Reports

Winter Dormancy in Sea Turtles: Independent Discovery and Exploitation in the Gulf of California by Two Local Cultures

Abstract. *Documentation is reported for sea turtles overwintering on the sea bottom. Seri Indians have traditionally hunted nonmigrating dormant green turtles (*Chelonia mydas*) along the bottom of the Infiernillo Channel in the Gulf of California. Mexican fishermen independently discovered dormant turtles during winter 1972–1973, and with new hunting technologies are rapidly decimating these unusual stocks.*

The green turtle (*Chelonia mydas*) is well known for its ability to migrate 2000 km over open seas (*1*). Consequently, we were skeptical when we first learned from the Seri Indians of Sonora, Mexico (Fig. 1), that some *Chelonia* are partially buried on the sea floor during the colder months (*2, 3*). However, the Seri have proved to be highly reliable informants in botanical studies (*4–6*). Further, knowledge of winter sea turtles figures prominently in their oral history and language. In any event, we resolved any doubts by our own observations (i) from the surface, of Seri winter-hunting techniques, and (ii) with scuba equipment, along with commercial hunting parties after the independent discovery of winter dormancy by the non-Indian fishermen from Kino Bay (referred to hereafter as Mexican fishermen).

Traditionally the Seri are a hunting, gathering, and seafaring people (*4–8*), and until recently the green turtle was their most important single food resource (*9*). Seri knowledge of sea turtles is ancient, although traditional information and practices in their culture are rapidly being lost through acculturation. Sea turtles, including winter turtles, were once plentiful, and the Seri hunted only the largest ones "as needed" (*6*). Market demand has escalated, and the animals have become increasingly scarce in recent years (*1, 10, 11*). During the past several years we have observed a substantial decrease of local subsistence consumption of turtle meat. The great bulk of turtles taken at all seasons by Seri and Mexican hunters is shipped to the major cities of Sonora. The Seri began commercial exploitation of winter turtles in about 1959.

The Seri call partially buried, overwintering turtles *mosni ʔant kóit*, 'green-turtle land touch' (*12*), referring to the turtle "touching down" or "landing" on the sea floor. The Seri know of buried turtles at specific "homes" (each with a specific traditional name, and used as traditional hunting sites) along the sea floor of the Infiernillo Channel, and can locate these with precision on a map or at sea (day or night). Some homes serve as both summer retreat and wintering places. We find no evidence of the Seri hunting dormant turtles outside the Infiernillo. The Seri report that buried turtles are (or were) situated 3 to 5 m apart along muddy or sandy edges of undersea troughs, which are often at the edges of eelgrass (*Zostera marina*) beds. From approximately November through March, Seri hunters have mostly sought buried turtles or those grazing on eelgrass (*5, 13*). In the winter, sea turtles are seldom, if ever, seen to surface during windy weather, and surface only rarely on sunny, calm days. However, they frequently surface in the warm months, whether the weather is calm or windy.

Dormant turtles are harpooned from boats during low tide, while buried at water depths of about 4 to 8 m. The harpoons have a mainshaft 7 to 10 m long. The harpooner stands at the prow holding the long, flexible harpoon horizontally and, by complex, subtle movements of the harpoon, signals to the boatman to maneuver the boat (*14*). Another hunter or boy helps to boat the turtles and to bail.

Buried turtles are located by looking for the exposed portion of the carapace, which may appear as a circle or strip above the sand, sometimes only 10 to 15 cm wide. Turtles can be seen only during daytime at low tide when the sea is clear and calm and there is no cloud cover. The Infiernillo is often murky but tends to clear after several days of cool, calm weather. The best conditions are at neap tides; January neap tides are considered best of all. These turtles are harpooned by young men with keen vision; yet in the summer, even older men harpoon the active turtles and the long winter harpoons are not used.

The *mosni ʔant kóit* is described as often having seaweeds and a muddy, sandy film on the exposed portion of the carapace (*15*), but the marginal scales are clean because they have been covered. Seri report that turtles with much carapace seaweed are thin because they have been buried 1 to 3 months without eating, and that turtles with little or no carapace algae have more fat since they have been moving about feeding.

When harpooned, a buried turtle must be worked out of the substrate. In the process, a great deal of mud and sand is raised and the turtle cannot be seen until it moves or is pulled away. With a large turtle, a second harpoon is usually set in order to pull it free. In contrast to summer turtles, these turtles are torpid and easily boated.

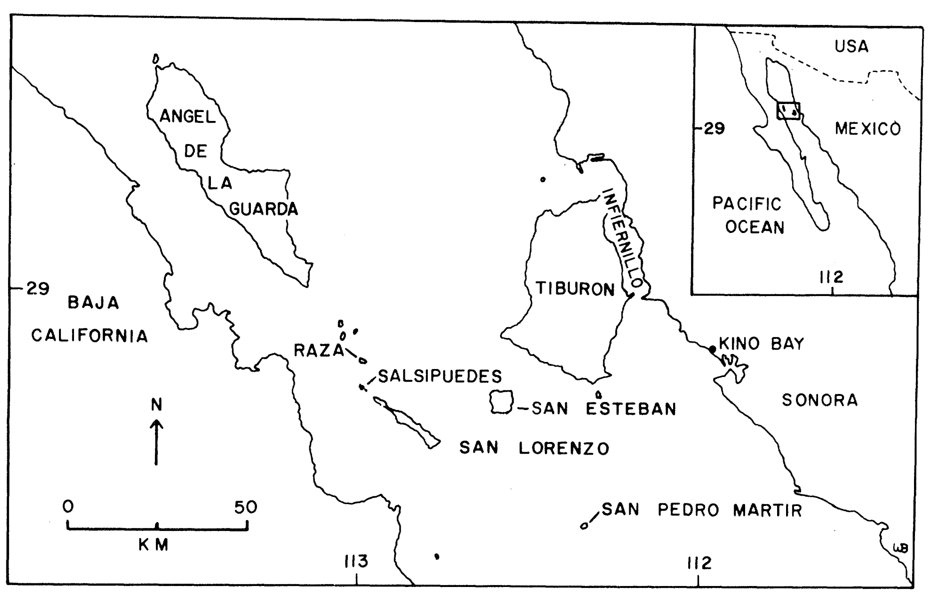
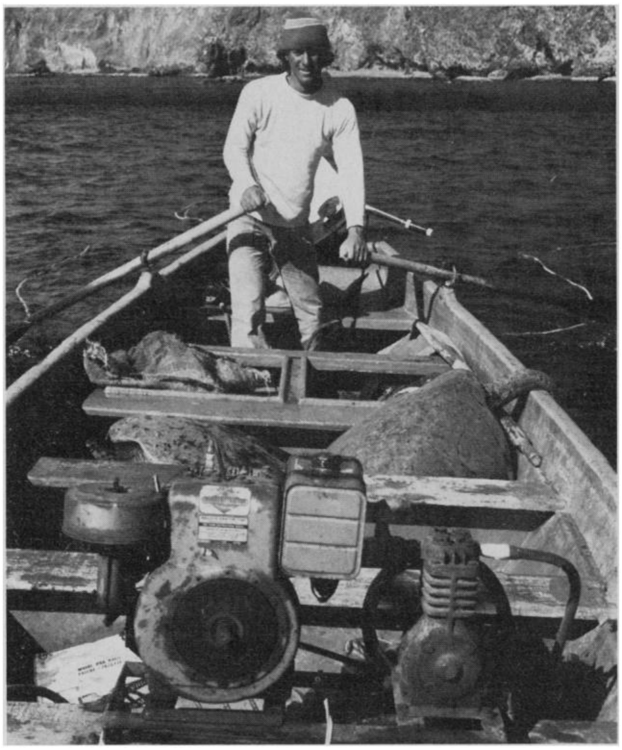


Fig. 1. Portion of Gulf of California with midriff islands. Commercial divers have taken dormant sea turtles offshore from each of the seven islands identified here as well as several localities along the adjacent coast of Baja California.



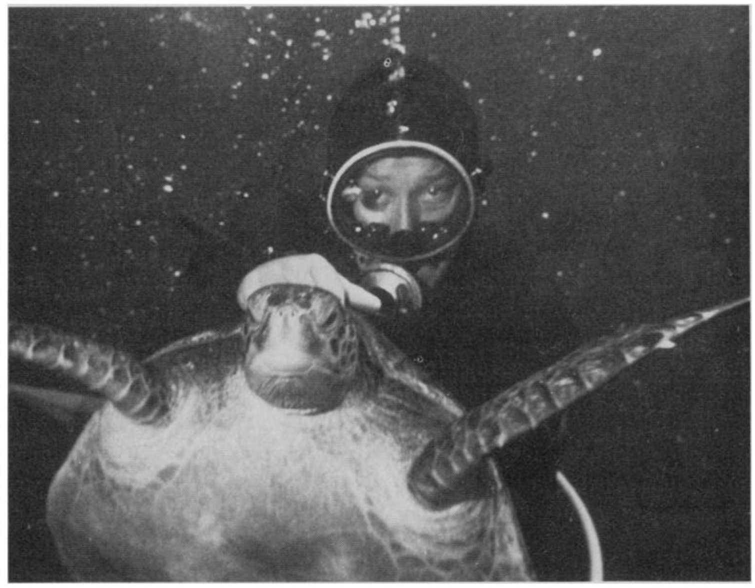


Fig. 2 (left). Fishermen hunting dormant sea turtles off the south shore of San Esteban Island, 23 January 1975. Note epizoophytic marine algae on carapaces and prehensile tail of large male *Chelonia* grasping gunwale. Also note plastic hoses, supplying divers with air, behind boat, and air compressor fastened to seat of boat. Fig. 3 (right). Mexican diver bringing dormant *Chelonia* to the surface from approximately 15 m depth, 23 January 1975, San Esteban Island.

Dormant turtles in the Infiernillo Channel (Fig. 1) now seem to be relatively scarce and are seldom hunted by the Seri.

Dormant winter sea turtles were accidently discovered during 1972–1973 by the Kino Bay fishermen when they initiated winter compressor-diving in rocky habitat off the south shore of Tiburon Island to hunt for lobster. They previously "just did not know" that winter turtles were present in large and easily exploitable concentrations, even though they live in contact with the Seri. At least several Seri turtle hunters were unaware of the Mexican fishermen's discovery of dormant *Chelonia* until one of us (K.C.) informed them of it in January 1975, and the magnitude of hunting success astonished them.

Mexican fishermen at Kino Bay describe dormant wintering turtles as *caguama echada*, 'sea-turtle lying-down.' During the past two winters *caguama echada* have been taken from the Gulf Coast of Baja California and the "midriff islands" (Fig. 1). The *caguama echada* season begins in December and can extend into April or May, depending on water temperature (*13*). During the unusually cool spring of 1975 it extended through May. The fishermen consider sea turtle movements generally to be random, except that the *caguama echada* does prefer specific winter homes, which are areas of high yield for divers.

The *caguama echada* are found lying motionless at depths of 10 to 15 m or more, (i) among small boulders in sandy, flat substrate; (ii) on ledge rock; and (iii) in sea caves and crevices. They are common in areas of *Sargassum* and other large marine algae. No Mexican diver has found a *caguama echada* even partially buried in the sea floor in the manner of the *mosni ʔant kóit*.

The Mexican divers use well-worn U.S. wet suits, weight belts, masks, and fins, and carry a 1-m-long gaff. Respiration is through a hookah arrangement with a low-pressure compressor powered by a 3.5-horsepower gasoline engine. The air is fed through 20 m of ¾-inch plastic hose to a regulator. There is no filter and the divers breath air contaminated with carbon monoxide and gasoline fumes.

The divers motor to the hunting area, where two crew members dive, one rows, and one tends the hoses and helps boat the turtles (Fig. 2). The turtles are torpid and rarely escape. They are easily captured by hand (Fig. 3). The gaff is used only if the animal tries to escape. Within 1 hour the men suffer headaches from breathing contaminated air. Within 2 hours they are severely chilled. These factors limit diving time. A 1- or 2-hour hunt commonly yields five to ten turtles weighing 30 to 80 kg each (*16*). The men usually hunt once in the morning and again in the afternoon. Despite the hazards, diving for *caguama echada* is presently the most effective method for hunting sea turtles in the Gulf of California (*17*).

During the 1974–1975 winter season, five turtle boats (*14*) operated out of Kino Bay. During one week in mid-January 1975, four boats took more than 80 turtles from less than 5 km of coast on the south and east sides of San Esteban Island. As hunting pressure rapidly reduced yields from this and other *echada* sites, the fishermen discovered and moved on to more distant populations (*17*).

Certainly not all of the world's populations of *Chelonia mydas* become dormant in the winter. Hence, if this unusual population survives, studies of the physiological mechanisms for winter dormancy would be of considerable interest as possible examples of population-level physiological adaptation (*18*). The *caguama echada* present unusual opportunities to tag and to study large numbers of turtles of both sexes away from nesting beaches (*19*). It has previously been impossible to mark males in large numbers, and studies of nonbreeding females are fragmentary.

The *caguama echada* has been systematically depleted in only two winters by a new hunting technique. Even more efficient techniques and their expansion appear imminent. Government and conservation agencies around the world should be alert to the possibility that other winter dormant populations of sea turtles may exist that are also extremely vulnerable to rapid overkill.

R. S. FELGER
Arizona-Sonora Desert Museum, Post Office Box 5607, Tucson, Arizona 85703
K. CLIFFTON
Route 15, Box 269, Tucson 85715
P. J. REGAL
Museum of Natural History, University of Minnesota, Minneapolis 55455

References and Notes

1. A. Carr, *So Excellent A Fishe* (Natural History Press, Garden City, N.Y., 1967); ______ and P. Coleman, *Nature (London)* **249**, 128 (1974).
2. Caldwell (*3*, p. 147), describing green turtle fisheries in the Gulf of California, states, "The fishermen say turtles are harder to find in winter as they are less active and in deeper water."
3. D. K. Caldwell, *Calif. Fish Game* **49**, 140 (1963).
4. R. S. Felger and M. B. Moser, *Econ. Bot.* **28**, 414 (1974); *Kiva* **39**, 257 (1974); *ibid.* **37**, 53 (1971); *ibid.* **35**, 159 (1970).
5. ______, *Science* **181**, 355 (1973).
6. ______, *Ecol. Food Nutr.*, in press.
7. T. Bowen, in *Handbook of North American Indians* (Smithsonian Institution, Washington, D.C., vol. 9, in press); W. B. Griffen, *Lat. Am. Monogr. No. 10* (1959); A. L. Kroeber, *Southwest Mus. Pap. No. 6* (1931).
8. W. G. McGee, in *17th Annual Report of the Bureau of American Ethnology* (Government Printing Office, Washington, D.C., 1898), pp. 9–344.
9. McGee (*8*) estimated that the green turtle constituted 25 percent of the Seri diet.
10. A number of astute Mexican and Seri fishermen, well known by us, report that turtles have become increasingly scarce, particularly in the last decade. [Also see O'Donnell (*11*); J. J. Parsons, *The Green Turtle and Man* (Univ. of Florida Press, Gainesville, 1962); R. Marques Millan and A. Villanueva O., *Gac. Coop. No. 52* (1974), p. 30.]
11. D. J. O'Donnell, thesis, California State University, Northridge (1974).
12. Standard phonemic conventions are used here, as in (*4–6*).
13. Our preliminary data indicate that the green turtle is dormant at water temperatures below approximately 15°C. For example, on 21 January 1974, at the north end of the Infiernillo Channel, turtles were active on the bottom at 18°C, and on 23 January 1975, we found dormant turtles off San Esteban Island at 14°C at a depth of 8 to 10 m. For surface water temperatures in the Gulf of California, see M. K. Robinson, *San Diego Soc. Nat. Hist. Mem. 5* (1973).
14. The Mexican fishermen use open fiberglass boats (*boas*), generally 7 m long with 25- to 40-horsepower Johnson or Evinrude outboard motors. For turtle hunting the Seri prefer their somewhat smaller and more maneuverable plank boats, also with outboard motors.
15. Epizoophytic marine algae are common on winter turtles in the Gulf of California, but not on those taken in summer. J. N. Norris (in preparation) has identified more than 20 species of epizoophytic algae from winter *Chelonia* discussed here. See also G. J. Hollenberg, *J. Ariz. Acad. Sci.*, in press.
16. We have detected little difference between summer and winter catches, although catches of *caguama echada* usually include a higher percentage of large adult animals. For dormant winter turtles, *caguama echada*, in 1975: $N = 69$, range of carapace length = 50.0 to 92.5 cm, mean ± standard deviation (S.D.) = 68.9 ± 9.96 cm. For summer *Chelonia* from same region, 1974 and 1975: $N = 67$, range = 47 to 88 cm, mean ± S.D. = 65.3 ± 10.36 cm. Adult males are in the Gulf of California throughout the year, although females are more numerous; see also (*2, 3*).
17. Although the green turtle has become more scarce in recent years (*10, 11*), exploitation of dormant winter turtles produces particularly rapid results. In January 1975 hunting was intensified around San Esteban Island. Depletion of these turtles stimulated rapid expansion of winter hunting throughout the midriff islands and to Baja California (Fig. 1). The efficiency of the new methods is indicated by the great enthusiasm of the fishermen for them and by the rapidity with which one area is depleted and the hunters move on. We have been able to gather some relevant numerical data. In late May 1975 four parties that "summer-hunted" [see Caldwell (*3*) and O'Donnell (*11*)] for 23, 20, 25, and 12 hours of real effort each obtained N = 13 (total weight = 247 kg), 13 (413 kg), 13 (384 kg), and 6 (?kg) turtles, respectively. In January 1975 two parties that "winter-hunted" for 7 to 8 hours of real effort each obtained N = 26 (> 800 kg) and N = ? (718 kg) turtles, respectively. These rates of success provide high economic incentives.
18. Some aquatic reptiles may extract some oxygen directly from the water [D. Jackson and K. Schmidt-Nielsen, *J. Cell. Physiol.* **67**, 225 (1966); D. Belkin, *Respir. Physiol.* **4**, 1 (1968); J. Graham, *ibid.* **21**, 1 (1974)]. If buried turtles cannot use this strategy their anaerobic capacity may be great, although one study in Florida suggested a surprisingly small anaerobic capacity for sea turtles in contrast to other turtles [D. Belkin, *Science* **139**, 492 (1963)].
19. Nesting beaches and reproductive migrations of these populations are not known. The fishermen believe that the nesting beaches are in Sinaloa, Mexico.

20. We thank the Seri for sharing their knowledge. We thank the fishermen at Kino Bay for extended cooperation and express deep concern for their economic welfare, which depends on diminishing marine resources. For assistance in the field we thank M. Drees, G. Kooyman, J. N. Norris, M. Owens, A. Russell, J. Russell, A. Topete, and J. Turner. B. L. Fontana and J. R. Hendrickson provided valuable discussion, and the staff of the Centro Regional del Noroeste of the Instituto Nacional de Antropología e Historia helped in many ways. Supported by NSF grant SOC 75-13-628 to R.S.F. and a University of Minnesota graduate school grant to P.J.R.

26 September 1975; revised 2 December 1975

Island Biogeography Theory and Conservation Practice

Abstract. *The application of island biogeography theory to conservation practice is premature. Theoretically and empirically, a major conclusion of such applications—that refuges should always consist of the largest possible single area—can be incorrect under a variety of biologically feasible conditions. The cost and irreversibility of large-scale conservation programs demand a prudent approach to the application of an insufficiently validated theory.*

Recent interest has been generated in the application of island biogeographic theory to the design of wildlife refuges, especially through a news brief by May (*1*), who has summarized recent studies on birds (*2, 3*) as a basis for specific conservation suggestions of general utility, while cautioning that current models do not incorporate potentially important biological facts. We propose that the proof of the underlying theory has not been so broad that conservation applications ought clearly to follow, and that the main specific suggestion (*4*)—that refuges should always consist of the largest possible single area—need not be correct. Hooper's suggestions along the same lines (*5*) seem not to have been heeded. It is important to enlarge on Hooper's views and to present new evidence because widely publicized briefs may be adopted as canon in conservation planning without appropriate discussion.

The equilibrium theory of island biogeography applies in part to any system, since turnover (extinction and immigration) must occur, given sufficient time (*6*). At issue is the definition of sufficient time; one can reasonably claim for some taxon and location that turnover is so slow that equilibrium will never be reached (*7*). In particular, data implying high avian extinction rates (*8*) have been impugned (*9*). It is these high extinction rates, which are higher on smaller islands because smaller populations are more susceptible to aleatory breeding failure and mortality, that lead to the imperative that refuges be as large as possible (*1*): "In cases where one large area is infeasible, it must be realised that several smaller areas, adding up to the same total area as the single large area, are not biogeographically equivalent to it: they will tend to support a smaller species total."

The same species-area relationship cited by advocates of single large preserves could as well be adduced in support of several small ones. If $S = kA^z$ (where S is the number of species; A is the area; and k and z are constants, the latter in the vicinity of 0.2 to 0.35 for most taxa and regions), let us consider the following decision. We may construct either one large refuge of area A_1 or two small ones each of area $A_2 = A_1/2$. By which plan would we preserve the most species? Each of the two small refuges would have $S_2 = kA_2{}^z$ species. If all species P in the species pool are equally adept at dispersing to and surviving in refuges, the expected total number of species in the two refuges together (species in both refuges counted once) would be $2S_2 - S_2{}^2/P$ (*10*). More realistically, we would hypothesize a gradient of total species number between S_2, where a well-defined gradient of dispersal and survival abilities exists, and $2S_2$, where no such gradient exists but where competitive interactions prevent many pairs of species from coexisting in the same refuge (*11*). In contrast, how many species, S_1, might we expect in one large refuge of area A_1? Letting $z = 0.263$ (a widely used value for log-normal distributed population sizes; the qualitative result does not depend on the exact value of z),

Table 1. Relative numbers of species in one large refuge (S_1) as compared to the number of small ones containing S_2 species each. The P species in the regional pool are assumed to be noninteracting and equally adapted to refuge existence.

N	S_T = total species in N refuges	Factor by which S_1 exceeds S_2	Minimum fraction S_1/P for which $S_T > S_1$
2	$2S_2 - (S_2{}^2/P)$	1.200	0.960
3	$3S_2 - 3(S_2{}^2/P) + (S_2{}^3/P^2)$	1.335	0.981
4	$4S_2 - 6(S_2{}^2/P) + 4(S_2{}^3/P^2) - (S_2{}^4/P^3)$	1.440	0.991
5	$5S_2 - 10(S_2{}^2/P) + 10(S_2{}^3/P^2) - 5(S_2{}^4/P^3) + (S_2{}^5/P^4)$	1.527	0.995