Radiocarbon Confusion Dating: Problems and Prospects for the Study of Baja California Sur Prehistory

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Abstract

The dating of historic or protohistoric Pericú Indian skeletons from the Cape Region of Baja California Sur yield radiocarbon results that appear younger than their actual age. This pattern appears to result from problems inherent in all radiocarbon dates of marine origin, including the skeletons of ancient people who derived their food from the sea. This paper is an archaeological case study, showing that marine and terrestrial radiocarbon samples of the same depositional age can lead to confusion about patterns of historic versus prehistoric cultural development.

Problems of Coastal Radiocarbon Dating

No innovation has done more to revolutionize modern archaeology than the advent of radiocarbon dating shortly after World War II (Fagan 2000; Taylor 1987). Before the introduction of ^{14}C (carbon 14) dating, prehistoric archaeologists could construct regional chronologies of cultural development based only on the study of artifact styles. Aside from limiting the time available for study of other topics, these stylistic analyses simply could not be used to develop inter-regional or global cultural chronologies. The universal time scale afforded by ^{14}C dating made possible the outlines of world prehistory that archaeologists take for granted today.

Despite these advances, ^{14}C dating has by no means achieved its full potential in archaeological research. The "marine reservoir effect" (MRE) remains a basic challenge to the dating of coastal cultural deposits around the world. A full description of the technical basis of radiocarbon dating is precluded by the space available here (Taylor 1987). Important to the present discussion, however, are differences between the atmospheric and marine ^{14}C reservoirs.

Radiocarbon is produced naturally in the earth's atmosphere, making its way into marine and terrestrial food chains via the uptake of ^{14}C (in carbon dioxide) by plants during photosynthesis. Radiocarbon is rapidly mixed in the earth's atmosphere, where it readily can be absorbed by terrestrial plants. Marine plants not only receive ^{14}C from the atmosphere, but also take up ancient, ^{14}C-depleted carbonates from considerable depths, resulting from local differences of upwelling and other oceanographic factors. Consequently, organic materials of marine origin tend to be depleted of ^{14}C as compared to terrestrial materials of the same age, and subject to a great deal of variability in the absorption of ancient carbon. When materials of marine origin are radiocarbon dated, they often appear to be older than they actually are (Taylor 1987; Molto, Stewart, and Reimer 1997).

On average (global ocean average), marine materials return ^{14}C ages about 400 years older than their actual age (Taylor 1987:127-128; Stuiver and Braziunas 1993), but local marine conditions can further alter the magnitude of the difference in age between terrestrial and marine materials (combined global and local offset, given by R+ΔR). By convention, this difference is symbolized by ΔR (Delta-R), which is the variation from the global average of the marine-terrestrial offset. As a practical matter, the best way to determine ΔR for any particular coastal region is by empirical observation. Paired samples of terrestrial and marine materials from contexts known to be contemporaneous can be radiocarbon dated, with the resulting offset in ages used to estimate ΔR.

Archaeological excavations in Baja California Sur, like other coastal regions of the world, present an excellent opportunity for such an investigation. In this paper, we report some preliminary steps toward developing a ΔR-corrected radiocarbon chronology for the Cape Region of the Baja peninsula.

Dating the Dead

The MRE is a significant problem for archaeologists trying to assign accurate ages to prehistoric objects or events in coastal areas. Depending on the magnitude of ΔR, radiocarbon ages of materials from the sea can appear to be as much as a thousand years older than they actually are (Taylor 1987:126-132). On the other hand, depending on the magnitude of the ΔR correction, it is also possible to understate the age of marine samples. Molto, Stewart, and Reimer (1997) offer a fascinating instance of the latter problem from a study of human skeletons from the Cape Region of Baja California Sur (Fig. 1).

Molto, Stewart, and Reimer (1997) evaluated radiocarbon dates from several prehistoric human skeletons excavated by the archaeologist William C. Massey in the Cape Region during the 1940s and 1950s. Massey (1955, 1966) used these burials to define his Las Palmas Culture. The Las Palmas Culture is recognized as ancestral to the region's Pericú Indians, encountered by Europeans during the early-mid sixteenth century, such as Fortún Jiménez and Hernán Cortés. Since the prehistoric Pericú almost certainly got a sizeable (but unknown) portion of their food from the sea, ^{14}C dating of the skeletons requires correction for the MRE. Radiocarbon dating skeletons ostensibly of prehistoric origin, Molto, Stewart, and Reimer (1997:501) found that some of these individuals dated to the early historic era, depending on the ΔR correction applied to the date and the assumed percentage of skeletal carbon of marine dietary origin. The latter can be estimated by measuring the ratio of the stable isotopes ^{15}N to ^{13}C in human bone. As we shall see below, computer programs allow these factors to be estimated, yielding a range of possible ages for the marine samples being dated.

These findings are problematic. As Molto, Stewart, and Reimer (1997:503) note, Spanish explorers and Jesuit clerics neither observed nor reported Pericú mortuary ceremonialism. Had Europeans either witnessed or had been informed of this behavior (as the Jesuit missionary Baegert [1942:121] was by Guaycura groups), it seems likely they would have made mention of it in their diaries, notes, or letters, just as they did other aspects of Indian life in the region.

Based on this lack of information, it seems unlikely these burials are actually of historic age. Indeed, as Molto, Stewart, and Reimer (1997) point out,

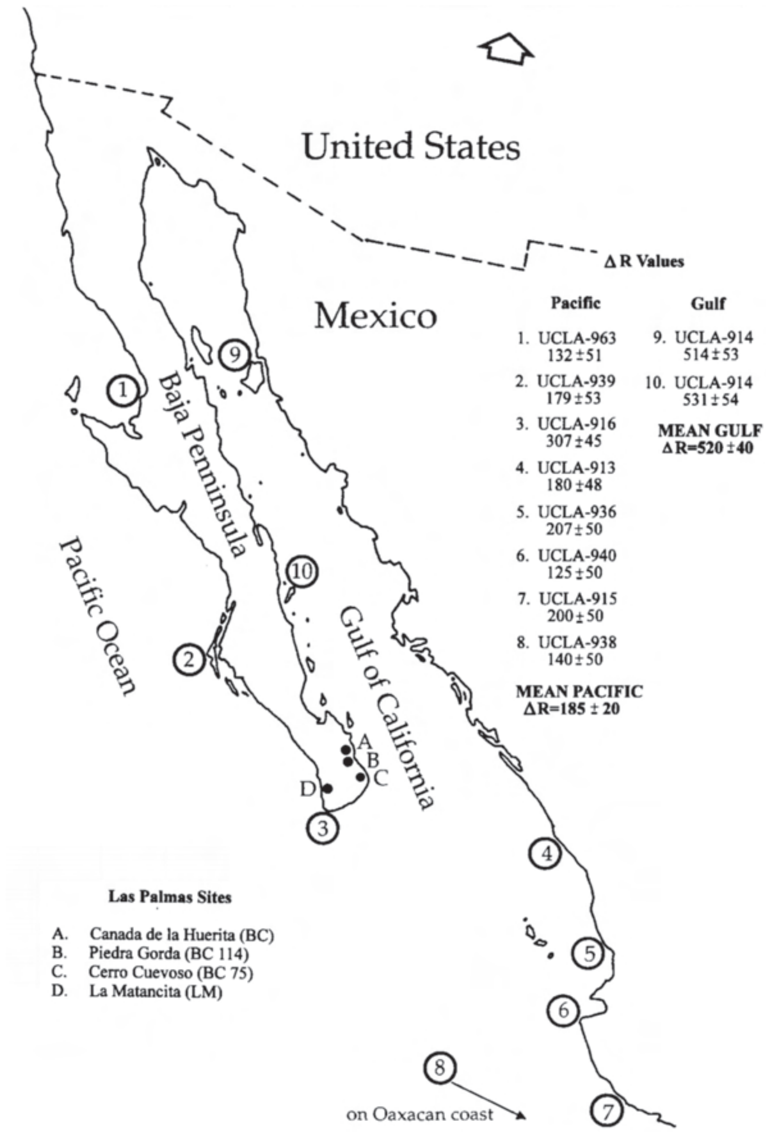

Fig. 1. Map of the Baja Peninsula. Note the location of burial sites (A-D) an ΔR values based on 10 shell samples studied by Molto, Stewart, and Reimer 1997. D-21 Cabo Pulmo#1 is roughly one kilometer northeast of Cerro Cuevoso, BC 75 (C) and 35 kilometers southeast of Piedra Gorda, BC 114(B). (After Molto, Stewart, and Reimer 1997:490).

these findings suggest another possibility: the apparent radiocarbon age of the burials is highly dependent on the ΔR correction applied to them. Unfortunately, estimates of the appropriate ΔR for the Cape Region of Baja California Sur vary by hundreds of years, producing markedly different dates. Previous research has set these values between about 185 ± 20 radiocarbon years and 520 ± 40 radiocarbon years (Molto, Stewart, and Reimer 1997:490). These are the average ΔR values for the Pacific and Gulf of California sides of the peninsula, respectively, reflecting the dating of marine shells of known historic age from various coastal locations (Taylor 1987:130).

But what correction factor should be applied to dates from the Cape Region of the peninsula? While one might simply apply the correction factor specified for each side of the peninsula, this approach may not yield accurate results. Below, we conduct a “thought experiment” in which we derive differing corrections for marine and terrestrial radiocarbon dates. We have done this to show how markedly different dates could be obtained, depending on whether corrections are used for the waters of the Pacific Ocean or the Gulf of California. These bodies of water represent vastly different marine systems, with disparate temperatures, biota and circulation patterns. As one nears the tip of the Baja California Peninsula, it appears that waters from both seas can mix, further complicating the problem of determining an accurate correct correction factor. In this sense, our "experiment" may have value as a cautionary tale about radiocarbon dating in the region.

Particularly in the case of samples from near the tip of peninsula, we should note the absence of oceanographic separation between the waters of the Pacific Ocean and the Gulf of California. To the extent that mixing of Pacific Ocean and Gulf of California waters may occur in this area, it may be hazardous to apply automatically generalized ΔR values. If the region is influenced by such mixing, radiocarbon dates of marine origin may diverge significantly from the results one would expect from applying what is ostensibly the correct ΔR value.

A brief experiment, shown in Table 1, shows the impact that differing ΔR factors can have on calibrated radiocarbon dates. Given a hypothetical skeleton with an age of 700 ± 50 radiocarbon years, we can employ the widely used CALIB (version 4.4) computer program (Stuiver and Reimer 1993; 2004) to calibrate the age of the skeleton, assuming for the sake of illustration a diet of 50 percent marine foods, but varying the estimated ΔR correction between 185 ± 20 and 520 ± 40 radiocarbon years.

The calculations used in this simulation yield probabilities at one standard deviation from the mean (1-sigma). One could make these calculations

Table 1: Two Hypothetical Calibrations of a Skeletal Radiocarbon Date Using Two ΔR Corrections (CALIB Program, v. 4.4).

Radiocarbon Age BP 700 ± 50 radiocarbon years, Calibration data set: Marine/INTCAL98		
Delta R = 185 ± 20 radiocarbon years:		
% Area Enclosed:	Cal AD Age Ranges:	Relative Area Under Probability Distribution:
68.3 (1 sigma)	cal AD 1440-1528	0.954
	1602-1610	0.046
Delta R = 520 ± 40 radiocarbon years:		
68.3 (1 sigma)	cal AD 1534- 1562	0.101
	1578-1586	0.029
	1620-1693	0.648
	1743-1747	0.015
	1761-1802	0.207

at two standard deviations in order to obtain broader estimated age ranges, but the results point to same essential conclusion. Depending on the ΔR employed in these calibrations, the skeleton could be either prehistoric or historic. With a ΔR of 185 ± 20 radiocarbon years, the skeleton has a 95 percent probability of dating to between AD 1440 and 1528, or pre-European contact. With a ΔR of 520 ± 40 radiocarbon years, the skeleton has about a 65 percent probability of dating to AD 1620 to 1693, well after European contact.

Researching the Problem of Marine Radiocarbon Dates

While the experiment above might seem to paint a discouraging picture, archaeologists can improve the accuracy of marine radiocarbon dates. One of the best ways to do this is by comparing terrestrial and marine archaeological materials that derive from the same context or event. The difference between the ages of these materials should yield ΔR. Of course, for this method to be valid, we must have a high degree of certainty that the materials in question were deposited at the same time and were of the same original age (old wood). Research by the authors in the Cabo Pulmo area of Baja California Sur illustrates how we might approach this research problem.

Cabo Pulmo Study

Between July 5 and 11, 1994, the authors carried out a brief excavation at D-21 Cabo Pulmo #1, which is located on the Gulf of California about 70 kilometers south of La Paz, Baja California Sur (Fig. 2). Archaeological Site D-21 Cabo Pulmo #1 remains one of the few stratigraphically intact deposits in a region seriously threatened by development. It is geomorphologically characterized by shifting sand dunes, which have deflated and destroyed countless coastal midden sites. Investigations at D-21 Cabo Pulmo #1 were designed to establish links between coastal sites and burial caves, such as the kinds described by Massey (1966) and discussed by Molto, Stewart, and Reimer (1997). Excavation at D-21 Cabo Pulmo #1 addressed issues of chronology, diet, and settlement. Shellfish and faunal remains present at the study site indicated a diverse prehistoric economy. Chipped and ground stone artifacts reflect both vegetal and animal food processing. These

Fig. 2. Looking northeast toward Cabo Pulmo from Cerro Cuevoso (BC). Pulmo Bay is in the foreground. Photo taken by M. Boxt.

data provide a basis for comparative archaeological analysis, contributing further to our understanding of the Las Palmas tradition.

Two areas of the site were selected for excavation. Unit 1 (1 by 1 meter) was placed adjacent to the southern edge of an arroyo which cuts through

Fig. 3. Members of the Cabo Pulmo crew, excavating Unit 1. Left to right: Roscoe Loetzerich, Matthew A. Boxt, Katherine Bradford, Mario Guzmán Acevedo, Judith F. Porcasi, and Harumi Fujita. Photo taken by M. Raab.

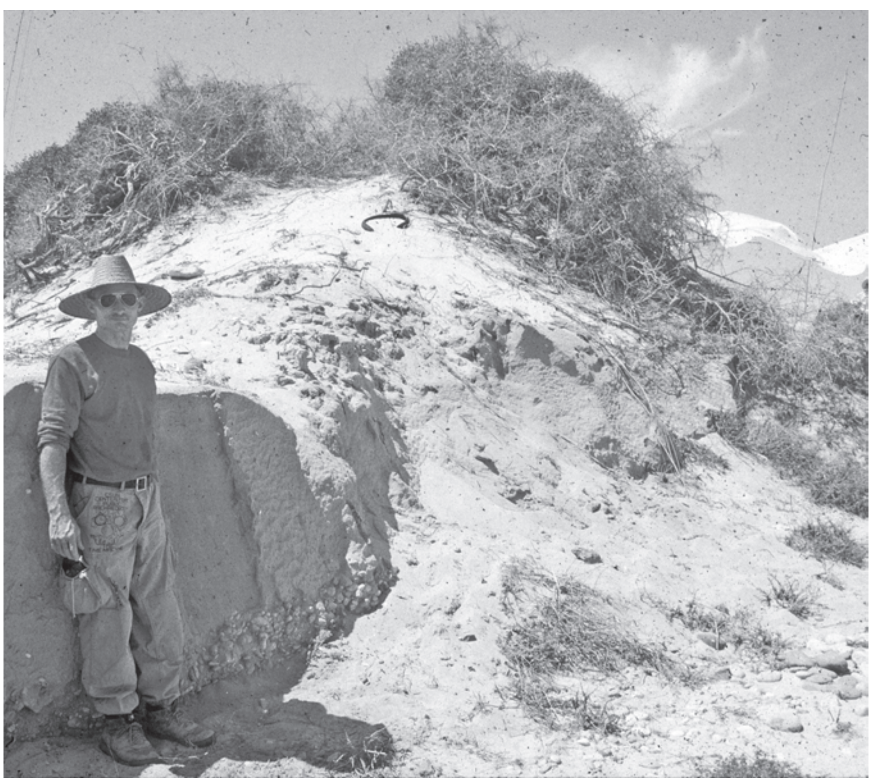

Fig. 4. L. Mark Raab inspects the stratigraphic profile of D-21 Cabo Pulmo #1; a deep erosion cut exposes a cobble bed at 90 centimeters below surface. Photo taken by M. Boxt.

the site center (Fig. 3). This location was chosen based on an assessment of the stratigraphic profile visible in the arroyo face (Fig. 4). The stratigraphy in this portion of the site consists of a cobble bed at the base (90 centimeters and below), an apparent fossil or coastal carbonate dune remnant (30 to 60 centimeters), and a cap of loose sand or active dune deposit (0 to 30 centimeters). Unit 2 (1 by 1 meter) was placed within the active dune field located above the high tide line, north of the Cape promontory. Although dark-colored soil was present on the surface, three soil auger tests revealed that deposits in this portion of the site were largely deflated, containing no intact stratigraphy. Movement of these by the wind resulted in the mixing of artifacts near the dune surface. In fact, the possibility of finding preserved cultural deposits and features in these dunes is poor.

A hearth feature, containing shells and charcoal within a fossil dune deposit, was excavated (Fig. 5). The hearth contained abundant charcoal and shells of the pearl oyster (*Pinctada mazatlanica*), some of which showed signs of burning. Together, these data clearly represented a food-processing episode. Moreover, this hearth reflects just the kind of association of terrestrial (charcoal) and marine (shell) materials that raise questions about local ΔR values. Radiocarbon dating of charcoal and shell from the hearth produced the following results in Table 2.

The results in Table 2 should not be viewed as definitive time estimates, but rather as a heuristic device for demonstrating the significant variation in age determinations that result from differing ΔR corrections. These results nevertheless have interesting implications. Note, first of all, that the calibrated age of the charcoal sample from the Unit 1 hearth yields two time ranges: AD 1263 to 1315 and 1353 to 1387. The first range of dates is the more probable (0.64 of the area under the probability distribution). However, the total span of both time ranges is from AD 1263 to 1387. These dates place the hearth in the pre-European era (first European contact in the region occurred at AD 1533). Like the experiment in Table 1, we calibrated the shell sample from the Unit 1 hearth (Beta-82969) using two ΔR values. If we use larger ΔR for the Gulf of California, the shell sample falls

Fig. 5. Close-up view of the D-21 Cabo Pulmo #1 hearth. Photo taken by M. Raab.

well into the historical era, being much younger than the charcoal associated with it in the Unit 1 hearth. On the other hand, if we use the smaller ΔR (Pacific Ocean), the age range of the shell (AD 1364 to 1488) overlaps the total time range of the charcoal date (AD 1263 to 1387), making the shell contemporaneous with the charcoal and of prehistoric age.

The D-21 Cabo Pulmo #1 data generally parallel the problem identified by Molto, Stewart, and Reimer (1997) in dating human skeletons from the same region as Cabo Pulmo. If one assumes that historical-era shell dates are correct, one might conclude that charcoal date is too old. Such a pattern could conceivably reflect the “old wood” problem, where centuries-old wood was collected to make a fire (Erlandson 1994; Taylor 1987). Alternatively, the alignment of the shell and charcoal dates could depend primarily on the ΔR value used to calibrate the shell sample. In effect, using the older (Gulf of California) ΔR value over-corrects for the MRE, making out shell dates from the study area to be younger than they actually are.

Clearly, these problems cannot be solved on the strength of a single pair of dates from D-21 Cabo Pulmo #1. However, in light of the fact that the Cabo Pulmo dates reflect the same pattern identified by Molto, Stewart, and Reimer (1997), we suspect the younger ΔR value (185 ± 20 radiocarbon years) is probably closer to the actual age off-set of marine vs. terrestrial materials from the Cape Region during late prehistory. We believe this hypothesis is plausible, owing to the oceanographic setting of the study area. We note that the older ΔR

Table 2: Calibrated Radiocarbon Dates from the Unit 1 Hearth at D-21 Cabo Pulmo #1, Using the Charcoal Hearth Sample (Beta-82968) for Comparison with Two Trial ΔR Corrections with one Shell Sample (CALIB Program, v. 4.4).

Charcoal Sample from hearth:		
Beta-82968 $^{13}C/^{12}C$ adjusted age= 700 ± 60 radiocarbon years. Calibration data set: INTCAL98		
% Area Enclosed:	Cal AD Age Ranges:	Relative Area Under Probability Distribution:
68.3 (1 sigma)	cal AD 1263-1315	0.648
	1353-1387	0.352
Two trial corrections for shell sample from hearth:		
Correction example 1: Beta-82969 $^{13}C/^{12}C$ adjusted age= 1130 ± 50 radiocarbon years. Calibration data set: Marine/INTCAL98, ΔR= 520 ± 40:		
68.3 (1 sigma)	cal AD 1644-1802	1.0
Correction example 2: Beta-82969 $^{13}C/^{12}C$ adjusted age= 1130 ± 50 radiocarbon years. Calibration data set: Marine/INTCAL98, ΔR= 185 ± 20:		
68.3 (1 sigma)	cal AD 1364-1488	1.0

value employed by Molto, Stewart, and Reimer (1997:490) came from two sampling locations well within the Gulf of California. By contrast, the study area is located near the tip of the peninsula, in relatively close conjunction with the Pacific Ocean. In this location, it seems possible that mixing of waters from the Pacific Ocean and the Gulf of California could result in ΔR values closer to that of the Pacific coast.

The results described here are preliminary. However, in view of the importance of radiocarbon dating to archaeological research in any region of the world, researchers could productively devote attention to dating paired marine and terrestrial samples of the sort seen at D-21 Cabo Pulmo #1. As the number of these test cases grows, we can place more confidence in the results. At the same time, efforts might be made to find and date "pre-bomb" samples of shell from the study area. This would allow determination of the contemporary (pre-1950) ΔR value for the region. Archaeologists need to compare the radiocarbon dates they receive with the archaeological contexts in which the dates are being applied. One implication of this fact is that archaeological research can be used to improve the realism of radiocarbon dating techniques, not merely the other way round.

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