

ARTICLES

CREDIT WHERE CREDIT IS DUE: THE HISTORY OF THE CHUMASH OCEANGOING PLANK CANOE

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Recent publications debate the origins of the Chumash plank canoe (tomol) of southern California. The timing of its appearance is of considerable scholarly interest because of its significant role in the evolution of sociopolitical complexity among the coastal Chumash, who were among the world's most complex hunter-gatherers. This paper closely considers: (a) what constitutes reliable empirical evidence for canoe making and maintenance; (b) the most current estimate for the date of origin of this sophisticated watercraft (and the empirical foundations for such an estimate); (c) a scenario for the development of the tomol as a complex technological system (CTS) and why credit is appropriately assigned to the coastal Chumash for its development; and (d) the impacts of this technological system on Chumash sociopolitical evolution.

Publicaciones recientes debaten los orígenes de la canoa de tablas (tomol) construídas por los Chumash del sur de California. El período de aparición de las canoas es de un interés considerable en los círculos académicos porque estas juegan un papel significativo en la evolución socio-política de los Chumash de la costa, los cuales se encuentran entre los más complejos de los grupos de cazadores y recolectores en el mundo. Este artículo considera: (a) que constituye evidencia empírica confiable en la construcción y mantención de la canoa; (b) la estimación más corriente en cuanto a la fecha de origen de esta sofisticada embarcación (y las fundaciones empíricas para tal estimación); (c) un escenario para el desarrollo del tomol como un complejo sistema tecnológico y porqué crédito por su desarrollo ha sido asignado al los Chumash de la costa; y (d) el impacto de este sistema tecnológico en la evolución socio-política de los Chumash.

As one of the most sophisticated technological innovations in precolonial North America, the Chumash plank canoe (*tomol*) has attracted considerable scholarly attention. The timing of its appearance is of notable theoretical and historical interest because it was a technology that played a central role in Chumash sociopolitical evolution. *Tomols* were the single most important, valuable property in the Chumash economy, and ownership was confined to chiefs and certain elites among these complex hunter-gatherers. It has never been questioned that the Chumash were using *tomols* when European explorers arrived during the mid-1500s, but when was this boat first invented? Recently, several divergent hypotheses about the timing and impetus for the development of plank canoes have appeared. On the one hand, the suggestion has been made that a prototype may have been locally invented more than 8,000 years ago in the Santa Barbara Channel region (Fagan 2004), and Cassidy et al. (2004) argue that a similar wooden canoe type appeared

very early on the nearby southern Channel Islands. On the other hand, it has been argued that the Chumash failed to develop the canoe themselves and mimicked the form of an Oceanic composite canoe after a boatload of Polynesian sailors purportedly reached California some 1,500 years ago (Jones and Klar 2005).

Several new data sets can be brought to bear on these hypotheses. Among the most important of these are notable chronological refinements from Polynesia and a significant date revision for the Chumash area. These changes serve to repudiate some of the more extreme suggestions about *tomol* origins and instead lend support to interpretations that the plank canoe originated locally at about A.D. 500 (Arnold 1995, 2001a; Arnold and Bernard 2005; see also Gamble 2002). In southern California, an elaborate Chumash swordfish dancer head-dress that to some scholars suggested a pre-2000 B.P. origin for the *tomol* (Davenport et al. 1993) now has been assigned a much later date of ca. A.D. 600, according to John R. Johnson of the Santa Bar-

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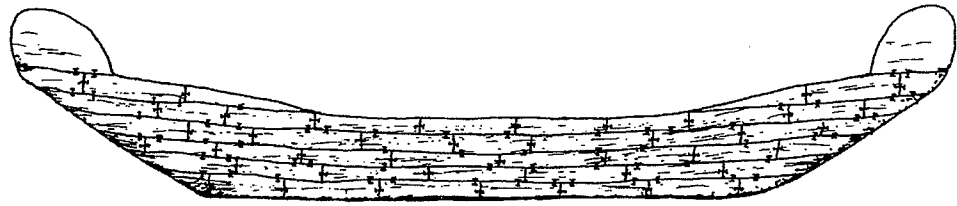


Figure 1. The Chumash plank canoe, or *tomol*. The average length of this watercraft was 6 to 7 m.

bara Museum of Natural History (Noah 2005:139). This recalibration shifts this important artifact into a span concordant with the vast majority of other dated swordfish remains after A.D. 600, thus reinforcing the position—based on several kinds of evidence—that the *tomol* first dates to about A.D. 500 (e.g., Arnold 2001a). And in Oceania, as will be discussed below, important new chronological evidence from throughout the Hawaiian Islands and other parts of the south-central and eastern Pacific shows that Polynesian populations colonized the eastern Pacific several centuries later than previously assumed, after A.D. 800–900 (Hunt and Lipo 2006), which clearly undermines the notion that Polynesians could be responsible for the invention of the California plank canoe.

Beyond these new dating sequences, we can draw on new and chronologically well-situated faunal data that highlight Chumash open-ocean animal procurement, essential for reconstructing the local trajectory of development of ancient watercraft. The emerging capability of California hunter-fishers to capture certain very large-bodied, aggressive, pelagic fish is revealed through a record of preserved faunal remains from a broad spectrum of sites across several millennia. Such data sets shed considerable light on the timing of the appearance of the large, substantial canoes needed for regular big-game pelagic fishing (Bernard 2004).

As well, newly published artifact assemblages from northern Channel Islands Chumash residential sites make much clearer for the first time what the data expectations ought to be for documenting plank canoe *manufacturing* (Arnold and Bernard 2005). These allow us to propose general standards of evidence for identifying places on the landscape where composite canoes were made or repaired. Useful also is recently compiled evidence from ancient canoe parts in Chumash burials (Gamble 2002). These many lines of evidence intersect, as

we will see, to support an interpretation of local invention and development of the *tomol* at or just after A.D. 500. Lastly, there is much to be gained by evaluating the plank canoe as a complex technological system, or CTS, as outlined by Michael Schiffer's (2005) invention cascade model, and doing so results in the assignment of credit to the Middle period coastal Chumash—not outsiders—for this important technological development.

Reliable Empirical Evidence for Plank Canoes

Expectations

From an engineering standpoint, Chumash plank canoes may have been the most sophisticated and laborious-to-build large watercraft of the New World. They required roughly 500 person-days of skilled labor to construct, and consequently were prized property. *Tomols* were high-capacity watercraft (6 to 7 m in length, holding a 2-ton cargo or up to 12 passengers) made from dozens of planks of planed redwood (Figure 1). They were sewn together with hundreds of fibers of twisted red milkweed (*tok* string) and amply caulked with heated asphaltum (*woqo*) blended with pine pitch (Hudson et al. 1978:53–54; Hudson and Blackburn 1987:155). Pigments such as red ocher may have been used in decorating the finished canoes, along with shell ornamentation. Several major sets of tools were used in their construction. We can reasonably expect, then, to find certain of these constituent materials and tools at sites where canoes were made and maintained.

Redwood (*Sequoia sempervirens*) is not a native southern California tree. Redwood logs appear occasionally as driftwood on the beaches of the Channel Islands and nearby mainland, carried by powerful currents from northern California. Red-

wood is sturdy and light, preserves well against rot (both in the ocean and in the ground), and was by all accounts strongly preferred for *tomol* making. Although other conifer wood was also (rarely) used in making *tomols*, no uncharred wood other than redwood tends to preserve in local coastal sites for more than 100 to 150 years. Thus, it is the only *tomol*-associated wood type likely to be found in pre-contact Chumash contexts (and specimens exceeding 1,000 years have indeed been recovered). So among expected evidence for ancient canoe construction activities are planed or cut pieces of redwood or unrefined "waste" pieces that may be byproducts of splitting redwood logs.

Milkweed fibers, although tough and also used to make strong fishing line and nets, are not good candidates for long-term preservation. Some milkweed fragments have been found under exceptional conditions at several Santa Cruz Island sites (Martin and Popper 2001:254), but these particular rare specimens cannot be linked definitively with canoe making.

Asphaltum, on the other hand, is a tacky, messy adhesive that preserves indefinitely and, where used, remains highly visible in the archaeological record. It ought to be a prominent constituent in site deposits where canoes were being made or maintained, since all gaps between planks and all drilled holes had to be caulked generously to keep a *tomol* safely afloat. We might imagine that most boat building and caulking tasks would have been done in locations away from houses and other daily activities, but we would expect that within main site areas we may find (1) evidence of spills from heating the adhesive at fires, (2) large "cakes" of pure asphaltum stored in containers in preparation for canoe-related tasks, (3) asphaltum-coated application tools, and (4) perhaps old "plugs" that dropped out of *tomol* planks under repair. It is possible one could find decorative elements such as red ochre and abalone (*Haliotis* sp.) or *Olivella biplicata* shell ornamentation associated with *tomol*-making activities, but in practice bits of ochre and tar-embedded beads would be difficult to distinguish from parallel decorative uses on other artifacts such as stone mortars or wooden bowls.

Tools used to make the canoe planks, or the holes in the planks, may also be expected in sites where *tomols* were made or maintained. Planing tools could include bone wedges and lithic or

clamshell adzes (Hudson and Blackburn 1987:52–53, 57–59). However, obvious splitting and planing tools are virtually nonexistent in recently sampled coastal Chumash sites (Arnold and Graesch 2001; Arnold et al. 2001; Arnold and Rachal 2002). We must continue to search for these or alternative woodworking tools. Large drilling tools, or macrodrills (Arnold 1987; Arnold et al. 2001), are fairly common at coastal sites, but microwear analyses show that many of these were used to drill holes in shell rather than wood, and it is not possible to single out any type based on form alone that exclusively indicates canoe plank drilling (Arnold et al. 2001). Few or none seem to have been specialized tools for plank drilling, and most exhibit shell residues and polishes indicating their use in making shell fishhooks (Arnold and Graesch 2001:108–109). We also often find mixed wood and shell polishes on large drills (Arnold et al. 2001:126–130). Thus there is no macrodrill type that unambiguously signals *tomol*-making (Arnold and Bernard 2005).

Recovered Archaeological Evidence for Plank Canoes

We must assiduously avoid simplistic readings of archaeologically recovered redwood and asphaltum evidence because both of these materials were employed by the Chumash for other tasks. Redwood was used—in a few rare cases—to construct Island Chumash house frames, including an elite house on Santa Cruz Island (Arnold 2001a:50–51; see also Rick 2004). Fortunately, the slender redwood limbs used for this purpose (pole-sized limbs typically 3 to 4 cm in diameter) do not resemble planed redwood. Other redwood finds are very rare (boxes, ladles, knife handles, bullroarers, ritual poles) and are easily distinguishable from plank canoe parts (Arnold 1993). These are generally discovered only in cemetery settings (Hudson and Blackburn 1986:78, 96, 319; 1987:80).

Most asphaltum used in the region was mined within Barbareño Chumash (mainland) territory from extensive, solidified coastal bluff exposures at several source areas to the east and west of Santa Barbara. Nonsolidified but fairly high-grade asphaltum may also have been available, albeit unpredictably, on Channel Islands beaches. Torben Rick (personal communication, 2006) and Braje et al. (2005) note that today, offshore tar seeps near San

Miguel Island occasionally generate good-sized masses of asphaltum that come ashore intact. In their estimation, these beached masses are of a quality to be usable as adhesives, but we cannot be certain that such sources produced reliable, predictable, or sufficiently pure supplies of asphaltum in the past. These merit further investigation for their potential to have been useful to islanders. Nonetheless, I suggest that the mainland coastal bluff "outcrops" clearly stand out by contrast as superior sources due to their predictable, fixed location, their massive size (extending hundreds of feet), and their material purity. These sources clearly were exposed (and mined) during later prehistory, and Hudson et al. (1978) substantiate the premium placed on material from this source area. According to ethnographer John P. Harrington's Chumash informants, only this "hard tar" source was good enough to be used for canoe caulking, and islanders who wanted it for canoe making needed to obtain it from the Santa Barbara mainland (Hudson et al. 1978:51–52).

Since the best of this material apparently had to be traded across the channel to the islanders, local efficiency would dictate that high-grade asphaltum be reserved for purposes primarily associated with artifacts that could be manufactured easily on the islands. Many of the region's baskets and basketry water bottles were apparently made (and waterproofed with adhesives) most efficiently on the *mainland*—since the plant materials for these containers were far more common on the mainland, *and* the asphaltum was a mainland resource—but of course some asphaltum was used on the islands to make or repair basketry water bottles and repair breaks in stone vessels as needed (Arnold 1998; Braje et al. 2005; Rick 2004).

This adhesive was also used by the Chumash to coat their small tule (*Scirpus* sp.) balsa watercraft and make them more resistant to waterlogging (Hudson et al. 1978). The reeds used to make these bundled balsas were found predominantly at extensive mainland estuaries such as the Goleta Slough and the Carpinteria marsh (just west and east of Santa Barbara, respectively), and I have as a result suggested that most of these small watercraft were likely made on the mainland rather than on the islands (Arnold 1995, 2001a:14). It has been rightly pointed out by Glassow (2004:21) and others that *Scirpus* is experiencing a modest rebound at the

mouths of ecologically recovering stream systems on the Channel Islands in recent years, and these reeds were undoubtedly also present at a few of the largest wetlands areas on the northern Channel Islands during prehistory. Indeed, I have noted their resurgence myself during the last 20 years at two of the largest Santa Cruz Island marshy areas. But all of the Channel Islands wetlands were, at their physiographically largest possible extent, orders of magnitude smaller than the big estuaries on the mainland and thus could not have supported equally abundant stands of tules. My point is simply that tule balsa boats were almost certainly *primarily* (but not exclusively) a mainland product rather than an island product due to the much greater availability of *Scirpus* and asphaltum outcrops. Construction and waterproofing could have been accomplished far more readily there, but tule boats may have been made or repaired on a small scale on the islands.

On the other hand, drift redwood was disproportionately abundant on the southern and western shores of the larger northern islands (Santa Rosa and Santa Cruz islands), more so than on the mainland. Islanders would have had strong incentives to bring chunks of "hard tar" to the islands and keep caches of it there for making *tomols*. But of course plank canoes were so important that they would have been made wherever possible: both on the mainland, where asphaltum was abundant but wood a bit harder to come by (e.g., at Carpinteria), and on the islands, where all *woqo* had to be brought in but redwood logs were a bit more plentiful.

Let us turn now to some specific evidence. Asphaltum has a long history in the region but came into more frequent use during the Middle (600 B.C.–A.D. 1150), Transitional (A.D. 1150–1300), and Late (A.D. 1300–1782) periods along the Santa Barbara Channel, including at sites SCRI-191, SCRI-240, and other large island villages (Arnold 1998, 2001b). Arnold and Bernard (2005:118–119) recently presented a sample of redwood and asphaltum data that indicates a probable canoe-making/canoe-maintaining activity area at the coastal village site of *Shawa* (SCRI-192) on Santa Cruz Island. The roster of evidence from just one of the 1-x-1-m units I excavated at the village features 280 pieces of rough, unhewn redwood (including smaller fragments and 16 larger pieces) from domestic site areas, the most recorded for a Chumash site (Arnold and

Table 1. Redwood and Asphaltum Artifacts at *Shawa* (SCRI-192), 80-105cm Stratum, 2N 23E.

Material	Artifact Type	Count
Redwood	Small fragments	205
	Large (in situ) specimens	11
Asphaltum	Large asphaltum cakes	3
	Abalone containers with asphaltum	2
	Sandstone slabs with asphaltum	6
	Tamper with asphaltum	1
	Plugs	91
	Small amorphous pieces	1,165

Bernard 2005). Most of the more substantial specimens appear to come from larger wedges of redwood, not small (rounded) limbs.

Large quantities of asphaltum were also found at *Shawa*, much of it in direct association with the bulk of the redwood assemblage (including 11 of the 16 large pieces) in one specific 25-cm-thick stratum of this unit (see Table 1). For the reasons noted above, these asphaltum artifacts may be reasonably suggested to be linked primarily with activities such as canoe making and repair rather than water bottle making or tule balsa making. Within this single stratum were recovered several large cakes and containers of stored asphaltum, six pecked sandstone slabs covered with asphaltum, one stone tamping tool (possibly used to press hardening asphaltum into drilled plank holes), and more than 1,200 small pieces and asphaltum plugs that may have fallen from canoe lashing holes or abalone storage dishes. This stratum (80-105 cm depth) dates to A.D. 1300-1400, based on absolute and relative dating (Arnold and Bernard 2005:118-120). While it is therefore too recent to tell us about the period of origins of the *tomol*, I suggest that this assemblage of redwood and asphaltum provides a good, reasonable standard of evidence for documenting *tomol* making and maintenance at Chumash sites more generally. In short, this is the kind of evidence we should expect and search for at *tomol*-making sites.

Indirect Archaeological Evidence

Indirect lines of evidence for the appearance and more widespread use of the *tomol* include an increasing cross-channel movement of bulky, weighty objects such as large mortars and soapstone vessels and rising quantities of other distinctive and prized trade objects such as high-caliber toolstone

and finished fine bifaces from distant sources. As noted earlier, the other line of indirect evidence that plays a major role is the first regular appearance of large animal species whose acquisition required a sturdy watercraft like the *tomol*, namely large-bodied, aggressive fish such as swordfish and certain species of tuna. These data sets are discussed in depth below as I outline what we now know about the timing of the development of the *tomol*.

The Current Chronological Estimate for the Invention of the *Tomol*

We have increasingly good empirical foundations for estimating a date of origin for the *tomol*. Gamble (2002:308), for example, reports a calibrated date of A.D. 625-700 (2-sigma range) for a canoe plank recovered at a San Miguel Island site (SMI-261). Direct evidence from radiocarbon dating of planks (rare specimens typically found only in burials) would appear to be a promising way to attack the problem, although this approach can be complicated by the "old wood" issue: mature redwood logs that could have stayed in the ocean for lengthy periods before being used for canoe making. Dates from planks must thus be interpreted with caution (Gamble 2002). Direct or relative dating of diagnostic artifacts in contexts that also contain planks is an approach with fewer pitfalls, and several preserved planks have been assigned to the region's later periods this way (see King 1990:86). Unique artifacts such as a wooden model canoe found on Santa Rosa Island dating to early in the second millennium A.D. also assist in our chronological placement of the *tomol* (Rick et al. 2004). As a group, however, these rare (and mostly funerary) objects largely frustrate our efforts to solidly document the earliest appearance of the *tomol*.

A strong case for systematically dating the origins of the *tomol* can be made using a large database of fish remains from the Santa Barbara Channel region. After careful analysis of the sizes and behavioral characteristics of a range of pelagic fish, Bernard (2004) has argued that seven species of large, aggressive, open-ocean fish—swordfish, striped marlin, albacore, yellowfin tuna, bluefin tuna, blue shark, and shortfin mako—could not be acquired by fishing from the presumed smaller boats antecedent to the *tomol* (see also Arnold 1995,

2001a). We do not know exactly what these antecedents were, but bundled tule reed balsas or some other similar boat types were probably devised very early in local prehistory and were used largely in the nearshore environs for thousands of years. Even the most robust of these types of tule watercraft—which continued to be used historically and were observed by the Spanish—were capable only of taking small numbers of people and limited goods across the channel and between islands. Boats of this general type may well account for the earliest occupation of the islands, which occurred more than 12,000 years ago, and much of the sea travel during the subsequent Early and Middle Holocene (Johnson et al. 2000; see also Erlandson's [2002] discussion of early seafaring and colonization along the Pacific Coast and Des Lauriers's [2005] comparative analysis of early coastal watercraft in the region).

Glassow (2004:20–21) has suggested that perhaps early forms of these tule reed balsas were enlarged or elaborated ca. 6300 B.P. and could account for accelerated dolphin capture on the northern Channel Islands around that time, but he does not suggest that plank canoes appeared during that era or that they were needed for dolphin capture (see also Porcasi and Fujita 2000:558). Indeed, the Porcasi and Fujita study shows that certain unique dolphin capture methods may not require much boat support and may succeed where physiographic features such as deep submarine canyons are situated close to shore, as is true at both Glassow's Punta Arena site (SCRI-109) and at points around some important southern Channel Islands sites such as Eel Point (SCLI-43).

Tule boats continued to be used regularly for nearshore light fishing and local coastal forays (and occasional cross-channel trips) into the Historic period. Balsas were composed of lashed bundles of hollow reeds and were about 2.5 m in length, sufficient to carry two or three people and a small cargo. They waterlogged easily and were unreinforced. Fishers would not only take their lives in their hands trying to subdue a thrashing swordfish from a tule balsa, but they likely could not bring the fish aboard without completely overloading it. It was, simply, a small, low-capacity watercraft.

As Bernard (2004) shows, we can begin to estimate the time during which the larger, sturdier, high-capacity *tomol* came into use—whatever form

its lower-capacity antecedent may have taken—by tracking the earliest regular appearance of these large-bodied pelagic fish in sites. This approach has the distinct advantage of drawing on a substantial inventory of sites from mainland and island settings with large collections of faunal remains within which the bones of very large species like billfishes and large tunas are readily identified. Data from many independent locations can thus be used to develop a regional-level pattern of capture of the new fish species and, by extension, adoption of the new boating technology.

The results of this study (see Arnold and Bernard 2005; Bernard 2004), based on faunal data from more than 70 substantial Chumash collections with components dating from ca. 8000 B.P. to A.D. 1800, point to A.D. 500–600 as a key phase during which small but steady numbers of these species began to appear at coastal villages. Importantly, extensive examination of faunal reports and collections dating to the *earlier* periods failed to yield more than an isolated specimen or two, even from high-volume excavation projects (Bernard 2004:34). The data from the Middle period assemblages that span various segments of the first millennium A.D. reveal the gradual emergence of this new set of species during the mid-Middle period. For example, the data demonstrate that albacore, yellowfin, and bluefin tuna began to be acquired in the A.D. 500–700 interval, and swordfish began to appear after A.D. 700 or so, although it was not until the A.D. 1300–1400s that swordfish became much more common. Taken as a whole, there are several marked increases in frequencies of these prized pelagic species after A.D. 500–700, using measurements of their NISP per cubic meter at various of the more rigorously excavated sites throughout the region (see Bernard 2004:34–37, 44).

Thus, we can infer that the appearance of a new boating technology permitted the earliest pelagic fishing successes and then allowed increasing acquisition of these large-bodied, aggressive species as gradually increasing numbers of people in various coastal communities developed the capacity to construct the costly boats. The region's abundant and well-preserved marine faunal assemblages permit a high level of confidence in these data, although it would be ideal to be able to draw on even larger samples from the heart of the Middle period. Significantly, the most pronounced

increases at A.D. 1200–1400 correspond with the emergence of chiefly organization in the region (Arnold 2001a). *Tomol* ownership almost certainly contributed centrally to accelerated social differentiation and to effective costly signaling through owners' procurement and sharing of large-bodied marine fishes (Arnold 1995, 2001c; Arnold and Bernard 2005; Noah 2005).

Shifts through time in the patterns of movement of nonperishable goods from circumscribed source areas, such as distinctive lithic materials, can also be informative. Although Santa Cruz Island has its own massive chert quarries (Arnold 1987), analyses show that mainland chert types such as red and green Franciscan cherts and laminar Vandenberg cherts began to appear in greater numbers in mid-to-late Middle period sites on the Channel Islands (Arnold et al. 2001; Pletka 2001), suggesting that the movement of nonessential trade goods accelerated after about A.D. 600–700. This outcome can potentially be explained in several ways, the simplest of which is an increase in the cargo capacity of watercraft engaged in cross-channel voyages. Prior to the appearance of the *tomol*, the presumably arduous and dangerous channel crossings in tule balsas would have carried as many people and essential foods and tools as their small size permitted, but, one would imagine, few nonessentials. The luxury of routinely shipping cores and projectile points of noncrucial exotic materials to the islands likely only emerged once the 6- to 7-m long, 2-ton capacity *tomol* was available. Many other goods and foods also began to be moved across the channel in increasing numbers during the later Middle and Transitional periods (see Arnold 1992, 2001a).

To summarize, data from dozens of Chumash sites converge on about A.D. 500 (plus/minus a century, to be conservative) for the invention of the *tomol*. It is hard to imagine the capture of large-bodied and aggressive pelagic fishes without such a watercraft, and the regular cross-channel movement of "luxury" tools and goods from distant sources in increasing quantities seems unlikely without it. Although Cassidy et al. (2004) and Fagan (2004) have made a case for the local use of composite wooden canoes 8,000 or more years ago (the former for the southern Channel Islands, the latter a hypothetical *tomol* prototype for the northern islands), there is currently no evidence for this kind

of watercraft in Chumash territory during the Early or Middle Holocene. Neither the pelagic faunal assemblages, nor the exchange data, nor the artifact assemblages for the coastal Chumash region (including redwood, asphaltum, and canoe-making tools) currently yield any indications of the presence of the *tomol* before A.D. 500. As noted above, the famed swordfish dancer headdress from the Santa Barbara area mainland is now also dated to after A.D. 500.

No Polynesian Influence: Interpreting Chronology, Artifacts, and Language

Closely linked to this discussion of the chronological anchoring of the canoe, it is important to devote a few paragraphs to Jones and Klar's (2005) recent contention that ancient Polynesians traveling from Hawaii were responsible for the origins of the Chumash *tomol* ("*tomolo*" in their article). Their supporting evidence consists of linguistic data focused on the similarities between the word *tomolo* and words of Polynesian origin and some similarities in shape between a compound bone fishhook type found in Hawaii and one found in the Chumash region. The argument contends that the arrival of these foreigners occurred, obviously, before the *tomol* came into existence.

However, compelling new archaeological evidence from eastern Polynesia now indicates that the Hawaiian Islands were not colonized earlier than A.D. 800 and quite likely as late as A.D. 900 (Terry Hunt, personal communication 2006) or A.D. 1000 (Patrick Kirch, personal communication 2007; see also Burney and Burney 2003; Hunt and Lipo 2006). Moreover, the colonization of Easter Island is now identified as occurring at ca. A.D. 1200; thus, both occupations started many centuries later than previously asserted (Hunt and Lipo 2006). Even the Cooks, Societies, and Marquesas island groups—from whence Hawaiians likely first came—may not have been populated until after A.D. 800 (Hunt and Lipo 2006:1603).

In arriving at these conclusions, Hawaiian archaeologists have closely reconsidered the oldest deposits and sequences throughout the islands. Radiocarbon dates and assemblages (including pollen, rat bones, and macrobotanical specimens) associated with these deposits have been thoroughly scrutinized by a large number of scholars (see, for instance, Athens et al. 2002; Burney and

Burney 2003; Tuggle and Spriggs 2000). Many regional experts now view dates before A.D. 900 in Hawaii as barely tenable or untenable. The parallels for Easter Island are striking. The same kinds of rigorous reanalyses of radiocarbon dates, stratigraphic sequences, and assemblages have engendered a similar conclusion in an independent data set (Hunt and Lipo 2006).

This revolutionary reevaluation of the dates and pollen cores in eastern Polynesia has important consequences for our Chumash case. If people did not reach the Hawaiian Islands from the middle and southwestern Pacific until the tenth century A.D., this was some 300 to 400 years *after* the plank canoe was in use in southern California. Obviously such a late arrival would eliminate the possibility that the Chumash plank canoe had a Polynesian origin. Polynesian voyagers had evidently come nowhere near Hawaii—or California—by A.D. 500.

Other conundrums associated with a Polynesian hypothesis emerge as well. I briefly note a few of these. It is odd that just one word (*tomolo*) was borrowed if Hawaiians arrived and stayed among the Chumash, as Jones and Klar suggest. Would we not expect other borrowed words associated with Hawaiian boat parts, leaders, clothing, status markers, or weapons, all of which would have been salient for the Chumash? Also puzzling is an absence of Chumash oral narratives about foreigners teaching ancestors how to make boats (as are found frequently on the Northwest Coast, for example) or visitors who appeared in large, impressive boats. Recorded Chumash narratives about *tomol* making clearly focus on elders and other local agents of invention and teaching (Blackburn 1975). The absence of genetic evidence for Polynesians also begs for explanation.

Applying Occam's razor, it is more simple and reasonable to attribute the appearance of new subsistence technology, such as two-piece bone fishhooks in the Chumash Middle period, to new marine animal targets (as recorded in dozens of local faunal analyses) rather than to Polynesians (see Jones and Klar 2005). Moreover, one can observe more morphological differences than similarities in the two compound bone fishhook designs. The conjoining ends of the two sets of tools are different; Chumash bone barbs do not possess terminations like the Hawaiian example depicted by Jones and Klar (2005:468). Also, the

arcs of the barbs are dissimilar, as are the sizes of the elements within the pairs (Chumash: one is long, the other short; Hawaiian: nearly same size). Moreover, the *tomol* and the composite curved bone fishhook did not appear contemporaneously. This is a good case for independent invention and a poor one for diffusion. There is an obvious local precedent in compound bone hooks used by the Chumash in the preceding centuries (King 1990).

The Polynesian and Chumash canoe-making tools and facilities are portrayed as remarkably similar (Jones and Klar 2005:465), although examination of the data shows they were not. Polynesians typically used bone drills, wooden caulking tools, plant sandpapers, and shell adzes, and they often constructed their canoes inside enormous and impressive covered canoe sheds (see Haddon and Hornell 1975:328). Considerable local evidence shows that the Chumash used stone macrodrills, a variety of caulking tools, sharkskin sandpapers, and lithic and clamshell adzes. And, according to Hudson et al. (1978:44), *tomol* makers propped simply woven tule mats against a little 3-pole frame when they needed to screen the drying asphaltum on a *tomol* from the hot sun. Canoe-making sheds did not exist—indeed no structure of any kind on this scale existed in the Chumash region. The modest 3-pole frame bore no resemblance to the Polynesian canoe shed.

There are striking formal differences between the *tomol* and the Polynesian voyaging/sailing craft that was suggested by Jones and Klar (2005:their Figure 2, bottom) to be a model for the *tomol*. This model was the Gilbert Islands sailing vessel, or *baurua*, as shown by Haddon and Hornell (1975:351) in *Canoes of Oceania*. It resembles the *tomol only* in that it is composite. Figure 2 illustrates the two vessels to scale and as they looked in operation. They differed radically in size (6–7 m vs. 17–23 m), capacity, materials, and construction (number of planks, sewn areas, and keel), and, most importantly, the Polynesian vessel was stabilized by an outrigger and had a prominent mast and sail (Haddon and Hornell 1975:346, 351). In the truncated rendering of the Gilbert Islands sailing vessel provided by Jones and Klar (2005:462), the outrigger, mast, and sail were all omitted. What few similarities there are rank as insignificant compared to these structural distinctions.

Lastly, the linguistic evidence—that the word

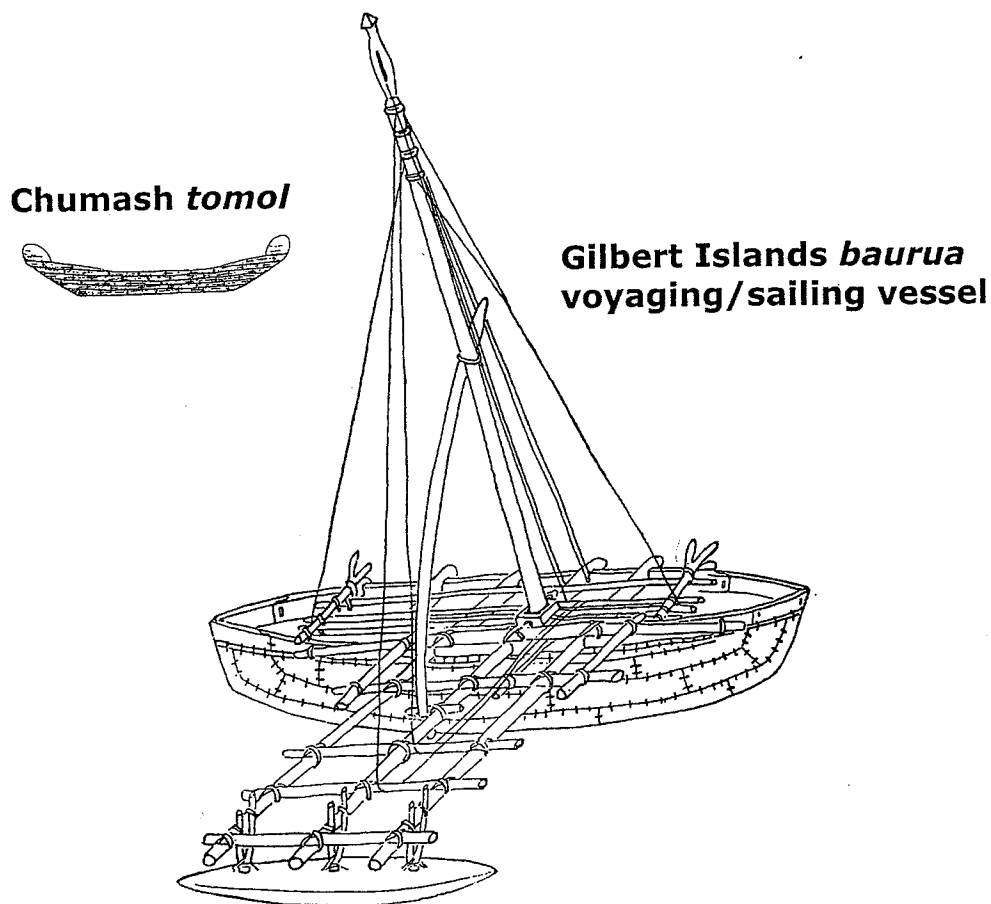


Figure 2. The Gilbert Islands sailing/voyaging vessel (*baurua*) is pictured to scale with the Chumash plank canoe (*tomol*). The average length of the *baurua* was at least 18.5 m (about 60 feet), and length ranged from 17–23 m (up to 75 feet). This one is pictured conservatively at 16 m and is shown relative to a *tomol* measuring 7 m. Source for the *baurua* image: Haddon and Hornell (1975:351), with permission from the Bishop Museum Press, Honolulu.

tomolo could have derived from Polynesian roots—is difficult to categorically accept or reject, and I leave that to linguists. If acceptable, still no grounds have yet been provided, as I understand it, to contend that it was *borrowed at a specific time*. A brief episode of contact responsible for the borrowed term could have occurred any time before observers began to record the Chumash languages—theoretically as late as the 1700s. In the absence of historical linguistic evidence providing time depth, this word's presence among postcontact Chumash speakers does not have specific chronological significance and tells us nothing of note about the origins of the *tomol*.

Development of the *Tomol* as a Complex Technological System

Much attention has been showered on the invention of the *tomol*, and deservedly so, as an important artifact of transportation in western North America. It is instructive, therefore, to explore the details and dimensions of invention processes more broadly, and Michael Schiffer (2005) provides a useful framework for thinking about the origins of complex technological designs in his recent “invention cascade” model. His analysis encourages a careful, stepwise tracing of the many complex elements associated with bringing a sophisticated

invention to realization, which of course is a productive way to conceptualize its historical-archaeological roots. The Chumash plank canoe is an ideal candidate for close consideration as a complex technological system (CTS), and the process allows us to pinpoint who deserves credit for the development of this sophisticated watercraft and the scope of what those innovators accomplished.

Schiffer's (2005:486–489) approach focuses on critical "performance characteristics" to highlight how an invention must perform to accomplish the tasks it is designed to fulfill. For the *tomol*, the critical performance characteristics included *seaworthiness* (hull strength and resistance to taking on water) during 40 to 50 km cross-channel and inter-island voyages that were often rough and dangerous; *passenger capacity* and/or *cargo capacity* adequate to surpass existing watercraft (eventually, up to a 12-person or 2-ton capacity); *maneuverability*; *operational stability*; *energetically efficient (speedy) operation* in the water; *sturdiness and size* for capturing and boarding aggressive, large-bodied fish; appropriate *hull configuration* for negotiating local beaches; and efficient *supporting technologies* (e.g., paddles and bailing tools). These performance requirements are stringent, and the *tomol* was a complex, demanding craft to make. At some stage, presumably later rather than earlier, it also had to meet perceptual/ideological performance criteria such as the ability to symbolize *high status*. The utility of focusing on specific performance characteristics is underscored by noting that, for example, the composite Cedros Island watercraft of Baja California (Des Lauriers 2005), which were also seaworthy and capable of cross-channel voyages, and were also made of materials like drift redwood, nonetheless varied notably in form and in performance requirements relating to carrying capacity, stability, speed, and large-fish acquisition.

Historically, the Chumash plank canoe was large, consisted of many parts, entailed complex planning and precise engineering, required rare and costly materials, and depended on the arrival of materials (such as redwood) from great distances. By the contact era, the *tomol* was made by members of a formal and exclusive craft guild who were highly specialized and had proprietary knowledge and rights. Boat makers in this guild, the Brotherhood of the *Tomòl*, had to know where and how to

gather the most appropriate materials (driftwood logs, fibers for sewing, adhesives), prepare them to exacting specifications (e.g., planing, cutting, and drilling planks; mixing asphaltum adhesives and pine pitch), and put them together with precision. In the early stages of this invention, these steps were only beginning to be envisioned. The *tomol* would have gone through repeated bouts of experimentation. The width (beam) likely increased in size through time, but the overall hull needed to retain a "V" shape. The height of the freeboards (sides) had to be balanced against other variables. Length had to be experimented with to judge strength, stability, maneuverability, and the like. Flaring gunwales were eventually adopted to help with stability (Hudson 1981) at some unknown juncture in the process.

People had to take what were almost certainly smaller prototypes out on the water to test them, surviving long enough to convince others (and themselves) that such a craft could be practicable. Using, I believe, *both* the versatile tule balsa and the wooden dugout canoe (used only in local nearshore/estuary settings) as models (Heizer 1938; Hudson 1981:279), early innovators would have made a whole succession of improvements in size, strength, and stability. Details such as plank size, numbers of drilled and sewn holes, and caulking mixes would have been refined. More tests on the water followed. This succession of purely technological refinements might have taken a few decades, possibly even a few generations. Boat makers also had to develop good paddles and perfect the tools used to fashion planks, to drill holes, to bind fibers, to shape bent wood, and more.

As Schiffer (2005:487) points out, most inventions are unsuccessful because many flaws emerge in the performance characteristics. It is impressive that the Chumash reached a point where the early-stage plank canoe became operational and viable. But once the basic design elements were in place, core group(s) of inventors still had to find apprentices, pass along critical construction and maintenance knowledge, and train operators. In order for the design to spread, those in a few coastal villages who first learned how to make the *tomol* needed to selectively share their knowledge with people in communities across thousands of square kilometers on the mainland coast and on the three large northern Channel Islands regarding how to select

appropriate materials and how to put the craft together. This process was likely reflexive, with many design improvements moving back and forth among innovators. Eventually enough *tomols* were in circulation that we can start to see—in the archaeological record—evidence for tuna fishing and swordfish harvesting and abundances of exotic stone tool materials showing up in increasing numbers at great distances from their points of origin.

Innovators had to get others to adopt the *tomol* widely, to gain confidence in its safety through demonstrations, and to see its value. Such efforts came with no guarantee given the tremendous expenses involved. Because of its many complex parts and the high costs in material and human resources involved, the *tomol* had great “developmental distance” (Schiffer 2005:497–498), referring to lengthy phases of experimentation necessary when people develop momentous technological systems, such as a new architectural mode or large-scale canal systems. I have suggested, and continue to argue, that several centuries could have passed before the *tomol* reached its final size and capacity and a form closely resembling its historically documented design (Arnold 2001a; Arnold and Bernard 2005). The main point to take from this discussion is that the heavy lifting of this developmental process was done by many coastal Chumash leaders and skilled craftspersons, over generations and probably centuries, and likely across multiple communities and subregions of Chumash territory.

We might also briefly consider how the adoption process would have unfolded if the Chumash had been visited by (hypothetical) Polynesians in their massive voyaging vessel. With or without overt assistance from visitors, they would have had to figure out how to replicate a composite canoe locally. This would have included radically adapting the craft in size and form, dropping the mast and sail, eliminating the outrigger, and identifying appropriate local materials (of wood and fiber) to use. All of the “critical performance characteristics” would still have had to be reached (Schiffer 2005:489), but with a whole new set of boatmakers; resources, engineering aptitudes, and skill levels. As many tracing the histories of technological innovations have pointed out, the idea may be among the least remarkable parts of an invention. Ideas may be obvious to many knowledgeable

members of society, or to people in a range of societies. The complexity of the construction of North and South American composite vessel types (e.g., the *tomol* and the Chilean *dalca*) and various Polynesian sailing vessels (see Haddon and Hornell 1975) in no way precludes their having independent invention status (Schiffer 2005:497). The conceptualization of the composite plank canoe was, it now seems clear, achieved in many places and times, just as the notion of a flying craft was envisioned in disparate places many centuries before the plan was first executed. But the hard work of bringing the invention to fruition is in the details, the trials and experiments with new materials, the long cascade of inventions, and the underwriting of labor and resources. In cases where diffusion prompts a mimicked invention, the locals must proceed through all of these technological steps. They still had to secure rare and costly materials requiring substantial cultural capital in the form of resources, skills, labor/time, and underwriting. The innovation’s eventual spread would have the same effects as a local invention on sociopolitical evolution by reinforcing the gaps between emerging elites and non-elites and would allow the same efficiencies to develop (Arnold 1995). Although we can reject the idea that Hawaiians shipwrecked among the Chumash before A.D. 500, I argue that, had it happened, a brief pulse from hypothetical Polynesians would have at most affected a couple of generations in a centuries-long technological and sociopolitical developmental trajectory.

Impacts of the *Tomol* on Chumash Sociopolitical Evolution

The profound impacts of the plank canoe on Chumash culture and evolution have long been recognized and are well documented (Arnold 1992, 1995, 2001a; Arnold and Bernard 2005; Hudson et al. 1978; King 1982; and others). In short, its development during the mid-first millennium A.D. helped to precipitate a wider range of pelagic fishing (including the acquisition of showy, large-bodied fish useful in status competition), expanded trading systems, localized and massive craft specializations (including shell-bead money making), and more reliable cross-channel and interisland transportation of Chumash people that enabled more intensive social networking. The *tomol* was

tremendously expensive to construct, involving more than 500 person-days of highly skilled labor, encompassing the many steps and costly materials enumerated above. It was as a consequence only owned by very high-status people such as chiefs and community elites in this complex hunter-gatherer-fisher society. It was integral in creating and maintaining status differentiation. As Ames (2002) has noted, these same kinds of ramifications of sophisticated, high-capacity watercraft can be observed in other cultural contexts.

We must not lose sight of the fact that the Chumash created rich cultural traditions in lockstep with the development of the plank canoe, and their own leaders, specialists, fishers, and many others in society were the principal participants in the development of the simple chiefdoms that were documented in the Santa Barbara Channel region when Europeans arrived during the mid-1500s. Whether a name for the plank boat came into the language from Polynesia somewhere along the way—well after the *tomol* was locally invented, perhaps—is of little relevance in looking at the complex internal technological and sociopolitical evolutionary sequences of the last few thousand years among the Chumash. The Chumash people did the laborious work in developing this boating technology, and the society and its political economy co-evolved with that technology for more than 1,000 years across the Middle, Transitional, and Late periods. Chumash leaders needed to supply the economic and social capital for the *tomol* to come into routine use, and they had to secure the material means to maintain it.

The Chumash certainly possessed sufficient knowledge of materials in their environment (such as drift redwood and asphaltum) and knowledge of the seas to have conceptualized this complex technological system on their own. We do not need to look, as so many commentators have in the past, to an agricultural society to come along and solve the technical problems of hunter-gatherers. Credit is due fully to the Chumash for having the capability and knowledge to invent the plank canoe.

Conclusion

Local independent invention during the middle of the first millennium A.D. is a fully satisfactory and empirically well-supported account for the appear-

ance of the Chumash *tomol*. At present, there is no evidence to substantiate the idea that the *tomol* has much greater time depth in the region or that the invention was borrowed from visitors. Given the lengthy local developmental trajectory of the *tomol* over several generations and even centuries, we can point directly to the central roles of Chumash leaders and innovators for providing the social and economic capital for this significant watercraft. It was of paramount importance in ultimately helping to facilitate the region's expanding exchange systems, intensive craft specializations, and chiefdom-level political complexity.

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