 000 mm, [illegible] the east than on the west [illegible] 700 mm [illegible]

[illegible] up to 500 mm, [illegible]

July and August, with monthly rainfall of about 48 mm. Lack of water is unlikely to have been a limiting factor on the human economy, although the seasonal variations of rainfall are of some relevance.

Snow cover is an important seasonal factor influencing economic exploitation in the region today. There is no permanent glaciation in the Cantabrian mountains under present climatic circumstances, although the theoretical figure for the permanent snowline can be estimated as 2 900 m in Asturias (Obermaier 1915) and 2 400 m in Guipúzcoa (Kopp 1965). During winter, however, there are heavy snowfalls on high ground. The winter snow-line is about 1 650 m or lower (Obermaier 1915) and roads are usually blocked above 1 400 m and sometimes as low as 1 000 m (Gilbert & Beckinsale 1941). Thus snow cover renders large areas inaccessible to economic exploitation during winter. Only low ground near the coast is relatively free from snow cover, with no more than two days of snowfall per month, even in January, and this does not accumulate to any depth.

Climate during the Last Glacial

The late Pleistocene climate of Cantabria has been compared to present-day Scotland (Obermaier 1925) and southern Norway (Vega del Sella 1921), that is to say a climate which retains its general oceanic features but which has colder and more snow-bound winters than modern Cantabria. Precipitation would have been about 67% of the present day but with much the same seasonal distribution (Kopp 1965), while temperatures would have been lower by about 6°C in Asturias (Vega del Sella 1921) and by somewhat more in the Basque region (Kopp 1965). However, neither change is likely to have had much direct influence on patterns of economic exploitation. Low temperatures are likely to have rendered the winter a lean season for terrestrial resources whether in the Last Glacial or the Postglacial. But the changes are related to a general lowering of the snow-lines, which may have had a considerable influence on patterns of seasonal movement.

The evidence of terminal moraines suggests that the permanent snowline

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[illegible] (1974), [illegible] would have been formed by about [illegible] However, [illegible] is likely to have had much [illegible] had a considerable [illegible]

[illegible]

during the maximum of the Last Glaciation was lowered to about 1 300 to 1 500 m in Asturias (Obermaier 1925) and 1 050 m in Guipúzcoa (Kopp. 1965), representing a drop of more than 1 000 m from present-day levels. There are few data on winter snow-lines, but if it is assumed that winter temperatures in Asturias were about 2°C, that temperature drops by ½°C for every increase in altitude of 100 m, and that the 0°C isohyet for winter is a reasonable guide to the position of the winter snow-line (Vega del Sella 1921), then it would have been as low as 400 m.

This reconstruction refers to the situation at the maximum of the Last Glacial at about 18 000 BP. Presumably the climate would have undergone progressive amelioration with the various stages of glacial retreat, although exact parameters cannot be established. However, the modern situation and the above reconstruction, especially with reference to snow-lines, do provide a useful guide to the extreme limits of variation relevant to the period we shall be concerned with.

The Postglacial Optimum

Something must be said about the hypothesis of a Postglacial climatic optimum, which is supposed to have occurred during the occupation of the Asturian shell middens. The hypothesis is based mainly on the evidence of molluscan species (Clark G.A. 1971; Vega del Sella 1923). Specifically the Asturian shells differ from their predecessors by the absence of *Littorina littorea* and the presence of *Trochocochlea crassa*. Both are periwinkles found on Cantabrian shorelines to-day and are of similar appearance and economic potential. The former is an Atlantic species, whose present distribution extends as far south as the Canary Islands, while the latter is a Mediterranean species, whose distribution extends into the Bay of Biscay (Vega del Sella 1916, p. 82). Therefore the absence of *Littorina* from the Asturian period is taken to indicate warmer water temperatures than at present. But, even if this is a correct interpretation - and it is difficult to see how the absence of Littorina for upwards of a thousand years can be

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accounted for in any other way, no information has been brought forward to suggest what order of temperature change this would require or what would have been the relationship of such change to terrestrial climate. Other evidence of climatic change is the cementation of the shells in the Asturian middens, which, according to Vega Del Sella (1923), could only occur with lower precipitation than that of the present day.

There is thus some evidence that the climate of the Asturian period may have been warmer and drier than the present, although the evidence of climatic change is far less substantial than that available in Denmark. In the absence of any reliable quantification of these effects, it is difficult to imagine that climate would have differed to any large degree from the present, given the dominant influence of the Cantabrian mountains, and least of all in ways which would have had a significant effect on the human economy. As we have emphasised in discussing the evidence in Denmark, climatic and geological changes are not necessarily of sufficient magnitude to cause human behavioural changes.

Topography

The Cantabrian mountains dominate discussions of topography as of climate. As already noted, the watershed is rarely more than about 50 km from the coastline and in many cases is much closer, particularly in the area of the Picos de Europa in Asturias, adjacent to the main distribution of the Asturian shell middens. Here the straight-line distance from the highest peak to the nearest shoreline is only 25 km, a distance which gains emphasis from the fact that the Picos are also the highest part of the cordillera, about 2 600 m above sea-level. Elsewhere the mountain range varies in height between about 1 000 m and 2 000 m.

Thus the topography of the area generally is broken and mountainous and as such represents a major limiting factor on economic exploitation, posing

problems of access to resources and restricting the availability of good soil cover to low-lying valleys and coastal plains. As might be expected, the shoreline is an exposed, cliff-bound one, heavily battered by the sea. Easy access to shore resources is possible only at beaches and river mouths, and these are usually widely separated and of limited extent.

Important features are the rasas or coastal terraces, probably of terrestrial rather than marine origin (Hernández-Pacheco 1957). These are more or less level plains which extend along much of the Cantabrian coastline and are best developed in Asturias and Santander, where they offer a strip of fertile ground running parallel to the shore and varying in width from as little as 1 km or less to a maximum of about 20 km.

During the Last Glacial the main outlines of the topography would have been similar to those observed to-day. Apart from occasional local instances of slope-wash (Vega del Sella 1921, p. 11-12), some evidence of tectonic uplift has been claimed on the basis of raised beaches and river terraces, but these are generally thought to result from climatic effects rather than tectonic movement (Cendrero 1932; Vega del Sella 1921), and there is evidence to suggest that the coastline, at least in Asturias, has remained quite stable since Magdalenian times, if not earlier (Hernández-Pacheco 1957).

Eustatic changes of sea-level are an important variable. It is generally estimated that world sea-levels were about 130 m lower than the present at the maximum of the Last Glacial (Emery & Milliman 1970). Assuming that the coastline has remained tectonically stable since that time, this would have had the effect of extending the coastal plain by a maximum of about 15 km and an average of 5 km, a highly significant factor in assessing the territories of many coastal sites.

Figures IX.3 and IX.4 show the archaeological sites of Asturias and Santander and illustrate the limiting effects of topography on their distribution. Figures IX.5 and IX.6 show the same sites in relation to the areas of good soil cover on the coastal plains and adjacent low-lying valleys. It will be seen that there is an obvious correlation, although there are some [illegible] grazing and natural plants. It might be expected, [illegible]

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Figures 11.7 and 11.8 show the [illegible]

[illegible] Figures 11.5 and 11.6 show the same [illegible]

[illegible], although there was some

gaps in the site distribution which we shall examine more closely in the section dealing with patterns of exploitation. Also shown is the 50 fathom (c. 90 m) submarine contour, which is the nearest available equivalent to the maximum drop in sea-level.

Vegetation

The natural climax vegetation under present-day climatic conditions is deciduous forest dominated by oak, *Quercus spp.*, although much of this has been cleared by recent human activity or replaced by economically more valuable species such as eucalyptus. Above 700 m oak gradually gives way to beech, *Fagus sylvatica*, as the predominant species. Above about 1 900 m deciduous trees are replaced by conifers, mainly pine, *Pinus sylvestris*, which extends up to about 2 600 m (de Terán 1952). On slopes with poor soil cover a subclimax association of shrubs and ferns, called *matorral* or *monte bajo*, is commonly found, and at higher altitudes it is often associated with mosses and lichens in a type of moorland formation.

During the Last Glacial the major variation would most probably have been the lowering of the tree lines. Taking temperature as a guide, and using the conversion factors established for Last Glacial temperatures in the preceding section, we should expect the deciduous forest to have been dominated by beech and to have extended up to about 700 m, with the coniferous tree cover extending to about 1 400 m at the maximum of the Last Glacial.

Pollen diagrams from the Santander caves of Pendo, Morín and Otero (Leroi-Gourhan 1966, 1971a, 1971b) suggest that, in fact, oak maintained its position without apparently giving way entirely to beech. Pine is also relatively rare or absent at the first two sites, whereas it is the dominant tree species at Otero, a difference which probably represents the varying location of the sites with respect to the 700 m contour. It is difficult to judge how much weight should be attached to these results as a guide to the local vegetation pattern in view of the marked changes of altitude within

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close proximity to the pollen cores and the inherent biases of pollen diagrams. But they would not appear to conflict with the expected pattern except to suggest that oak woodland persisted at least throughout the latter part of the Last Glacial in some lowland areas.

The Meseta

The central plateau or meseta requires some discussion since it is an area of potential importance as a seasonally complementary zone.

The meseta is an extensive upland plateau at least 500 m above sea-level with a climate of continental type. Mean temperatures at Burgos in January are 2°C and in August 19°C, with minima of -10.8°C and maxima of 35°C (Solé Sabarís 1952). Precipitation is about 600 mm with maxima in spring and autumn and minima in July and August (Gilbert & Beckinsale 1941). From November to April much of this falls as snow and lies for quite long periods. Reinosa, for example, has 33 days of snow in an average year (Hernández-Pacheco 1944).

Vegetation is broadly of Mediterranean type, although much of the landscape is now dominated by cultivation. Otherwise the main vegetational association is Artemisia steppe with occasional patches of ilex and box (de Terán 1952), a pattern which appears to have remained unchanged since at least 10 000 years ago (Menéndez Amor & Florschütz 1963).

The general situation is unlikely to have differed much during the Last Glacial. If anything winters would have been longer and colder and summers shorter and less arid (Obermaier 1925).

Terrestrial Resources: Animals

The animal biotope is a relatively rich one and the principal species available for exploitation during the prehistoric past were red deer, Cervus

elaphus; the large bovids, including aurochs, Bos primigenius, and bison, Bison priscus; horse, Equus caballus; ibex, Capra pyrenaica; chamois, Rupicapra rupicapra; roe deer, Capreolus capreolus; and pig, Sus scrofa (Altuna 1971a; Freeman 1973). Reindeer, Rangifer tarandus, occurs sporadically in the Last Glacial but does not appear to have made any significant contribution to the diet (Altuna 1971b).

Table IX.2 presents some general data on the relative importance of these species in archaeological sites throughout Cantabria. There is a total of 132 Palaeolithic and Mesolithic deposits from 51 sites with faunal identifications and 73 levels from 19 sites with some indication of relative proportions, so that it seems reasonable to expect to find some broad trends in such a large sample, even if the data are of variable quality. Some measure of the consistency of the data may be derived from the fact that a similar ranking of species is obtained by listing both in terms of presence/ absence and in terms of number of occurrences as dominant and codominant species. From this it will be apparent that red deer, although by no means the exclusive focus of exploitation, is pre-eminent.

TABLE IX.2 - General Data on the Representation of Mammalian Fauna in Prehistoric Cantabria

Species	Presence/Absence No. of Occurrences in 132 Levels from 51 Sites	Dominant/Codominant No. of Occurrences in 73 Levels from 19 Sites
Cervus elaphus	121	59
Equus caballus	89	13
Capra pyrenaica	73	8
Large Bovids	72	6
Rupicapra rupicapra	53	3
Capreolus capreolus	51	1
Sus scrofa	47	1
Rangifer tarandus	20	1

Sources: Altuna 1971a; Clark G.A. 1971; Freeman 1973

[illegible]

Table IX.3 presents some more detailed data about relative proportions. Particular attention is directed to the figures for the Last Glacial, which refer to Solutrean and Magdalenian occupations in Asturias and show that red deer accounts for between 28% and 78% of the total in terms of minimum individuals. Horse and bovid are also quite prominent, a feature which is thrown into sharper relief when the data are expressed in terms of meat weights. But the overall predominance of red deer is clear enough, and similar high percentages have been recorded from deposits of a comparable period at Cueva Morín in Santander (Freeman 1971) and at Aitzbitarte in Guipúzcoa (Altuna 1963).

As regards long-term changes, the major feature of the archaeological record is the continuity in the representation of species. Apart from reindeer and bison, which had disappeared by the Postglacial period, presumably in response to climatic change, all the other species persisted throughout the period with which we are concerned in this investigation, although there are some changes in relative representation which require comment.

Broadly speaking there are two trends over time. The first concerns the red deer, which undergoes some fluctuation in relative representation. It appears to have been less important in the earlier part of the Last Glacial according to the evidence from the Gravettian and Solutrean levels at Castillo (Altuna 1971a, Obermaier 1925) and the Mousterian and Aurignacian levels at Morín (Freeman 1971), where horse and bovid predominate. But thereafter deer becomes a persistently important item in the mammalian diet, and if there is any chronological trend during the Last Glacial it is towards an increasing dependence on deer at the expense of other species (Freeman 1971), a dependence which persists into the Mesolithic occupations of the Postglacial and, according to the evidence of Santimamiñe (Aranzadi *et al.* 1931) and of Marizulo (Altuna 1967), until at least the end of the Neolithic period. In this respect the situation in Cantabria is closely comparable to the evidence of deer exploitation elsewhere in prehistoric Europe (Jarman 1972a).

TABLE IX.3 - The Relative Representation of Mammalian Fauna in Deposits of the Last Glacial and the Postglacial in terms of Minimum Individuals and Meat Weights

Site		Cervus %	Equus %	Bovid %	Capra %	Rupi-capra %	Capre-olus %	Sus %	Total Mind/Kg
Last Glacial:									
Cueto Mina	Mind	46	19	12	16	5	2	0	57
	Kg[a]	33	25	35	6	1	0	0	7 910
Bricia	Mind	28	19	6	29	6	6	6	17
	Kg	27	29	22	14	1	1	6	1 850
Lloseta	Mind	78	5	2	6	6	2	1	166
	Kg	70	8	6	3	12	0	1	18 670
Cierro	Mind	62	16	10	2	4	2	4	55
	Kg	43	21	31	1	1	0	3	7 770
Cova Rosa	Mind	45	17	3	14	14	7	0	29
	Kg	45	31	14	7	3	0	0	2 920
Postglacial:									
Marizulo[b]	Mind	33	0	0	9	0	29	29	21
	Kg	44	0	0	6	0	5	45	1 600
Asturian[c]		A	P	P	P	P	P	A	-

a. - Individual meat weights are based on Freeman 1973, p. 22
b. - Altuna 1967
c. - Clark, G.A. 1971, Table 1. A = Abundant; P = Present

The second trend is the fluctuation in the relative representation of horse and bovid, on the one hand, and pig and roe deer, on the other, which is probably related to changes in the vegetation cover from more open to more wooded conditions respectively. Indeed there appears to be a consistent increase in the two woodland species at the expense of horse and bovid throughout the latter part of the Last Glacial, a trend which reaches its culmination in the Postglacial period, as is shown in Table IX.3. The

emergence of pig as a major food item in the Postglacial is particularly apparent, although deer also maintains a relatively high representation as well, a combination which closely parallels the situation in Denmark of the Ertebølle period. But, apart from these changes, there is little in the data to suggest major transformations of the animal biomass with the transition to Postglacial climatic conditions, and the emphasis on red deer is a major continuity throughout.

Plant Resources

There is no positive archaeological evidence of plant-food exploitation, so that little can be added to the discussion of this problem in connection with prehistoric Denmark in Chapter VIII, except to reiterate the conclusion stated there, that plant foods may have been a staple resource but are unlikely to have exceeded in overall importance the mammalian food supplies. In any case it is worth emphasising that, in so far as the major focus of the present investigation is the relationship between marine and terrestrial resources, the apportionment of the terrestrial sector between plants and animals is to some extent immaterial. The exploitation of plant foods is, in general, subject to similar limitations imposed by the time-distance factor as the exploitation of animal foods, and it is arguable that the use of site territories and the organisation of annual territories in relation to seasonally complementary zones would follow a somewhat similar pattern whether human groups extracted their food energy directly from the plant biomass or indirectly through an animal converter. Thus, although the remainder of this investigation will be developed on the assumption that the mammalian resources provide the main key to the organisation of the terrestrial economy, it is thought unlikely that any shift of emphasis in interpretation to plant foods would necessarily affect our conclusions about the use of territory in relation to the sea-shore.

[illegible] in the background, is particularly [illegible] with [illegible] relatively high representation of [illegible] the [illegible] of the [illegible]. [illegible], there is little in the data [illegible] in [illegible] a major [illegible].

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[illegible] The significance of these [illegible] is, in general, [illegible] by the [illegible] of the [illegible], and it is [illegible] that the use of this [illegible] in relation to [illegible]. [illegible] Thus, although the [illegible] of this [illegible] [illegible] be [illegible] that [illegible].

Marine Resources

There is little detailed information about fish, but it is probable that species such as flounder (Pleuronectes sp.), wrasse (Labrus sp.) and gar-fish (Belona sp.), would have been available, judging by the modern potential of the coastline, and cave paintings and engravings suggest that they were also available throughout the Last Glacial (Madariaga 1969). Another species which may have been of some importance is salmon (Salmon salar), for which the rivers of eastern Asturias are renowned (Ross & Stonehewer-Cooper 1885). The salmon make their spawning migration upstream from the beginning of winter through to spring, with the main season lasting from February to June. Since Cantabria is at present on the southern margins of the salmon distribution, it is probable that the salmon would have flourished in the area throughout the Last Glacial. In general, however, the Cantabrian coastline is relatively unproductive of fish, at least in the immediate vicinity of the shore, since there are few inshore waters suitable for feeding and spawning (Beckinsale et al. 1944), and this is likely to have been a major limitation throughout the prehistoric period.

In keeping with the nature of the shoreline the dominant molluscs are rocky-shore species, principally Patella vulgata, the limpet. All the major types of bivalves occur, but quantities are limited by the lack of extensive river estuaries. The limpets would certainly have flourished throughout the Last Glacial period, but the area was probably marginal for most of the bivalves because of low temperatures. As regards seasonal availability, Patella spawns on the north Spanish coast at the present day in spring, from about March to May (Madariaga, pers. comm.). Assuming that the most favourable period for exploitation is in the months immediately preceding spawning, when the gonads are ripening, this would suggest late winter or early spring as the best season. However, during the Last Glacial the season is likely to have been a little earlier, by analogy with Britain, where the spawning period is October to December, suggesting an optimum

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season of exploitation in autumn (Fretter & Graham 1962, p. 495).

As for other aquatic resources, seals were available, at least during the Last Glacial, but the only evidence of exploitation is a single seal tooth (Phoca sp.) from the Solutrean level at Altamira (Breuil & Obermaier 1935) and a doubtful engraving at Candamo (Hernández-Pacheco 1919), scarcely sufficient to justify detailed examination of this resource. Crabs (Cancer pagurus) and sea urchins (Paracentrotus lividus) have left their remains in the Asturian middens, but were most probably exploited as a casual or supplementary resource.

Exploitation

Following the pattern of the previous case studies, it is possible to distinguish four potentially complementary zones. The first two are the coastal zone and the coastal hinterland, representing the low-lying areas of good soil cover near the coast and broadly corresponding to the coastal rasas and their immediately adjacent areas below the winter snow-line. By virtue of the mountainous topography and the relative narrowness of the coastal plain, combined with the relatively low economic potential of the marine resources, these two zones might almost be amalgamated to form a single category. A third zone is the upland areas between the winter snow-line and the watershed of the Cantabrian mountains, and the fourth zone is the upland plateau of the meseta.

The season of optimum economic potential in each zone is relatively straightforward, given the extreme climatic conditions which prevail in the area generally. The coastal lowlands would have been the most suitable areas for winter occupation, with their good soil cover and high grazing potential, their relatively high winter temperatures and their woodland vegetation, and their freedom from snow cover. On the other hand the two upland zones are rendered difficult or impossible to exploit except in spring

and summer. Thus an obvious pattern of integration would be one which incorporated all four zones within a wide-ranging annual territory, extending over distances of 300 km or more. Such distances are not excessive by the standards of long-distance transhumance. For example, sheep and horse herders in central Asia regularly travelled up to 800 km in the course of the year between winter and summer pastures (Forde 1963). In Spain itself there are numerous examples of long-distance transhumance traversing the length and breadth of the peninsula (Fribourg 1910).

Indeed, if we are correct in the assumption that the mammalian resources were a major element in the economy, then it is legitimate to examine the transhumant patterns of the recent historical period, not in any mistaken belief that modern behavioural patterns in their entirety can be uncritically extrapolated with impunity to the prehistoric past, but as a guide to the distribution of grazing resources and the seasonal directives which are likely to have influenced any animal-based economy operating under similar conditions.

The most important animal resource throughout Cantabria today is cattle, Bos taurus, followed by pig and sheep, and until at least the end of the 19th century cattle transhumance was a major element of the economy (de Terán 1947).

From about March onwards the transhumants leave their winter cabañas, moving up to spring pastures at higher altitude, and from May onwards they move up to summer pastures above 1 000 m, ranging up to the watershed. With the first chill of autumn in September they begin to descend again.

Winter is the lean season and large areas of meadows are set aside for winter hay. Additional winter fodder is obtained from the leaves and branches of trees and from fodder crops such as maize and beetroot. The coastal areas are especially favourable as winter zones, for the peak of rainfall occurs in the autumn and early winter, promoting flushes of growth to coincide with the return of the animals from higher ground. There is also a relative lack of snow cover and an early spring growth of new shoots and grasses. As these become exhausted, successive flushes of growth become available at

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higher altitudes, attracting the animals away from the low-lying areas and allowing the winter pastures some respite and a chance of recovery. Climatic and vegetational factors therefore combine to reinforce a seasonal pattern of movement and are likely to have promoted similar movements of grazing animals at all periods.

At the present day large areas of the <u>meseta</u> are given over to cereal cultivation, and the available grazing resources are integrated by long-distance sheep transhumance-routes, some of which extend across the Cantabrian watershed and into the coastal lowland. Thus our four complementary zones are integrated by two mobile economies; a short-distance one based on cattle, which involves movement between the coastal lowland and the summer pastures of the Cantabrian mountains: and a long-distance one which incorporates the grazing on the <u>meseta</u> as a summer resource with winter exploitation on the coast. However, the overlapping of the two systems on the coastal lowland in winter is made possible by a sedentary agricultural element which boosts the supply of winter resources and by the complementary grazing requirements of sheep and cattle. It is thus considered unlikely that such a dual system would have been possible for prehistoric economies based on red deer.

The possibility that a sedentary or near-sedentary economy tied to the resources of the coastal zone existed alongside a mobile economy dependent largely on the resources of the coastal hinterland and the inland zones should be recognised. But a preliminary survey of economic potential suggests that the resources of sea and littoral would scarcely be sufficient to support a shore-based economy throughout the year. In particular the lean season for such an economy, when it would have to depend most on the exploitation of animals in the vicinity of the shore, would be the winter season, precisely the season when its animal-dependent neighbours of the hinterland would be most dependent on the coastal <u>rasas</u> for scarce winter pasture. The two economies would therefore be in competition at the leanest period of the year, and it is highly unlikely that they could co-exist for long without being absorbed into a single comprehensive economic unit.

In any case the seasonal optima of the available marine resources coincide for the most part with the season when people dependent on herd animals would be in closest proximity to the shore, that is to say in autumn, late winter and spring, so that there would be no difficulty in incorporating these resources into a mobile economic unit. Marine resources available in summer could be taken at the beginning of the season, before the group abandoned its winter quarters, or else be left to a sedentary element in an overall pattern of mobile-cum-sedentary exploitation. At any rate an independent, shore-based economic system would seem to have little chance of long-term survival, and as such we would not expect it to leave any visible impact in the archaeological record.

In considering how these patterns of mobile exploitation might have differed under the more extreme conditions of the Last Glacial, the major question arises over the use of the meseta. Vega del Sella (1921) claimed that the severity of climate would have inhibited occupation and that the lowered snow-lines would in any case most probably have blocked the mountain passes across the Cantabrian watershed.

As far as occupation of the plateau is concerned, the climatic data considered above suggest that, although the winter climate may have been more severe during the Last Glacial, the summer climate would not have been greatly different from to-day. If anything, the cooler and less arid conditions would have been more favourable to summer occupation, so that no climatic objection can be raised to such a proposition.

As for the question of access from the coastal lowland, Figures IX.5 and IX.6 illustrate the distribution of prehistoric sites in relation to the 1 300 m contour, which is said to represent the maximum lowering of the permanent snow-line. It will be seen that even at the maximum of the Last Glacial several of the major mountain passes could have been traversed during the summer thaw, assuming that glaciers posed no obstruction.

What is especially significant about the distribution of archaeological sites is that the major groupings of deposits with the densest and longest

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record of occupation - the preferred sites - tend to be situated opposite these gaps in the snow-line. Particular attention is directed to the arc of major sites including Altamira, Pendo, Morín and Castillo, which are grouped around the valley which represents one of the shortest and easiest ascents to the watershed and offers the easiest route of access to the plateau. Also many of the smaller sites are strung along potential routes of access between the major sites on the coast and the complementary zones in the hinterland.

Conversely, areas of lowland situated opposite the higher and less accessible mountain passes which would have been permanently impassable during the maximum of the Last Glacial, notably the area between the Candamo group of sites in west-central Asturias and the Lloseta group in the east, have little or no evidence of prehistoric occupation, least of all during the Upper Palaeolithic period, in spite of the apparently favourable economic potential of the winter grazing resources, and this is not for lack of investigation. Indeed it is significant that the little evidence that does occur in this area consists of occasional surface finds of Lower and Middle Palaeolithic artifacts (González 1968), which refer to a period of warmer climate. Even under present-day climatic conditions, the approach to these higher mountain passes is relatively tortuous and poorly supplied with pasture, and it is probable that similar directives on access to the <u>meseta</u> would have continued to apply throughout the Postglacial, albeit less severely perhaps than during the maximum of the Last Glacial.

It can of course be argued that the distribution of sites is incomplete, highly biased and thoroughly misleading, especially in view of the fact that the majority of the evidence refers to caves and rock shelters. But the relationship between prehistoric occupation, and in particular major preferred sites such as Castillo, and the pattern of access to the <u>meseta</u> is not a coincidence which can be lightly dismissed.

Further support for long-distance seasonal mobility comes from the

evidence of contemporaneous archaeological sites on the northern meseta. Any exploitation of this area is likely to have been a highly mobile one of limited seasonal duration and would thus probably have resulted in a scattering of transitory occupations which, by their very nature, are unlikely to have left much substantial archaeological evidence. But traces of occupation representing almost every major archaeological period from the Acheulean to the Bronze Age have been recorded in this general region.

Of particular importance is the group of some nine sites near Burgos (see Figure IX.1 for general locations), which include artifacts of Mousterian, Gravettian and Magdalenian periods and a fauna of, among other species, red deer and ibex (Santa-Olalla 1925).

The evidence of parietal and mobiliary art is especially interesting. Apart from the well known engraved goats of Penches, there is the perforated baton of deer antler at Cueva de Caballón found with bone engravings which have been compared to those in the Solutrean and Magdalenian levels of Cueto de la Mina on the Asturian coast. Similarly the nearby site of Atapuerca has evidence of paintings whose technique and colouring are said to show similarities with La Pasiega and Covalanas. This evidence of connections with the coast gains in significance from the fact that the Burgos group of sites are situated near the River Ebro, whose head-waters emerge from close below the mountain passes which lead directly down to the major sites on the Santander coastal plain.

Another art site which should be mentioned in this context is Maltravieso near Cáceres in the south-west, some 500 km from the Cantabrian coast, where Upper Palaeolithic paintings of hands, signs and a deer's head have all been compared to the Castillo paintings (Almagro 1960).

Miscellaneous archaeological evidence of mobile exploitation is also to be found on the north side of the Cantabrian watershed. The presence of small quantities of limpets and other marine shells in archaeological deposits, as illustrated in Figure IX.2, sometimes as much as 40 km inland from the

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contemporaneous shoreline, has long been a matter for comment (Madariaga 1964). The site of Bolinkoba in Vizcaya is of particular interest. It is some 30 km inland from the sea-shores adjacent to Santimamiñe and has yielded small numbers of marine shells used for personal decoration. The Marqués de Loriana (1941) thought that these might be evidence of trade with the inhabitants of Santimamiñe in return for deer antler, which is totally lacking from Bolinkoba. However, the absence of antler from the inland site might equally be explained by the fact that it represents occupation only during summer, when the antlers of any deer culled within the vicinity would have been in velvet.

Sporadic evidence of red-deer antlers is scattered throughout the prehistoric deposits of Cantabria but is too meagre and poorly documented to justify detailed analysis. However, both shed and unshed specimens are generally present, which is at least positive evidence of occupation in winter and spring, even if it does not exclude occupation in summer. Altuna's (1971b) seasonal analysis of six reindeer teeth from sites in the Basque provinces is also worth mentioning. The dates range from January to June/July, which is not inconsistent with seasonal occupation extending through winter into spring or early summer, especially if allowance is made for the inaccuracies of the technique (Sturdy 1975), although Altuna prefers to interpret the results in terms of year-round occupation.

3. Midden Analysis

Although no detailed quantitative analysis of individual sites could be carried out, several general observations can be made about the character and distribution of the shell middens and the approximate quantity of molluscs involved. As in the discussion of mammalian fauna, the large sample of sites available compensates to some extent for the lack of details from individual deposits.

Marine mollusc shells occur in numerous sites and in association with

most periods from the Mousterian up to the Bronze Age or later. Although quantitive data are usually lacking or incomplete, it is possible to make a distinction between two broad categories of shell middens: "deposits-with-shells", in which molluscs occur only in small quantities and are a relatively minor constituent of the deposits; and shell middens proper, in which shells are the dominant visible component of the deposit and may occur in sufficient quantity to form sizeable mounds. This restricted definition of the term "shell midden" should be distinguished from the Spanish term "conchero", which is used to describe any deposit containing shells of edible molluscs, irrespective of quantity (Clark, G.A. 1971, Madariaga 1963; Vega del Sella 1923).

The shell middens in the restricted sense are exclusively confined to the Postglacial period and specifically to the period between the end of the Azilian and the beginning of the Neolithic, from about 9 000 BP to 5 000 BP. Some may have continued in use into later periods since the upper part of the deposits sometimes contains pottery, as at Santimamiñe (Aranzadi et al. 1931) and some of the Asturian sites (Obermaier 1925 p. 388), but the chronology of this later development is not well established and the major part of the midden deposits is apparently confined to the time brackets assigned above.

The largest group of shell middens are those associated with the Asturian industry, including at least 21 sites in Asturias (Jordá 1954; Vega del Sella 1923) and two further Asturian shell middens in Santander, at Cueva del las Cáscaras (Obermaier 1925 p. 383) and, possibly, at Cueva del Pendo (Carballo & Gonzaléz Echegaray 1952 p. 38 and 41), although the latter deposit is completely destroyed, and nothing is known about it except that it was described as an Asturian "conchero".

Table IX.4 is a list of molluscan species found in the Asturian middens. As will be seen, the common limpet, Patella vulgata, is the most frequently occurring. According to the quantitative data in Clark (G.A. 1971, table V), limpets account for between about 60% and 90% of the total in terms of minimum individuals.

TABLE IX.4 - The Representation of Molluscan Species in Asturian Shell Middens

In order of frequency:

Patella vulgata	Tuberculata atlantica
Trochocochlea crassa	Charonia nodifera
Mytilus edulis	Haliotis tuberculata
Cerastoderma edule	Astralium rugosus
------------------------------	Tellina tenuis
Ostrea edulis	Oricium sp.
Venerupis decussata	Gibbula umbilicalis
Nassarius reticulatus	Littorina littorea

Species below the dotted line and in the right hand column are represented by isolated specimens only.

Sources: Clark G.A. 1971; Fraga Torrejón 1958.

A third shell midden recorded in Santander is at Cueva de la Chora (González Echegaray et al. 1963). The shell midden at this site has not been excavated, but since it lies on top of deposits containing a late Magdalenian industry, it is presumably of Postglacial date. In Vizcaya only one shell midden is known, at the cave of Santimamiñe, stratified between Azilian and Neolithic levels (Aranzadi et al. 1931). Oysters are the dominant species in both these latter two sites. No shell middens have been recorded in Guipúzcoa.

Data on size and quantities are limited. The Santimamiñe midden was estimated to contain 76 m^3 of deposit with more than one million shells - that is about 10 000 shells/m^3 (Aranzadi et al. 1931). The Chora midden cannot have been larger than about 10 m^3, judging from the published plan, representing some 100 000 shells by analogy with Santimamiñe. Erosion of the Asturian shell middens naturally makes size estimation more difficult, but the largest are reported to have been up to 50 m long and 12 m high (Obermaier 1925 p. 386). Assuming a cone-shaped formation, an approximate

volume of 1 000 m^3 can be reconstructed from such dimensions, representing at least 10 million shells.

Estimation of mean annual shellfood output from such data is subject to very large uncertainties, given the lack of detailed radiocarbon dates and the lack of information about the size of other middens, but Clark's radiocarbon dates for the Asturian suggest a total duration of at least 2 000 years (Clark, G.A. 1971) and thus allow a very crude approximation. Making the generous assumption that all 21 Asturian shell middens had the dimensions of the largest site noted above, the total volume would be 21 000 m^3 and the mean annual increment 11 m^3. Making the further assumption that 1 m^3 of midden represents about 150 kg of molluscan meat or about 75 000 kcal, by analogy with the Danish and Australian data, mean annual shellfood output can be estimated as 825 000 kcal or 330 man/days of food per year. That is enough to feed 25 people for about 2 weeks or 5 people for about 2 months. Since the main group of middens extends along about 30 km of shoreline, this is an exceptionally low result.

A check on this figure can be derived from the data on modern output discussed in Chapter III (p. III :10), which suggest a meat output of about 140 kg/km of shoreline under ideal conditions for limpets. Hence 30 km of shoreline should be capable of producing a maximum of some 4 200 kg of limpet meat, which is equivalent to 21 x 10^5 kcal or 840 man/days of food - enough to feed 25 people for about 1 month and 5 people for about 5 months in the year.

Such a figure assumes a continuous shoreline of shallow, shelving rock platforms, whereas in practice the Asturian coastline consists mostly of cliffs alternating with sandy beaches and may be assumed to have had much the same character in the earlier Postglacial, so that a lower figure for shellfood potential would be more realistic. A reduction to about 25% does not seem excessive to suit the Asturian conditions, in which case total potential shellfood output for 30 km of shoreline would be 210 man/days.

At any rate the modern data are within the order of magnitude derived from the archaeological estimate, and, although there is a considerable range of variation in the results, there is little support for the assertion that shellfish provided the basis for daily subsistence (Clark, G.A. 1971 p. 1253), unless we assume exceptionally low densities of human population.

Excavated data that would allow some assessment of relative shellfood output are unavailable, and in this context we can do no better than refer to the data of Table IX.3 (p. IX : 17), which at least show that mammalian resources were exploited from the shell middens and represent a range of species which does not differ to any significant degree from inland sites of a comparable period such as Marizulo.

Turning to deposits-with-shells, typical of so many Palaeolithic levels in coastal caves, a quite different picture of shell quantities is presented. Quantitative data are scarce, but about 700 shells are recorded from Magdalenian and Solutrean levels at Altamira (Cartailhac & Breuil 1906) and rather smaller quantities at Aitzbitarte (Barandiarán 1961, 1964, 1965) and Urtiaga (Barandiarán 1960), to name the best available records. Even allowing that the recorded quantities form only a percentage of the total represented by the whole deposit, it is clear that the numbers involved are of quite a different order of magnitude from those found in the Postglacial shell middens, and this generalisation appears to hold true for other Palaeolithic deposits in which shells have been found. There is some suggestion that there may have been a gradual increase in the number of shells collected towards the end of the Palaeolithic sequence, but there are not really adequate data to test this proposition. All that can be reliably stated is that shells of edible molluscs were deposited in small quantities during most periods from the Aurignacian to the Azilian, and that any variations in quantity from one period to another are of minor significance in comparison with the major quantitative break represented by the post-Azilian shell middens, in which shells are numbered in millions rather than hundreds.

It would thus seem to be well established that there are major discon-

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tinuities, both quantitative ones through time and geographical ones in the representation of shell middens, in the strict sense of the term, along the Cantabrian coastline. It would also seem to be highly probable from the quantitative data already presented that shellfood was a relatively minor element in the coastal economy, so that the way is thus open for a closer examination of the directives on coastal site location imposed by the non-molluscan resources and in particular the terrestrial mammals.

4. Site Catchment Analysis

In order to simplify the dynamic aspects of the economic record and to provide some control over the data, two contrasting periods of time have been chosen for especial emphasis and comparison. At one extreme there is the situation which obtained at the maximum of the Last Glacial, about 18 000 to 16 000 BP, when snow-lines and sea-levels were at their lowest. At the other extreme there is the situation of the early Postglacial, when climatic conditions approximated those of the present day. While accepting that these two periods are arbitrary points on a continuum, they do represent the extreme limits of variation in those environmental changes which are likely to have had most impact on economic organisation. They also conveniently coincide with two archaeological periods which are particularly well represented, namely the Lower Magdalenian and the Asturian, and which are characterised by contrasting evidence of shellgathering.

Sites

The sites available for analysis are, almost without exception, caves and rock shelters. Numerous art sites occur in the area, but these have been excluded from consideration, except in so far as they contain evidence of occupation.

A problem that has to be dealt with here is the possibility that the known archaeological sites reflect the distribution of available caves and rock shelters rather than the distribution of prehistoric settlement. For example, it might be argued that caves were chiefly important as shelters used on an occasional basis, highly atypical of the normal habitation site but favourable for the preservation and discovery of archaeological materials, whereas the home-base sites of greatest importance in the pattern of settlement were open sites which have so far escaped detection. The results of the Australian analysis are a reminder of the discrepancies which may occur between the archaeological visibility of durable materials and their occupational significance.

However, there are several objections to this view. In the first place there are many hundreds of caves distributed throughout the Cantabrian zone, of which more than 100 contain some evidence of prehistoric occupation. It seems improbable that none of these coincided with locations favourable for use as home bases. Even if the caves themselves were used only on an occasional basis or by a small part of the community, the Australian data show that occasional sites often cluster in the vicinity of home bases, even though the latter may be archaeologically invisible.

Secondly, the manufacture of stone artifacts is a well-developed tradition with no lack of raw material throughout the area. Numerous isolated specimens of Lower and Middle Palaeolithic artifacts have been found in the open (e.g. González 1968), so that substantial open-air sites, where presumably the manufacture and utilization of stone tools would have been most frequent, should stand at least an equal chance of discovery.

Thirdly, not all potentially habitable cave sites do in fact contain traces of occupation, and, of those that do, some clearly contain more abundant material and were used over a greater span of time than others. While not excluding the operation of biases, it seems reasonable to expect the existing sites to reflect some preferences in the choice of occupation site and to

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Thirdly, not all potentially [illegible] were [illegible] in their earliest [illegible], many of those that [illegible] clearly [illegible] and were [illegible] a greater span of time than others. While any [illegible] of history, it seems [illegible] to expect the [illegible] provide some information about the uniformities of human settlement in the area. Unless there are obvious reasons not to do so, for example lack of exploration or obvious differentials of preservation, it has been assumed that the available distribution of sites can be accepted as an initial basis for investigation.

Assessment of contemporaneity also poses problems, as always, compounded in this case by lack of radiocarbon dates and by sequences extending over many thousands of years with numerous potential gaps in their occupation. The device of treating artifact assemblages which are typologically similar as contemporaneous must, of necessity, be assumed to provide the chief guide, an assumption which seems acceptable at least on a long time-scale.

A total of 83 sites is available for analysis in Asturias and Santander (Figures IX.3 and IX.4). A complete list is presented in Appendix D with details of the archaeological periods represented at each site. The small group of sites to the west of Oviedo has been excluded from further analysis. The remainder are considered in greater detail as the analysis proceeds.

Resource Potential

Only three resource categories have been used in the analysis: good grazing; rough grazing; and marine. As in Denmark the two terrestrial categories refer to differences of soil cover rather than vegetation. The major limiting factor on soil cover is topography, as might be expected in such mountainous terrain, and it has been assumed that this would have been the major influence on economic potential. This is borne out to some extent by the modern pattern of land use, which broadly corresponds to soil and topographical features. Indeed, extensive use has been made of the 1 : 50 000 maps of land use of the area to check and supplement observations in the field.

The modern land use can be divided into six categories, which is over-detailed for our purposes, but it is worth noting what they represent in economic terms and how they relate to the simpler classification used here.

Three categories correspond to good grazing. They are: prados, representing cultivated meadows which yield at least one crop of hay per year; pastos, referring to permanent meadows grazed by livestock; and labor, which is arable land, a relatively insignificant category, since most fertile ground is used for animal production. The three categories corresponding to rough grazing are: monte bajo ("low forest"), which represents thickets of bushes and shrubs with sparse browse, mainly important as a source of fodder for cattle and pannage for pigs; monte alto ("high forest"), mature forest and the least productive of all the categories, being used to-day mainly for timber; and erial a pastos, which are natural pastures, usually on steep ground or at higher altitude.

In an area where topography is the major limiting factor on soil cover, some consideration must be given to the possibility of changes resulting from deposition or erosion which may have taken place since the period of prehistoric occupation. Local occurrences of erosion and alluviation in the vicinity of stream beds have already been referred to in the climatic section above. Areas of high altitude are also likely to have undergone some changes of soil cover caused by glaciation or periglacial phenomena. Apart from this, however, there are no other records of major transformations of soil cover within the prehistoric period, and the possibility of such change has been discounted except where the local effects referred to above are likely to have had a major impact within the territories of the archaeological sites considered in the analysis

Coastal Site Territories

Of the total number of 39 sites available for study in eastern Asturias, some 27 are located on or close to the sea-shore. Not all are of equal weighting, however, and the territorial analysis is focused on those sites which have yielded the largest quantity of artifacts and food remains and the longest sequences - the preferred sites, on the assumption that these are

likely to be of greatest occupational and economic significance. Length of occupation has been assessed mainly by the number of archaeological periods represented, according to the data in Appendix D. In the absence of detailed quantities or radiocarbon dating, conclusions are necessarily tentative and open to revision. But, even allowing for the potential biases involved, there are some striking patterns.

Of the 27 coastal sites, 21 have only one or two periods of the possible maximum of 10 represented. Thereafter there is a sharp break. There is only one site (Arnero) with three periods, two sites (Cierro and Lloseta) with four periods, two sites (Riera and Balmori) with five, and just one site (Cueto de la Mina) with seven periods. Considered from a territorial point of view, these six sites can be reduced to two groups: Lloseta and Cierro on the one hand, and Riera, Balmori, Cueto de la Mina and Arnero on the other, the sites within each group being so close as to have virtually identical site territories.

It is also noticeable that many of the smaller sites cluster within one or other of these major groups, five additional sites in the case of the former, and seven additional sites in the latter. The clustering of so many sites within what is effectively the same site territory is strongly reminiscent of the coastal home bases in Australia, where several sites formed the core of a loosely defined home-base territory, although it is not possible to be sure with the Spanish data what was the precise function of all the sites within each cluster. Some of the smaller sites may have been used as occasional shelters, or transitory sites with specialised economic functions, or as an alternative focus for home-base exploitation. It seems probable, however, that some of the sites were pre-eminent within the cluster, judging by the number of occupation periods represented, and it is certainly the case that Lloseta and Cueto de la Mina are two of the richest sites in Asturias in terms of artifacts and faunal material, at least during the Magdalenian period (Jordá 1958). Thus all these various features strongly suggest that we are dealing with two major home base clusters.

[illegible]

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[illegible]

A third cluster, rather less well-defined than the other two, is identifiable, comprising the sites of La Franca, Pindal, Colombres and Unquera. However, apart from the nearby site of La Loja, which has rather poorly described evidence of Upper Palaeolithic occupation, and which does not properly belong to the coastal cluster anyway, there is no apparent record of substantial archaeological material until the Asturian period at La Franca, either because the area was not economically important until a late period, or because sites have been destroyed on a larger scale than elsewhere. The art site of El Pindal is high up in what is now a coastal cliff overlooking the sea, so that it seems possible that habitable caves occurred elsewhere in this outcrop at periods of lower sea-level and were subsequently engulfed. If there was indeed a home-base cluster in this area of comparable importance to the other two, then over half the total number of known sites in eastern Asturias are subsumed within three major groupings, representing only three distinct site territories.

A territorial perspective also casts doubt on the common assumption that the number of sites occupied within a given period can be taken as an index of economic productivity and population size. On the face of it the totals recorded in Appendix D suggest that there were marked fluctuations in density of occupation, with a general trend towards population expansion over time, culminating in some sort of peak in the early Postglacial, when the Asturian is represented at 21 sites. Quite apart from the biases in the archaeological visibility of different periods, caused by the differential occurrence of distinctive and easily recognisable artifact types, such as Solutrean laurel leaves or Magdalenian bone work, or of durable materials, such as mollusc shells, such an interpretation fails to take account of the very different occupational significance of transitory sites and home bases.

The most outstanding feature in the chronological distribution of the coastal sites is their territorial continuity, although the precise focus of each site territory may have varied from period to period according to micro-

[illegible] third cluster, rather less [illegible] than the [illegible] two, is [illegible], comprising the sites of La [illegible], [illegible], [illegible] and [illegible], however, apart from the [illegible] site of [illegible], which [illegible] evidence of [illegible], and which [illegible] belong to the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

A territorial [illegible] [illegible], that [illegible] of sites [illegible] the [illegible] of [illegible] productivity and population [illegible]. On the [illegible] of [illegible] it [illegible] that [illegible] were [illegible] the [illegible] of [illegible], with a general trend towards [illegible] over time, [illegible] in some [illegible] to the [illegible], when the [illegible] [illegible] that the [illegible] in the [illegible] of different periods, [illegible] by the differential occurrence of [illegible] and [illegible] types, such as [illegible], as of [illegible] materials, such as [illegible], such an [illegible] to [illegible] of the [illegible] significance of [illegible] sites and [illegible].

The most [illegible] the [illegible] distribution of the [illegible] sites in this [illegible], although the [illegible] of [illegible] may have [illegible] from period to period [illegible] to [illegible].

locational factors which now elude analysis. It is also apparent that there are some differences over time in the number of occupation periods represented in each cluster of sites. Only the Cueto de la Mina group has all 10 archaeological periods represented, from the Acheulean to the Asturian. The Lloseta cluster lacks any record of Acheulean or Gravettian, while there are rather more gaps in the La Franca group.

Whether these features reflect local divergences from the general trend or factors of differential preservation is hard to judge. Whatever the correct explanation, the overall picture suggests remarkably little evidence of major change in territorial organisation from at least as early as the Mousterian period through to the Asturian. Even the latter period conforms to the general pattern, in spite of the larger number of sites recorded. The largest shell middens, in so far as it is possible to judge size differences from the existing data, appear to have occurred at Les Pedroses, San Antonio, Balmori and La Franca, that is close to the core of each main cluster.

Thus in the following analysis attention is focused on only three territories along this stretch of coastline, centred on Lloseta, Cueto de la Mina and La Franca (Figures IX.7 to IX.9).

In Santander a similar pattern prevails. Of the total of 36 sites, 20 can be considered as coastal in the general sense, and these can be grouped into 6 major clusters centred on La Meaza, Altamira, Pendo, Morín, Fuente Francés and Otero (Figures IX.10 to IX.14).

The geographical distribution of these 9 territories is shown in Figure IX.15 and illustrates the close approximation to the expected pattern for home-base sites, providing some further confirmation for our assessment of the home-base function of these coastal sites. But there are some deviations from the ideal pattern, notably at least one instance of a substantial degree of overlap and one example of a gap in the distribution.

The clustering of sites is a matter that we have already commented on, and in most cases the archaeological data suggest as the simplest explanation a grouping of transitory sites, or sites with specialised functions, within

home-base clusters. But in some cases the clustering appears to include more than one home-base site, or at any rate preferred sites with considerable evidence of human activity. The major example is provided by Pendo and Morín, hence the territorial overlap illustrated in Figure IX.15, and it is probable that the nearby sites of Cobalejos and Peña del Mazo are of a similar character, judging by the number of archaeological periods or the quantity of archaeological material represented, and would thus add to the overlap effect, although their territories are not illustrated. Similarly the sites of Lloseta and Cierro should probably be viewed in this manner, although only the Lloseta territory is drawn in.

In our previous case studies, evidence has been presented to suggest that territorial overlap of this sort is related to resources of high economic potential but of restricted distribution or accessibility, a particularly common feature with marine resources. What is interesting about the present examples is that they are related primarily to terrestrial resources, indeed exclusively so in relation to the lowered sea-levels of the Last Glacial. More specifically, they occur in lowland areas situated opposite major routes of access to the complementary zones of the hinterland. They would thus have represented the most accessible areas of winter resources for people and animals moving into the coastal zone and a potentially concentrated focus of seasonal settlement during the winter months for people who dispersed widely throughout the hinterland during the summer.

Conversely, the major gap in the distribution of coastal territories occurs between La Franca and La Meaza, an area which has relatively poor access to the hinterland, especially if summer exploitation of the plateau is involved, and which during the maximum of the Last Glacial would have been permanently barred from direct access by the lowered snow-lines.

The territorial distribution therefore provides an interesting illustration of the problem of access as this applies to the exploitation of terrestrial resources and an extension of the underlying principles which have been abundantly illustrated in our preceding discussions of marine exploitation.

It also provides further support for two propositions which are essential to the successful establishment of the hypothesis which we wish to apply to the Cantabrian shell middens: first, that marine resources are of relative insignificance and that the major draw to occupation of the coastal zone is the winter-grazing potential of the coastal plain; second, that the occupation of the coastal zone is related to and even to some extent dependent on the seasonal exploitation of complementary zones in the hinterland. In this area it is the pattern of access between coastal and hinterland zones which is the major directive on site location and density of settlement rather than the pattern of access between land and sea.

A second feature of the territorial distribution is the way in which it is squeezed up against the coastline in eastern Asturias but swings progressively further away from the coastline as one moves eastwards into Santander. This feature can be directly related to the topography and in particular to the zone of transition between the relatively level coastal plain and the steep, broken relief of the more mountainous country behind. The 200 m and 500 m contours shown in Figure IX.15 provide a useful approximation of this zone of transition. Its importance is that it represents the point where the access routes to the hinterland fan out into the winter-grazing areas of the coastal plain, so that it would have represented a zone of considerable strategic importance in the observation and control of mobile animal resources. A subsidiary advantage is that it brings potentially complementary resources comprising the rough grazing of steeper ground and the good grazing of the coastal plain within reach of a single site location.

Economic Potential: Last Glacial

The relative representation of resource categories in the 9 coastal site territories under Last Glacial conditions is shown in Table IX.5. As a guide to the position of the shoreline during the maximum of the Last Glacial, the 50 fathom submarine contour has been used. This is equivalent

to a drop in sea-level of slightly less than 100 m and is therefore a slight underestimate of the maximum extent of the coast, although it is unlikely to involve serious error. In assessing the territorial boundary for what is now submerged land, it has been assumed that there were no serious limitations on access and that the potential radius of exploitation would have been slightly less than the theoretical maximum of 10 km, to allow for minor topographical variations. It has also been assumed that good grazing and rough grazing would have been distributed in the submerged area in the proportion 3 : 2. If anything, this errs on the low side for good grazing, which is often of greater predominance on the modern coastal plain.

TABLE IX.5 - The Economic Potential of Coastal Site Territories in Asturias and Santander during the Last Glacial

Site Cluster	Terrestrial				Marine
	GG	RG	Total	Percentage of Ideal	
	%	%	Hectares	%	Hectares
Asturias:					
Lloseta	61	39	20 000	64	1 200
Cueto de la Mina	47	53	22 600	71	200
La Franca	53	47	18 800	60	2 800
Santander:					
La Meaza	52	48	19 700	63	-
Altamira	84	16	19 500	62	-
Pendo	54	46	21 000	67	-
Morín	52	48	18 300	58	-
Francés	47	53	18 700	60	-
Otero	32	68	11 300	36	-

As a measure of territorial size, the total area of land is expressed as a percentage of the ideal territory, following our usual procedure. There is some variation in the results, which are generally on the low side, especially at Otero with a figure of 36%, and which reflect the limiting effects of topography on access even in the relatively flat coastal areas.

In general, however, there is an overall uniformity of economic potential throughout. The marine category is almost completely absent, apart from small inroads into the edges of the Asturian territories, which are scarcely significant, and it is thus not surprising that evidence of marine resources of any sort is sparse in all the deposits of this period. The possibility that sites with greater evidence of marine exploitation may have existed closer to the contemporaneous shoreline on what is now submerged ground cannot be excluded, but the territorial data are consistent with the other evidence already examined, which suggest an emphasis on terrestrial rather than marine resources.

The territorial data also show quite clearly why marine molluscs are so rare in the Upper Palaeolithic deposits of these sites. They are all marginally placed or completely out of range altogether for the transportation of shellfood, even for the limpet with its relatively high time-distance factor (Table III.10). We cannot say with certainty whether the available limpet supply of this period was neglected, or whether it was effectively incorporated by foraging activity or by the use of specialised shell middens subsequently submerged. What we can say is that the distances involved are sufficient to account for the low quantities that have been preserved in the existing sites.

On the terrestrial side both good grazing and rough grazing are well represented. Since much of the rough grazing would presumably have been given over to pig and roe deer and, on higher and steeper ground, to ibex and chamois, it is possible that the high representation of this category reflects the complementary importance of these smaller animals in the site economy. On the whole, however, there is not much support for this proposition

As a measure of agricultural value, the total area of land is expressed as a percentage of the total land area, including the small settlements. There is some variation in the results, while the percentages on the low side, generally at those with a figure of [illegible] and which reflect the limiting effects of topography or [illegible] than natural ones.

In general, however, [illegible] of economic potential throughout. The [illegible], upper from such [illegible] into the [illegible] are extremely significant, and it is [illegible] of actual reduction along with or [illegible]. The possibility that sites with [illegible] have adopted closer to the [illegible] ground would be explained, [illegible] to the other evidence already [illegible] that either the [illegible].

The territorial [illegible] the arable [illegible] are in the [illegible] of rough grazing. They are all [illegible] placed as completely [illegible] rough [illegible] the [illegible] of [illegible], even for the [illegible] from the relatively high [illegible] (Table III, [illegible]). It [illegible] whether the [illegible] direct supply of this ground was [illegible], or whether it was effectively [illegible] by [illegible] of [illegible] small [illegible] subsequently [illegible]. [illegible] to [illegible] are sufficient to account for the low [illegible] that have been [illegible] in the [illegible] sites.

On the [illegible] good grazing and rough grazing are well represented. Since much of the rough grazing would presumably have been given over to [illegible], as [illegible] and [illegible] ground, [illegible] then [illegible], it is possible that the high representation of this category reflects the [illegible] importance of [illegible] in the site economy. On the whole, however, there is not much support for this proposition in the relatively meagre quantitative data available from excavation. According to the figures in Table IX.3 (p. IX : 17), the contribution of these smaller animals in terms of meat weight ranges between 7% and 22%. Alternatively the areas of rough grazing may have offered additional grazing or browse for deer, horse and bovid.

One point that is worth making about the presence of chamois and ibex, which are consistently recorded in small numbers in coastal deposits throughout the prehistoric period, is that during the summer they usually range above the tree line as high as the summer snow-line in search of grasses and shrubs and only descend to lower altitude in winter (Corbet 1966). Thus their presence in coastal sites, whose territories are mostly below 500 m, may be taken as a positive indication of occupation in winter. Their disappearance in summer would also have been a contributory factor, albeit a small one, to the lower economic potential of the coastal zone at this season.

Further data on the possibility of seasonal occupation can be derived from estimations of total food output. For this the same procedure has been followed as in Denmark, except that in this case slightly higher deer densities of 1/40 hectares have been assumed. We have also made the further generous assumption that the whole territory would have been favourable for deer, although in fact much of it consists of steep ground and rough grazing. Assuming, as before, individual meat weights of 114 kg, calorific values of 1 400 kcal/kg, and individual human calorie requirements of 2 500 kcal/day, the results for Lloseta, as a typical example of a coastal site territory, are as follows:

$$\frac{20\ 000 \times 114 \times 1\ 400}{40 \times 10 \times 2\ 500} = 3\ 192 \text{ man/days}$$

This has been further increased to 4 560 man/days to allow for the fact that deer account for only 70% of the total animal remains in terms of meat weight (Table IX.3). Thus the total meat output of the Lloseta territory

would have been capable of supporting 25 people for about 182 days or 6 months in the year, and 50 people for half that time. In short, the results admit the possibility of seasonal occupation, and indeed, unless the assumptions on which the calculation is based are wildly in error, or unless we assume exceptionally low population densities or exceptionally high outputs of food other than animal meat, a seasonal interpretation would seem to be the only possible one.

The Postglacial Situation

The major change to be considered in the economic potential of the coastal site territories with the onset of Postglacial conditions is the effects of the rise in sea-level. From the available chronology (Emery & Milliman 1970), it is possible to establish that sea-level was about 10 fathoms (c. 20 m) below the present level at about 8 000 BP, and this has been accepted as an adequate measure of the position of the coastline during the Asturian period.

The Time-Distance Factor for Transportation of Limpets

The first point to be established is the effect of this sea-level rise on the distance between the sea-shore and the coastal sites. Table IX.6 shows the minimum distances of the major coastal sites from their contemporaneous shorelines during the maximum of the Last Glacial and the Asturian period respectively.

It has already been established that the optimum distance for the transportation in quantity of limpets-in-the-shell is about 3½ km or less and that above this distance there is a progressive fall-off in quantities (Table III.10). It is therefore of some importance to note that the major shell middens of the Asturian coastline are all situated within 3 km or less of their contemporaneous shoreline. Conversely, any early Postglacial occupation

TABLE IX.6 - The Distance between the Sea-Shore and the Coastal Sites of Asturias and Santander during the Maximum of the Last Glacial and the Postglacial Period

Site Cluster	Last Glacial (50 Fathom Contour) km[a]	Postglacial (10 Fathom Contour) km[a]
Asturias:		
Lloseta [b]	7	2
Cueto de la Mina[b]	9	3
La Franca [b]	8	3
Santander:		
La Meaza	11	5
Altamira	11	5
Pendo	14	9
Morín	17	12
Francés	22	12
Otero	24	15

a - Distances to the nearest kilometre
b - Major evidence of shell middens

at the major site clusters of Santander would have been marginally placed for transportation of limpets in comparable quantities if not totally out of range. Similarly, all the sites, whether in Asturias or Santander, would have been out of range for the transportation of large quantities of shellfood during the maximum of the Last Glacial, as we have already observed.

Therefore the differential occurrence of shell middens, both with respect to time period and geographical location, can be accounted for solely in terms of the differential effect of rising sea-levels on the distance between the source of shellfood supply and the nearest scene of occupation, without recourse to more complex considerations such as the possibility of population

pressure in the Postglacial, of differential preservation of the data, or of differing local traditions of economic exploitation.

There are, however, some uncertainties in the data, which require comment. The site of Las Cáscaras, belonging to the Meaza cluster, is reputed to have had an Asturian shell midden, although it is some 5 km from the contemporaneous shoreline, whereas Altamira, also at a distance of 5 km, has no such evidence. But no quantitative data are available from Cáscaras, and there is no suggestion in the literature that the midden was comparable in size to the large sites on the Asturian shoreline. The distance of 5 km is in any case approaching a marginal situation for shellfood transportation, so that absence of evidence from Altamira is not especially significant. Pendo is also reported to have had an Asturian conchero at the top of the sequence, but as noted above this does not necessarily imply large quantities of shells, and total destruction of the deposit renders further field observation impossible. The site of Otero also has a shell midden, although some 15 km distant from the 10 fathom contour. In this case, however, the midden is undated; it contains oyster shells rather than limpets; and there has never been any suggestion that it belongs to the Asturian period. It might equally refer to a later date in the Postglacial period, as late as 6 000 BP, by which time world sea-levels had reached to about the present level, in which case the contemporaneous shoreline at Otero would only have been about 3 km distant. The possibility of transporting shellfood would in any case have been improved at this site by the presence of a relatively large river estuary and the consequent opportunities for the use of boats. There is therefore nothing in the available data to justify rejection of the interpretation offered above.

Economic Potential

The second point to establish is the effect of rising sea-level on the general economic potential of these coastal site territories. Table IX.7 shows the relative representation of resource categories under Postglacial

conditions.

The results emphasise the differential effect on sites in Asturias and Santander respectively. Whereas most of the site territories in the latter area were affected scarcely at all, those in Asturias and, to a lesser extent La Meaza, suffered major losses of land amounting to more than 40% of the total formerly available, and it is these territories which are associated with the evidence for Postglacial shell middens.

TABLE IX.7 - The Economic Potential of Coastal Site Territories in Asturias and Santander during the Postglacial

Site Cluster	Terrestrial				Marine
	GG	RG	Total	Percentage of Ideal	
	%	%	Hectares	%	Hectares
<u>Asturias</u>:					
Lloseta	62	38	11 800 (41)	39	10 500
Cueto de la Mina	38	62	13 300 (41)	42	9 500
La Franca	47	53	11 000 (42)	35	11 000
<u>Santander</u>:					
La Meaza	48	52	13 700 (30)	44	6 000
Altamira	89	11	16 100 (17)	51	3 400
Pendo	54	46	20 000 (5)	64	1 000
Morín	52	48	17 100 (7)	54	1 200
Francés	46	54	18 500 (1)	59	200
Otero	31	69	11 000 (3)	35	300

The figures in brackets refer to the percentage loss of land compared with Last Glacial conditions.

Now, according to the logic of territorial analysis, which we have successfully applied in all three previous case studies, any coastal home base where half the site territory consists of open sea or, put another

way, where the amount of land available is half what it would be at a location further inland, must by definition be a site where marine resources supplied a major complement of the site economy. Hence we should expect one of two possible hypotheses to follow in the case of the Asturian sites; either the loss of terrestrial resources resulting from the submergence of nearly half the site territory was compensated by a corresponding gain of marine resources; or the sites ceased to function as home bases.

If we take the case of the Lloseta cluster as a representative example, the amount of land lost relative to Last Glacial conditions is 8 200 hectares, representing some 1 870 man/days of mammalian meat, so that any marine resource that is claimed to offer a replacement must supply the equivalent amount of food.

The first possibility to consider is the shellfish. According to the position of the 10 fathom contour, the shoreline of the Asturian period within the 2 hour territory would have been about 20 km, and this would have represented about 140 man/days of shellfood, applying the data considered above (p. IX : 29) and assuming that the character of the shoreline was similar to the present day. Clearly this is no substitute for the loss of terrestrial resources and indeed represents a mere 5% of the mammalian resources that would have been available in the intact half of the territory. It is clear that shellfood was no more than an incidental item in the exploitation of the coastal area, a result which corresponds with our findings in all the other three case studies, and this resource can be eliminated from further consideration as a major influence on the location of coastal home bases. Similar comments probably apply to the crab pincers and numerous spines and carapaces of sea urchins which have been found in the Asturian middens.

A second possibility is the exploitation of fish. Although some spines and vertebrae of large marine fish have been recovered from the Asturian middens, there is no evidence to suggest that the quantity is greater than that recovered from the Ertebølle mounds of Jutland, where fishing appears to have played quite a minor role in the coastal economy. Rather, the nature

of the Asturian shoreline suggests that the potential for fishing would have been considerably lower in this area. It is also relevant to note the absence from the artifact record of the Asturian period of commonly preserved fishing gear such as bone gorges or spear barbs, fish hooks or net sinkers.

The only fish resource that appears to have been available in potential abundance is salmon. But this is a riverine rather than a coastal resource, and there is no reason to suppose that its successful exploitation would have required a specifically shoreward site location or that it would have been available in lesser abundance during the Last Glacial. As support for both these points we may note the numerous salmon vertebrae that have been found in some Upper Palaeolithic deposits (Fraga Torrejón 1958). Even if we persist in assigning a measure of importance to fish resources, on the assumption that the archaeological record is biased against their preservation, we are still faced with the problem of accounting for the scarcity of coastal middens elsewhere along the Cantabrian coastline, in spite of conditions of access to the shore no less favourable than in eastern Asturias and in spite of the availability of marine resources in no lesser abundance.

In short, if marine resources became a major focus of exploitation during the Postglacial, why is it that the home-base sites centred on Altamira, Pendo, Morín and Fuente Francés did not move closer to the shoreline? There are some Mesolothic sites of an indeterminate character nearer the Postglacial shoreline in Santander, notably Cuchía, Ciriego and Los Moros (Madariaga 1963). But little is known about dating, archaeological contents or quantity of shells, if any, and there is at present no evidence to suggest a substantial shift of occupation towards the modern shoreline with the onset of Postglacial conditions in Santander.

The second hypothesis to be considered is a change in the function of the Asturian sites from home bases to transitory sites, presumably used for the exploitation of shellfish and other supplementary or casual resources near the shore. Here too there is the difficulty that if the formation of transitory sites should have been favoured on this stretch of coastline, why are similar

sites not found in comparable abundance elsewhere in Asturias and Santander as outliers to the home bases situated further inland? There is also the difficulty that no site with any remote claim to be considered as a major home base, whether in the Last Glacial or the Postglacial, has been found in the hinterland behind the Asturian middens. Other objections to this hypothesis are the distribution of the shell middens, which continues to approximate the ideal home-base pattern as in the preceding periods of the Palaeolithic, and the presence of bones of animals such as deer, pig, chamois and ibex, which suggests a continuing emphasis on a wide-ranging exploitation of the terrestrial resources available within the full extent of the 2 hour boundary.

Thus in eliminating the above two hypotheses, we are left with the question of why the encroachment of rising sea-levels in eastern Asturias did not cause the abondonment of the Upper Palaeolithic sites and promote a shift of settlement to the coastal hinterland in response to the considerable narrowing of the coastal plain. Even a cursory glance at the small-scale map of Figure IX.5 shows that quite extensive areas of good grazing would have been available further inland.

On the face of it this would seem to represent an exception to the situation we have observed in the other three case studies, namely the existence of coastal home bases with a large part of their site territories given over to the marine sector but at which marine resources were of minor significance, an exception which might appear to weaken the theoretical basis which has so far provided a consistent interpretation of the previous data.

There is, however, a third hypothesis and one which is perfectly consistent with directives of accessibility and economic potential. For we have already noted how the limiting effects of steep topography in this area tend to impede the pattern of access to resources, distorting the shape of site territories and reducing their size, even on the coastal plain, and this is an effect which becomes more pronounced as one moves away from the coastal plains and into the hinterland. Now, under normal conditions it is true that a coastal

site territory bisected by the sea-shore would have substantially less land available for exploitation than a site territory situated further inland. But in areas of sharp topographical relief the possibility arises that a truncated terrestrial territory situated on the coast may nevertheless have at least as much land available for exploitation as a distorted territory in the hinterland. Thus the continued use during the Postglacial of the Upper Palaeolithic site locations, although relatively disadvantageous by comparison with the conditions of the Last Glacial, would still be the preferred pattern of occupation for economies focused primarily on terrestrial resources. If we can establish that a distortion of this sort does apply to Asturias, we will not only have vindicated the underlying theory of economic directives but we will have supplied the final link in the explanation of the discontinuities in the occurrence of the Cantabrian shell middens. It is to this possibility that the following section is directed.

Inland Site Territories

In assessing the economic potential of the hinterland, a total of 13 site territories have been examined, representing all the major known inland sites. In Asturias there is La Loja (Figure IX.9), Ferrán, Buxu, Meré, Collubil, Hermida and Mora (Figures IX.16 to IX.20); in Santander, Castillo and Hornos de la Peña (Figure IX.21), Rascaño (Figure IX.13), Salitré (not illustrated, but a close neighbour of Rascaño), Valle (Figure IX.14) and Covalanas (Figure IX.22). It is not certain that all these territories were in use during the Last Glacial and the Postglacial - indeed Mora seems to be exclusively Mousterian, but it has been assumed that they offer a representative sample of economic potential in the hinterland at whatever period and thus offer a basis for further discussion. The only major difference between Last Glacial and Postglacial conditions is likely to have resulted from the shift in snow-lines, which is likely to have had some effect on economic potential.

The relative representation of resource categories within each territory is shown in Table IX.8 together with data on territorial size. Broadly two categories of territory can be distinguished: sites of the coastal hinterland, with slightly larger territories and higher figures for good grazing; and sites of the upland zone with smaller territories and higher percentages of rough grazing.

Comparison of the coastal hinterland sites of Asturias and Santander is of some interest, notably La Loja and Ferrán in the former area and Castillo in the latter. For, whereas all three sites are closely comparable in terms of the economic potential of their respective site territories, there are major discrepancies in the evidence of occupation. Castillo is perhaps the single largest prehistoric site in the whole of Cantabria both in terms of the quantity of material recovered and the number of archaeological periods represented - 9 of the maximum possible of 10. Ferrán and Loja on the other hand have yielded quite minor evidence of occupation, as far as it is possible to judge from the available publications of these various sites.

This discrepancy can be most easily resolved by reference to the strategic location of Castillo. Not only is it situated on the major route of access between the coastal plain and the plateau and between the major evidence of occupation in these two complementary zones, but it is also located in a controlling position at the intersection of several of the larger valleys leading down from the plateau at the point where they begin to open out into the coastal plain, in contrast to the situation at Loja and Ferrán, where the strategic possibilities of the site location are more limited.

In Asturias, the much closer proximity of high mountains to the coast is such that comparable positions of strategic importance are located in the coastal zone. It is sites such as Lloseta and Cueto de la Mina which combine the strategic advantages of the Castillo location, at least in relation to the lowered sea-level of the Last Glacial, with comparable archaeological evidence of substantial occupation, and it is probable that the strategic aspect of these sites would have continued to exercise a directive on the

TABLE IX.8 - The Economic Potential of Inland Site Territories in Asturias and Santander

Site	GG %	RG %	Total Hectares	Percentage of Ideal %
Asturias:				
La Loja	38	62	13 100	42
Ferrán	50	50	12 100	39
Buxu	72	28	8 600	27
Meré	27	73	10 000	32
- - - - -				
Collubil	37	63	7 800	27
Hermida	7	93	5 300	17
Mora	28	72	5 300	17
Santander:				
Castillo	44	56	13 100	42
Hornos de la Peña	25	75	9 900	32
- - - - -				
Valle	1	99	6 600	21
Covalanas	4	96	7 300	23
Rascaño	18	82	6 900	22
Salitré	4	96	6 800	22

Sites above the dotted line within each province are classified as coastal hinterland sites; below the dotted line as upland sites.

exploitation of seasonally mobile animal resources during the Postglacial too, in spite of the reduced width of the coastal plain.

This evidence is, in itself, a strong indicator that a seasonally mobile pattern of exploitation was practised, and it is also a reminder that, in economies of this type, it is not only the economic potential within the site territory that is of importance in directing the nature of occupation but the strategic position of the site in relation to the complementary resources of the annual territory.

The sites of the inland zone all have territories of limited size and a pronounced emphasis on rough grazing, which is reflected in the predominance of ibex and chamois in the faunal remains, according to the evidence of Collubil (Obermaier 1925) and Bulnes (Hernández-Pacheco 1959). Deer is also represented in small quantities. The high altitude and small size of the territories and the relatively sparse archaeological material render it highly probable that these were transitory sites used in the course of the summer dispersal throughout the resource zones of the hinterland.

Turning to the evidence of territorial size, it will be immediately apparent in Table IX.8 that the territories all show marked distortions, as is shown both by the figures for total area of land and by the percentages of land expressed in terms of the ideal territory. In fact none of the figures in the latter category exceeds 50%. Close comparison of these results with the data for the Postglacial site territories of the Asturian shell middens (Table IX.7) shows that there is almost no significant difference between the quantities of land potentially available. Indeed the maximum figures on the coast are 13 700 hectares of land at La Meaza and 13 300 hectares at Cueto de la Mina. The largest shell middens within these two site territories are in fact located at Cáscaras and Balmori respectively, but in territorial terms they have almost identical locations with the sites after which the territories are named, and there is no difficulty in applying the above figures to the shell middens. Conversely, the maximum figure for the inland site territories is only 13 100 hectares.

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Turning to the evidence of [illegible], it will be immediately apparent in Table [illegible] that the territories all have [illegible] of land and up the [illegible]. In fact [illegible] of the [illegible] category [illegible]. [illegible] (Table [illegible]) shows that there is [illegible] significant differences [illegible] of land [illegible]. Though the [illegible] figure [illegible] hectares [illegible]. The largest [illegible] within [illegible] kilometres [illegible] respectively, and [illegible] after [illegible] to the [illegible]. Consequently, the average figure for the [illegible] is only 11,000 hectares.

Now, assuming that the territories we have examined are typical of the potential locations available anywhere in the hinterland - and the uniformly variable nature of the topography supports such a proposition, then it follows that any move from a shell-midden location to a site situated further inland would not involve an increase in the amount of land potentially available, as one might normally expect, but a decrease. There is therefore no need to invoke a local increase in the exploitation of marine resources during the Postglacial in order to explain the anomalous site locations of the known shell middens. Similarly, the site of Otero, the other shell midden within our area of study, has 11 000 hectares of land available within the Postglacial site territory, compared with only 6 600 hectares of land within the territory of its nearest hinterland neighbour of Valle.

Even if we suppose that some favourable inland sites might have existed, offering slightly larger territories than those recorded, it is clear from our previous figures on potential meat output that an additional 1 000 hectares of land would only represent an additional 228 man/days of food, which is only marginally higher than the 140 man/days of shellfood that would have been available nearer the coast, especially if one allows for the margins of uncertainty in these calculations, not to mention the small additions to the coastal diet offered by the sea urchins and crabs.

A further disincentive to winter occupation in the coastal hinterland is the fact that even short distances involve some small increase in altitude, with corresponding decreases in temperature and length of growing season for pasture or fodder plants. The crucial resource category in winter would presumably have been areas of good grazing. Hence the percentage area of this category found at different altitudes within the coastal and inland site territories of Asturias is shown in Table IX.9.

At the coastal sites it will be seen that the majority of good grazing lies below 100 m. Inland, however, the main areas are between 100 and 200 m at Loja; 200 to 300 m at Buxu; 300 to 400 m at Ferrán; and 200 to 700 m at Collubil. These differences are perhaps small, but they would nevertheless

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have added a small contribution to the reduction in the economic potential of the terrestrial resources available in the hinterland.

TABLE IX.9 - Frequency Distribution of Good Grazing according to Height above Sea-Level in Coastal and Inland Site Territories of Asturias

Site Cluster	0-99m %	100-199m %	200-299m %	300-399m %	400-499m %	500-599m %	600-699m %	700-799m %
Coastal:								
Lloseta	47	38	11	3	1	-	-	-
Cueta de la Mina	64	34	2	-	-	-	-	-
La Franca	60	30	9	1	-	-	-	-
Inland:								
Ferrán	-	1	28	40	19	8	3	-
Buxu	-	16	41	27	11	5	-	-
Collubil	-	-	18	18	14	18	14	4
La Loja	41	52	4	2	1	-	-	-

Therefore, there would have been four disadvantages in shifting the location of the Asturian coastal home bases inland in response to the Post-glacial rise of sea-level: first, the loss of the strategically advantageous locations for the control of animal movements; second, a reduction, in some cases, of the total area of land potentially available, and certainly no substantial increase; third, the loss of the supplementary resources available on the sea-shore; fourth, a reduction, albeit small, in the economic productivity of the terrestrial resources, because of increasing altitude.

It is highly probable that the quantity of terrestrial resources available in the coastal site territories of Asturias would have been considerably less than during the maximum of the Last Glacial, but this

is a loss which could have been accomodated in one of two ways: either by a reduction in population size; or by a reduction in the seasonal duration of occupation on the coast.

If it is remembered that the progressive encroachment of the sea was directly linked to a progressive contraction of the permanent snow-line the latter alternative would appear to have been at least as feasible as the former. For it is reasonable to assume that larger areas of summer pasture would have been available during the Postglacial - and available at an earlier period of the year, thus permitting an earlier departure from winter quarters without any necessary drop in total population size. Furthermore, if seasonal occupation of the Asturian coastline was a probability in the Last Glacial, such a proposition seems all the more likely during the Postglacial period.

Thus the territories of the Asturian shell middens would not only have been relatively more favourable for the winter exploitation of terrestrial resources than sites further inland, but they would also appear to have been less unfavourable for the pursuit of an essentially terrestrial economy than during the Last Glacial, although a superficial reading of the evidence might suggest otherwise.

5. Conclusions

There is no more evidence here than in Denmark to suppose that the chronological restriction of the known shell middens to the Postglacial period is the result of population pressure or of a decline in the other resources available for exploitation, or that it is in any way a symptom of large-scale transformations of the human economy. The evidence in Cantabrian Spain is most simply explained by the relationship between high sea-levels and topographically restricted areas of winter grazing on the coastal plain, and there is no reason why mollusc shells should not have been accumulated in comparable abundance at any other period when similar conditions occurred. In this sense our hypothesis is equally consistent with a Last Interglacial

dating for the Asturian shell middens as with a Postglacial date, or indeed with any other period when sea-levels were comparable to those of today.

The hypothesis that we have advanced to deal with the evidence of the shell middens is one which makes the minimum of unsupported assumptions about changes in the biotope or changes in human behaviour or about the interference of differential destruction of archaeological evidence. It offers a simple explanation of all the available data and one which is consistent with the underlying theory of economic directives which has been applied with some success to the prehistoric coastal economies of Denmark and Australia.

In some ways this case study is the most satisfying demonstration of the theory, illustrating the transformation of basic principles to meet the atypical conditions of northern Spain, where, in contrast to all the other areas examined, the coastal economy appears to have been primarily focused on terrestrial resources. So far from providing evidence of long-term change in the human economy, the discontinuities of the Cantabrian shell-midden data reflect an underlying continuity in the exploitation of terrestrial resources and a set of directives on their exploitation which persisted for at least 70 000 years. In so doing, they also provide us with evidence of underlying continuities of human behaviour extending not only through tens of thousands of years of time but across tens of thousands of miles of space.

CHAPTER X

CONCLUSION

The examples analysed in preceding chapters have been drawn from two quite remote and unconnected continents and from a time range which spans more than 40 000 years from the Last Glacial to the ethnographic present. Yet it is apparent from the unfolding of the archaeological exposition that, interwoven with the multitude of local factors which provide the immediate context for human behaviour, there are certain recurrent themes which give shape and continuity to the overall pattern and which may justifiably be regarded as universal features in the organisation of the economies which have given rise to shell middens.

In the first place, it is clear from all four case studies that shellfood has a generally low economic potential in relation to other resources. Whether it should be treated as a supplementary or a casual resource is a matter which seems to be locally variable, although in most cases where large middens are found the former assessment probably applies. But in none of the areas examined is there evidence to suggest that the molluscs were abundant enough to have influenced to any large degree the size of coastal populations or the location of their settlements.

Positive evidence elsewhere which might weaken this conclusion and detract from its status as a universal proposition is lacking. Shawcross's data on potential food outputs per unit area from New Zealand are higher even than commercial figures in comparable conditions by a factor of 10 and some 30 or 40 times higher than the results presented from Australia, an exaggeration which is probably due to errors in the application and interpretation of ecological sampling. Other factors which have promoted the persistence of the more commonly held view of shellfood as a major resource are the failure to take account of the relatively high archaeological visibility and indestructibility of

mollusc shells compared with other food remains or to appreciate the transitory nature of occupation compatible with the shell quantities. As the Ballina example demonstrates, a diet based on shellfood for one day in the year, if repeated over a period of 1 700 years, would be quite adequate to accumulate the large mounds observed in this area.

The analyses are based on a variety of data and techniques in a diversity of areas and include some of the largest and most numerous shell mounds in existence, so that it is unlikely that any further archaeological evidence of a contradictory nature remains to be discovered. It is not inconceivable that economies based exclusively or to a large extent on molluscs may have existed as a rarity in exceptional circumstances, but our data suggest that such economies would have been low-powered ones, incapable of supporting more than a few people in one place for any length of time. In this sense the data are consistent with the strandlooping hypothesis, to the extent that any economy compelled to depend primarily on marine molluscs would have to be a mobile one, incorporating a string of sites along a considerable stretch of shoreline.

If large accumulations of shells are not evidence of shellfood-based economies, they are nevertheless evidence of powerful directives on the repeated use of specific locations over many centuries, and the results of the preceding investigations suggest that it is to the non-molluscan resources that we must turn for a full explanation. Once again the picture varies somewhat from place to place depending on how far local factors distort the underlying pattern. On the basis of some of the Australian data, for example, it might be argued that mound formation could be accounted for solely in terms of the concentrated distribution of the shellfood supply, with the added restrictions on site location imposed by a waterlogged environment, such that one might expect middens to have formed irrespective of the role of the molluscs in the local economy. But these are probably local reinforcing factors rather than

total explanations of the situation, since the shell middens of Denmark do not occur in marshy conditions, while the Spanish sites are not associated with a concentrated distribution of molluscs, at least not to the same extent as elsewhere.

The most satisfactory explanation of all the data is the hypothesis that shell middens are home-base sites, or specialised sites forming part of a home-base cluster, focused on the integration of complementary non-molluscan resources. Since the time-distance factor for transportation of live shellfood is generally low, it follows that the accumulation of mollusc shells in quantity is unlikely to occur except where marine resources other than molluscs are available for exploitation in sufficient abundance to justify the location of a home base on or close to the sea-shore.

In theory it might seem reasonable to expect that archaeologically substantial shell middens would have formed in response to a specialised exploitation of shellfood, and it is probably true that many of the middens encountered in the archaeological case studies were used exclusively for the consumption of molluscs or the dumping of their shells. But, in practice, such middens are invariably found in close proximity to sites concerned with a more generalised pattern of exploitation, and nowhere, either in the areas examined in detail above or elsewhere, is there any available evidence for isolated clusters of shell middens which, by reason of their location or of their contents, can be confidently considered to have been focused exclusively or predominantly on molluscs. This may be because abundant supplies of shells are rarely found except in close proximity to other resources, or because a specialised shellgathering economy would tend to be a foraging economy, which, as suggested on theoretical grounds in Chapter III, is a pattern of exploitation less likely to leave archaeologically visible remains.

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Occasionally, isolated clusters of middens occur which appear to be focused primarily on aquatic resources, whether fish, fowl or mammals such as seal, for example the Oronsay middens of western Scotland. But these are usually confined to small islands or to areas where the terrestrial resources of the coastal zone were probably of low economic potential or difficult of access, and they do not undermine in any way the general hypothesis of coastal site location.

One of the difficulties of testing this hypothesis in distributional terms is that locations which are favourable for the exploitation of molluscs in quantity, for example river estuaries, are also often equally favourable for access to and exploitation of other marine resources, so that it is impossible to judge with certainty which resources imposed the over-riding directive on midden distributions. Yet it is highly probable in the three examples from Australia and Denmark that non-molluscan marine resources formed a major supply of food - mullet and perch in the two Australian areas, and seal in Denmark - offering a sufficient attraction to the formation of coastal home bases without the need to invoke molluscs as a necessary additional factor in their location. Indeed the presence of coastal sites in which shells are rare or absent, both in Queensland and Denmark, is further evidence that molluscs were more of an incidental than a primary factor in coastal occupation.

Northern Spain is the exception which clarifies the rule. For here is a coastline where molluscs are quite widely distributed but where other marine resources are relatively sparse or inaccessible, so that potentially complementary resources are almost exclusively terrestrial. In accordance with hypothesis, the shell middens have a limited distribution, coinciding with quite specific and unusual distortions of topography which would have made it advantageous to pursue a terrestrial economy in immediate proximity to the shoreline rather than further inland out

of convenient reach of the sea-shore and its shellfood supply. Just as the absence of molluscs is not sufficient to deter coastal occupation, so the presence of molluscs is not sufficient to encourage it.

It is possible that the absence of shell middens around much of the European coastline may be similarly explained by reference to the distribution of the non-molluscan resources. It is certainly worth observing that the two other isolated groups of Mesolithic shell middens in north-west Europe which are comparable to the Asturian, the Brittany sites of Téviec and Höedic and the Obanian middens of western Scotland, occur in areas which are noted for their inshore fishing. Recent excavations in the latter group of sites have established that the fish bone accounts for at least as much food as the molluscs, even in terms of the archaeological remains (Mellars and Payne 1971).

This is not to deny the influence of differential preservation resulting from changes of sea-level relative to land, which would probably have destroyed any Mesolithic shell middens that may have existed in low-lying areas such as south-east England or the Low Countries, nor the importance of discontinuities in the distribution of the shellfood supply itself. The isolated grouping of the Tagus shell mounds in Portugal, for example, is most probably due to the relative lack of extensive estuaries suitable for the settlement of molluscs in large quantities elsewhere in the Iberian peninsula. Even here the middens are some 70 km inland from the mouth of the Tagus River and are situated in locations which, from the territorial point of view, would have been focused primarily on terrestrial resources. Furthermore, the area of the river from which the shellfood was formerly collected has silted up at some time since the period of the Mesolithic occupation and is used to-day for rice cultivation. It is thus possible that here as in Denmark the rarity of shellgathering in later periods of prehistory can be attributed quite simply to the disappearance of the shellfood supply in response to environmental change.

Seasonal directives also play a prominent role in the occupation of shell middens. It is certainly the case that the shell middens of all four case studies are situated on coastlines with access to potentially complementary resource zones in the adjacent hinterland, and it is probably the case that these inland resources were generally incorporated by seasonal movement into the coastal economy. There are, of course, local variations on this theme. In New South Wales, for example, the pattern of integration appears to have involved overlapping movements of different groups of people; in Queensland the direction of seasonal movement was in some areas aligned more in parallel with the coastline than at right angles to it, in response to distortions in the distribution of the complementary resources; in Denmark the pattern appears to have been constrained to some extent by the presence of inland waterways capable of providing a convenient means of access to the hinterland; and in Spain by easily traversed mountain passes.

But if, as seems likely, seasonal movement in one form or another was a recurrent mode of exploitation in all these areas, then this must presumably have been an integral feature in the long-term viability of the coastal economies and a major factor in maintaining regular visits to the coastal middens by large numbers of people overlong periods of time. Thus it seems reasonable to conclude that the number, size and duration of shell middens apparent in the archaeological record is not solely dependent on the local shellfood supply, nor solely dependent on the presence of abundant non-molluscan staples in close proximity to the shore, but is also dependent, in part, on the distribution of complementary resources in the adjacent hinterland.

Whether the absence of such complementary resources would have completely inhibited coastal settlement or rendered the exploitation of coastal resources less effective is not something about which our data allow any very positive conclusions. Occasional examples have been noted

in the ethnographic record discussed in Chapter IV of shell middens occurring on coastlines which are largely lacking in adjacent hinterland resources, for example in parts of Tierra del Fuego. But in these areas the problem of sustaining an economy throughout the year appears to have been solved by the incorporation of complementary resources elsewhere along the coastline or by projecting the pattern of integration out to sea to include offshore islands or complementary resources within the marine sector, so that the underlying principles of seasonal mobility would appear to apply with equal force in these circumstances too. It is therefore possible that a lack of complementary resources may be an additional factor to be considered in discussing large-scale discontinuities in the distribution of coastal sites, although it is not a factor which we have found it necessary to emphasise to any extent in the four areas that we have examined in detail in this investigation.

Turning to the question of long-term trends, it is clear that shell middens cannot be regarded as exclusively Postglacial phenomena. This follows from our general analysis of the time-distance factor for shellfood transportation, which renders it highly probable that most shell middens of earlier periods would have been destroyed by changes of sea-level and from our more detailed examination of the problem in the context of prehistoric Spain and Denmark. But in spite of the probable destruction of most of the relevant evidence from the Pleistocene period, the scope of our investigation allows us to make some general observations about the probable antiquity of intensive shellfood exploitation.

That abundant supplies of shellfood would have been available in the remotest epoch of human prehistory is undisputed. Whether or not these would have been incorporated into the human economy by the use of shell middens depends on whether the other factors which we have cited above as necessary conditions for the successful long-term pursuit of a shellgathering economy could also have been fulfilled.

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Perhaps the single most important variable in this respect is technology, both directly in terms of its effect on shellfood exploitation and indirectly in terms of its effect on the exploitation of non-molluscan marine resources. For, according to the logic of the case established above, the successful long-term use of shell middens normally depends on, among other things, the exploitation of marine resources such as fish or seal as staple resources, except in unusual circumstances such as those described for northern Spain, and these are resources which not only require technological devices such as spears, hooks, harpoons or other specialised equipment but, more importantly, the use of boats to provide access to the marine zone. Indeed in conditions such as those found at Weipa the shellfood supply itself would scarcely have been accessible without the use of some form of water transport. Thus the antiquity of shellgathering would appear to be directly related, at least in part, to the antiquity of specific technical and technological skills and in particular the ability to construct boats.

Direct archaeological evidence for the use of boats is, by its very nature, unlikely to be preserved except as a rarity, especially from earlier periods. But there are some indirect clues. For example, it is generally accepted that the Australian continent would not have been connected by a land bridge to adjacent land masses at any period during the Pleistocene. Hence the evidence of human occupation in Australia dating from about 30 000 BP provides one of the earliest _termini ante quem_ at present available for the use of boats. Furthermore, the edge-ground axe, a critical implement in facilitating the construction of boats, whether of wood or of bark, by the Australian Aborigines, has also been recorded in northern Australia from a comparable date. There is thus no reason why shell mounds like those at Weipa should not have come into existence at any time during the last 30 000 years, wherever comparable estuarine environments occurred. That shell middens of this

age have not been found at Weipa itself can be attributed to the relatively recent formation of estuarine conditions in this area.

Whether the proto-hominids of 10 million years ago took the first crucial steps towards tool-using and bipedalism as the result of a semi-aquatic existence subsisting mainly on molluscs (Hardy 1960) is not a question which our data have any direct bearing on. For one thing the constants which have been used in assessing the time-distance factor would probably not have applied to the tropical, amphibious creature envisaged by the hypothesis, especially if it were of smaller body size and lower daily calorific requirements than the average human. But in so far as our data allow any judgement on the problem, it seems probable that such an economy, even in the different conditions of this remote period, would have required a highly mobile existence and extremely low population-densities.

For the human epoch proper, it seems as unlikely that molluscs would have been ignored for long on the prehistoric time scale as that they should have ever formed the staple basis of a coastal economy. Such long-term changes as may have occurred in the intensity of shellfood exploitation are likely to have resulted from changes in the pattern of marine exploitation generally under the impetus of a developing technology.

If any of the economic directives that we have examined above can be singled out as pre-eminent, it is perhaps directives of accessibility and in particular the time-distance factor which deserve greatest emphasis. For it is this directive, more than any other, which has permeated almost every detailed aspect of our interpretations, ranging from considerations of the possible destruction of Pleistocene evidence, through the analysis of site territories and seasonal directives, to the very shape of the Weipa shell mounds. It is this directive which demonstrates more emphatically than any other that the economic optimum

is no simple mirror reflection of some theoretical ecological optimum, on the one hand, by whatever criteria that may be defined, nor, on the other hand, is it a statement in more subtle language of outmoded concepts of environmental determinism. It is the proximate limitation on economic output imposed by the operation of the time-distance factor which provides the essential clue to the understanding of discontinuities in the palaeoeconomic record and allows us to perceive how the general interaction of economic directives may maintain long-term stability in one set of circumstances while promoting change in another.

If the theory of economic directives is as successful as we have claimed above in interpreting a diversity of prehistoric coastal economies ranging across a geographical span of at least two continents and a chronological span of at least 40 000 years, then it is not unreasonable to suppose that it might be elaborated and applied with equal success to more complex types of economic behaviour and specifically to the accelerating pace of discontinuity and disruption which has characterised the economies of more recent periods. If this is an over-optimistic assessment of an essentially rational approach to the interpretation of human behaviour, it is nevertheless one which can only be properly judged from a large-scale perspective, not only global in its extent but evolutionary in scope and thus, necessarily, an archaeological perspective.