

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 funebris*) 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 funebris*) 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 funebris*) ont été découvertes au sein de vestiges résiduels préhistoriques de coquillages aborigènes (250 à 2830 années radio-carbones 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 plus petits, s'est accrue 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 funebris* 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

have existed in the California Bight (southeastward bend of the California coast below Point Conception). A spatulate prying device (aboriginal forms were made of bone or wood) is generally required to break the animal's extremely powerful grip on its rocky perch.

Water temperature has a major impact on the life-cycle of subtidal abalones, with each species exhibiting a particular tolerance range. The red abalone, for example, feeds between 7° and 20°C, but the thermal optimum for the species is between 14° and 18°C (Ault 1985:15). Water temperature requirements are probably more important in relation to paleoenvironmental reconstruction than assessment of dietary yield. Use of abalone species as indicators of past marine environmental regimes is a topic important to archaeological research in southern California, but beyond the scope of this paper (Walker and Snethkamp 1984:7; Glassow 1977:19; Glassow et al. 1988:70; Raab and Yatsko 1990a, 1990b).

During abalone reproduction, eggs and sperm are released into the water, where fertilization occurs. After fertilization, larvae begin grazing within a few days. Initial growth of all species is relatively rapid, reaching about 20–30 mm within the first year (Morris et al. 1980:232–237; Ault 1985:5–6). After reaching the juvenile stage, abalone grow more slowly, adding a few millimeters length each year. Abalone appear to reach sexual maturity within 3–5 years, and it is thought that few individuals live longer than 20 years (Morris et al. 1980:232–237). All abalone species are slow growing organisms with few defenses against human predators. Consequently, their numbers are rapidly reduced under sustained collecting, and considerable time is required for a population to recover.

The black abalone (*Haliotis cracherodii*), the species of interest in the present discussion, is largely an intertidal form. These organisms frequently are exposed during low tides on rocks, where they can exist in large numbers. These abalone may be particularly at risk from human predators because they are easily harvested without diving. Individuals of this species reach a maximum size of about 200 mm, but few individuals exceed 150 mm. Black abalone have temperature requirements similar to red abalone (Ault 1985:15). Black abalone, as in the case of other abalones, requires several years to reach maximum size; about 2 years to reach 55 mm, then growing about 4 mm a year after reaching 90 mm in length (Ricketts et al. 1985:245). During early phases of growth, abalones seek the protection of rock crevices to avoid predators. Individuals become *emergent* upon reaching a length of 75–100 mm; i.e., they venture onto exposed rock surfaces in search of food (Ault 1985:6).

The black turban snail (*Tegula funebris*) is common to abundant on open rocky surfaces of the intertidal habitats that support the black abalone (Morris et al. 1980:253). The smooth, rounded to conical shell may reach a diameter of 30 mm, though many individuals are much smaller. At low tide *T. funebris* is sedentary, and hundreds of individuals often aggregate in rock crevices. Locomotion is achieved with a muscular foot in the same fashion as other marine gastropods. Tegula are herbivores that eat many species of algae, including microscopic films and kelp fragments (Morris et al. 1980:253). They may reach 20–30 years of age, and thus may have a lifespan longer than any other gastropod (Morris et al. 1980:254). Like black abalone, black turban snails are readily exploited by terrestrial predators during low tide.

RETHINKING THE LOWLY SHELLFISH

As compared to terrestrial resources, shellfish often have been characterized as "emergency" or low-yield foods of comparatively minor importance. Osborn (1977) argues, for example, that marine environments are generally less productive per unit area than terrestrial environments. He suggests that human populations tend to relegate marine resources to a lower order of importance if terrestrial resources are available. The open ocean is less productive than many terrestrial ecosystems (Pianka 1974:48), but Yesner (1980) and Erlandson (1988, 1991) point out that this fact is misleading in view of the comparatively high productivity of certain coastal habitats.

Shellfish collecting has long been regarded as unimpressive as a gauge of cultural "advancement." Uhle (1907:31), for example, dismissed the prehistoric inhabitants of the Emoryville shell mounds in California as representative of the "lower classes of society" owing to their dependence on shellfish:

The manner of procuring the essentials of life by collecting shells in itself indicates a low form of human existence. In all parts of the world, even today, people may be seen by the shore at low water collecting for food the shells uncovered by the retreating tide; and although under changed conditions of life they raise shellmounds, these people always belong to the lower classes of society, and lead in this manner a primitive as well as simple life.

Meehan (1982), in her excellent ethnographic study of shellfishing in Australia, points out the many misconceptions and biases that have worked against an informed understanding of shellfish economies. Fortunately, the significance of shellfish in maritime adaptations recently has received more objective attention. Sanger (1988:91), for instance, notes the important role of shellfish in settlement patterning and subsistence in the northeastern United States:

Shellfishing, obviously an important aspect of the Gulf of Maine maritime adaptation, required only the use of hands to pluck mussels from rocks, or "pick" clams through their siphon holes... Briefly, shellfish, although frequently belittled in the literature as gross contributors to the overall caloric component of shell midden sites, may have constituted the primary motivation for site selection and abandonment. They constituted a reliable, if not spectacular, food source, and it would have been possible to over-exploit resources in the kinds of intertidal flats commonly found associated with habitation sites. A pattern of brief occupation, followed by movement to another site, may help to explain the presence of nearly 2,000 known shell midden sites on the coast of Maine that have survived erosion due to a submerging shoreline.

Erlandson (1988:107), in evaluating the role of shellfish in the prehistoric maritime economy of southern California, makes a similar point:

... I have tried to counter previous assertions that shellfish exploitation is universally inefficient subsistence strategy by demonstrating that, under

