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## Osborn's response to Yesner (Maritime Hunter-Gatherers: Ecology and Prehistory)

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Yesner's paper reiterates a major concern of the symposium "Man the Hunter" (Lee and DeVore 1968a)—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 1977a, 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/macrosopic 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<sup>2</sup> for thornbrush steppe to 31,000 kg/km<sup>2</sup> 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 1977a, 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 nutri-

tional needs (Osborn 1977c). 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 1977c, 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 1977b, 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."