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AN OPTIMAL FORAGING ANALYSIS OF PREHISTORIC SHELLFISH COLLECTING ON SAN CLEMENTE ISLAND, CALIFORNIA

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ABSTRACT.—The subsistence yield of black abalones *(Haliotis cracherodii)* and black turban snails *(Tegula funebralis)* was estimated within prehistoric aboriginal shell middens dated 250–2830 B.P. on San Clemente Island, California. Abalones were the key element of the aboriginal shellfish economy, but consumption of the smaller turban snails increased with depletion of abalones in a pattern that conforms to an optimal foraging model of predation.

RESUMEN.—El rendimiento de abalón negro *(Haliotis cracherodii)* y caracol de turbante negro *(Tegula funebralis)* para la subsistencia de las poblaciones indígenas fue estimado en concheros prehistóricos (250 a 2830 años antes del presente, datados con carbono radioactivo) en la Isla de San Clemente, California. Los abalones fueron el elemento clave en la economía aborigen de mariscos, pero el consumo de los caracoles de turbante, más pequeños, aumentó con el agotamiento de los abalones en un patrón que concuerda con un modelo de depredación como forrajeo óptimo.

RESUME.—Des traces de présence d'haliotides noires *(Haliotis cracherodii)* et d'escargots noirs à turban *(Tegula funebralis)* ont été découvertes au sein de vestiges résiduels préhistoriques de coquillages aborigènes (250 à 2830 années radiocarbones avant le temps présent) sur l'île de San Clemente, en California. Les haliotides constituaient l'élément principal de l'économie de coquillages aborigènes, mais la consommation des escargots à turban, bien plûs petits, s'est acrue au fur et à mesure de la disparition des haliotides selon une progression conforme à un modèle optimal de ravages causés par des prédateurs.

Marine gastropod species were important subsistence resources among the aboriginal peoples of the southern California Channel Islands. Two species, the black abalone *(Haliotis cracherodii* Leach, 1814) and the black turban snail *(Tegula funebralis* A. Adams, 1855), are the focus of the present discussion. Abalone shells are a conspicuous component of prehistoric middens (domestic refuse deposits) on the Channel Islands. Beads, ornaments, fishhooks, containers, and other artifacts were manufactured from abalone shells. Despite this presence, reconstruction of the subsistence role of abalones and other shellfish species remains a relatively poorly developed area of investigation. Reconstructions usually estimate food yields based upon shell weight or MNI (minimum number of individuals) figures. Frequently, such estimates do not reflect the possibility that several species may have been utilized in shifting patterns of exploitation over

the time interval represented by a midden. This situation is surprising when one considers that the role of shellfishing by maritime hunter-gatherers is currently undergoing reexamination in many quarters. Recent archaeological and ethnographic studies have demonstrated the important role that shellfishing may play within a variety of economic adaptations. Consideration of biological characteristics of shellfish species, combined with appropriate analytical methods, reveal dynamic patterns of aboriginal shellfish collecting on San Clemente Island, southern California.[1]

ABALONE AND TEGULA BIOLOGY

Abalones are large, herbivorous marine snails that inhabit many regions of the world. They require rock surfaces, where they attach themselves with a large, muscular "foot." Thus attached, they are protected by a thick univalve shell from predators and other hazards while grazing on floating kelp fragments. Species are readily differentiated based upon shell morphology. Water drawn through the gills is expelled through a series of prominent respiratory pores arrayed along the shell, the number and characteristics of which also vary by species (Howorth 1988:38–44). Abalone species occupy much of the Pacific Coast of North America, including California (Morris 1966:52), as well as Australia, New Zealand, and elsewhere.

Four species occur in significant frequencies within archaeological deposits of southern California. The three largest of these species generally occupy the subtidal zone; i.e., rocky substrates that remain submerged even during the lowest tides. Although these species vary in size and specific habitat requirements, they all inhabit substantially similar environments. Among the subtidal forms is the largest species in the world, the red abalone *(Haliotis rufescens)* with a shell length approaching 300 mm and a soft-tissue weight of as much as 3 lbs (1.36 kg; Morris et. al. 1980:232; Ault 1985:4). The green *(H. fulgens)* and pink *(H. corrugata)* abalones reach a maximum length of about 250 mm (Ault 1985:4; Morris et. al. 1980:234–235). All the subtidal species inhabit a depth gradient from the intertidal zone to at least 165 m for the red abalone, 18 m for the green abalone, and 50 m for the pink abalone. In cooler waters, such as found north of Point Conception in California, red abalone and other species may be found in the intertidal zone. The majority of individuals of subtidal species tend, however, to occur most frequently between about 6 m and 24 m (Cox 1960:386–390; Ault 1985:15–16). A number of factors appear to affect preferred depth, including algal production, habitat that offers protection to juvenile abalones, the presence of predators such as the sea otter, and water temperature (Ault 1985:15–16; Morris et al. 1980:232).

Generally, subtidal species can only be obtained by diving. Where these species exist in comparatively shallow water, diving can produce large harvests. The relatively large size of the subtidal forms may compensate for the effort involved in diving. It has also been suggested that red abalone may have been intertidal during the early and mid-Holocene (i.e., around 5000–7000 B.P.; Glassow et al. 1988:70), when periods of sea temperature cooler than at present may