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Maritime Hunter-Gatherers: Ecology and Prehistory[1]

by David R. Yesner

HUNTER-GATHERERS: ECOLOGY, DEMOGRAPHY, SOCIAL ORGANIZATION

For more than 99% of their history, humans have been hunter-gatherers. Hunting and gathering may well be considered the "basic" human lifeway. Any valid understanding of cultural evolution requires a thorough comprehension of the way in which hunter-gatherer societies have adapted to various environments. In particular, assessing the relationships between the resource base, population dynamics, and social organization of human populations calls for a detailed examination of the way in which hunting-and-gathering societies have adapted to the specific requirements of a wide variety of ecological niches.

Our current understanding of the hunting-and-gathering way of life is derived from two data sources: ethnographic and archaeological. Ethnographic studies, particularly the quantitative studies of the 1960s, have given us a general picture of hunter-gatherers as people possessing a simple technology with a low extractive potential, exhibiting limited energy expenditure in subsistence activities, and possessing a flexible social organization, in other words, having overall low energy budgets and limited energy flow. Coupled with these are low average population densities and static, near-equilibrium populations maintained below average "carrying capacity" through a mix of biological and social regulators.

There is no question that such studies have broadened our perspective on the hunting-and-gathering way of life, particularly by linking earlier perspectives on social organization with newer quantitative data on subsistence, energy flow, etc. The "textbook" picture of hunter-gatherers generated by these studies has, however, three basic deficiencies. To begin with, most studies have been undertaken among peoples occupying relatively simple ecosystems, such as high-arctic Eskimos, South African San, or Australian Aborigines. This has tended to give rise to a false sense of cultural homogeneity among hunter-gatherers. In addition, while most hunter-gatherers of the ethnographic present have occupied relatively marginal resource zones, the situation may have been very different for Pleistocene and early Holocene *Homo sapiens*. Finally, ethnographic studies lack sufficient time depth to flesh out a complete picture of the hunter-gatherer lifeway; they suffer from what Ammerman (1975) has termed a tendency to see the behavior of such populations in essentially static terms.

What have been the theoretical consequences of these three methodological deficiencies? First, there has been a tendency to view hunting and gathering as a single economic "type." In truth, there is great diversity among hunting-and-gathering peoples in terms of subsistence, demographic features, and social organization. There are several ways, in fact, in which one might assess the degree of heterogeneity among hunter-gatherer populations. One is latitudinal. Lee (1968), for example, uncovered good correlations between latitudinal gradients and *major* subsistence types, with hunting predominating at high latitudes, fishing in temperate zones, and gathering in equatorial regions. A single latitudinal zone, in addition, may encompass several biomes, depending on the operation of various geological and climatic factors. There are great differences, for example, in the ecology and social organization of riverine, lacustrine, and coastal hunter-gatherers, among the inhabitants of tundras, deserts, and grasslands, or among the occupants of boreal, deciduous, and tropical forests. Broadly similar biomes may have very different ecologies and therefore yield different nutrient complexes and total energy levels, even to peoples who possess comparable technologies. Even within the same biome, there may be great ecological and cultural diversity, particularly in "patchy" environments (MacArthur and Pianka 1966, Winterhalder 1978). Ecotones also tend to promote diversity in subsistence and social organization (Rhoades 1974, 1978).

The chief theoretical consequence of relying on data from occupants of marginal resource zones is that a mistaken picture of hunter-gatherer population dynamics and social organiza-

David R. Yesner is Assistant Professor of Anthropology at the University of Southern Maine (Department of Geography-Anthropology, University of Southern Maine, 37 College Ave., Gorham, Maine 04038, U.S.A.). Born in 1948, he was educated at Cornell University (B.A., 1971) and at the University of Connecticut (M.A., 1974; Ph.D., 1977). He has taught at the University of Alaska (1975–77). His research interests include coastal/maritime adaptations, circumpolar North American archaeology, quantitative methods, human ecology, and hunter-gatherer band organization. Among his publications are "Archaeological Applications of Optimal Foraging Theory: Harvest Strategies of Aleut Hunter-Gatherers," in *Hunter-Gatherer Foraging Behavior*, edited by B. Winterhalder and E. Smith (Chicago: University of Chicago Press, 1980); "Nutrition and Cultural Evolution: Patterns in Prehistory," in *Nutritional Anthropology*, edited by N. Jerome et al. (Pleasantville, N.Y.: Redgrave, 1979); "Animal Bones and Human Behavior" (*Reviews in Anthropology* 5:333–55); and "Resource Diversity and Population Stability among Hunter-Gatherers" (*Western Canadian Journal of Anthropology* 7:18–59).

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tion may result. High-density populations—rarely practicing artificial population regulation and frequently exhibiting complex social organization—have been reported only among certain coastal peoples, such as the Aleuts or Northwest Coast Indians. Perhaps, however, this was formerly the rule rather than the exception among hunting-and-gathering societies. This brings up the third consequence of ethnographic analysis: that because of its limited time depth, *archaeological* data are required to answer definitively questions concerning the size and density of hunter-gatherer populations and whether—and to what extent—those populations deviated from "equilibrium" values and/or overexploited their resource bases.

The greatest problem, then, involved in the study of hunting-and-gathering peoples is selection of the proper cultural and ecological units for analysis (to avoid spurious correlations) and selection of the proper spatial and temporal perspective. One final problem arises, also, in relation to the level of abstraction of the environmental analysis undertaken. General concepts such as "carrying capacity" (Glassow 1978, Hayden 1972) and "stability" (Holling 1973, Yesner 1977*a*) must be eschewed in favor of more detailed analysis of specific ecological constraints acting upon hunter-gatherer populations. The latter include (1) the various "limiting factors" (sensu Odum 1971) acting upon hunter-gatherer societies; (2) the overall species diversity and resilience of the ecosystem; (3) the primary production and standing-crop biomass of each resource available to human populations, including seasonal and long-term fluctuations in resource availability; (4) habitat preferences and aggregation tendencies of various species, which greatly affect human exploitational strategies; (5) the potential caloric and nutrient yield of each resource; and (6) patterns of energy flow and loss through the human trophic level (Yesner 1979, n.d.). All of these—but particularly the last—are greatly affected by the particular type of technology and economic organization required to exploit each resource (Oswalt 1976).

MARITIME HUNTER-GATHERERS: A POPULATION CONCEPT

Maritime hunter-gatherers—those that in some manner exploit the seas—are a specialized subset of hunting-and-gathering peoples. As a group they are not easy to define; for example, how does one classify populations that exploit maritime resources only during a portion of their annual round, or exploit maritime resources along with terrestrial ones, or both? Should one use percentage criteria to define maritime populations? And how does one deal with coastal peoples that practice horticulture to a greater or lesser degree? The latter would include such diverse groups as the (late) Jomon peoples of Japan, the Ertebølle shellmound peoples of Denmark, and coastal Woodland and Formative cultures of North and South America, respectively. For convenience, maritime hunter-gatherers may be considered those for whom marine foods form the largest portion of the intake of either calories *or* protein in the diet (an issue that will be considered subsequently).

Beyond the problem of definition is a more basic problem of whether or not a general middle-range theory of maritime cultural ecology can be developed. For example, Osborn (1977*a*, *b*) has recently argued that the intensive exploitation of marine resources on the coast of Peru—and the dense populations and monumental architecture that accompanied it—can only be comprehended as a "unique" phenomenon resulting from a localized nutrient-rich upwelling system. Although Osborn enters a plea for a more general theory of maritime adaptation, the implication of his argument is that such a general theory would be difficult, if not impossible, to achieve (Yesner 1978). Are coastal ecologies really so different—in terms of primary plankton production (the base of the marine food chain) or the diversity of available marine resources (fish, shellfish, sea birds, marine mammals)—and are the technologies and forms of social organization required to exploit these environments really so different as to preclude development of a general theory of maritime adaptation? It seems that a more profitable approach might be to develop a set of common denominators for maritime populations that *accommodate* various "unique" localized phenomena. This is not simply an academic argument, for without the development of such comprehensive theory it is difficult to explain the origins of maritime adaptation (of which more later on).

The following features, then, seem to be generally identified as characteristic of maritime-adapted populations:

1. *High resource biomass.* It may be true, as Osborn (1977: 161) argues, that "the oceans, in general, are less productive per unit area than terrestrial environments." However, this does not mean that there is a low availability of edible biomass to human populations living in coastal areas (as opposed to the open sea). On the contrary, coastal zones are generally highly productive; on a worldwide basis they show a gross primary production of 7×10^{16} kcal./yr., excluding highly productive estuarine zones (Odum 1971: 51). Gross primary productivity in coastal zones (excluding upwelling zones and estuaries) is ca. 2,000 kcal./m^2/yr., or at least twice that of open oceanic zones (Odum 1971, Steele 1974, Bunt 1973). This high productivity results from the mixing of cold waters bearing nutrient-rich sediments from ocean depths with warmer, sunlit waters in the photosynthetic zone of the ocean surface. Several distinct but interrelated processes are responsible for accelerated mixing in coastal zones. True "upwelling" occurs when winds move surface waters away from shore to be replaced by deeper, nutrient-laden waters. Depth differentials along coastal slopes, tidal effects, and nearshore currents also contribute greatly to mixing of the water column. Particularly accelerated mixing occurs where waters are funneled through straits and island passes, known as the "island mass effect" (Sander and Steven 1973). Intertidal zones and estuaries are also very high in primary productivity, as much as ten times greater than coastal zones in general (Odum 1971, Lieth and Whittaker 1975). Other coastal waters, particularly those of volcanic archipelagos, have a high nutrient content as a result of submarine volcanic activity (Buljan 1955, Wilcoxon 1959).[2] Foggy coasts, because they retain diurnal heat in the photosynthetic zone, also tend to accelerate nutrient blooms (Hurlburt and Corwin 1970).

At one time, high primary productivity was thought to be confined primarily to the western coasts of continents, since in these areas (as a result of the circulation of the earth) prevailing winds tend to blow alongshore (parallel to the coast) toward the equator, forcing the surface water away from shore to be replaced by the deeper, nutrient-rich waters (the Ekman effect). However, recent studies have shown that major ocean currents, rather than winds, similarly enrich the marine ecosystems of eastern continental margins. Pietrafesa, for example (cited in Hartline 1980), notes that southeastern United States coastal waters are nearly as rich in nutrients and phytoplankton as west-coast upwelling zones, as a result of activity of the Gulf Stream. Increased upwelling has additionally been attributed to western American shores because of the steeper coastal gradient, which accelerates mixing. However, on many eastern coasts, for example, the Gulf of Maine, the same effect is achieved through accelerated *tidal* mixing, resulting from the geometry of the nearshore ocean bottom, which induces greater tidal amplitudes (Sanger 1975). In a similar fashion, the advantages of increased sunlight in the photosynthetic zone for primary production in the tropics are largely balanced off by the opportunities for

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[2] It should be noted that *excess* wind will reduce coastal productivity by increasing turbulence in the water column and limiting sunlight penetration through the photosynthetic zone (Hartline 1980). Similarly, *excess* submarine volcanic activity may have a devastating effect on both intertidal biota and humans that depend on it (Moreau 1978, Black 1978).

greater upwelling of cold, nutrient-rich waters in the subarctic and subantarctic regions (Dunbar 1968). In fact, the subarctic North Pacific region—an area of great current- and wind-induced mixing—exhibits some of the highest primary productivity in the world, 90–240 g C/m^2/yr. (Koblents-Mishke 1965, Larrance 1971). I am not denying the fact that particularly strong upwelling occurs along certain tropical western coasts, particularly southern California, Panama, Peru and northern Chile, western Portugal and Morocco, and southwestern Africa. I merely wish to offer the observation that much of the coastal zone in the rest of the world also exhibits high primary productivity, particularly in contrast to the open ocean, as a result of one or more of the factors cited above. High coastal productivity is not only a product of upwelling systems, and when it is it may be of the highly localized but pervasive type found in areas such as straits or island passes.

Many sea mammals, as well as fish and birds, directly depend on the primary production of the coastal zone. It is not always true, as Osborn (1977*a:*161) argues, that "marine mammals of large body size are at higher trophic levels in the food chain than are terrestrial mammals of large body size." Baleen whales of enormous size feeding on plankton are obvious counterexamples. In addition, marine food chains in coastal and upwelling zones tend to be much shorter than those in open ocean areas, leading to greater ecological efficiency, primarily because microzooplankton form an additional trophic level in open oceans (Steele 1974, Russell-Hunter 1970). Moreover, many migratory species, such as anadramous fish, migratory sea birds, and various sea mammals, do *not* depend on local primary production for their own food.

Shellfish are another critical resource for coastal human populations, since they exist as a highly concentrated resource, are easily collectable by all segments of the human population with a minimum of energy input, and often serve as an emergency buffer during times of relative food scarcity. Shellfish beds also depend on primary production (as well as proper geological context) for their development. Some quantitative studies have been undertaken which show the high biomass characteristic of strandflats. Shawcross (1967), for example, has demonstrated a shellfish biomass of 5.37×10^6 kg/km^2 for New Zealand harbors, which he compares with a biomass of only 0.02×10^6 kg/km^2 cited by Bourlière (1963, 1965) for the East African savanna. According to Shawcross (1967), the greater shellfish biomass more than compensates for the higher caloric value of red meat. Further, since shellfish can withstand a culling rate of ca. 14%, while savanna ungulates can only withstand a cropping rate of ca. 2.5%, Shawcross (1970) calculates that the *exploitable* biomasses for the two resources would have been 7.52×10^5 kg/km^2 and 0.6×10^3 kg/km^2, respectively. The same pattern holds true for sea mammals: even nonmigratory sea mammals can withstand higher cropping rates than many terrestrial mammals—on the order of 8–10% (McLaren 1961)—because of high annual net recruitment rates.

2. *Resource diversity*. Coastal areas tend to have a large number of ecological niches crowded into a given unit of area; that is, they exhibit higher "species packing" (MacArthur 1970). In addition, coastal settlements are frequently located in areas where migratory or "unearned" food resources are present (see below). As a result, coastal areas tend to exhibit greater species diversity. The major effect of this diversity on the coastal population is that, during the most critical parts of the year, when the biomass of preferred resources is low, alternate forms of sustenance exist as a buffer.

3. *Environmental stability*. Maritime environments are generally characterized by greater ecological stability than corresponding terrestrial biomes within the same latitudinal zone (Dunbar 1960). The meaning of the term "stability" is, however, somewhat elusive (Holling 1973). If it is taken to mean only the *amplitude* of resource fluctuations (i.e., the degree to which they diverge from equilibrium values), one might agree that coastal areas have greater ecological stability. The *frequency* of population oscillations is sometimes greater, however, because there are greater numbers of species and trophic linkages and therefore more opportunities for resource fluctuations (Phillips 1978, Brylinsky 1970). Furthermore, coastal zones, with shorter food webs, tend to be less stable than open ocean; this is not limited to upwelling areas, as is implied by Osborn (1977*a*, *b*). High frequencies of intertidal resource fluctuations have, in fact, been detected in otherwise "stable" marine environments (Dexter 1944). Fluctuations in high-biomass resources which are "inexpensive" to exploit are likely to have an impact on the human population, primarily at the time of year when such "emergency foods" are most needed. In this case, however, the impact may be highly localized, and the human response may involve only camp relocation to an area with more favorable shellfish beds. Fluctuations in resources of *low* biomass, or those relatively "expensive" to exploit, would also be likely to have substantial impact only if several resources were depressed simultaneously (Charnov, Orians, and Hyatt 1976). Fluctuations in availability of favored, high-biomass resources (such as anadramous fish) may have more impact on coastal populations, encouraging the development of redistributional institutions to smooth out energy flow over time and space (e.g., Piddocke's [1969] analysis of the Northwest Coast potlatch). There is also a latitudinal effect to consider here: northern regions tend to undergo a greater degree of biomass fluctuation (Pruitt 1968), although this is less true for oceanic than for terrestrial environments.

Seasonal (rather than long-term) resource fluctuations are more difficult to deal with in any holistic way. Here the latitudinal effect is more pronounced: seasonality of primary production increases markedly in high latitudes (Cushing 1975). Nevertheless, coastal environments of either high or low latitudes tend to show less seasonal differentiation in both climate and resource availability than do corresponding terrestrial biomes within the same latitudinal belt. One key to this situation is to be found in food storage practices. Binford (1980) has recently made the case that food storage increases with latitude, as a part of the "logistic" strategies of northern peoples. Among the exceptions cited by Binford, however, are several Eskimo groups, the subarctic Micmac, and the subantarctic Yahgan and Tasmanians, all of whom are maritime hunter-gatherers. The lack of food storage is probably due not so much to higher mobility, as Binford implies, as to reduced seasonality in resource availability. On the other hand, even coastal hunter-gatherers do tend to use more food storage techniques in the arctic, and some of these techniques (i.e., freezing) are unavailable elsewhere. To the extent to which food storage techniques, predominantly drying or smoking, *have* been applied to marine foods, they may have helped to maintain higher population densities in coastal regions than would have otherwise been possible.

4. *"Unearned" resources*. As indicated above, a significant proportion of maritime resources consists of what Birdsell (1957) has termed "unearned" resources: migratory species that can be intensively exploited with a higher maximum sustained yield. The term, however, is unfortunate, since exploiting many migratory species (e.g., seals or whales) requires a great deal of individual and group energy expenditure.

5. *Coastal settlement*. This sounds like a tautology, but linear (as opposed to planar) settlement patterns have important consequences for the shape and size of catchment areas, for the biomass of exploitable resources, and for boundaries to excess population growth. Coastal settlements tend to favor the following areas: (*a*) complex coastlines where protective and productive bays are found, (*b*) areas associated with streams or lakes serving as additional habitat for waterfowl and fish as well as a source of fresh water, (*c*) areas close to upwelling zones, (*d*)

strandflat zones where shellfish and other invertebrates are available, and (*e*) good areas for beaching boats. However, it should be emphasized that the linear nature of maritime settlement actually limits the number of locations that meet all of the prerequisites for settlement.

6. *Sedentism.* One consequence of linear coastal settlement patterns, and of the nature of maritime resources themselves, is that maritime collecting is best undertaken from a single location. Coastal hunter-gatherers, therefore, tend to be characterized by what has been termed "central-place foraging" (Orians and Pearson 1979) or "refuging" behavior (Hamilton and Watt 1970). In particular, the use of boats provides a tremendous transportation advantage for coastal peoples, allowing many widely dispersed yet locally concentrated resources to be harvested and returned to a central settlement. Coastal settlements, then, tend to be optimally located to take advantage of several resources from a single location—an example of what Binford (1980) terms "logistical" collecting behavior. Specifically, settlements tend to be located closer to low-cost, easily exploited resources that also serve as emergency food reserves (Yesner 1980). Coastal settlements are frequently located near intertidal strandflats where sessile invertebrates are easily accessible. Sea-bird colonies are also usually exploited within a limited distance of a settlement (Yesner 1976). Free-ranging pelagic mammals, such as seals, porpoises, walruses, and whales, are most easily obtained by exploiting nearby rookeries, hunting in bays near settlements, or intercepting at sea, if they are migratory species. Ocean fish are exploited in a similar fashion, using the settlement as a base of operations. Finally, anadramous fish may be exploited either at the main settlement, if it is located on an appropriate stream, or at separate camps on nearby streams. This "logistical" collecting pattern implies at least *semisedentary* communities, which may be defined as "communities whose members shift from one to another fixed settlement at different seasons or who occupy more or less permanently a single settlement from which a substantial proportion of the population departs seasonally to occupy shifting camps" (Binford 1980:13).

Again, however, latitudinal effects must be considered. In northern environments, there is much greater concentration on sea mammals and fish and correspondingly less attention to shellfish, particularly north of the boundary of winter ice (Yesner 1977*a*, *b*). While the former resources may be more "costly" to exploit, they yield the combined benefits of high calories, high protein, and high vitamin levels, particularly if eaten raw (Denniston 1972). At lower latitudes, however, it is by no means clear that coastal habitats offer foods sufficiently rich in calories or vitamins to sustain populations *entirely* on the basis of aquatic resources, even though the coastal resource biomass may be quite high (Stark and Voorhies 1978). At lower latitudes, therefore, vegetable foods may be necessary to complete the diet. For this reason, I have argued elsewhere (Yesner 1979) that Mesolithic settlement patterns could not have been completely sedentary, a fact which casts some doubt on Binford's (1968) model of population pressure arising from post-Pleistocene coastal sedentism. New evidence continues to accumulate that low-latitude coastal sites once thought sedentary were in fact seasonally occupied (Glassow 1967; Tartaglia 1976; Lubell et al. 1975, 1976; Parkington 1972; Rowland 1977). Stark and Voorhies (1978:279; see also Linares 1977) have raised the possibility that low-latitude coastal sites may have been "only seasonally occupied by early agriculturalists living inland." In order to deal with this question effectively, however, it is necessary to consider the nutritional advantages and disadvantages of coastal resources in some detail (see below). One area in particular that should be studied in more detail is the northern temperate coastal zone, where horticulture is only a marginal possibility, wild food plants are not greatly abundant, and high-fat, high-calorie sea mammals are less available than farther north. Examples of such areas would be northern Europe (Troels-Smith 1967) or the coast of southwestern Maine and New Hampshire in the northeastern United States (Yesner 1980). Shellfish resources may have played a particularly important role in these areas, and settlement patterns in these areas can be expected to have been very complex.

7. *Technological complexity and cooperation in resource exploitation.* This is a very general feature that must be qualified for specific resources. Collecting shellfish is an activity that only requires simple technology such as digging sticks (Greengo 1952) and is not "labor-intensive" as argued by Osborn (1977*a*, *b*). On the other hand, fishing—for either anadramous or deep-sea fish—and particularly sea-mammal hunting require more complex technologies, including composite tools with points, barbs, hooks, toggles, foreshafts, lines, and floats, as well as seaworthy boats. (Of course, some technologies, such as nets and snares, can be used to exploit a wide range of maritime resources.) Such technologies have apparently been developed independently in the western Pacific (Japan and Oceania), eastern Pacific (among the Eskimos, Aleuts, and coastal Indians), western Atlantic (the "Maritime Archaic," with an antiquity of ca. 6,500 years), and eastern Atlantic (dating back to Upper Palaeolithic times).

In addition, hunting of large sea mammals such as sea lions, walruses, and whales, fishing for swordfish or tuna, or seining of anadramous fish all require a good deal of cooperation among hunters, elaborate systems of food distribution, and a certain degree of boat crew specialization. These requirements have important ramifications for the social organization of maritime societies with significant involvement in sea-mammal hunting, swordfishing, etc. It is not necessarily important that large-sea-mammal hunting contribute a majority of the caloric input to a maritime society for it to rank as an "important" activity, because the requirements of economic and social organization to hunt these creatures are much more extensive than those for the littoral fishing or shellfish collecting which a society might also engage in. In northern environments, successful hunts of large sea mammals—no matter how widely spaced—preclude spending an inordinate amount of time and energy in pursuing smaller, more dispersed resources. In lower latitudes, the "expense" of obtaining large sea mammals can be balanced off against low-cost, predictable resources such as shellfish through division of labor along sex and age lines.

8. *Lower dependency ratios.* Because both old people and children are able to engage in activities such as shellfish collecting, and because they have lower caloric requirements, they are virtually able to support themselves in coastal zones and do not act as a sump for the population's resources (Laughlin 1968, 1972). Therefore, in any maritime society in which shellfish or other invertebrates are an important resource, dependency ratios tend to be lower, population pyramids broader, life expectancies higher, and potential for population increase consequently greater.

Infanticide has rarely been reported among maritime societies, except for those practicing some horticulture (e.g., the Polynesians: see Panizo 1965). Societies inhabiting simpler ecosystems and suffering from more severe resource crises require cultural devices such as infanticide to maintain "equilibrium" populations, as Birdsell (1968) has noted. In contrast, maritime societies can "allow" their populations to "track" (i.e., be regulated by) changes in resource availability.

9. *High population densities.* The eight features of maritime hunter-gatherers just listed have a common denominator: they make possible the support of relatively high human population densities. It appears that, within a given biome or latitudinal zone, maritime-adapted groups have achieved higher population densities. For example, Birdsell (1968) has calculated that, for Australia, coastal hunter-gatherers exhibited population densities 40 times those of interior groups. Similarly, Kroeber's (1939) data from aboriginal California show a decrease in population from coast to interior.

However, recent studies have shown that some of these population dichotomies may be too simplistic, i.e., based solely on contrasts between coastal and *marginal* interior zones. For example, Lourandos (1977), in a recent restudy of aboriginal Australian population densities, notes that the *richer* interior regions of southeastern Australia show equivalent densities to the highest recorded ones in the north-coastal regions, a fact which has been obscured by early European contact in the southeast. A similar objection might be raised to underestimation of eastern North American interior aboriginal population densities in Kroeber's (1939) data.

Nevertheless, coastal vs. interior contrasts in population density do seem to hold on a broad scale for a variety of environmental zones, including high as well as low latitudes. For example, Fitzhugh (1972) notes that greater prehistoric population densities developed in coastal than in interior Labrador. For the circumpolar region as a whole, peoples exploiting primarily terrestrial resources (Caribou Eskimos, subarctic Indians) tend to have lower population densities, shorter life expectancies, and narrower population pyramids. Exclusively maritime societies (e.g., the Aleuts) exhibit the reverse, while those societies possessing "mixed" economies (e.g., Eskimos of the eastern Arctic) tend to be intermediate in terms of demographic features (tables 1, 2). The Aleuts, as an exclusively maritime people, had the highest population density, greatest longevity, and proportionately largest elderly population among North American circumpolar societies (Harper 1975). Their demographic features are more like those of Mesolithic Old World populations than like those of other arctic societies. Maritime societies in Oceania, where maritime adaptation has been most fully studied (e.g., Fosberg 1963, Casteel and Quimby 1975), show demographic features similar to those of the Aleuts (table 3), although some do have economies including horticulture. Perhaps the major factor underlying these demographic similarities is the fact that, unlike many other circumpolar regions, the Aleutian archipelago is ice-free on a year-round basis, so that invertebrates such as sea urchins, shellfish, and octopus contribute important dietary supplements.

10. *Territoriality, resource competition, and warfare.* The limited ethnographic record of maritime hunter-gatherers indicates that these dense, semisedentary populations exhibit a significantly greater degree of territoriality than do other hunting-and-gathering peoples (Cordell 1978). Notions of resource control ranged from nuclear-family "ownership" of fish

TABLE 1

POPULATION DENSITIES AND DEMOGRAPHIC FEATURES, ARCTIC AND MARITIME SUBARCTIC HUNTER-GATHERERS

REGION	POPULATION DENSITY[a]	LIFE EXPECTANCY AT AGE 15	PERCENTAGE OVER 55 YEARS
Aleutian Islands	4.6 (64.7)	34.9	15.2
Northwest Coast	4.9 (24.6)	22.1	4.7
North Alaska	3.0	28.6	13.2
Southeast Alaska	2.8 (19.0)	18.2	4.8
Greenland	1.7	21.1	5.2
Labrador	1.5	30.7	7.6
Central Arctic	1.0	19.7	0
Northwest Interior Canada (Caribou Eskimo)	(0.4)	28.6	10.2

SOURCES: For population densities, Kroeber (1939); for demographic features, Aleutians and Central Arctic, Harper (1975); Northwest Coast, Hrdlička (1944); North Alaska, Milan (1970); Southeast Alaska, Taylor (1966); Greenland, Skeller (1954); Labrador, Laughlin (1972); Northeast Interior Canada, Weiss (1973).

[a] Shoreline density per mile, except that figures in parentheses are per 100 km.

TABLE 3

COMPARATIVE LIFE EXPECTANCIES AT AGE 15, MARITIME AND NONCOASTAL SOCIETIES

SOCIETY	LIFE EXPECTANCY AT AGE 15
Maritime	
Aleut	34.9
Cocos Islands	33.4
Tikopia	27.0
Ulithi	26.7
Noncoastal	
Birhor	24.0
Australian Aborigines	22.3
Yanomamo	21.4
West Africa	18.4

SOURCES: Aleut, Harper (1975); Cocos Islands, Smith (1960); Tikopia, Borrie, Firth, and Spillius (1957); Ulithi, Lessa and Myers (1962); Birhor, Williams (1974); Australian Aborigines, Rose (1960); Yanomamo, Neel and Weiss (1975); West Africa, Weiss (1973).

TABLE 2

LIFE EXPECTANCIES AT AGE INTERVALS IN PAST AND PRESENT ARCTIC POPULATIONS

E(*x*)[a]	MESOLITHIC	ALEUT	CHUKCHI	KONIAG	CARIBOU ESKIMO	SADLERMIUT	GREENLAND
E(15)	25.6	34.9	21.4	18.2	22.6	19.7	21.1
E(20)	22.8	31.8	20.1	16.8	20.0	16.8	18.5
E(25)	20.8	28.9	18.8	15.5	17.3	13.8	16.0
E(30)	20.0	26.2	17.5	14.2	14.7	11.1	16.4
E(35)	19.3	23.5	16.3	13.1	11.5	8.5	16.9
E(40)	17.3	21.3	15.2	12.0	8.2	4.2	14.5
E(45)	13.8	19.1	14.1	11.0	–	–	12.1
E(50)	12.8	16.9	13.0	10.1	–	–	10.6
E(55)	11.3	14.8	11.8	9.2	–	–	9.1
E(60)	9.8	13.1	10.6	8.3	–	–	8.1
E(65)	6.9	11.5	9.3	7.4	–	–	7.0
E(70)	4.0	11.3	7.7	6.4	–	–	–
E(75+)	2.0	11.0	5.6	4.9	–	–	--

SOURCES: Mesolithic, Acsádi and Nemeskéri (1970); Aleut, Sadlermiut, and Greenland, Harper (1975); Chukchi, Hrdlička (1944); Koniag, Taylor (1966); Caribou Eskimo, Weiss (1973). Data for Chukchi and Koniag were graduated by the author.

[a] Life expectancy at age *x*.

camps among Bering Sea Eskimos to clan control of halibut banks among the Tlingit and tribal control of shellfish beds among the Yahgan. There is no question that resource competition—as a "density-dependent" response—has affected maritime populations. In addition, while warfare is in general less frequent among hunter-gatherers than among more complex societies, high-density coastal peoples such as the Aleut or Tlingit were characterized by a higher degree of endemic warfare. Undoubtedly this was related to resource circumscription and competition, as described by Carneiro (1970) for coastal Peru. However, warfare alone was probably insufficient among maritime societies—as among other hunter-gatherers—to keep population in check (Harris 1975).

BIOGEOGRAPHICAL VARIATION

Population densities are generally high among maritime peoples, but they vary according to the strength of primary production in a given area, coastline complexity, likelihood of exploiting "unearned" resources, and suitability of areas for coastal settlement. Island chains are particularly good areas for testing the strength of correlations between population density, subsistence strategies, and settlement patterns because they are closed, easily defined systems (McCartney 1975). In addition, zoogeographers have intensively studied island ecosystems and have isolated the major variables involved in biotic distributions in such ecosystems (Gorman 1979; Diamond 1977, 1978). MacArthur and Wilson (1963, 1967), for example, have derived correlations between species diversity and both island area and distance from major land masses. As noted previously, heightened species diversity affects hunter-gatherer populations principally by offering alternative resources that buffer the population and help minimize the risk of local group extinction. Since this simultaneously increases the probability of sedentism, one would expect to find generally larger human populations on larger islands and those closer to the mainland, all other things being equal (that is, assuming that coastline complexity and species packing do not vary independently of island size). In archipelagos, total biomass is in part a function of island area but also depends on the location and productivity of interisland mixing systems. Human population densities should therefore be expected also to covary with the latter features.

Few systematic attempts have yet been made to test such linkages between human populations and ecological variables in island ecosystems (Underwood 1965, 1969). Analogies have been drawn between species-diversity models and human linguistic diversity as a function of island distances (Terrell 1976, 1977); similar linkages between ecological and linguistic diversity have been sought in other coastal zones (Stuart 1971). Some success has also been achieved in relating material-culture distributions to island distances as a result of human cultural dynamics analogous to animal population movements (diffusion, trade, or migration). However, studies of human population distributions in island ecosystems have rarely been undertaken (Kirch 1980, Kriszcziokaitis 1975).

On the basis of their study of coastal California middens, Cook and Heizer (1965; Heizer and Cook 1968) have argued for a statistically significant linkage between settlement area and human population size. Wiessner (1974) has argued the same for ethnographic populations of San. Such linkages are seen to be valid as long as one is dealing with a limited and relatively homogeneous region. Exponential (curvilinear) or logarithmic functions seem to fit the data best, but even strictly linear regressions based on least-squares methods produce correlation coefficients on the order of +0.70 to 0.90. Using site area, then, as an index of population density, I sought to test the strength of the relationship between prehistoric population density and island area, using as a test case the Casco Bay region of southwestern Maine (table 4). Because of differences in precision of measures of site and island area, both measures were converted into ranks. The Spearman rank correlation coefficient between the two sets of ranks was +0.62 ($.001 < p < .01$).

TABLE 4

Island and Settlement Areas, Casco Bay

Island	Island Area (km²)	Rank	Settlement Area (m²)	Rank
Little French	.00035	1	1	1
Little Iron	.00097	2	33	3
Sow and Pigs	.0046	3	607	12
Horse	.0054	4	1,160	18
Shelter	.0080	5	248	6
Barnes	.0090	6	316	9
Scrag	.0108	7	241	5
Pettingill	.0110	8	740	13
Little Birch	.0115	9	70	4
Stockman	.0173	10	7	2
Bates	.0236	11	960	16
Williams	.0241	12	308	8
French	.0254	13	1,290	19
Little Moshier	.0258	14	905	15
Ministerial	.0263	15	772	14
Upper Flag	.040	16	1,102	17
Bangs	.060	17	300	7
Stave	.061	18	2,330	21
Upper Goose	.105	19	560	11
White	.159	20	384	10
Whaleboat	.181	21	6,178	23
Haskell	.184	22	2,052	20
Lower Goose	.222	23	5,852	22

$r_s = +0.62$; $t = 3.59$ (22 df); $\alpha = 0.01$

Of the eight islands with the greatest discrepancy from the overall trend, six were either very close to or very far from the mainland. Food storage may have been a factor on distant islands, while trade may have played a larger role on islands closer to the mainland. In addition, there is some suggestion from ethnographic data that local hunter-gatherer microband fragmentation patterns may have been affected by distance from the mainland during seasonal occupation of offshore islands (i.e., a greater degree of band aggregation occurred closer to the mainland). These cultural factors find no direct analogies in zoogeography.

In larger archipelagos, species diversity also declines with distance from the nearest land mass (MacArthur and Wilson 1963, 1967). This trend is apparent, for example, in the Aleutian Islands off the southwest coast of Alaska. A parallel pattern emerges from the study of faunal remains from Aleutian archaeological sites. An analysis of 6,437 mammalian and 9,668 avian remains excavated from sites in all parts of the Aleutians shows that people living in the easternmost islands (closer to the mainland) were particularly well placed to exploited "unearned" seasonal resources: sea mammals (mostly fur seals and whales) migrating past the Alaskan coast and birds migrating along the North Pacific flyway (Yesner 1977*a*, *b*). Furthermore, the eastern Aleutian island passes, unlike those farther west, are dominated by true gyral upwelling systems (Kelley, Longerich, and Hood 1971). One result is a seasonal florescence of sea birds that utilize these plankton blooms. Sanger (1972:599) has shown a several hundredfold increase in the biomass of these species during late summer and early fall, when upwelling (as measured by CO_2 concentrations in surface waters relative to the air) is at its peak. These seasonal species were important to the prehistoric Aleuts, comprising up to 93% of the avifaunal assemblage in the eastern Aleutians but declining to ca. 60% in the western islands (table 5). One result of these biogeographical trends is that site dimensions in the eastern Aleutians tend to be larger. One can postulate, therefore, higher population densities in the eastern than the western Aleutian Islands in prehistoric times, since upwelling systems and proximity to

TABLE 5

Seasonal Resource Availability and Archaeological Site Dimensions in the Aleutian Islands

Area	Percentage of Avifauna Seasonal[a]	Percentage of Mammalian Fauna Seasonal[a]	Mean Number of Species[b]	Largest Site Dimensions (m^2)
Akun	92.7	58.4	33.0	16,500
Unalaska	77.6	–	26.0	3,600
Southwestern Umnak	65.3	37.2	–	12,900
Central Aleutians (Amchitka, Atka, Kiska)	61.5	5.2	20.5	1,537
Attu	60.4	–	17.0	–

Sources: Akun, Turner, Turner, and Richards (1975); Unalaska, Bank (1963); Southwestern Umnak, Turner, Aigner, and Richard (1974); Central Aleutians, Desautels et al. (1971).

[a] Derived from minimum numbers of individuals calculated from archaeological faunal remains.

[b] Derived from several site excavations in each region; calculated from avian faunal remains.

the mainland combined to increase resource biomass and diversity in that area. (Similar correlations have in fact been established by Linares and Cooke [1975] for the Atlantic vs. the Pacific coast of Panama.) Yet the settlement areas do not correlate perfectly with the faunal data. The explanation apparently lies in the fact that Akun and Umnak Islands were closer to highly productive upwelling systems. Even highly localized upwelling systems, therefore, must play a role in the formulation of general theory of human biogeography in maritime regions.

MARITIME SUBSISTENCE

What are the advantages (or disadvantages) of maritime subsistence? Is it true, as Osborn (1977*a*, *b*) has argued, that sea foods are less attractive for subsistence than terrestrial fauna? Clearly, it has been established that the biomass of coastal resources is high. However, marine foods do differ considerably in nutritional value. High-latitude coastal populations are in a sense more fortunate, in that they are able to exploit a number of high-calorie resources. Sea mammals, in particular, are known for their high fat content, an important source of calories particularly for activities not related to metabolic maintenance. Recent studies among Eskimos (Draper 1978) show that the human body is capable of obtaining energy without ketosis from fats as easily as from protein, through the use of alternative metabolic pathways. In addition to calories, sea mammals also provide an excellent source of vitamins if consumed raw.

Fish and shellfish provide an excellent source of calcium, iodine, electrolytes, and other minerals. However, except for oily fish (found in some parts of the Arctic), these foods are notoriously low in calories. Diets based primarily on shellfish, sea urchins, lobsters, octopus, crab, shrimp, or other invertebrates would be dangerously low in calories. Recently, Wing (1978) has suggested that some tropical coastal groups may have even supplemented their diet with domesticated dog meat in order to achieve caloric sufficiency. On the other hand, these foods do provide a perfectly adequate supply of *proteins* to support coastal populations (Nietschmann 1972, 1973; Stark and Voorhies 1978). In low-latitude regions, the protein supply is generally great enough to enable trade with interior-adapted peoples for high-calorie foods such as grains or other vegetables (Stark and Voorhies 1978). This would have been particularly advantageous for protein-limited interior groups such as those in the Amazon Basin (Gross 1975, Harris 1975).

Before assuming that low-latitude coastal populations were calorie-deficient, however, it should be noted that the shellfish content of many prehistoric coastal diets may be vastly overestimated, since most archaeological midden studies have failed to use appropriate units of analysis to quantify and compare invertebrate with vertebrate faunal remains (Osborn 1977*a*, Shenkel 1971, Ambrose 1967). In addition, important nonfood yields of shellfish are often ignored (Wing 1974, Speck and Dexter 1948).

Furthermore, nutritional yields (protein, calories, vitamins, and minerals) represent only half the dietary picture. The other half involves the relative "costs" of coastal resource exploitation in terms of required time and energy investments per unit of nutritional yield. Unfortunately, very limited data are available in this area, and they are somewhat conflicting. For example, on the basis of modern collecting techniques Perlman (1976) calculates a caloric yield of ca. 2,300 kcal./hr. for shellfishing, while on the basis of direct ethnographic evidence Meehan (1977*a*) calculates a yield of only 800 kcal./hr. for this activity and Nietschmann (1973) only 375 kcal./hr. In spite of the lower caloric yield in comparison with other marine foods, it should be remembered that minimal technology is needed for all members of the population to engage in this activity, and therefore the ecological efficiency is high. (The actual number of hours per day that can be spent in shellfishing, of course, depends on both the local tidal range and nature of nearshore topography.) Nietschmann (1973) notes that turtle fishing produces a higher yield than shellfishing (ca. 960 kcal./hr.), while sealing and sea-bird hunting produce still higher average yields of ca. 1,500–2,000 kcal./hr. (Perlman 1976). Fishing appears to produce the highest yields—up to 5,000 kcal./hr. (Perlman 1976). The caloric yield of fishing therefore tends to be greater than that of terrestrial mammal hunting (ca. 4,000 kcal./hr. [Perlman 1976]) and within the range of extensive horticulture (Nietschmann 1973:229). However, most horticultural techniques require a greater average number of hours per day (Harris 1975). Furthermore, if one considers *protein* rather than caloric yields, the efficiency of oceanic fishing (in kcal. investment per g of protein yield) is higher than that of intensive agriculture (Rawitscher and Mayer 1977). Therefore, marine foods do offer some distinct nutritional advantages in comparison with other subsistence regimes.

PREHISTORY OF MARITIME SOCIETIES

Up to this point I have discussed some of the major features of maritime hunting-and-gathering societies upon which, I believe, most scholars would agree. Three important theoretical questions arise from this discussion for which there are no ready solutions in the literature: (1) How does one explain the origin of maritime societies? If the coastal lifeway is so advantageous, why didn't it become prevalent until Upper Palaeolithic times? (2) If high population density is a feature of coastal societies, how were favorable population/resource ratios maintained? How frequent was resource overexploitation? (3) Why and how did more complex societies emerge from a maritime base (e.g., in Peru?) The remainder of this paper will be devoted to tackling these questions.

The geographers Sauer (1962) and Hardy (1960) proposed that the seashore was the "primitive home of man," but if so the evidence of early—that is, early Pleistocene—use of the sea has been lost through sea-level changes occurring since that time. As far as we know, the utilization of marine foods dates back perhaps some 400,000 years. The Middle Stone Age of South Africa has yielded the oldest evidence to date of marine foods as a central subsistence focus—dating back perhaps 150,000 years at sites such as Sea Harvest and Hoedjies Punt on Saldanha Bay (Volman 1978) and the Klasies River Mouth caves (Klein 1974, 1975; Voigt 1973). In Europe, *H. erectus* populations included shellfish and other sea foods in their diet at Terra Amata on the south coast of France (de Lumley 1969), while the later Mousterian site of Devil's Tower in Gibraltar and the "pre-Aurignacian" site of Haua Fteah in Libya have yielded large numbers of shellfish such as mussels and limpets (Reinman 1967). The location of these early sites of maritime exploitation is by no means an accident of preservation. There is too good a correlation with the location of Atlantic coast upwelling zones for that to be the case. However, these sites represent only isolated instances of the use of marine resources before the late Upper Palaeolithic. It was during Upper Palaeolithic times that the entire range of fishing and sea hunting equipment (harpoons, gorges, sinkers, fishhooks, traps, etc.) began to appear on a worldwide basis, along with the earliest appearance of shellmound and other coastal sites in Europe, North Africa, and Japan and, slightly later (10,000–8,000 B.P.), in Oceania, the Pacific Northwest, and Brazil. The favorable geological situation in early postglacial Europe and North Africa—where isostatic rebound kept pace with sea-level rise—yielded coastal plains (see Binford 1968) and an opportunity for the creation of shellfish beds. However, this cannot entirely explain the phenomenon of the European Mesolithic, particularly for areas where shellfish were replaced by sea mammals as the major focus of maritime exploitation, as in northwestern Europe (Clark 1946).

Climatic factors were involved here too: specifically, the loss of the Eurasian tundra-steppe formation and, with it, a large biomass of megafauna. In part, however, humans themselves may have been responsible for the extinction of the late Pleistocene megafauna, as a result of both technological efficiency and population growth (Martin and Wright 1967). Cohen (1977) has stressed the latter factor as a stimulus to coastal settlement in postglacial Europe; human population growth must be seen as both an explanandum and a consequence of early maritime adaptation. Whatever the cause—climatic or demographic—one thing is clear: for many people, large sea mammals such as seals and whales were the best available replacement for the Pleistocene megafauna on which they had depended. Clearly, whether one is speaking of whales or shellfish, it appears that Mesolithic Europeans were simultaneously given the opportunity for—and pushed into—the maritime lifeway.

However, in spite of our classical (European-based) conception of the Mesolithic, maritime exploitation did not intensify significantly on a worldwide basis until the Hypsithermal interval of ca. 5,000 B.P. The underlying factors again appear to be geological and climatic. Emery and Garrison (1967), Jelgersma (1966), Fairbridge (1966), and Coleman and Smith (1964) have concluded that worldwide eustatic sea level rose rapidly until ca. 7,000 years ago, when it began to slow markedly, finally approximating modern sea level by ca. 4,000 years ago. This late Holocene levelling of eustatic sea-level rise was responsible for the cutting of strandflats from rocky platforms in many parts of both the Old and New Worlds; for North America, this was particularly true on the northeast coast (Salwen 1962), in the Pacific Northwest (Larsen 1971, Fladmark 1978), and in Alaska (Black 1974, 1975, 1976). Lampert and Hughes (1974:228) have presented one of the clearest statements of this phenomenon in connection with the geological background for coastal sites in Australia; they note that "intertidal rock platforms . . . are clearly tidal features whose development is linked closely with a stand of sea level," and "as their formation takes a reasonable length of time, rock platforms could only have been weakly developed and very limited in extent when sea-level was rising." Finally, with sea level rising at a much slower rate, sedimentation could keep pace with or exceed sea-level rise (Keene 1971), resulting in the formation of extensive shellfish beds on these rocky platforms as a newly available marine food source. At the same time, geological stabilization of the coastline lowered gradients of rivers emerging at the coast, creating a situation favorable to the establishment of anadramous fish runs on both Pacific (Fladmark 1978) and Atlantic (Sanger and Bourque 1979) coasts of North America.

Of course, this process was highly variable on a worldwide scale; the above scenario applies primarily to areas with stable or submerging coastlines. In areas where isostatic or tectonic factors have resulted in late Holocene emerging coastlines, marine transgressions interrupt the process. Examples of the latter would include the coasts of California (Bickel 1978), Brazil (Fairbridge 1976), the Mediterranean (Kraft, Rapp, and Aschenbrenner 1975, 1977), and the southeastern United States (Brooks et al. 1979, DePratter and Howard 1977).

While geological stabilization of the coastline was creating a situation favorable to the development of a marine food base, late Holocene climatic cooling simultaneously brought to bear a certain degree of pressure on the forest resources of the interior, primarily affecting various members of the deer family and some smaller mammals, particularly in northeastern North America. As in the origin of the classical European Mesolithic, a combination of push and pull factors oriented people further toward the sea, resulting in an intensification of the maritime lifeway. In some cases (e.g., northern New England, the Canadian Maritimes, the Pacific Northwest, and Alaska) experimentation with sea-mammal hunting pre-dated intensive shellfish collecting until the biomass of the latter resources made their collection truly rewarding. At the same time, gradually increasing population densities would have favored increasing use of shellfish resources as semisedentary groups became locked into the maritime lifeway. In the eastern United States, this may have been coupled with overexploitation of sea-mammal resources. The result was a transition from a Maritime Archaic tradition to a coastal Woodland focus.

One thing is certain: there is no need to call upon increased technological efficiency to explain the intensification of maritime exploitation, as Snow (1972) has for coastal New England. Only sea-mammal hunting and anadramous or deep-sea fishing require sophisticated technology. Fishing technology itself is as old as Olduvai Gorge. For shellfishing, as indicated above, all that is required is a simple stick or rake. To argue that the development of shellmounds in coastal New England reflects discovery of shellfish resources or the development of technology to exploit them is particularly difficult to accept, since much more complex technology, involving composite toggling harpoons, was available to earlier peoples of the Maritime Archaic tradition. No one would seriously propose such an argument for the *western* coast of North America, because there sea-mammal hunting evidently pre-dates shellfishing and salmon fishing by some 4,000–5,000 years. Geological and climatic arguments simply offer a more parsimonious explanation of the nearly universal phenomenon of mid-Holocene intensification of maritime adaptation. Continuing changes in shellfish types found in late Holocene middens are also best considered a result of these factors (Braun 1974, Ritchie 1969, Goggin 1948, Foster 1975).

POPULATION REGULATION

I have argued earlier that, as a result of high resource diversity and low dependency ratios, maritime societies have in general had little need to resort to cultural practices such as infanticide to maintain equilibrium population levels, since the risk of total population decimation is very low. As Denham (1974) has noted, the absence of cultural regulation of population produces recurring cycles of population growth and decline as the population tracks the rise and fall in the food supply. One result would be *occasional* overexploitation of food resources. There is preliminary evidence from several parts of the world, including New Zealand (Shawcross 1975, Swadling 1976), Oceania (Kirch 1980, Reinman 1967), and Alaska (Yesner 1977*a*, *b*) to suggest that maritime peoples *did* occasionally overexploit their resource base.

One mechanism is available to maritime hunter-gatherers, however, that enables them to adjust their population levels to their resource base: shifts in settlement pattern. Since, as stated above, a coastal group tends to exploit a number of ecological niches, it can "ride its niches" (Thomas 1971) by shifting settlement pattern to meet changing resource demands. One means for doing so is exercising "decreased selectivity in the micro-niches it exploits, utilizing portions of its environment that have previously been ignored while continuing to exploit the old niches" (Cohen 1975: 5). One would hypothesize, therefore, that coastal settlements in areas of highest diversity would be continuously occupied villages; that those in areas of least diversity would be short-term special-purpose camps; and that those in areas of intermediate diversity would be short-term camps that were more intensively exploited during periods of relative population stress on resources.

In order to test this hypothesis, I examined in detail the prehistoric settlement patterns on southwestern Umnak Island in the Aleutian Islands (Yesner 1977*a*, *b*). Species-diversity data are not readily available for different parts of this region, but a previous study of faunal remains from middens in this area (Yesner n.d., Yesner and Aigner 1976) had shown that the prehistoric Aleuts exercised little hunting selectivity as far as most species were concerned ("random" hunting, in Wilkinson's [1976] terms). Generally speaking, food preferences ranked similarly in different archaeological sites in the region. Since all sites seemed to have been affected about equally by the "cultural filter," I felt confident in using the archaeological materials themselves as an index of diversity. Various ecological diversity measures were therefore applied to the archaeological faunal data (Pielou 1972, Hardesty 1975). The measures chosen (Shannon-Weaver, Simpson, and Hardesty indices) involve not only the numbers of species, but the "evenness" with which they are represented in the assemblages. The evenness aspect of diversity is important; if there are ten resources available to a human population and nine of those represent only 1% of the total biomass, there is effectively only one resource available. The results are shown in table 6 (for more detail, see Yesner 1977*a*, *b*). The Chaluka site had the greatest diversity of resources available; faunal remains indicate that it was occupied year-round in all site components. The Sheep Creek site, with the least diversity, appears to have been throughout its history a specialized camp for fishing and other limited activities (Aigner 1974). The Oglodax' site, in an area of intermediate diversity, was clearly occupied seasonally throughout its history (winter/spring occupations during its early history, summer/fall occupations more recently) but was more intensively utilized during certain periods, with faunal remains for those periods indicating occupation during all seasons of the year. In general, the Umnak data seem to support the hypothesis quite well. Population/resource imbalances were absorbed in the Aleutians, and probably in other maritime societies, by shifting settlement pattern to make more intensive use of marginal zones.

TABLE 6

DIVERSITY OF FAUNAL ASSEMBLAGES AT UMNAK ISLAND SITES BY VARIOUS MEASURES

SITE	INDEX		
	SHANNON-WEAVER	SIMPSON	HARDESTY
Chaluka....................	12.99	0.725	13.24
Oglodax'....................	6.94	0.691	10.53
Anangula Village............	1.65	0.689	10.31
Sheep Creek................	1.14	0.527	3.41

GENERATION OF COMPLEX SOCIETIES

What happens, then, when, as Cowgill (1975) puts it, the available niches are filled up and populations are no longer able to emigrate or make further use of marginal zones? In this case, population pressure *may* stimulate developmental innovations, leading to the development of more complex societies, through a number of possible avenues. Trade with other groups would have been one such avenue, and intensive trade alone may have had important consequences for the development of centralized elites to manage that trade (Adams 1974). Where domesticates were not available, this may have included trade with neighboring farmers. Possibly this is what occurred in the adoption of horticulture by groups such as the Ertebølle shellmound peoples of Scandinavia, although they may have simply been swamped by more technologically sophisticated farming peoples (Troels-Smith 1967). Where domesticates were available, however, independent development of horticulture may have taken place.

Perhaps the most likely situation to stimulate the growth of complex societies from a maritime hunting-and-gathering base—even without the development (at least initially) of horticulture—would be a very sudden disruption of population/resource equilibrium. This is evidently what happened in that very special situation on the coast of Peru. The cold Humboldt Current yields an exceptionally resource-rich coastline there, except for the few years out of every century when El Niño occurs, reversing the south-to-north flow. Given this type of situation, an optimal strategy is *not* for coastal groups to maintain their populations below a level that can be supported by the once-in-a-generation resource low. Those groups will be at a selective advantage that can take advantage of the rich marine food base and develop some kind of cultural device to get the population over the once-in-a-generation hump. A priestly class—possibly combined with secular leadership—would have been valuable in such a situation, because it could have both appealed to the gods for aid and traded with other groups for products from different ecological zones (e.g., the Peruvian highlands). It is not difficult to imagine how this could have led such a class to demand supplication and eventually obtain power over members of the group. The development of early complex society on the coast of Peru, as evidenced by "temple" structures that pre-date effective horticulture (Moseley 1972, 1975), may have been a logical outgrowth of, and an effective mechanism for dealing with, a volatile ecological situation not characteristic of most maritime societies, as Osborn (1977*a*) indicates. Unlike the situation in most maritime societies, prehistoric population growth on the Peruvian coast could *not* be absorbed through settlement-pattern dynamics. Coastal Peruvian prehistory *is* unique, but not because of unusually high coastal resource productivity. What is unique about prehistoric Peru is the phenomenon of El Niño and the existence of a large number of diverse *terrestrial* environments in close proximity to the coast. It is this unique ecological combination, not coastal productivity per se, that may have contributed to the rise of an aristocracy, promoted continued population growth, and led to increased cultural complexity. Viewed in this light, prehistoric Peru does not invalidate a general theory of maritime hunter-gatherers, but is in a sense the exception that proves the rule.

Comments

by William S. Ayres

Department of Anthropology, University of Oregon, Eugene, Ore. 97403, U.S.A. 23 vi 80

Yesner's paper raises a number of questions about the archaeological study of maritime-oriented peoples. All his points relate ultimately to the uniqueness of marine-based subsistence and the potential for formulating a comprehensive theory of maritime adaptation. I certainly second his call for more detailed analyses of specific ecological constraints; these are needed for the study of any subsistence pattern, but they do require expertise beyond the scope of most archaeologists.

Yesner stresses that the northern temperate coastal zone needs more detailed study because horticulture there is only a marginal possibility. The Pacific Islands present another area where studies are beginning to provide detailed and crucial data on coastal adaptation (Kirch 1979, Kirch and Kelly 1975, Leach and Anderson 1979). It is feasible to control ecological factors more successfully on isolated islands because nonmarine biota and exploitative systems are limited (e.g., Easter Island) and because ethnoarchaeological data on traditional subsistence patterns are available.

A major complication in any effort to develop a comprehensive theory of coastal adaptation results when hunters and gatherers who are fully dependent on wild foods are lumped with peoples using domesticates. Most would agree that the long-standing dichotomy between "Neolithic" and hunting-and-gathering subsistence bases has been overplayed, but I would maintain that this dichotomy is still of greater significance in economic and cultural adaptation than the one between coastal and inland continental exploitation. Cultivators, because of their comparative lack of mobility, are qualitatively different from hunters and gatherers when considered in the context of maritime adaptation.

Problems of comparison are evident in Yesner's table 3, where Ulithi and Tikopia are included with Aleuts and Cocos Islanders. He notes that some societies in Oceania have economies including horticulture; in fact, all Oceanic peoples (Melanesia, Micronesia, and Polynesia, by convention) are horticulturalists, and existence without a mixed economy in those Pacific habitats would be precarious if not impossible. The inclusion of Oceanic peoples that rely on mixed economies in the same category with northern-latitude maritime hunters and gatherers obscures rather than clarifies the reasons for any overt similarities that exist, e.g., life span.

The point is not that the diversity of coastal ecologies and the technologies and social systems required to exploit them precludes a general theory of maritime adaptation, but that to do so is to emphasize an artificial separation of subsistence components—marine from terrestrial resources and wild from domesticated forms. Yesner is correct in stressing that it is misleading to think of hunters and gatherers as a single economic type; but it seems that it is even more misleading to lump coastal peoples into a single economic category. Such a simplification of maritime adaptation may very well obscure the significance of the subsistence mix, which is so essential for understanding cultural adaptation.

by David L. Carlson

Department of Anthropology, Illinois State University, Normal, Ill. 61761, U.S.A. 26 vi 80

I am generally enthusiastic towards Yesner's efforts to synthesize a large quantity of data on and relating to maritime hunter-gatherers. His presentation is thorough and systematic. I have five comments, two technical and three theoretical.

1. Yesner confuses population *size* with population *density*. Settlement area is correlated with population size, and therefore table 4 tells us only that bigger islands have more people. If the settlement areas are divided by the island areas (square meters of settlement per square kilometer of island), Spearman's r between island size and the estimate of population density is $-.29$, which is in the opposite direction from that expected and not significant.

2. Table 6 should include the number of individuals at each site, since these diversity indices tend to be positively correlated with sample size. If some of the sites contain far more individuals, they could be subsampled and the diversity indices for the subsamples used for comparison.

3. Yesner may be underestimating the importance of large-amplitude fluctuations in maritime environments. The evidence he cites for overexploitation might equally indicate periods of low resource availability. El Niño is well known because of its importance to the Peruvian fishery. It seems at least possible that other areas of upwelling are susceptible to similar fluctuations. Furthermore, Yesner is inconsistent in identifying the frequency of El Niño ("few years out of every century"–"once-in-a-generation"). Recent studies would seem to indicate a frequency of about once a decade (Hartline 1980:38–40; Cromie 1980:36–43).

4. Data on infanticide are notoriously difficult to acquire, and therefore the lack of data should not be taken as strong evidence against the practice. Divale and Harris (1976) report infanticide as commonly practiced among the Andamanese, most Eskimo groups, the peoples of Groote Eylandt and Tasmania, and other groups which might be considered maritime hunter-gatherers.

5. Yesner ignores the importance of maritime societies for understanding the shift from band to tribal societies. The importance of localized, highly productive resources which can be protected and "owned" by a corporate group must be appreciated in any research into the role of maritime and unearned resources in cultural evolution. With respect to the shift toward chiefdoms, Pebbles and Kus (1977) have played down the importance of redistribution at this level of socioeconomic development. Yesner's hypothesis of redistribution as a solution to El Niño requires a demonstration that settlement shifts and exchange via simple kinship networks would be unequal to the task of buffering coastal populations.

by Richard S. Davis

Bryn Mawr College, Bryn Mawr, Pa. 19010, U.S.A. 10 vi 80

Yesner's paper has focused attention on an important set of problems: the dynamics and origins of marine adaptations of hunters and gatherers on a worldwide basis. There is much of value in it. My comments will be largely critical, but I hope they will be taken as constructive.

The spirit of Yesner's paper is clearly nomothetic and generalizing, but it seems to me that maritime adaptations per se are not an appropriate realm for universal theory building. The overall message of the paper seems to be that maritime hunter-gatherers are parts of ecological systems and that ecological principles should be useful for understanding how these societies operate. Human ecology, not a particular subset of hunter-gatherers, is, I think, the area where our attention should really be focused and the place where useful generalizations will be found. These generalizations should be applicable to both maritime and terrestrial hunters and gatherers.

Yesner lists ten "features" of maritime-adapted populations. With the exception of No. 5, these are all variables which can be measured in any biome. Because Yesner provides practically no quantitative comparative data with terrestrial hunter-gatherers on these points, the significance and reality of his qualitative statements cannot be ascertained. Clearly there are many terrestrial environments with less seasonality, higher species diversity, or greater technological diversity than marine ones. The point is that the abundance, timing, and spacing of resources should have some effect upon human population density, technology, demography, and social organization, not that marine vs. terrestrial adaptations have certain weakly ascribed general characteristics.

Also important here is, of course, the definition of marine adaptations. If Yesner's criterion that marine food is the largest portion of caloric or protein intake is used, then some inland groups (such as those of the lower Klamath province) that heavily depend on anadramous fish have to be included. Others, perhaps even those represented by many of the Maritime Archaic sites, that use many marine resources and have considerable marine-related technology would have to be excluded. Also excluded would be many riverine- and lacustrine-based groups, whose resource exploitation patterns share many similarities with coastal settlers.

The Casco Bay study is offered as a test of the relationship between population density and island area. Here there is no stated temporal control. Is Yesner referring to all archaeological sites found in the study area or just sites from a particular time horizon? If they come from a number of periods, then the correlation has less meaning, because a variety of factors could have influenced observed settlement distributions over time. It seems almost certain that inhabitants of the Casco Bay islands chose sites where marine resources were the most available, reliable, or easy to procure. The size of the island was of secondary importance. In addition, if zoogeographical principles can be overridden by "cultural factors," one wonders in this case what the relation between the two really is.

In the Aleutian case, the Aleuts were totally dependent upon sea food, and hence the pattern of island terrestrial faunal diversity postulated by MacArthur and Wilson would seem to have no relevance for Aleut settlement sizes and distribution.

Why marine adaptations appear to have intensified dramatically in the Holocene is an important question. Climatic and demographic factors no doubt played an important role, but it is hard to deal with them on a worldwide basis with much reliability at the present time. What real evidence is there that "climatic cooling . . . brought to bear a certain degree of pressure on the forest resources of . . . northeastern North America"? that "maritime societies have in general had little need to resort to cultural practices . . . to maintain equilibrium population levels" (it would be a strange society indeed that had no cultural controls of fertility and mortality)? that certain prehistoric societies actually overexploited their marine resources?

Yesner seems overly concerned that Peruvian prehistory may be seen as a significant challenge to a "general theory of maritime hunter-gatherers," and he takes Osborn to task for not seeing the "true" uniqueness of the situation. It all seems quite beside the point to me. If the origin of ranked and stratified society is to be understood as a function of resource allocation during periods of scarcity, then it doesn't really matter if terrestrial or maritime items were in short supply. In any case, this freewheeling form of functional argumentation is not very compelling.

by Robert Dewar
Department of Anthropology, U-176, University of Connecticut, Storrs, Conn. 06546, U.S.A. 17 vi 80

Yesner is certainly correct in arguing that hunter-gatherer societies in the past were more diverse than the small and biased sample of surviving nonagricultural groups; the study of foraging economies will necessarily rely upon the analysis of archaeological data. His argument about the nature of maritime hunter-gatherer ecology is marred, however, by errors of fact and interpretation which diminish its force and call into question his attempt to define this as a unique and coherent subset of hunter-gatherer economies.

1. While shellfish strandflats are rich food patches, Yesner's comparison with terrestrial biomes is inappropriate. Savannah hunters have hundreds of times more savannah within a day's walk than most coastal villages have strandflats. In addition, the suggestion that terrestrial herbivores can only be cropped at 2.5% per annum is highly questionable (see Delaney and Happold 1979:347); the potential cropping rates are probably not far from the 8–10% that Yesner cites for nonmigratory sea mammals.

2. Yesner fails to note that many terrestrial mammals are migratory and that the use of migratory species is not a unique feature of maritime economies. Further, he is incorrect in implying that "unearned" resources are necessarily exploitable at a "higher maximum sustained yield"; many migratory species have proved vulnerable to hunting pressure.

3. Yesner argues that "maritime societies can 'allow' their populations to 'track' (i.e., be regulated by) changes in resource availability." However, he neither offers data which demonstrate this association between population density and resources nor describes any unique feature of "maritime" population dynamics. In times of food scarcity, it is almost universal for diets to expand in breadth and for settlement patterns to change. Though Yesner cites Cowgill (1975), he seems to have missed the central thesis of that article: "In fact, empirical data do not support the assumption that human populations normally tend to increase until serious resource shortages are experienced or at least clearly foreseen" (Cowgill 1975:127).

4. Yesner misapplies MacArthur and Wilson's (1967) island biogeography theory in the Casco Bay example. Since the resources sought were presumably marine, rather than terrestrial, the determinants of occupation were more likely the extent of the submerged resources than the area of exposed surface or the diversity of terrestrial forms. In a location like Casco Bay there is no necessary relationship between area of exposed and shallow submerged surface, nor would rookeries and nesting areas necessarily be only on the largest islands. In any case, MacArthur and Wilson's "islands" are potential habitat patches, and the determinants of species diversity—distance to mainland and island size—predict the number of species which will occupy these patches and not surrounding zones.

5. Yesner's test of the hypothesized relationship between species diversity and intensity of occupation is flawed. He fails to note that (*a*) the components analyzed are drawn from more than 3,000 years of occupation (Yesner 1977*b*:283); (*b*) the sites are all less than six nautical miles from one another (Yesner 1977*b*:106); (*c*) the absence of hunting selectivity is supported *only* by his analysis of avian species, but both sea mammals and invertebrates were collected nonrandomly and mammals contributed 100 times more to diet than birds did (Yesner 1977*b*). As a result, the midden contents cannot be considered unbiased samples of local species diversity, and the differences in settlement intensity are not explained by differences in local species diversity. I find it unlikely, at least without further demonstration, that the "cultural filter" remained unchanged for more than 3,000 years. Finally, Yesner disregards the possibility of changes in avian distribution and abundance in the past 4,000 years.

In short, these data are insufficient to support the claim that "maritime hunter-gatherers" had population dynamics substantially different from those of other human populations.

by Manuel R. González Morales
Departamento de Prehistoria, Universidad de Oviedo, Oviedo, Spain. 17 vi 80

I agree with most of Yesner's paper and have only a few remarks to make based on our studies of the Asturian, a local post-Pleistocene "maritime" culture on the north coast of Spain

(González Morales 1980) known through former investigations by Vega del Sella (1923) and Clark (1976).

First of all, there is no evidence of sea-mammal hunting in Asturian and other maritime postglacial groups of southwestern Europe. Thus there is no evident increase in technological complexity, related by the author in Point 7 to such hunting, but rather a real simplification in lithic technology and antler/bone industries. This trend is well recorded in Azilian times in the area (Fernández-Tresguerres n.d.) and developed to the extreme during the Asturian period, when littoral and estuarine fishing and shellfish collecting became very important, although the hunting of terrestrial mammals still represented a good portion of subsistence. This process seems to be related to an increase in the extent and density of forests on the Cantabrian coast beginning at the end of the Tardiglaciar and reaching its climax during the Atlantic period.

From this perspective, some hypotheses can be proposed in response to the theoretical questions raised by Yesner with regard to the prehistory of maritime societies. First, as to origins, in the case of the Azilian/Asturian transition of northern Spain it seems that, together with the environmental factors traditionally considered, there are also cultural and demographic ones: the trends toward simplification of industries and resource diversification are present at least in the local Azilian *before* the development of intensive shellfish collecting and fishing and without a clear coincidence with environmental changes; on the other hand, there is evidence of population concentration on the narrow coastal plain of eastern Asturias, where Asturian groups lived; the topography of this area seems to be closely related to population increase and diversification of exploitable resources. On the problem of the emergence of more complex societies from a maritime base, we have radiocarbon dates from the 8th to the beginning of the 4th millennium for Asturian-type shell middens, a fact evidencing a long duration for this maritime-based economy. The presence of pottery in late Asturian middens without evidence of any other alteration—either cultural or economic—points to the presence of late Neolithic or "megalithic" groups close to late Asturian sites. Because of the topography of the area, groups of littoral hunter-gatherers could live side by side with groups exploiting nearby high grassy plains without effective interference. I think that the presence of these intrusive groups in the Asturian region curtailed the development of this culture: instead of the emergence of more complex societies there seems to have been acculturation and/or substitution. Like most maritime societies, according to Yesner's point of view, the Asturian seems to have achieved a high degree of stability and shown no tendency toward the development of more complex social structures.

by Fekri A. Hassan

Department of Anthropology, Washington State University, Pullman, Wash. 99164, U.S.A. 27 v 80

Reacting against what he perceives to be a textbook stereotyping of Pleistocene hunter-gatherers after the Kalahari San or the high-arctic Eskimo, Yesner argues that maritime groups provide a better analogue. He further argues that such groups were characterized by high population density, complex social organization, and lack of artificial population regulation. In addition, he hazards an explanation of the emergence of maritime adaptation and complex social organization among coastal groups.

I have recently stated that it would be a grave mistake to model prehistoric hunting-gathering populations on any of the ethnographically known populations because of the variability exhibited in both the past and present (Hassan 1979:139), and therefore I find myself in agreement with Yesner's skeptical attitude toward the treatment of hunter-gatherers as a homogeneous economic type. I also applaud his discussion of the characteristics of maritime resources as a basis for interpreting the high population density and the sedentariness characteristic of many coastal groups (cf. Hassan 1979:143 on Northwest Coast groups). I do not, however, find his empirical analysis of population density and ecological variables convincing. He accepts the idea of a relationship between settlement area and population size based in part on Wiessner's work on !Kung Bushmen. Wiessner's (1974) equation, however, is erroneous; the data are best described by the equation Area = 0.1542 × Population 2.3201 (Casteel 1979), where Area is what Yellen (1977) calls "LNAT"—the area of all huts, their associated hearths, and the debris surrounding the hearths. This empirical finding cannot be generalized to situations in which the layout of camps differs from that of the !Kung (see, for example, Read 1978, Hassan 1981). Yesner rejects the Bushmen as a model of hunter-gatherers, yet does not hestitate to use data on their settlement and population to draw inferences about maritime groups. Further, it is unclear what is meant by "settlement area" (table 4) and how it compares with Yellen's LNAT.

I am more disturbed, however, by Yesner's perfunctory treatment of the concept of "population pressure" and his uncritical acceptance of this concept to explain the emergence of the maritime economy and of complex societies. With almost total disregard for the vast literature on population regulation among people and animals (see, for example, Cohen, Malpass, and Klein 1980, especially the papers by Cohen, Hassan, Lee, and Ripley), Yesner suggests that the high biomass of coastal resources and their low seasonality, high diversity, and aggregation would favor a permissive population growth pattern. Obviously, no wild resources are so rich and expandable as to remove all limits on population growth (Hassan 1978:78), and the model suggested by Yesner, in which populations boom and crash as resources fluctuate, seems disruptive to the continuity of cultural traditions and likely to produce loss of life and misery. It is this untenable model of "natural" population regulation that leads Yesner to embrace the population-pressure model as an explanatory framework for the emergence of complex societies. The fallacies of this model have already been discussed (see Hassan 1974, 1978, 1979; Cowgill 1975; Bronson 1977). It must be mentioned, however, that infanticide is not the only method of "artificial" regulation of population.

Maritime fishers and sea-mammal hunters are undoubtedly a distinct group of food collectors. Their adaptive patterns and the implications of their unique ecological setting for demographic conditions and social organization are indeed worthy of our attention as an analogue of *some* prehistoric groups, but we should be forewarned against "idiographic analogy" and should seek to elucidate the structural basis (i.e., orderly set of basic relationships among essential variables) of the relationship between ecological circumstance, demography, and social organization (Hassan 1979). Yesner's cautionary remarks on the uncritical acceptance of ethnographic groups from marginal areas as exemplary of Pleistocene populations should be coupled with a warning against the eager adoption of current concepts in archaeology that may have an equally stultifying effect on the understanding of prehistoric adaptations.

by Brian Hayden

Department of Archaeology, Simon Fraser University, Burnaby, B.C., Canada V5A 1S6. 9 vi 80

Yesner asserts that maritime hunter-gatherers employ no cultural population controls, and at the same time he states that these populations "track" resource fluctuations. How both can be true remains a mystery. Similarly, he argues that sedentism implies population growth, but if this growth was uncontrolled and especially if, as he suggests, overexploitation of resources occurred, it would seem that these populations were not "tracking" their resources. Perhaps the best thing that can be said of this "resource-tracking-without-population-control" concept is that it is not necessary for his conclusions.

Yesner's propositions that coastally adapted hunter-gatherer populations constantly expand to overfill all niches and that they avert resource crises by temporarily reshuffling local populations are both difficult to accept. While he implies that the latter strategy was unique to them, in reality it is probably common to all hunter-gatherers and can be documented or inferred from a number of ethnographic accounts (e.g., Gould 1969:266–67; Tindale 1972:234–42; Strehlow 1965; Silberbauer 1972:295–304). As a result, Yesner's "test" of his "hypothesis" (that areas of lower resource diversity and abundance are occupied less regularly) not only tells us little we did not know, but has no implications for his thesis. Moreover, it has never been documented that constant, prolonged population growth could be effectively dealt with by population shuffling of the type Yesner outlines. Conservative estimates are that, without cultural population controls, hunter-gatherer groups would increase at the rate of about 0.2% per year (Angel 1975; see also Hassan 1975). This would result in rapid saturation of the "carrying capacity" of any area and a tremendous absolute increase in population within only a few thousand years. It is inconceivable that the small-scale, temporary population movements portrayed by Yesner could offset the effects of such increase.

Given the inevitability of resource stress, the question once again is why these hunter-gatherers would not have employed some form of population control. Yesner reverts to his black box, and this time "sudden" population pressure results in priests, exchange, and Andean civilization. Such pressures almost certainly occurred throughout the Pleistocene among all hunter-gatherers (Hayden 1975) and are even regularly documented for other coastal groups (Jewitt 1974:46, 73, 93; Colson 1979; Drucker 1951:37; Oberg 1973:89–90). Why should they have resulted in state society only on the Peruvian coast?

Even the factors Yesner believes responsible for uncontrolled population growth are difficult to accept. He claims that reduced dependency ratios, sedentism, and low risk of population decimation in times of shortage allowed populations to climb. Again, assertions take the place of documentation: warfare is disregarded as a control on population, and dependency ratios are never quantified. Almost all hunter-gatherers have some easily collected resources available to them, and children and the elderly can usually contribute significantly to the daily larder. In addition, shellfish were generally a small proportion (ca. 5%) of coastal diets (Bailey 1975, Meehan 1975). There is no reason to believe that dependency ratios were any different among coastally adapted hunter-gatherers than among continental ones. Similarly, decisions to employ most cultural means of population control are made not at the community but at the family level, and therefore there is no reason to believe that a low risk of "population decimation" would influence them. More important, there are no data to demonstrate that this risk actually was low. Finally, while sedentism is often more pronounced among coastal groups, there are indications that it does not significantly affect population growth. For the most sedentary groups in Australia, linguistic evidence indicates stability with considerable time depth. In addition, highly nomadic hunter-gatherer populations have exhibited impressive growth.

Yesner claims that since fish have been used since Oldowan times technology was not a factor in the development of intensive coastal adaptations in the Holocene. He overlooks the difference between obtaining fish sporadically from chance finds in drying pools or along the shore and procuring marine resources as regular staples. For the latter, technology is the key. The central role of complex technology in the efficient, regular exploitation of deep-sea resources is even a clearer argument against Yesner's dismissal of technology. While little technology is required to harvest many species of shellfish, the use of shellfish, as Yesner himself notes, is not very worthwhile from a caloric or protein point of view (see also Bailey 1978, Cipriani 1966); thus the reader is left wondering why they should ever be used intensively.

Finally, Yesner's characterization of contemporary knowledge concerning hunter-gatherers as pertaining only to "marginal" groups living in simplified habitats is unjustifiable. Elsewhere, his logic could be used to argue that all hunter-gatherers should be sedentary, since most situate campsites so as to take advantage of several resources. He makes a number of good observations about coastal environments, but I find his model full of internal inconsistencies, contradictions, and unsupported, highly speculative assertions presented as fact.

by JOSEPH J. LISCHKA *and* PAYSON D. SHEETS
Department of Anthropology, University of Colorado, Boulder, Colo. 80309, U.S.A. 19 VI 80

Yesner's article is a welcome addition to the literature on maritime hunters and gatherers. We would caution, however, against too great an emphasis on energy inputs and outputs in the analysis of subsistence systems. The Bushmen, for example, maintain a high diversity of diet even though it would be more labor-efficient to exploit a more limited range of plant and animal foods (Cohen 1977:35–36). It is surprising that Yesner does not refer to Jochim's (1977) analysis of hunter-gatherer subsistence systems. Shellfish collecting and the harvesting of the other small fauna and flora of intertidal zones appear to play a role in marine subsistence systems comparable to that of the exploitation of terrestrial small animals and wild plant foods, which Jochim classifies as high-security/low-prestige resources. The hunting of large mammals gives a less secure energy return but confers greater prestige on the hunter, according to Jochim (pp. 15–28).

Yesner proposes that coastal Peruvians responded to niños during the Preceramic by importing food from other regions. However fashionable it is to invoke exchange systems to resolve economic difficulties, we suggest that a feature of niños allows a transfer to local production. Heavy rainfall accompanying a niño raises water tables in coastal valleys for several years, temporarily improving conditions for floodplain agriculture. Biomass production in *lomas* areas also increases temporarily (Murphy 1926). Coastal populations could have increased exploitation of these resources while the marine ecosystem recovered, with agriculture assuming greater importance as coastal populations increased during the Preceramic. As the marine ecosystem recovered, exploitation of the less labor-intensive marine resources again became primary, with agricultural production continuing at a relatively low level to maintain seed stocks and obtain desired products such as cotton (Lischka 1975). Increased territoriality, then, would have pertained not only to marine resources, but also to agricultural land, even though that land would only be of critical importance for a few years during a generation. Flannery (1972) has suggested that the construction of substantial structures is a function of territoriality, which could explain the early appearance of public architecture at Preceramic sites. Also, religious intensification may have served to maintain the necessary minimal level of agricultural production during the 25–40-year intervals between niños, at least along the central coast. Mild niños occur more frequently along the north coast of Peru, and the need for such religious intensification would have presumably been less. The difference in frequency of niños between the north and central coasts may explain the absence of maize south of Aspero during the Preceramic. Water requirements, in terms of scheduling, tend to be more critical for maize than for most other domesticated plants. It might have consequently been prohibitively difficult to maintain maize production during the longer periods between niños on the central coast.

Yesner is to be commended for correcting the many misconceptions contained in Osborn's (1977*a*) article on marine ecosystems. The trophic level of a resource is less relevant than its density and availability to human consumers. Here, the key is using figures for *exploitable* biomass, on a long-term, sustained-yield basis, rather than crude total biomass. Also, knowledge is not well served by using only one species of shellfish to evaluate the subsistence potential of marine ecosystems everywhere. Osborn calculates (p. 172) that one adult would have to eat 494 mussels (*Mytilus edulis*) per day to satisfy a minimum daily protein requirement of 40 g. Two six-year-old Pismo clams (*Tivela stultorum*) provide the same amount of protein (Tomlinson 1968). Professional fishermen working Pismo clam beds at San Quintín, Baja California, using techniques available to aboriginal populations, each collected enough clams during a low tide to satisfy the daily protein requirements of between 100 and 450 adults (Aplin 1947).

An extremely important marine-vs.-terrestrial comparative study of adaptive stability in the Aleutians and the boreal interior is provided by Workman (1979). Workman compares the Eastern Aleuts, characterized by densely concentrated populations living in sedentary villages, with the interior peoples of the Yukon, characterized by lower population density and high mobility. He notes that while the Aleutians are subject to frequent natural disasters in the form of explosive volcanism, the Yukon suffers sudden declines in life-support capacity from ash falls only very infrequently. From this one might expect far greater historic significance of volcanic perturbations in Aleutian societies, but the opposite is the case. The explanation rests on the greater resilience of marine ecosystems in recovering from volcanic disasters and on the Aleuts' having developed cultural mechanisms to cope with more frequent disasters. Our suggestion is that comparative stability of terrestrial vs. marine adaptations can be explained by comparing how artificially induced instabilities are handled.

by ALAN OSBORN
Department of Anthropology, University of Nebraska–Lincoln, Lincoln, Nebr. 68588, U.S.A. 20 VI 80

Yesner's paper reiterates a major concern of the symposium "Man the Hunter" (Lee and DeVore 1968*a*)—the need to develop generalizations which accommodate the behavioral variability exhibited by hunter-gatherers, past and present. Much of the literature, Yesner reemphasizes, fails to deal adequately with groups characterized by "atypical" variations in energy flow, technological complexity, population density, sociopolitical organization, and so forth. He focuses on a subset of foragers and collectors (Binford 1980) that appears to be among the most aberrant—"maritime" hunter-gatherers.

While Yesner provides insight into the recent literature on exploitation of marine environments and expresses ephemeral concern for a nomological approach. I do not believe that his discussion helps us to understand aboriginal use of the oceans. Anthropologists must not only be aware of the range of hunter-gatherer behavioral diversity and develop methodologies for pattern recognition, but also construct a body of theory to explain such patterned variability. The development of general theory requires that we evaluate our assumptions about the operation of the empirical world—particularly those which repeatedly conflict with our experience. Herein lies the problem with Yesner's discussion.

Contrary to his impressions, my discussions of aboriginal coastal adaptations (Osborn 1977*a*, *b*, *c*, 1979, 1980) argue strongly for general anthropological theory of the exploitation of marine environments. The questions posed in these studies include: (1) If the oceans are vast cornucopias of energy/protein-rich, easily acquired food, why did they remain little used for most of hominid evolution? (2) If the Peruvian coast is adjacent to the world's most productive marine ecosystem, why is there little or no evidence for marine resource exploitation prior to 4000 B.C.? (3) If marine environments are "optimal" for food getting, why do we observe rapid shifts from coastal to terrestrial adaptations in northern Europe, the Mediterranean, eastern Russia, Southeast Asia, and Peru? (4) If marine foods are low-cost/high-return subsistence items, why do some of our earliest coastal sites in Africa and southern Europe contain faunal assemblages dominated by terrestrial vertebrates? Yesner does not recognize any of these contradictions.

Are there differences between marine and terrestrial ecosystems which might greatly affect the distribution, abundance, and quality of food resources? Can anthropologists/archaeologists demonstrate such differences and thus require that we reevaluate our view of coastal/maritime adaptations? Three aspects of Yesner's paper in particular must be reexamined: (1) the assumed high biomass and productive potentials of the oceans, (2) the differential costs/benefits of marine resources, and (3) the determinants of high coastal population densities for hunter-gatherers.

The productive capabilities of oceans are significantly different from those of terrestrial environments. Solar energy and nutrients are restricted to the euphotic zone, 0.9% of the total ocean volume. Although the oceans cover more than 70% of the earth's surface, they generate less than one-third of the total world primary production. Furthermore, terrestrial biomass exhibits a density 1,230 times that for marine biomass. More than 86% of the ocean is essentially devoid of life (Rounsefell 1975:115). Plankton, which must pass through long, energy-expensive food chains to be consumed by humans, constitutes 97% of total marine biomass. While continental-shelf waters are high in primary production in comparison with the open ocean, their production is one-third that of upwelling regions (Whittaker and Likens 1973, Cushing 1969, Ryther 1969, Rounsefell 1975) and they cover less than 8% of the ocean. Primary producers are very small (0.010 mm–0.20 mm) one-celled plants (phytoplankton); these plants must be consumed by microscopic/macroscopic herbivores whose energy must then be passed on through successively higher trophic levels until large fish and carnivorous sea mammals derive needed energy/nutrients.

Yesner does appreciate the calorie-protein dichotomy I have proposed for evaluating the role of marine resources (animals) in aboriginal subsistence. Given this perspective, we can anticipate the manner in which marine animals will be used along a latitudinal gradient as a response to variations in terrestrial plant resources (cf. Lee 1968).

Yesner considers marine shellfish to be aggregated, high-biomass, and easily exploited. His comparison of shell-fish productivity with that for the African savanna is grossly inaccurate. Terrestrial mammal standing crops for East African grasslands range from 4,418–12,261 kg/km^2 for thornbrush steppe to 31,000 kg/km^2 for open savanna (Bourlière 1963). Actual values for terrestrial mammals, then, range from 220,900 to 1,550,000 times as high as the figures offered by Yesner. Given this revision, shellfish remain more "productive" if resource cropping rates (2.5%) are unchanged; this rate seems quite low for ungulates (cf. Whittaker 1975:217). Resource "productivity" must, however, be viewed within the context of the energy, matter, and time constraints imposed on *Homo sapiens* (Pianka 1978; Schalk 1977, 1978).

Shellfish are small-body-sized food resources and exhibit high shell-to-meat weight ratios; protein and energy content is low, processing time is high, and shellfish beds may be quickly destroyed by storms. One white-tailed deer (64 kg live wt.) contains more calories than a metric ton of shellfish (*Mytilus* sp.), and one llama (90 kg live wt.) contains 12.58 kg of protein—equivalent to the protein content of 135,269 mussels (4,329 kg live wt.) or 17,000 clams (9,350 kg live wt.) (Osborn 1977*a*, *b*, *c*). Prehistoric Gaviota-phase inhabitants (4,500 persons) of coastal Peru would have had to collect, transport, and process 5,900,000,000 mussels (192,000,000 kg) to satisfy annual nutritional needs (Osborn 1977*c*). Shellfish exploitation is labor-intensive; the Anbara of northeastern Australia invest ca. 1,300 producer-hours in order to obtain 1,000,000 kcal., whereas wet-rice agriculture in China requires only 186 producer-hours/1,000,000 kcal. (Townsend 1974, Osborn 1977*c*, Meehan 1975). It is clear that resource productivity is not solely a function of primary or secondary production in ecosystems.

Finally, we must reevaluate the assumption that marine resource productivity underlies high coastal population densities for aboriginal groups throughout the world (Kroeber 1939; Mooney 1928; Birdsell 1953, 1977; Hassan 1975; Bowdler 1977). In cases involving the exploitation of carnivorous marine mammals, conversion of *gross population density* to *effective population density* reverses the values for marine vs. terrestrial hunters; effective density is based on persons per unit of productive biosphere exploited (cf. Osborn 1977*b*, 1980; Schalk n.d.). In addition, if we play out the ecological and behavioral implications of the protein vs. calorie dichotomy concerning marine animal exploitation, we find that aboriginal coastal population density varies directly with terrestrial plant use and inversely with dependence on marine resources (Osborn 1980). Additional and more powerful support for these conclusions is provided by Schalk (1977, 1978, n.d.). High aboriginal population density along many coastlines, rather than a consequence of high marine productivity, diversity, and biomass, was a function of the manner in which marine resources were incorporated into terrestrial resource exploitative systems.

Despite these apparent inadequacies, Yesner's paper is a useful contribution, for it offers new evidence and insights into a research problem area which has too long been viewed as a "closed case."

by DAVID L. POKOTYLO

Department of Anthropology and Sociology, University of British Columbia, Vancouver, B.C., Canada V6T 2B2. 13 VI 80

Yesner's paper is a commendable attempt to present a general comparative view of maritime hunter-gatherer adaptations. It represents a timely contribution to a growing body of literature that views maritime adaptations not as exceptions to the usual ethnographic hunter-gatherer lifeway, but as a distinctive cultural ecological type (e.g., Casteel and Quimby 1975, Fitzhugh 1975). This article clearly demonstrates that the maritime variant merits consideration in anthropological studies of the organization and evolutionary development of hunter-gatherer adaptations (cf. Lee and DeVore 1968*b:* 5; Suttles 1968:56). While in agreement with the overall thrust of the article, I would like to comment on some points which I perceive as being weak or debatable.

The main issue addressed is the development of a theory of maritime cultural adaptations. The approach involves the presentation of a series of empirical generalizations (which constitute the bulk of the paper) about maritime hunter-gatherers and their environment. This is one of the most positive features of the article, but one could debate the extent to which empirical generalizations per se contribute to theory construction. Rather, the main contribution of the approach taken here is to focus attention on salient features and relationships which may lead to more hypotheses and testing. It is also apparent that Yesner is concerned with the development of both "middle-range" and "general" theory of maritime adaptations. However, from my understanding of the differences between these two levels (cf. Binford 1977:6–7; Goodyear, Raab, and Klinger 1978:161–62) the orientation of the paper is towards the general at the expense of the middle-range. Nevertheless, the need for the latter is quite evident; many of the bridging arguments used in tests of relationships involving biogeographical variation and settlement pattern change appear, to me at least, to rest on untested assumptions. Substantial advance will not occur until we can start providing some reasonable expectations of the maritime hunter-gatherer archaeological record given the generalizations presented here. For example, the role of shell middens in the overall economy as well as the implications of the variability present are only beginning to be studied, and this is mainly through ethnoarchaeological work (e.g., Bigalke 1973; Meehan 1977*a*, *b*).

Yesner acknowledges the definitional problems surrounding maritime adaptations and of necessity is somewhat arbitrary in his own, particularly in restricting his discussion solely to marine and coastal aspects. However, the construction of any theory on maritime hunter-gatherers needs to take into account terrestrial components of the adaptive pattern, as very few groups are wholly dependent on coastal and maritime resources. As a case in point, I was rather surprised to see that not more attention was given to anadramous fish resources, considering their importance in the economies of ethnographic and archaeological maritime populations not just in the Pacific Northwest. The terrestrial environment appear to be a dominant factor affecting the temporal availability and distribution of this resource for human groups (Schalk 1977:212–13).

The major features of maritime hunting-gathering societies are perhaps best evaluated by examining their goodness of fit to specific ethnographic and archaeological situations. Yesner's discussion on sedentism presents an optimum-single-location model for coastal settlements to maximize access to resources. This, however, appears to be insufficient to account for the settlement variability present for the Coast Salish of the Pacific Northwest, a group characterized by a high population density distributed in large villages and located in an abundant but varied resource zone. The regional adaptive pattern for the Coast Salish emphasizes the high degree of mobility involved in the annual round and indicates that the populations of sedentary (winter) villages did not depend directly upon the local adjacent area for subsistence during the period of occupation (Mitchell 1971:26–27). Storage technology is a feature that requires more analytical importance than it currently has.

I find the test of relationships between settlement pattern shifts and resource diversity difficult to evaluate given the data provided. The hypothesis of differential settlement shifts in zones of varying resource diversity might be better tested through examination of patterning evident between components at each site in addition to the intersite analysis presented. Given the hypothesis, one would expect to find internal trends among components which show the addition and deletion of species through occupational episodes, reflecting relative increase and decrease in selectivity with regard to resources utilized. An effective test of this hypothesis calls for a finer-grained analysis.

by TOM ROGERS

Stone Age Studies Research Association, c/o 140 Nant-y-Coed, Holywell, Clwyd CH8 7AZ, North Wales, U.K. 2 VI 80

We cannot expect to understand the behaviour of Stone Age societies, past or present, unless we view them with the understanding that man never has behaved or ever will behave in any ecosystem, coastal or interior, in such a way as to satisfy the verbal equations of the archaeologist. Furthermore, it is by no means certain that anthropological studies made among living tribal peoples are relevant to the life led by human groups in the Paleolithic. No specialist (least of all Yesner, though I appreciate his plausible theories describing the reasons for dense maritime populations) has ready answers to any of the questions posed in this paper because of the enormous gaps in the scientific record. Yesner underlines this inadequacy by including only four maritime societies in table 3. He also seems to forget that the coastal sites now found must have been inland ones because of the rise of some 30 m in sea level after the Ice

Age. It is not possible, in my opinion, to define any site as being "maritime" either at the end of the Würm or later, the sea having destroyed most of them.

Breaks and discontinuities must have taken place in the evolution of fossil man; logical, continuous though gradual human development, whether from coast to interior or the opposite, is not consistent with present-day human behaviour, much less that of early man. Comparison with other living Stone Age tribes is essential, but Pleistocene societies are not available for study; thus all Yesner's archaeological conclusions are purely a matter of interpretation. Mathematical equations and such statements as "exponential (curvilinear) or logarithmic functions seem to fit the data best" in my opinion cloak the real subject of his paper, human behaviour, in unnecessary camouflage.

The fact that the greater concentration of food resources in coastal areas can support large populations does not mean that men live there, and points, barbs, hooks, etc., are not confined to maritime peoples. The Magdalenians were very expert at their manufacture in the Dordogne, an inland area, not a coastal fringe.

Yesner concentrates a lot of his argument on the "prehistoric Aleuts"; I would have liked to know how "prehistoric" they were. He easily dismisses pre-Mesolithic times (in fact, there is little consistency in his treatment of time scales), but while discussing the European Mesolithic ignores Star Carr and continues with such statements as "for many people [who?] large sea mammals . . . were the best available replacement for the Pleistocene megafauna" and "the Mesolithic Europeans were . . . pushed into the maritime lifeway." How does he know? He also contradicts himself more than once; for example, he writes that "fishing . . . [and] hunting require more complex technologies" and later that "there is no need to call upon increased technological efficiency to explain the intensification of maritime exploitation." Finally, after the extraordinary statement "Fishing technology is as old as Olduvai Gorge," Yesner tells us towards the end of his paper of his detailed examination of prehistoric settlements in the Aleutians, having written previously in some detail about Aleut behaviour patterns. I for one would have been happier to have had a summing up based on his Aleut research rather than a discussion on the priestly class of Peru. My impression is one of interesting ideas submerged by confused thinking leading to disorganised presentation.

by Ehud Spanier
Department of Maritime Civilizations, University of Haifa, Mt. Carmel, Haifa 31999, Israel. 22 vi 80

Yesner refers to the general picture of hunter-gatherers as "people possessing a simple technology" and "exhibiting limited energy expenditure in subsistence activities" and points out that this picture does not seem to fit populations utilizing maritime resources. With the exception of shellfish collection, the catching of nonsedentary marine organisms, such as fish, even in a highly fertile marine environment, requires a considerable degree of sophisticated technology, quite different from that used for freshwater fisheries. Even modern fishermen employing highly sophisticated gear cannot be categorized as "exhibiting limited energy expenditure."

Yesner emphasizes the important contribution of upwelling and mixing processes to the high primary productivity of certain coastal areas. Without intending to diminish the role of these aspects, one should also consider other factors which elicit high marine productivity in coastal environments. The two basic "limiting factors" essential for primary productivity in the sea are light and nutrients (Gerlach 1974). Because of the low penetration of light in seawater, photosynthesis is limited to the uppermost layer of the ocean. Nutrients from the bottom layers reach the photic zone by the processes of mixing and upwelling, but in coastal water there is also a supply of nutrients from terrestrial sources, mainly through the outflow of rivers and streams. Another possibility is primary production by marine flora which are not planktonic microalgae. Russell-Hunter (1970) has pointed out that in many areas of coastal shallows the primary production of the local phytoplankton may be quantitatively of less importance to the nutrition of the local fauna than the detritus resulting from the breakdown of larger attached plants. Seagrasses absorb nutrients through their leaves and roots and have high growth rates (Thayer, Wolfe, and Williams 1975). Ecosystems associated with the eelgrass *Zostera*, the turtle grass *Thalassia*, and the cordgrass *Spartina* could have been important food sources for maritime hunter-gatherers. Another important ecosystem is that associated with mangroves. Heald and Odum (1970) have shown that leaf detritus from mangroves contributes a major energy input to fisheries.

Coral reefs and atolls are other zones of high productivity. Often, the productivity of the ocean which surrounds them is very low, and thus they have been compared to "oases in the desert" (Odum 1971). Much of the high productivity in such habitats appears to depend upon efficient and very local recirculation of nutrients (Russell-Hunter 1970). The coral reef environment, as well as the previously mentioned fertile biomes, could have supported populations of maritime hunter-gatherers, and therefore ethnographic and archaeological studies should also be directed to these sites.

High population density in coastal areas may be due not only to their potential food resources, but also to climate. Owing to its great heat capacity, water is an ideal temperature-stabilizing medium on the surface of the earth. Thus, the annual temperature range is much greater in midcontinent than along the shore (Weyl 1970). Therefore, coastal areas have a more moderate climate than the interior and would be preferable for human settlement.

Finally, I would suggest including another factor when considering the regulation of human maritime population. The open sea is a hostile environment from both a physical and a biological standpoint. Losses of young and adult maritime hunters through drowning in rough seas and losses due to injuries inflicted by various dangerous marine organisms (see, e.g., Halstead 1978) were probably not rare and may have been additional factors enabling the maintenance of favorable population/resources ratios in these societies.

by B. L. Turner II
Graduate School of Geography, Clark University, Worcester, Mass. 01610, U.S.A. 2 vi 80

Several inconsistencies mar the argument. For example, the first four characteristics of "maritime-adapted populations" are not that, but environmental attributes of maritime zones. Again, the diversity of "broadly similar biomes" and in intra-biome zones is expounded, followed by a plea that coastal ecologies (biomes) are not "really so different" in terms of particular resource attributes. The apparent argument is that coastal biomes, as a class of habitats, are qualitatively different from noncoastal biomes. While this statement may be generally correct, biomass figures comparing coastal biomes with tropical lacustrine and other highly productive inland environs, not diversity-poor savanna zones, would enhance the argument. Indeed, Yesner provides examples of quality inland environs that support large hunter-gatherer populations, equivalent to maritime circumstances. Such examples may have been more prevalent before prime inland zones were taken over by agriculturalists.

Yesner's undertaking of the formidable task of establishing the common denominators for the development of a general theory of maritime adaptation is to be applauded, although it is doubtful that such a theory is possible. To develop a general theory of *maritime* adaptation, it must be demonstrated that these environs possess different attributes (not different qualities of attributes) from others and/or that behavioral norms (in regard to adaptation) in these environs are distinct from those in others. Neither is demonstrated here. The environmental and adaptive denominations provided are attributes of all environments and all populations inhabiting them, and, as indicated above, contemporary examples may distort the qualitative differences in the attributes of maritime and inland habitats once occupied by hunter-gatherers.

A more fruitful approach to such a theory might be the identification of the common denominators of livelihood behavior which could be placed in an explanatory structure and applied to all biomes. One approach focuses on such behavioral norms as risk avoidance and least effort, among others. These norms interact with habitat and result in a strategy which fulfills production demand. Simplistically, the strategy which provides sufficient sustenance at an acceptable level of risk and with the greatest ease is the one that will be employed. This approach suggests that maritime hunting and gathering would have emerged as a major livelihood when it provided a viable alternative (in terms of production levels, degree of effort, and degree of security) to existing strategies in other habitats, especially when those strategies were under duress. This scheme supports Yesner's contention that coastal biomes may not have provided a viable alternative for hunter-gatherers until the Upper Paleolithic, although the loss of evidence of an earlier occupation due to sea-level fluctuations cannot be dismissed.

The population and cultural development issues are complex. I find it interesting that only one population/resource argument —food supply determines population—is presented given the interest over the past decade in the opposite argument (Spooner 1972, Cohen 1977). Some evidence supports the view that, through time, a population engaged in a particular livelihood garners considerable knowledge of alternative procurement strategies. This knowledge is stored in the "knowledge pool" and may not be used in a major way until it offers some advantage to the existing strategies. Population growth is one factor that can precipitate this strategy change. Environmental and cultural perturbation (Butzer 1980) or disruption, as discussed by Yesner, is another triggering mechanism. Perhaps the interesting question is why so few maritime hunter-gatherers apparently made the incipient move to agriculture and associated sociopolitical organization. The answer may well lie, in part, in the site-specific attributes of many maritime habitats—the fact that the resource base of these biomes could support large populations without major strategy changes and was not particularly vulnerable to environmental perturbations, as suggested by the author.

Yesner's contribution is that he has focused our attention on the relative qualities of the attributes of maritime biomes. However, until it is demonstrated that maritime biomes possess a class of unique traits (attributes) or that maritime hunter-gatherers operate within a unique class of norms, a theory of adaptation cannot be devised solely for maritime biomes. A general theory of adaptation explains circumstances for all biomes, although it is useful to focus on the consequences of the explanation for certain classes of biomes.

by ERNST E. WRESCHNER
Department of Anthropology, University of Haifa, Mt. Carmel, Haifa 31999, Israel. 30 v 80

Yesner presents quite an impressive amount of data on the resource potentials which can constitute the basis for maritime subsistence. The extent to which the exploitation of these resources was practiced by prehistoric coastal populations can be proved only by archaeological findings. The term "maritime hunter-gatherers" seems justified solely in specific ecological and economic contexts. It is feasible to use ethnographic data for the study of prehistoric subsistence and settlement pattern only when similarity of environmental factors can be established. With the probable exception of shell mounds, the factors that influenced Pleistocene and Holocene population trends can hardly be understood in terms of Yesner's model of specialized maritime society's economy and settlement distribution (Wreschner 1977*a*). It is thus questionable to try to coordinate specific criteria with the variegated ecological and demographic criteria applicable to Pleistocene and Holocene hunter-gatherers in a generalized fashion.

Yesner remarks that coastal environments tend to show less seasonal differentiation in climate and resource availability, but it seems that it is the topographic morphological factors of coast and hinterlands that have played a prominent role in subsistence patterns since Palaeolithic times, especially in the Mediterranean region. Evidence from Upper Palaeolithic and Epipalaeolithic sites, in the form of both tools and fish motifs, points to the prominence of stream fishing. On the other hand, there is abundant evidence for contact with the sea in the form of seashells in habitation sites and burials, whether they represent trade or migratory contact with the sea.

It can be assumed that the feedback mechanisms of population growth during the Epipalaeolithic in the Mediterranean coastal regions were based not on maritime resources, but on the collecting of plants and hunting combined with complementary fishing. Coastal regions with hilly hinterlands favored the exploitation of seasonable available food resources which, in certain nuclear areas, may have led to domesticates and sedentary settlements or transhumance (Redman 1978). It is during the later Neolithic that sedentary coastal populations of farmers and pastoralists seem to exploit their maritime environment as well by salt collecting, probably for use in hideworking, and trade boosted by coastal shipping. These developments seem to be partly reflected in the faunal remains and the tool assemblages (Wreschner 1977*b*).

Yesner suggests that population pressure on local food resources led to innovations and horticulture. The question is what supporting archaeological evidence besides fauna he can present. The lack of this kind of information limits his argumentation and conclusions at best to the causal factors of geographical limitation of available space in specific maritime environments.

Reply

by DAVID R. YESNER
Gorham, Me., U.S.A. 21 VII 80

The purposes of my article were to counteract the spread in the literature of arguments I felt mischaracterized maritime lifeways and to create an opportunity for dialogue on the role of coastal ecology in the adaptation of hunting-and-gathering peoples, a topic of increasing interest to both archaeologists and ethnographers, as Pokotylo notes. On the whole I feel that I have succeeded in both of these goals. The main thrust of these comments (except for those by Dewar and Osborn) and of private communications from other scholars leads me to conclude that recent attempts to characterize maritime hunter-gatherers as generally low-density populations subsisting on "poor" food resources have largely fallen on deaf ears. Carlson, Pokotylo, Turner, Wreschner, and Lischka and Sheets appear to applaud my attempt to piece together a more valid picture of maritime lifeways. I am grateful that Carlson finds my presentation "thorough and systematic" and Lischka and Sheets consider it a "welcome addition to the literature." I have attempted to be careful to generalize only when the data warrant it. I have tried to show that not only are hunter-gatherers in general a variable lot in terms of adaptation, but so are coastal peoples specifically.

For example, I have emphasized latitudinal differences in maritime adaptations and the effects of juxtaposition of particular terrestrial environments with coastal ones. Indeed, I agree with Davis—and with Winterhalder (1980)—that the *major* goal of human ecological studies is to identify the variables relevant to human adaptation in both spatial and temporal contexts, including the "abundance, timing, and spacing of resources." However, once we have identified such variables, our goal should be to demonstrate their relevance by linking them to human behavior under appropriate sets of circumstances. Thus, in my attempt to counteract some of the recently offered ideas about resource-poor coastal adaptations, it has been necessary to offer alternative generalizations in order to achieve an improved "middle-range" theory of maritime lifeways. This has resulted in a mix of the model building cited by Davis and Osborn with attempts to understand meaningful variation within this important class of hunter-gatherers.

Certainly, as Osborn notes, many of these generalizations remain to be tested. I have presented them in a frank attempt to stimulate discussion. I cannot but agree with Pokotylo that "substantial advance will not occur until we can start providing some reasonable expectations of the maritime hunter-gatherer archaeological record given the generalizations presented here." My hope is that, through continued discussion, some consensus may eventually be achieved, at least on the best methods for identifying and testing hypotheses relevant to maritime hunter-gatherers.

Clearly, another major concern was to offer alternative models to the low-density, low-energy extracting picture of hunter-gatherers as a homogeneous group, as noted by Dewar, Hassan, and Spanier. In doing so, I have presented something of an extreme picture, particularly by focusing on groups such as the Aleuts, with virtually an exclusive maritime subsistence focus. The purpose of this has been to counterbalance ideas about hunter-gatherer adaptations based primarily on marginal groups (cf. Yesner 1977*b*, Hassan 1979). I am trying to argue not, as Hayden suggests, that "all hunter-gatherers should be sedentary," but that more sedentism may have been characteristic of at least late Pleistocene hunter-gatherers than is commonly acknowledged. Unlike Carlson, I have great doubts that "most" Eskimo groups, as opposed to only those in high-arctic environments, practiced infanticide. On the other hand, Hassan's accusation that, while rejecting the Bushmen as a model, I "use data on their settlement and population to draw inferences about maritime groups" is unjust; I merely accept that the nature of the *linkage* between population and settlement area, not the specific equation or constants within it, is likely to hold across different classes of hunter-gatherers.

Unquestionably, as noted by Turner and Davis, my argument holds best in the more extreme situations in which coastal environments may be contrasted with resource-poor interior zones—for example, in the Arctic, where low-density caribou-hunting interior Eskimos may be contrasted with high-density sea-mammal-hunting coastal Eskimos, or in aboriginal Australia or California, where low-density interior desert populations may be contrasted with high-density coastal ones. However, when one compares coastal environments with relatively *richer* interior environments, the differences are markedly reduced, as Lourandos's (1977) data suggest. Any attempt to apply a maritime model more generally to late Pleistocene populations would require that this be the case. Indeed, there would be little need for examining a maritime model if there were surviving hunter-gatherer populations in richer interior environments. In this regard, Turner calls for "biomass figures comparing coastal biomes with tropical lacustrine and other highly productive inland environs." These figures, as presented by Odum (1971), support rather than refute my contention of the former generalizability of the maritime model. However, they will be considered of little relevance both by Hassan and Rogers, who apparently reject any analogy between modern and prehistoric hunter-gatherers, and by Hayden, who accepts such analogies but sees factors such as warfare as more powerful determinants of population density and distribution.

As I stated, the problem of definition greatly affects our ability to understand maritime hunter-gatherer adaptations. While the maritime model has been constructed primarily on the basis of exclusively maritime groups such as the Aleuts, Pokotylo notes that "very few groups are wholly dependent on coastal and maritime resources"—a statement undoubtedly deriving from his experience on the Northwest Coast. Indeed, I agree that "the construction of any theory on maritime hunter-gatherers needs to take into account terrestrial components of the adaptive pattern"; I have tried to do this for interior plant-gatherers and horticulturalists but perhaps have neglected interior fishermen to some degree, as Davis also indicates. As noted by Ayres, the problem is particularly severe in dealing with Oceanic peoples, since "existence without a mixed economy in those Pacific habitats would be precarious if not impossible"; yet excluding these populations from the analysis eliminates a large proportion of maritime-adapted low-latitude populations, which would lead to equally skewed results.

While in dealing with island populations the problem of definition is largely cultural, in dealing with noninsular coastal zones it is largely geographic, as is implied by Turner. Since the 1960s, archaeologists and anthropologists have wrestled with the problem of research universe definition in an attempt to elucidate units of study that show congruence between populations and distinct ecological zones. In isolated archipelagos, such as the Aleutians or South Pacific island chains, "it is feasible to control ecological factors more successfully . . . because nonmarine biota and exploitative systems are limited," as noted by Ayres. However, when dealing with noninsular coastal zones or even with archipelagos easily reachable from the mainland by boat, one immediately faces the problem of coastal-interior interaction, including population movement as well as exchange systems. The tendency of archaeologists working in coastal zones—and I have been no exception—to define a research universe on the basis of island groups or sections of coastline may thus lead to possibly erroneous conclusions about settlement patterns and seasonal occupation of coastal sites. In addition, we have found in our research in Casco Bay (Yesner et al. n.d.) that islands closer to the mainland show increased exploitation of terrestrial resources, such as deer. When relevant ethnographic data are absent, it is by no means clear whether this phenomenon represents trade relations, human population movements coupled with storage of resources (i.e., jerked meat), or offshore movements of deer and other species usually classified as "terrestrial" resources. Mellars (1978) has been wrestling with very similar problems in his study of Mesolithic island populations in northern Scotland.

Theoretically, this situation might be expected to complicate somewhat our attempt to link island population densities with resource availability, but the correlations we have achieved suggest that it may not be of great significance. In addition, as Dewar notes, no clear relationship should be expected between island size and the location of sea-mammal rookeries or sea-bird nesting areas; these species are equally unlikely to have been important factors. Instead, the correlations we have found probably relate primarily to shellfish, the major constituent of coastal middens. Thus Carlson is correct in asserting that what we have done is to show that "bigger islands have more people." Island area is highly correlated with coastline length, which in turn is associated with the availability of sessile food resources such as shellfish. Pokotylo notes that I have developed "an optimum-single-location model for coastal settlements to maximize access to resources," but optimal settlement solutions for coastal hunter-gatherers have by no means treated all resources equally. Coastal peoples can be expected to show different degrees of mobility from different site locations—i.e., the catchment area related to a single coastal settlement may vary according to season of exploitation, patterns of species aggregation, etc. What seems to be a constant factor across space is the importance of shellfish exploitation; island area then becomes essentially a stand-in variable for shellfish productivity.[1] Evidently, following Liebig's Law, populations were adjusting primarily to the availability of shellfish; Casteel (1972) has made similar arguments about the importance of fish for interior North American populations. Shellfish and other invertebrates were extremely important, in spite of their low caloric yields, primarily because of their reliability and their low exploitation cost (contrary to Osborn's assertions). Ethnographic studies (Meehan 1977*b*) have reinforced our notion of the reliability of these resources, in spite of the fact, pointed out by Hayden, that shellfish rarely constitute in excess of ca. 15% of the caloric portion of diet. (Hayden's figure of 5% represents a minimal extreme.) I am not denying that, as Carlson suggests, large amplitude fluctuations may have occasionally affected such species; in fact, I suggested it earlier. However, shellfish and other invertebrates are undoubtedly more reliable than other coastal species, responding primarily to larger-scale variables such as water temperature, salinity, turbidity, sedimentation patterns, and tidal amplitude. Thus they represent—as Lischka and Sheets suggest—"high-security" resources.

In addition, ethnographic studies have demonstrated that coastal peoples rarely travel more than a short distance to collect shellfish (see Bigalke 1973; Bailey 1975, 1978); this is reflected in many archaeological studies by the fact that shellfish species frequencies in middens vary quite closely with differences in availability of these species in nearby strandflats (Yesner 1977*a*). Therefore, Dewar's assertion that "savannah hunters have hundreds of times more savannah *within a day's walk*" (italics mine) is hardly relevant, particularly in view of the facts that shellfish generally constitute no more than ca. 5% of the diet and that their lower mobility cost greatly enhances their comparison with the biomass of terrestrial herbivores from the viewpoint of optimal foraging (Yesner n.d.). It should be noted here, with regard to Osborn's (1977*a*) argument that shellfish found in high Andean caves 60 mi. inland reflect high mobility costs for shellfish collecting, that such instances undoubtedly reflect either trade or seasonal transport rather than daily collection as he implies.

The overall caloric contribution of a given species to the diet may also have little to do with its importance in buffering populations against starvation, particularly at resource-poor times of year such as early spring, when midden sites were occupied in many parts of the world (as is suggested by archaeological data from Africa and Australia as well as North America). For this reason, Dewar is incorrect in attacking my use of avian species for tracing patterns of resource diversity; in spite of the fact that they may make a low contribution to the total caloric base of coastal hunter-gatherers, their diversity (and their disparate migration patterns) may be of critical importance during resource-poor intervals.

With regard to the Casco Bay study, Davis asks whether the sites in question came from "a particular time horizon." Indeed, they cluster closely within a 1,000-year time period from ca. 1,500 to ca. 500 years B.P., with some sites dating to ca. 500 years earlier. It is this fact—the essentially synchronic nature of the site occupations—which has given us confidence in using Casco Bay site locations to model regional settlement patterns (Yesner 1980, Yesner et al. n.d.).

In the Aleutian study, the sites in question were indeed occupied for a somewhat longer period—since ca. 3,000 years B.P., as Dewar notes. However, in this case I have demonstrated that there were changes in settlement pattern over time. Pokotylo suggests that these settlement-pattern changes are perhaps best studied through "finer-grained" analysis, involving *intra*site comparisons and species selectivity; such analyses have in fact been presented elsewhere (Yesner 1977*b*, n.d. respectively).

With the exception of Dewar and Osborn (who merely reiterates his published arguments), the various respondents seem to have had little problem with my discussion of maritime subsistence. This is less true of my discussion of maritime demography. Spanier contributes a valuable comment in noting that boating accidents, paralytic shellfish poisoning, dangerous marine animals, etc., would have added a mortality factor in marine environments that would have helped to keep populations in check. I am not sure how these could be weighed against mortality factors affecting other hunter-gatherers (e.g., Dunn 1968), and in any case they would represent stochastic rather than deterministic variables. Hayden believes that "there is no reason to believe that dependency ratios were any different among coastally adapted hunter-gatherers than among continental ones"; such arguments cannot be settled simply by appeal to demographic statistics. Among maritime-adapted groups, for example, larger populations in older or younger age categories do *not* mean increased dependency, because of the contributions that individuals in these age groups can make to their own subsistence (e.g., shellfish collection). Arguments over the nature of population control mechanisms have devolved into shouting matches between advocates of very different models of human population growth and regulation. On the one hand, Hassan, Hayden, and Dewar, in common with Cowgill (1975), Dumond (1975), and Birdsell (1953), see most prehistoric hunter-gatherer populations as regulated by physiological mechanisms and/or social controls such as warfare or infanticide, all of which have been observed among modern hunter-gatherers occupying marginal environments. Hayden even refuses to acknowledge linkages between sedentism and fertility, in spite of excellent research in this area by Binford and Chasko (1976) and Lee (1972). Others, such as Cohen (1977), Harris (1975), apparently Osborn, and myself, tend to view long-term human population growth as a factor that still needs to be considered in dealing with problems of cultural evolution. There is no question that the latter approach has been helpful in explaining, for example, late Pleistocene exploitation shifts that pre-date wide-scale environmental change—e.g., González Morales's demonstration that "demographic factors" and "population increase" played a role in the intensification of maritime subsistence from Azilian to Asturian times in southwestern Europe. Straus et al. (1980) have recently independently developed a nearly identical analysis for subsistence shifts from the earlier Magdalenian to the Azilian (and Asturian) in the same area. Many archaeologists working with shell-midden sites have noted decreases in shellfish size over time and/or shifts to species with higher exploitation costs which they have correlated with overexploitation of intertidal zones (Swadling 1976, Botkin 1980, Wessen 1980, Yesner et al. n.d.), and there is good evidence from the Aleutian Islands, in particular, for overexploitation of sedentary sea mammals as well (Simenstad, Estes, and Kenyon 1978, Yesner 1977*a*). Given these data, it seems inconceivable that Davis can question "that certain prehistoric societies actually overexploited their marine resources." Overall, I see no immediate resolution of this conflict of models; one of the biggest problems is that they differ so widely in their temporal scale of resolution.

Similar arguments may be raised as to the role of environmental and cultural factors in culture change in maritime environments. On the one hand, Spanier emphasizes the role of maritime climate, particularly temperature. Both Osborn and Lischka and Sheets also note the importance of various short-

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[1] In an attempt to pursue this question further, we have tried to relate *modern* shellfish productivity to *prehistoric* site area and volume. Our lack of success in this area probably relates to shifting patterns of sedimentation as well as inadequacies in the available productivity data (Yesner et al. n.d.).

term environmental processes, the former stressing the impact of storms on intertidal biota and the latter the impact of volcanism on marine resources in geologically active archipelagos. Rogers clings to the view that post-Pleistocene sea-level change has submerged the evidence for exploitation of former coastal environments, but Osborn questions this, asking why "some of our earliest coastal sites . . . contain faunal assemblages dominated by terrestrial vertebrates." To me the data suggest that maritime exploitation is indeed a relatively late phenomenon and that this situation has more to do with demographic factors —i.e., pressure on larger game with low net replacement rate and lower culling rates—than it does with the "quality" of marine resources.

The role of technological change among maritime populations also seems to be fertile ground for debate. Hayden and Rogers have apparently misunderstood my disavowal of linkages between mid-Holocene intensification of maritime lifeways and technological development. Perhaps the problem lies in my failure to define properly what I mean by "intensification": increased exploitation of sessile marine resources, particularly shellfish, resulting in the development of shell-midden sites. In many parts of the world, such changes follow, rather than precede, the exploitation of other marine resources such as sea mammals or large offshore fish, which require much more complex technology to harvest. They should be seen not as cultural "devolution," but simply as the adoption of a technology requiring the least energy expenditure to obtain the optimal mix of available resources. Turner innovatively suggests the existence of a "knowledge pool" that is not used until it offers some advantage, i.e., under conditions of environmental change and/or cultural perturbation. Essentially, however, this is an old idea—that necessity is the mother of adoption rather than of invention.

Finally, we come to the question of cultural evolution and the origin of complex societies on a maritime base. Carlson, González Morales, and Lischka and Sheets question my model of intensified redistributive mechanisms originating in situations of sudden economic reversal. Carlson notes that Pebbles and Kus (1977) have played down redistributive mechanisms in chiefdom societies, but this notion is by no means universally accepted, nor is it clear that all maritime societies were chiefdoms (although most were probably more centralized than band-level societies). Citing evidence from the Asturian of Spain, González Morales feels that the juxtaposition of maritime populations with interior-adapted groups prevented rather than accelerated cultural evolution in this area; however, it is clear that this area was characterized by little or slow environmental change rather than sudden economic reversals. With specific reference to Peru, Lischka and Sheets suggest that social stratification is indeed likely to have emerged from the sudden reversal of littoral fortunes associated with El Niño—not, however, from exchange systems designed to bridge the economic gap, but from territoriality (corporate landownership?) exercised over areas of coastal valley floodplain capable of being farmed during the periods of higher water table associated with El Niño. One other possibility, however, derives from the fact that, as Lischka and Sheets note, "biomass production in *lomas* areas also increases" during El Niño. It is possible that the major subsistence shift during El Niño was not toward floodplain horticulture, but rather toward increased exploitation of both terrestrial vertebrates and plant foods in *lomas* areas; this would make sense in the context of earlier arguments concerning the minor caloric contribution of shellfish and the potential role of terrestrial vertebrates in coastal mixed economies. Until this hypothesis can be tested, the redistributive model remains viable as an explanation of cultural evolution in prehistoric Peru.

In sum, we badly need to develop models that encompass all of the above variables—environmental change, demographic pressure, redistributive systems, and so on—with a view to deriving testable hypotheses about maritime hunter-gatherers. Neither environmental change nor demographic pressure alone will suffice to explain such complex phenomena as the origin and intensification of maritime lifeways. No single variable will suffice to explain the evolution of maritime-based complex societies. Similarly, general descriptions of marine resources as "rich" or "poor" should be replaced by more complex models of maritime subsistence and settlement. I hope that this paper represents a first step toward developing such models.

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