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On the Antiquity of the Single-Piece Shell Fishhook: AMS Radiocarbon Evidence from the Southern California Coast

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During the Late Holocene, a number of new technologies (single-piece fishhooks, toggling harpoons, plank canoes, etc.) are thought to have significantly enhanced the fishing capabilities of California coastal peoples. The single-piece fishhook, perhaps the most common of these artifacts, appears to correlate with a regional intensification of marine fishing and a period of increased population growth. Determining the antiquity of the single-piece fishhook has been complicated by a variety of taphonomic and methodological factors. Consequently, age estimates for the initial appearance of these artifacts range from about 5500 to 2500 cal-BP. To help clarify the chronology of this important artifact type, we had eight of the potentially oldest shell fishhooks in the region AMS radiocarbon dated. These dates indicate that the single-piece shell fishhook appeared throughout the southern and central California Coast by at least 2500 cal-BP. Our data illustrate the utility of direct AMS dating of individual artifacts as a method of documenting site disturbances (bioturbation, historical land use, etc.) and refining artifact, site, and regional chronologies.

Keywords: MARINE FISHING, FISHHOOKS, SUBSISTENCE TECHNOLOGY, ACCELERATOR MASS SPECTROMETRY, CHANNEL ISLANDS, CALIFORNIA.

Introduction

In many of the world's coastal, riverine, and lacustrine regions, fishing was an integral part of human subsistence economies, supplying a resource base that promoted high population densities and cultural complexity (see Moseley, 1975; Arnold, 1992; Ames & Maschner, 1999; Butler, 2000; Kennett & Kennett, 2000; Erlandson, 2001). People living in aquatic areas often invested significant amounts of labor and raw materials in the construction of nets, weirs, hook and line, and a variety of other implements specifically designed to capture a diverse array of fishes. Documenting the antiquity of these various fishing technologies has recently played an important role in anthropological and archaeological theory, including discussions of early human evolution and adaptation (Stewart, 1994; Brooks *et al*., 1995; Yellen *et al*., 1995; Yellen, 1998; Erlandson, 2001) and the emergence of complex hunter-gatherers (Moss, 1990; Davenport, Johnson & Timbrook, 1993; Arnold, 1995; Gamble & Russell, 2001).

Unfortunately, defining the chronology of many fishing related artifacts is hindered by a variety of environmental, cultural, and methodological variables. Nets, line, and other fishing related technologies, for example, are often made of plant fibres that rarely preserve in the archaeological record, while other artifacts made of shell, bone, and especially stone are more often preserved. Bioturbation, historical land use, and numerous other taphonomic processes often heavily disturb and mix stratigraphic deposits in multicomponent sites (see Wood & Johnson, 1978). This stratigraphic mixing poses significant problems for defining artifact chronologies based on associated radiocarbon dates, resulting in age estimates that are hundreds or even thousands of years different than the actual age of the artifact (e.g., Erlandson & Rockwell,

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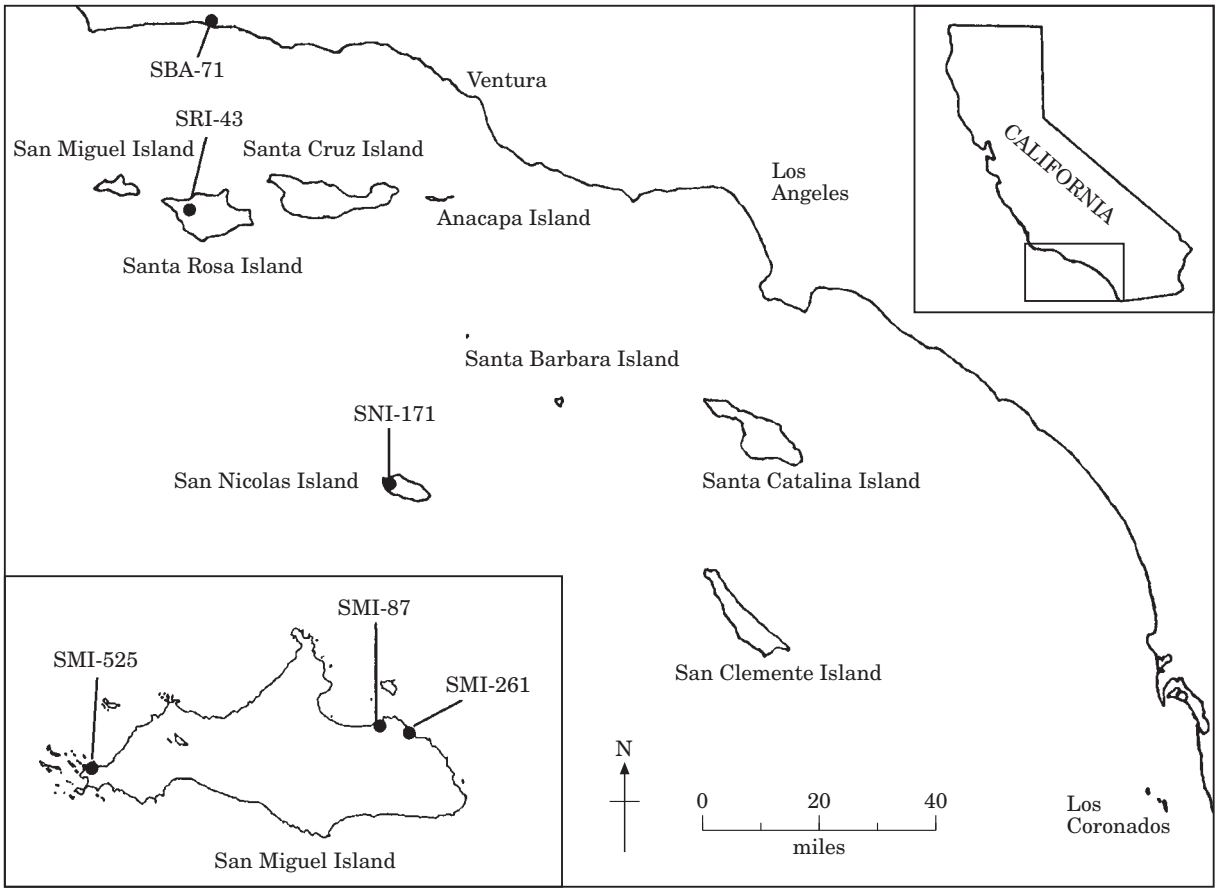

Figure 1. The Southern California coast and archaeological sites discussed in the text.

1987; Koerper *et al.*, 1995). To circumvent chronological problems posed by bioturbation and other disturbance processes, researchers have increasingly turned to direct dating of individual artifacts using Accelerator Mass Spectrometry (AMS) and conventional ^{14}C dating. The AMS method is particularly beneficial, as very small fragments of artifacts can be directly dated with high precision and only minimal destruction of the specimen. Recently, direct AMS or conventional ^{14}C dating have been used to revise a variety of chronologies in western North America, including *Olivella* shell bead production and exchange systems in California and the Great Basin (Vellanoweth, 2001), the antiquity of wood stake fish weirs in the Pacific Northwest (Moss *et al.*, 1990; Moss & Erlandson, 1998), and the development of the plank canoe in coastal southern California (Gamble & Russell, 2001).

In this paper, we report AMS dates for eight single-piece shell fishhooks from some of the earliest purported associations for these artifacts on the Channel Islands and mainland coast of Santa Barbara, California (Figure 1). The single-piece fishhook was an important subsistence technology for Native peoples of the southern and central California Coast that appears to be related to population growth and cultural complexity (see Tartaglia, 1976; Raab *et al.* 1995; Glassow, 1996; Gamble & Russell, 2001). Defining the first appearance and proliferation of this fishing technology, therefore, is crucial to understanding the timing of key regional cultural developments and fundamental shifts in human subsistence evident in the archaeological record (Strudwick, 1985, 1986; Koerper *et al.*, 1988, 1995; Salls, 1988, 1990; Kennett & Kennett, 2000; Rick, 2001). Our dates indicate a relatively complex framework for the origins of the shell fishhook and differ substantially from age estimates for similar hook types in other areas of the New World. We establish a broad temporal context for these important artifacts, review the changes in fishing strategies that coincide with their appearance, and speculate on the relationship of single-piece fishhooks with other New World fishing tackle.

Background and Context

In this paper, we use the term single-piece fishhook to refer collectively to any single-piece, curved fishhook, excluding composite forms and fish gorges (see

Strudwick, 1986). These artifacts have been identified in California mainland and island archaeological sites ranging from Monterey to San Diego, with the greatest abundance between Santa Barbara and Orange counties (Strudwick, 1985: 62). Single-piece hooks are usually circular or j-shaped and generally made of red abalone (*Haliotis rufescens*), California mussel (*Mytilus californianus*), or Norris top (*Norrisia norrisii*) shells, and occasionally from bone and stone (Hoover, 1973: 5; Strudwick, 1985, 1986). Shell fishhooks were made with grooved, notched, or plain shanks, were occasionally barbed, and range in size from about 2–8 cm in height (Hoover, 1973: 6). Shell fishhooks were usually attached to a line made of sea grass (*Phyllospadix sp.*), yucca, or other plant fibres, and asphaltum (bitumen) was sometimes used to aid in line attachment (Hoover, 1973: 6; Salls, 1989). Salls (1988: 126, 1989) argued that the use of the hook is analogous to the use of modern metal hooks, though the shell hooks were not as strong as modern forms.

The single-piece fishhook is part of a marine fishing tradition in coastal southern California that spans the last 11,000 years (Rick, Erlandson & Vellanoweth, 2001) and includes a wide range of fishing technologies such as spears, nets, traps, poisons, hook and line, harpoons, lures, and other tools (Bennyhoff, 1950; Hoover, 1973; Salls, 1988). Consequently, when evaluating the significance of these artifacts it is important to place them within the context of earlier, as well as contemporary cultural developments. With this in mind, we briefly highlight changes in fishing technologies across the Holocene to contextualize our analysis.

Fishing was primarily a supplementary subsistence strategy in Early Holocene coastal California, but a variety of fishing technologies, including gorge and line, nets, spears, and possibly traps and poisons were used by some of the earliest occupants of the region (Erlandson, 1994; Rick *et al.*, 2001). Bone gorges, a form of straight hook designed to toggle and catch in a fishes throat or stomach, are relatively abundant ($n=30$ whole and fragmentary specimens) in shell midden strata at Daisy Cave on San Miguel Island dated between about 9700 and 7800 radiocarbon years before present (RYBP; 10,100 to 8600 cal-BP; Rick *et al.*, 2001). There is considerable continuity between fishing strategies employed during the Early and Middle Holocene, with people relying largely on gorges, nets, spears, and other implements. One of the most important technological innovations of the Middle Holocene appears to have been the development of the composite bone fishhook, which according to King (1990: 81) appears in the Santa Barbara Channel region about 5000 to 4000 RYBP. It is not always clear, however, if bone barbs recovered from archaeological sites were part of composite hooks, or if they are fragments of harpoons, leisters, or other bone tools. By the Late Holocene (3300 RYBP to present), fish dominate human subsistence economies in southern California, roughly coinciding with the development of a number of new fishing technologies, including plank canoes, single-piece shell fishhooks, lures, toggling harpoons, and a variety of other implements (see Glassow, 1993; Kennett, 1998). The single-piece shell fishhook was perhaps the most important and widespread of these Late Holocene fishing technologies, and their initial appearance and proliferation is thought to mark a significant change in human subsistence strategies.

Beginning with Schumacher (1875) and Bowers (1883), archaeologists have pondered the chronology and ramifications of southern California shell fishhooks. Bowers and other early scholars assumed that many of the fishhooks were ornamental, often serving as funerary items. More recently, archaeologists have recognized that the majority of hooks were utilized for fishing, possibly resulting in increases in the amount and types of fish found in archaeological sites (Fitch, 1972: 115; Salls, 1988; Raab *et al.*, 1995). Early scholars also noted similarities between single-piece hooks in coastal California, Polynesia, and coastal Chile, arguing that these technologies may have diffused from one of these areas to the other two (Heizer, 1944; Landberg, 1966). Due to the vast distances that separate these regions, as well as the different time periods in which fishhooks appeared in the three areas, an independent origin for these artifacts now seems most likely (Reinman, 1968; Strudwick, 1986).

Robinson (1942) was among the first archaeologists to classify shell fishhooks and demonstrate their use through experiments with fishhook replicas. Heizer (1949) also classified single-piece fishhooks, placing them into six categories based largely on the presence of a barb and the location of the shank. Strudwick (1985, 1986) refined Heizer's original scheme, focusing largely on the shank as the most diagnostic feature of the hook. Relying on ethnographic analogy and experiments using shell fishhook replicas, Tartaglia (1976) argued that the various fishhook types were designed to capture specific types of fish or for use in distinct habitats.

Recent studies have focused on refining the chronology of these important artifacts (e.g., Koerper *et al.*, 1988, 1995; Rick, 2001). Strudwick (1985: 58–59, 1986: 271–272, 279) has presented the most elaborate chronological and cultural scheme for these artifacts to date, arguing that shell fishhooks may have been developed by 5000 years ago or earlier, with most appearing to date after about 2500 years ago. Orr (1968) also argued for a Middle Holocene origin of the single-piece fishhook, suggesting they appeared by 5000 years ago in the region. Similarly, Salls (1988: 361, 371–372) reported three direct conventional radiocarbon dates for shell fishhooks from Eel Point (CA-SCLI-43B) on San Clemente Island that produced age estimates ranging from 4400 to 2900 cal-BP (4500 to 3380 RYBP).

Several researchers have proposed a later date for the development of the single-piece fishhook. Glassow

(1996: 134), relying on data from the Vandenberg region, suggests that the single-piece fishhook became important between about 2500 to 2000 RYBP, and possibly on a more sporadic basis by 3000 years ago. Similar to Glassow, King (1990), relying largely on data generated by Tartaglia (1976), suggests that single-piece fishhooks may have first appeared during the Middle Period (1400 BC–AD 1150; 3000 to 800 RYBP), possibly as early as 2500 years ago in some areas. Research on San Clemente Island by Raab *et al.* (1995: 14) has produced associated dates for fishhooks or fishhook blanks of roughly 3500 to 3200 cal-BP (3300 to 3000 RYBP), substantiating some of Salls' dates, but indicating a slightly later arrival. On San Nicolas Island, Vellanoweth & Erlandson (1999: 268) reported a circular shell fishhook from CA-SNI-161 with an associated date of 3000 cal-BP (2980 RYBP). Three fishhooks from CA-ORA-378 in Orange County were dated by association to as early as 5000 years ago, but produced AMS dates ranging from 2750 to 1000 cal-BP (2780 to 1770 RYBP; Koerper *et al.*, 1995). Finally, Breschini & Haversat (2000: 27) recently obtained three direct AMS dates on mussel shell fishhooks from CA-MNT-113c in Monterey County, with calibrated midpoints ranging in age from 2140 to 1870 cal-BP (2290 to 2060 RYBP). Due to the current dearth of direct AMS dates on shell fishhooks, however, it remains unclear if the fishhook appeared during the Middle Holocene or if a later date around 2500 years is more correct.

Methods

Through a regional literature survey, analysis of museum collections, and our own current field research we selected fishhooks for AMS radiocarbon dating that potentially had great antiquity. To maintain the integrity of the original artifact, we obtained very small fragments (i.e., <1·0 g) of the specimens for AMS dating. We sampled areas of the hooks that had previously been broken, staying clear of intact tips, barbs, and shanks. Five specimens from San Miguel Island, San Nicolas Island, and Tecolote Canyon on the Santa Barbara mainland coast were sent to the National Oceanic Sciences AMS (NOSAMS) facility at Woods Hole Oceanographic Institute (WHOI). Two specimens from Daisy Cave, San Miguel Island were sent to Beta Analytic and dated at the Center for Accelerator Mass Spectrometry (CAMS) at the Lawrence Livermore National Laboratory. A final specimen was sent to NOSAMS and later dated by CAMS (see Rick, 2001). During pretreatment, all of the specimens were etched in dilute hydrochloric acid and rinsed in distilled water to remove contaminants. They were then dried and converted to CO_2 by reaction with 85% phosphoric acid under vacuum. Subsamples were used to measure the $^{13}C/^{12}C$ stable isotope ratio while the rest were converted to graphite before being dated.

Defining the antiquity of the single-piece fishhook and other artifacts is often complicated by problems associated with comparing uncorrected radiocarbon dates based on shell, bone, and charcoal, since the measured ages of terrestrial and aquatic materials can often differ by hundreds and even thousands of years. With the refinement of calibration curves and several computer programs available for calibration, it is crucial for researchers to discuss temporal trends primarily based on calibrated calendar ages to standardize results. To ease comparative analysis, moreover, researchers should report all dates (i.e., measured, $^{13}C/^{12}C$ corrected, and calibrated) and indicate which programs were used for calibration and what reservoir correction was used for shell samples. To standardize our results and increase the accuracy of our interpretations, all dates presented in this paper were calibrated with Calib 4·3 (Stuiver & Reimer, 1993, 2000), applying a ΔR of 225 ± 35 years for shell dates and $^{13}C/^{12}C$ ratios were either determined by the radiocarbon labs, or an average of +430 years was applied (Erlandson, 1988).

To compensate for local upwelling, the ΔR we used (225 ± 35) is an average value for the entire coast of California and is also the most common ΔR used by archaeologists in the region (see Kennett *et al.*, 1997). It should be noted, however, that due to variations in upwelling and other climatic variables there is spatial and temporal variability in the reservoir effect throughout California and beyond. Ingram & Southon (1996), for example, determined a ΔR estimate for the Santa Barbara Channel region of 233 ± 60, and demonstrate a range of 220 ± 40 for southern California to 290 ± 35 for northern California. Kennett *et al.* (1997) demonstrated temporal variability in ΔR, noting a slightly diminished value of 210 ± 80 between 8440 and 4310 RYBP. It is likely that the fishhooks in our study, ranging from San Nicolas Island to western Santa Barbara County, also require slightly different ΔR adjustments. Using the Ingram & Southon (1996) or Kennett *et al.* (1997) estimates instead of the 225 ± 35 average, however, would only adjust our calibrated midpoints by roughly 20 years, suggesting our use of the California average is justified. Nonetheless, it should be noted that the calibrated age estimates we provide for our samples are approximations rather than exact ages.

Recent research by Kennett & Ingram (n.d.) also noted variability in AMS ages obtained from different growth bands on marine shells from the southern California Coast. Their estimates indicate discrepancies between roughly 100 and 200 years per shell sample and appear to be closely linked to differences in upwelling intensity at the time the shell added each new growth band. While we attempted to obtain samples that extend along multiple growth lines, this possible source of error should also be noted when evaluating our dates. The results of our AMS analysis are summarized in detail below (Table 1).

Table 1. Direct AMS radiocarbon dates on southern California shell fishhooks

Site	Provenience	Lab number	Material	Uncorrected ^{14}C age	$^{13}C/^{12}C$ adjustment	Age range (cal BP 1 sigma)
Mainland Coast						
SBA-71	E148 0·5–1·5 ft	OS-26446	*Haliotis* sp.	2230 ± 45	2640 ± 45	2120 (2040) 1970
SBA-71	F6 2–2·5 ft	OS-26447	*Mytilus* sp.	2350 ± 30	2760 ± 30	2290 (2180) 2130
Southern Channel Islands						
SNI-171	Unit 1, 10–20 cm	OS-27838	*Haliotis* sp.	2010 ± 50	2440 ± 50	1880 (1820) 1730
Northern Channel Islands						
SMI-87	East Dune, Surface	OS-26071	*Haliotis* sp.	2530 ± 35	2980 ± 35	2540 (2450) 2350
SMI-261	Unit F5: 30–36 in	Beta-141219	*Haliotis* sp.	1450 ± 30	1910 ± 30	1280 (1250) 1210
SMI-261	Unit F5: 30–36 in	Beta-141220	*Haliotis* sp.	1630 ± 40	2080 ± 40	1460 (1390) 1330
SMI-525	Unit 1C, Strat. 4	OS-30000	*Haliotis* sp.	2280 ± 35	2730 ± 35	2260 (2150) 2100
SRI-43	Sq. 16 M, L5	OS-26072	*Mytilus* sp.	810 ± 35	1220 ± 35	630 (560) 530

Figure 2. Fishhooks discussed in the text. (a) CA-SMI-525, Unit 1C, Stratum 4, 210–220 cm; (b) CA-SMI-525, Unit 1B, Stratum 4, 210–220 cm; (c) CA-SMI-87, East Dune, Surface; (d) CA-SMI-261, specimen 10, Unit F5, 30–36 in; (e) CA-SMI-261, specimen 11, Unit F5, 30–36 in (actual size). Shaded areas on shank of specimens D and E indicate areas that contain asphaltum.

Radiocarbon Results

CA-SBA-71

This archaeological site, located at the mouth of Tecolote Canyon along the Santa Barbara Coast, contains Early, Middle, and Late Holocene deposits that have been mixed by bioturbation, occupational disturbances, historical land use, and other taphonomic processes. Late Holocene occupation of the site appears to have begun a little over 2000 years ago on a high terrace that forms the eastern canyon rim. In 1926, Rogers' excavated portions of a discrete cemetery plot in the southern site area, where he reported finding 75 closely-packed burials, including at least 69 articulated burials and four reburials (King, 1980: 40). Further excavation by Warren in 1971 yielded materials from the Early, Middle, and Late Holocene (DuBarton, 1991). The two fishhooks selected for radiocarbon dating were among several specimens obtained during Warren's excavation. They lacked solid chronological association, however, and were thought to have been as old as the Middle Holocene. AMS dating of a mussel shell fishhook midsection yielded a calibrated intercept of 2180 cal-BP, while analysis of a burned abalone fishhook midsection produced an intercept of 2040 cal-BP. These two Late Holocene specimens are currently the only directly dated single-piece hooks from the Santa Barbara mainland coast and fit nicely into King's (1990) and Glassow's (1996) shell fishhook chronology.

CA-SMI-525

Several fishhook specimens were recovered from CA-SMI-525 located near Point Bennett on the northwest shore of San Miguel Island. Excavation and radiocarbon dating of a column sample by Walker & Snethkamp (1984: 43) suggest that this site dates from about 3030 cal-BP (3450 RYBP) through 550 cal-BP (1200 RYBP) or later. Situated near rich kelp beds and a pinniped rookery, this site contained abundant evidence of marine fishing and sea mammal hunting. Kennett recently excavated portions of the CA-SMI-525 deposits and collected several unique shell fishhooks that were thought to date to 2500 years or earlier (Figure 2). These specimens are made of abalone and contain two notches near the slightly

recurved shank that were used to fasten the fishing line. AMS dating of one of the shell hooks provided an intercept of 2150 cal-BP.

CA-SMI-87

Located on the east side of Cuyler Harbour, this site is situated near the beginning of the wind tunnel, a deflated area caused largely by historical overgrazing. The site contains several unique archaeological features, including large rock clusters or pavements, numerous marine mammal and fish bones, asphaltum basketry impressions, and shell beads. Radiocarbon dates suggest that the site was probably abandoned shortly after 2500 cal-BP, with most of the site occupation occurring between roughly 4500 and 2700 cal-BP. Excavation and surface collection of the uppermost site deposits produced several bone gorges, and one single-piece, j-shaped abalone fishhook was obtained from the site surface. AMS dating of this fishhook produced a calibrated intercept of 2450 cal-BP, currently the oldest directly dated hook from the Santa Barbara Channel region.

CA-SMI-261

Daisy Cave, situated just above a rocky, surf-swept portion of the northeast coast of San Miguel Island, contains well-stratified archaeological deposits which span the Holocene (Erlandson *et al.*, 1996). The site was extensively excavated by Rozaire (1978) in the 1960s, with more limited work by Snethkamp in the 1980s, and Erlandson in the 1990s. Extensive Late Holocene occupation of the site occurred at roughly 3000 RYBP and these midden deposits currently cap the shell midden strata at the site. We selected two fishhooks from Rozaire's excavations for AMS dating from the 30–36 in (76–91 cm) level of Unit F5. These are both j-shaped, made of abalone, with straight-backed pointed shanks covered with asphaltum to aid in line attachment. Since asphaltum can greatly alter the radiocarbon age of a specimen (see Bowman, 1990: 53), we sampled areas of the hook that were well away from the portions that contained asphaltum. The AMS dating of these hooks produced calibrated midpoints of 1390 to 1250 cal-BP, almost 2000 years younger than originally presumed.

CA-SRI-43

This single-piece fishhook specimen and several others were recovered from CA-SRI-43, a site located between Arlington and Tecolote Canyons on the interior of Santa Rosa Island (Orr, 1968; Rick, 2001). CA-SRI-43 was extensively excavated by Orr (1968), who dug a large trench and between three and five test units (see Rick, 2001). The site contained at least eight burials and what Orr (1968: 182) interpreted as 16 house depressions, though this assertion has been challenged by Kennett (1998: 263). Orr (1968: 187) anchored the site chronology with two radiocarbon dates of 4790 ± 90 and 5370 ± 150 RYBP, leading him to conclude that the shell fishhooks recovered from these deposits were the earliest occurrence of the single-piece variety in California. The site, however, contained shell beads and microblades characteristic of sites which date to the last 1000 years, suggesting these fishhooks may actually have been several thousand years younger than Orr proposed (Glassow, 1997: 153). Direct AMS dating of a burned California mussel fishhook tip from Orr's collection housed at the Santa Barbara Museum of Natural History (SBMNH) provided a calibrated midpoint of 560 cal-BP, indicating that these hooks dated to the Late Holocene (Rick, 2001).

CA-SNI-171

This site is located on the eroded dune fields of northwestern San Nicolas Island. F. M. Reinman and colleagues first recorded the site during a survey and mapping project in 1983. These researchers described CA-SNI-171 as a large longitudinal dune measuring 245 m by 100 m wide, covered with artifacts and animal remains on the surface (Reinman, 1983). In 1986, archaeologists from Petra Resources, Inc. excavated a 1·5 by 1·5 m unit to a depth of 40 cm, recovering numerous ground and chipped stone tools, including a sandstone net weight, an obsidian biface, as well as a variety of shellfish, sea mammal, fish, and bird remains (Rosenthal & Jertberg, 1997). A mid-section fragment of a single-piece fishhook made from a red abalone shell was found in the 10 to 20 cm level. Two radiocarbon samples, both from this same level, produced corrected and calibrated intercepts of 2250 cal-BP (2220 RYBP) for charcoal and 4050 cal-BP (4250 RYBP) for marine shell (Rosenthal & Jertberg, 1997). Because of the large discrepancy between these two dates, we directly dated the fishhook to determine if its age corresponded with the earlier or later human occupation. The fishhook from CA-SNI-171 yielded a calibrated intercept of 1820 cal-BP, demonstrating that it corresponded with the associated charcoal date for the site.

Discussion

Our dates correspond well with previous chronologies for the appearance of single-piece fishhooks established by Glassow (1996), King (1990), and Koerper *et al.* (1995). The earliest date in our study is from a j-shaped, abalone hook from CA-SMI-87 dated to roughly 2500 cal-BP. Our data confirm Strudwick's (1986: 276) observation that abalone appears to have been the preferred material for some of the oldest hooks. Strudwick (1986: 276), however, argued that

many of the earliest hooks were circular in shape and subsequently became more j-shaped through time. While this may be the case with a 2750 cal-BP date on a circular hook from Orange County presented by Koerper *et al.* (1995), our data suggest that there was considerable spatial and temporal variability in fishhook shape and style. It is possible that in some areas hooks were primarily circular in shape, while others had more j-shaped hooks, but further examination and dating of fishhooks is necessary to define the timing of various stylistic changes.

While some researchers have argued that the single-piece fishhook may have appeared as early as 5000 years ago or earlier (e.g., Orr, 1968: 100, 184–187; Strudwick, 1985: 60–61, 1986: 279, 281; Salls, 1988: 361, 371–372, 1990), our AMS dates suggest that most of these age estimates based on radiocarbon associations are problematic. For example, the fishhook from CA-SRI-43 on Santa Rosa Island, previously thought to date to approximately 5500 cal-BP, was dated to 560 cal-BP. Similarly, the specimen from CA-SNI-171, associated with a 4050 cal-BP date on shell (Rosenthal & Jertberg, 1997), also was associated with a later date for the site. Previous chronological association for the specimens from CA-SMI-525, CA-SMI-261, and CA-SBA-71 were also thought to be potentially older than the post 2500 cal-BP dates that their analysis provided.

Salls (1990: 65–66) presented the only direct date that currently points to a Middle Holocene origin of the single-piece fishhook. As stated previously, Salls obtained three conventional ^{14}C dates on fishhooks with calibrated midpoints that range from 4400 to 2900 cal-BP (4500 to 3380 RYBP) from Eel Point on San Clemente Island. The large error ratio for these dates and the demonstration that many of the dates obtained from early work at Eel Point are problematic (Erlandson, 1994: 216; Raab *et al.*, 1995: 16; Raab, 1997) raises significant questions about the reliability of these dates. The oldest date, for example, could be the result of an ''old shell'' being used to make the hook, yielding a date older than the actual use and production of the artifact (see Vellanoweth, 2001). Furthermore, the two sigma age range for this artifact (5310 to 3400 cal-BP) slightly overlaps with the two younger dates from the site. While the 4400 year old date does not mesh with the current chronological scheme for these artifacts, the 3000 and 3600 year old dates obtained by Salls fit reasonably well with our chronology and recent associated dates obtained by Raab *et al.* (1995).

Based on radiocarbon associations, Raab *et al.* (1995) argued that the earliest fishhooks from Eel Point appear to date to *c.* 3230 cal-BP (3000 RYBP), with a possible fishhook blank dating to as early as 3500 cal-BP (3320 RYBP). These estimates correspond well with Salls' two dates of 2930 and 3630 cal-BP, making them about 500 to 1000 years older than our estimates from CA-SMI-87 (2500 cal-BP). Interestingly, the age estimates reported by Raab *et al.* (1995) are similar to associated dates on single-piece shell fishhooks reported by Vellanoweth & Erlandson (1999: 262, 268), who argue that shell fishhooks on San Nicolas Island may have appeared at roughly 3000 cal-BP (2980 RYBP). If the dates for the San Clemente and San Nicolas Island fishhooks are correct, the current evidence suggests that they may have originated on the southern Channel Islands. Direct AMS dating of the Eel Point and San Nicolas Island specimens, however, is necessary to securely identify their antiquity.

Elsewhere along the North American Pacific Coast, single-piece fishhooks are relatively rare. Several single-piece rectilinear fishhooks have been recovered in San Francisco Bay, Sacramento, and Humboldt County, California (Strudwick, 1986: 272–273). Two specimens from the San Francisco Bay (CA-ALA-307) were dated by association to the Middle Holocene (*c.* 5000 to 4000 years ago; Wallace & Lathrap, 1975), but Strudwick (1986: 272–273) argued that these hooks are probably more closely linked with Northwest Coast cultural developments. Many traditional Northwest Coast fishhooks are composites of bone and wood and differ substantially from southern California hook types (Ames & Maschner, 1999: 117–119).

Interestingly, single-piece shell fishhooks in southern and central California are quite similar to shell fishhooks from coastal Chile. Single-piece fishhooks associated with the Camarones Complex are thought to appear in coastal Chile by 7500 RYBP, about 4000 to 5000 years earlier than in coastal California (Llagostera, 1992: 91–92). Since the two regions have unique cultural histories and the appearance of the fishhooks seem to be independent inventions in both areas (Strudwick, 1986), the similarities may reflect comparable use of raw materials, marine habitats, and fishing strategies in Chile and California. To our knowledge, however, none of the Camarones fishhooks have been directly dated. Our revised estimates for many of the California hooks suggest that the Camarones specimens should be AMS dated to confirm (or deny) their apparent Early Holocene age.

Conclusions

Our data add to a growing body of research on the utility of direct AMS dating of shell and bone artifacts as a means of refining artifact, site, and regional chronologies (Koerper *et al.*, 1988, 1995; Vellanoweth, 2001; Rick, 2001). The AMS dates presented here significantly refine the chronology of the single-piece shell fishhook, suggesting that these artifacts appear along the southern California Coast between about 3500 to 2500 cal-BP. This is some 2500 years later than many researchers argued previously.

While specimens on San Clemente and San Nicolas islands may be the oldest in the region (Raab *et al.*, 1995; Vellanoweth & Erlandson, 1999), the precise area

of origin for the single-piece fishhook remains unclear. It is possible that they originated on the Channel Islands (Strudwick, 1986: 278)—where terrestrial resources are impoverished and maritime resources dominated human subsistence economies for roughly 11,000 years—but further dating is necessary to test this assertion. It is also possible that single-piece fishhooks that date before 3500 to 2500 years ago have yet to be identified in the archaeological record, but as research continues to accumulate on Middle and Early Holocene sites, it seems increasingly unlikely that these earliest forms exist in any abundance. Nonetheless, the possibility of earlier hooks cannot be ruled out, especially since only about 14 fishhooks have been directly AMS dated in California and to our knowledge no shell fishhooks from mainland sites in San Luis Obispo and San Diego Counties have been directly dated. This is a significant problem in light of the severe stratigraphic mixing caused by bioturbation and other disturbance processes throughout the region.

As stated previously, the single-piece fishhook is often thought to represent a significant increase in fishing efficiency. It is strange, however, that these types of hooks appear relatively late in the archaeological record of California, at least 7000 years after people first began fishing in the area (Rick *et al.*, 2001). They also appear about 4000 years later than they are thought to have been used in coastal Chile, suggesting that there were other reasons for adopting the hook at a later date in California. Glassow (1996: 140) and Raab *et al.* (1995: 15–16) argue that single-piece hooks are closely linked with growing population densities and resource intensification. While these factors undoubtedly played a fundamental role in the appearance, dispersal, and proliferation of the single-piece fishhook, we also believe that the late appearance of the single-piece fishhook suggests that early fishing technologies (gorges and composite hooks) were also quite efficient (see Tartaglia, 1976: 105; Salls, 1988: 130; Rick *et al.*, 2001). This is the case at CA-SMI-87, where bone gorges outnumber single-piece fishhooks 4 to 1 and fish dominate the site constituents. At a Late Holocene site in Malibu (CA-LAN-264), moreover, bone gorges continued to be used in nearly equal proportions after the appearance of single-piece and composite fishhooks (Tartaglia, 1976: 117, 121). Salls (1989: 191–194) also argued that gorges were an effective technology capable of taking a wide range of species. To Salls (1988: 130, 1989: 194) the advantage of the single-piece and composite hooks is that unlike gorges they do not need to be swallowed by the fish and consequently can be extracted in a shorter amount of time. The widespread occurrence of the single-piece fishhook and their general temporal correlation with heightened fishing efforts clearly indicates that they are a refinement in fishing techniques and strategies. It should be emphasized, however, that these artifacts had their roots in a successful hook and line fishing tradition that spanned over 10,000 years.

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