

Detecting Apprentices and Innovators in the Archaeological Record: The Shell Bead-Making Industry of the Channel Islands

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Abstract Archaeologists have demonstrated that it is challenging but feasible to identify the material remains of apprenticing activities associated with stone tool and ceramic assemblages. Building on this work, I explore apprenticing behavior in North America's most intensive ancient shellworking context, using the large bead-making assemblages from California's Channel Islands. I examine a spectrum of production errors associated with a newly identified variant of Olivella shell bead and offer generalizations about what we should find in the material record of apprentices engaged in manufacturing ornamental goods. I also explore how we may distinguish novices' errors from the mistakes of skilled experts experimenting with new bead forms. Existing ethnoarchaeological studies of children's roles and contemporary craft practitioners specializing in ceramics, bead making, stone work, and other materials are foundational sources of data for this project, providing insights into the transmission of technical information from experts to novices in communities of practice. Such work directly informs archaeological research and facilitates our understanding of apprenticing from periods and regions where ethnographic information is insufficient or inapplicable.

Keywords Apprenticing · Specialized craft production · Communities of practice · Bead-making assemblages · Learning · Skills

By the time they achieved competence, every flintknapper who ever lived had probably already littered the landscape with thousands of virtually indestructible stone artifacts (Shea 2006:212).

Growing interest in recovering the material remains of apprenticing activities has led archaeologists to systematically observe both the teaching environments associated with contemporary craft practitioners and the material products—

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including errors—made by tool replicators. Such studies generate increasingly robust understandings of the contexts of transmission of technical information from experts to novices. We have consequently gained important insights regarding attributes of novice-generated stone tools, pots, and other objects. In this paper, I focus on detecting apprenticing behavior in an underexplored specialized craft, shellworking, using collections from the intensive shell bead-making industry of California's northern Channel Islands (Fig. 1). The Island Chumash of the second millennium AD were among the most prolific and skilled bead and ornament makers in the world. At least eight centuries of sustained production by specialized practitioners in more than a dozen villages have generated huge assemblages of bead-making detritus and a rich assortment of beads at the Channel Islands sites (Arnold and Graesch 2001; Arnold and Munns 1994; Kennett 2005).

Bead Making in the Channel Islands of California

Scholars working with these assemblages have an embarrassment of riches: access to hundreds of thousands of shell-bead specimens recovered from undisturbed and well-dated stratigraphic contexts (see Arnold 2001a; Kennett 2005; King 1990; Rick 2007), both finished and unfinished, in a rich array of types. At least eight variants of beads were made from the *Olivella biplicata* (purple olive) shell (Fig. 2); four from the *Tivela stultorum* (Pismo clam), including an exceptionally prized tube bead

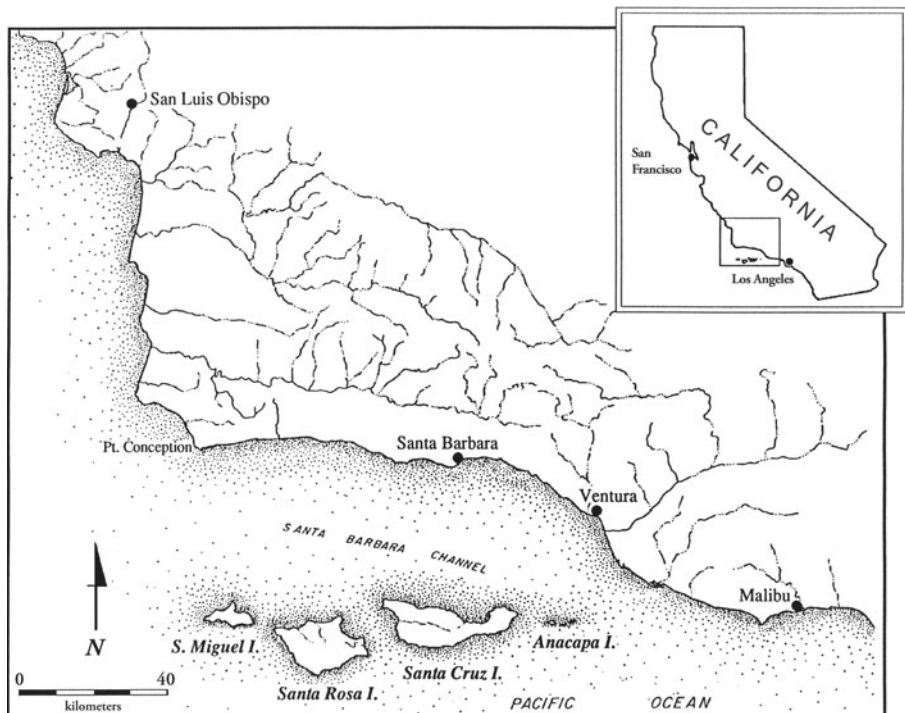
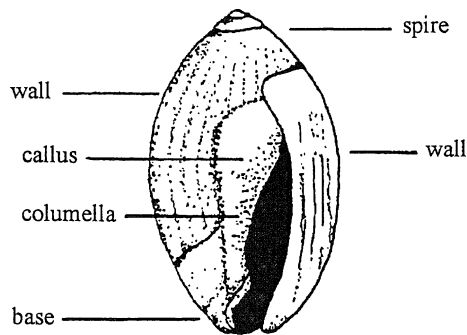


Fig. 1 The territory of the Chumash of southern California

Fig. 2 *Olivella biplicata* shell. Illustration by Jeanne Arnold (from Arnold and Graesch 2001:72). Average shell length is 1.5–2 cm. Reproduced with the permission of the University of Utah Press



type (Arnold and Rachal 2002; see also Arnold and Graesch 2001); three from the *Haliotis rufescens* (red abalone); and many others from another eight to ten species, including *Mytilus californianus* (mussel) and dentalium. Island shellworkers and some of their mainland counterparts also made ornaments from *Megathura crenulata* (giant keyhole limpet), cowrie, *Hinnites multirugosus* (scallop), the nacre of several abalone species, and columellae of Kellett's whelk (Arnold and Graesch 2001:106–108; Hudson and Blackburn 1985).

Olivella beads vastly outnumber the beads of these other shell types made over the centuries. This is not surprising considering that bead variants made from the dense callus (columella) portion of the *Olivella* shell (called *cupped* and *lipped* beads) served as currency for several centuries, and the variant made from the thinner wall of the shell served as both the most common decorative bead type for centuries and as a cheaper money form alongside *Olivella* callus beads during the colonial era (Arnold and Graesch 2001; Hudson and Blackburn 1985; King 1990). The value of *Olivella* beads was measured when they were strung (Fig. 3). A length of strung beads that was wrapped around the hand, then the elbow, and then back to a tattooed mark on the wrist had a specific value, as told to ethnographer John Peabody Harrington by Chumash descendants (Hudson and Blackburn 1987). A full string of beads was worth quite a bit at contact and served as a versatile currency used to purchase *all* kinds of goods (from soapstone bowls to planks of redwood for making canoes), foods (e.g., islanders purchased seeds and acorns from the mainland; mainlanders paid for fish from the islands), and services (e.g., payments were made to doctors, dancers for initiation rites, and undertakers).

Clam, mussel, and abalone beads, as well as other bead types such as serpentine and bone beads, functioned as personal adornments of varying values, but did not serve as money. A few of these bead types were exceptionally difficult to make due

Fig. 3 String of *Olivella* beads with dark mussel shell spacers. Illustration by Jon Standley (from Arnold 2001a:16). Reproduced with the permission of the University of Utah Press

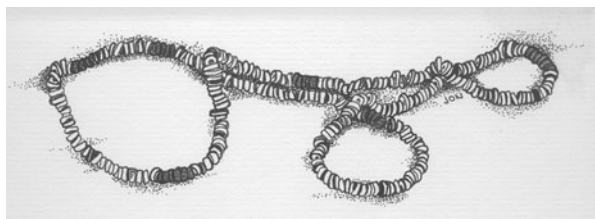
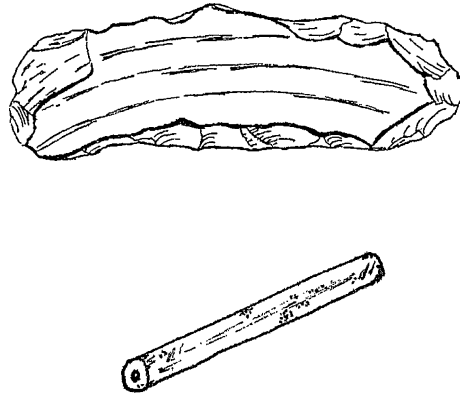


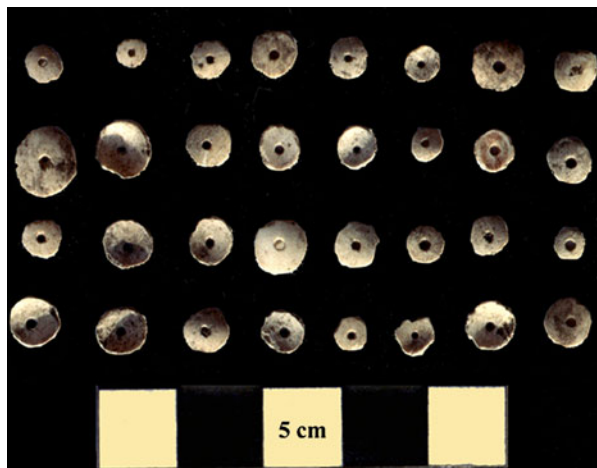
Fig. 4 *Tivela stultorum* (clam) bead blank and tube bead (bead is 40 mm long). Illustration by Anthony P. Graesch (upper) and Jeanne Arnold (lower)



to the hardness of the shell and the length of the bead. Prominent among these were the prized *Tivela* and mussel “tube” beads, which were typically just 5–8 mm in diameter and 30–45 mm long (Fig. 4). Island Chumash specialists drilled these using sea lion whiskers and sand (Hudson and Blackburn 1985). Estimates derived from experimental work as well as ethnographic accounts suggest that a single *Tivela* tube bead required as many as 80 hours to make (Arnold and Rachal 2002). As a consequence of these labor investments, such beads were rare and likely possessed only by elites (Arnold and Graesch 2001). Clearly quite expert shellworkers fashioned these beads, and although the required skill set overlapped with that needed to make *Olivella* disk beads, the manufacturing sequences were different. A more detailed discussion of the production of tube beads is found in Arnold and Rachal (2002) and Arnold and Graesch (2001). The remainder of the present analysis centers on the intensive *Olivella* bead production system.

The standard *Olivella* callus bead and the standard *Olivella* wall disk bead are simple in form. Both were made using circular or slightly ovoid shell blanks, the mean diameters of which varied through time from ~4 to 12 mm, and bead makers drilled a single perforation into the center (Fig. 5). The production steps were as

Fig. 5 Single-hole *Olivella* wall beads from the Channel Islands. Photo by Anthony P. Graesch



follows: (1) select an unflawed shell of appropriate size; (2) split the shell with percussion techniques designed to isolate specific, usable portions of the shell; (3) select an appropriately sized fragment of the callus or wall; (4) optionally “heat treat” the shell to facilitate chipping and drilling (this step is based on ethnographic descriptions of islanders “toasting” the shells (Hudson and Blackburn 1987:271) and my discovery of two *Olivella* heat-treatment features on a house floor on Santa Cruz Island in 1996 (SCRI-240)); (5) chip the perimeter of the selected pre-blank into a roughly circular shape (the bead blank); (6) using a chert microdrill hafted onto a dowel (see Arnold 1987; Arnold *et al.* 2001; Preziosi 2001) and using a sandstone slab or wooden tablet as an anvil, drill a perforation into the shell center (called the bead in production (bip) once any indication of drilling is evident); (7) place a few dozen bips at a time onto a length of strong fiber or a thin stick; (8) grind the perimeters of the bips on a sandstone grinding slab (specimens are called beads once perimeter grinding is evident); and (8) place finished beads on a string of milkweed fiber for use as currency or place on clothing, baskets, or elsewhere in decorative contexts.

In Late and Historic period deposits (1300–1782 AD) at Channel Islands bead-making villages, we find thousands of *Olivella* bead blanks, bips, and beads *per cubic meter*, reaching peaks in the tens of thousands. Also present at the Santa Cruz Island bead-making villages I have tested are up to 20 kg of *Olivella* fragments per cubic meter, all of which are detritus from the bead-making work (see Arnold and Graesch 2001:78–90 for a more comprehensive reporting of bead and detritus frequencies). The scale of production of this industry was sustained and it was intensive, and I am not aware of any pre-colonial shellworking activity in North America—even in the Southwest or at Mississippian sites—that exceeded this rate of production.

Experimental replication work in the region is still in development and has not been completed in any systematic or comprehensive way due to the practical challenges of the craft. We have gained insights into parts of the process, however. Ann Munns and I conducted unpublished heat-treatment experiments in 1990 that show that *Olivella* shells are clearly affected by exposure to hot coals. We created ten packets of unmodified *Olivella* shells, each set of 10–20 shells encased in foil with wet or dry soils in order to temper heat shock (mimicking the effect of burying the shells in the ground near a fire). Half were placed for varying times (8 to 24 min) in the hot coals of a contained campfire (temperature estimated at $\geq 700^{\circ}$). The other five sets were placed in an oven at about 500° for 8 to 15 min.

We found that the shells are rapidly damaged beyond utility by high heat or direct exposure to coals. They darken, develop fissures, and become highly friable in those conditions. Specimens exposed to moderate heat (the oven) over shorter periods remain an aesthetically pleasing bright white but become slightly chalky and softer and presumably thus easier to drill. Kozuch (2003:86) identifies a similar softening and chalkiness of *Busycon* shells that she subjected to experimental heat treatment in her studies of Cahokia shellworking. Mohs tests confirm a reduction in hardness of heated shells, but we do not know if heat-induced alteration of microstructure in shells (Claassen 1998) compromises the durability of the shell material or markedly facilitates chipping or drilling. Further work will be done with these specimens.

In 2010, Arnold and DiNapoli (unpublished notes) conducted a series of *Olivella* shell-splitting experiments using traditional tools: two sizes of quartzite hammer-

stones, an anvil stone, a wooden vice to secure the shells, and whole *Olivella* specimens collected from Santa Cruz Island beaches. We split 32 whole *Olivella* specimens, varying the orientation and rotation of the shells. The shells were oriented upright and either the spire was struck or the base was struck, or the shell was positioned on its side and the wall margin was struck. We recorded and photographed all resulting fragment types for each case (Fig. 6). This provided useful insights into varying strategies employed during different periods to isolate wall vs. callus shell segments, among other outcomes.

The replicative work most pertinent to understanding late stages of bead production was conducted by Michael Macko when he was a student at UC Santa Barbara. He chipped and perforated a number of *Olivella* blanks, discovering that it was quite a laborious process, but precise counts and labor investments are unavailable and his work remains unpublished. In other drilling experiments, Arnold and Rachal (2002) tested the sea lion whisker and sand method used by the Chumash to perforate Tivela tube beads, but our objective in that study was to test the efficacy of the unique drilling process and estimate the labor investment needed to drill a tube bead, rather than to replicate the beads.

A New *Olivella* Bead Type: Multi-hole Wall Beads

The present analysis concerns several hundred specimens of an *Olivella* wall bead type with multiple perforations (Fig. 7). These beads obviously fall outside the norm of the ubiquitous single-hole *Olivella* wall bead. I first noted small numbers of these multi-hole specimens several years ago (Arnold 2000), but the frequencies appeared insignificant. It is now clear that they are a modest but persistent presence in the bead assemblages at three early contact-era households from two Santa Cruz Island villages—places where large quantities of beads were manufactured for several centuries. Because virtually all of these multi-hole specimens are unfinished, and thus they constitute sets of artifacts that were mostly rejected or abandoned before completion, this soon unfolded into a broader investigation into apprenticing and the cultural transmission of technological information. I framed my analyses to address a central question: were these the production mistakes of experts experimenting with a new form, or were they instead the material outcomes of inexpert decisions and errors made by novices in training, practicing to make ordinary beads?

Fig. 6 Experiment 30, *Olivella* shell-splitting replication, showing all resulting shell segments. Each block on scale is 1 cm. Photo by Robert DiNapoli



Fig. 7 Sample of completed (perimeter ground) two-hole Olivella wall beads from Xaxas (SCRI-240). Photo by author



Apprentices in the Archaeological Record

Apprentices engaged in the manufacture of non-ornamental and ornamental goods from durable materials such as shell and stone obviously produce a material record of successes and failures *somewhere*, and the challenge is to recognize those products and partition them from those of skilled practitioners. Milne (2005:336) made the commonsense observation that “experts consistently produce finely made objects while novices frequently make mistakes.” I begin by suggesting that the evidence for novices—mostly mistakes and failures—in lithic and shell crafts should occur in spatially predictable patterns. Based on ethnoarchaeological observations (e.g., Kenoyer *et al.* 1991; Pigeot 1990; Stark 1995), I argue that the *breadth of practice*—the percentage of adults in a community who participate in making objects of a given class—has an impact on where training typically occurs and thus where many material indicators of apprenticing activity ought to be found.

Arguably, the most elusive figures of the quotidian past are the young, not-yet-trained members of society. With a few important exceptions to be noted below, archaeology as a discipline has struggled to reveal much about children’s material contributions to the preserved record of daily life and the processes of their socialization into ordinary adult roles and responsibilities. Children, of course, are hardly invisible archaeologically: publications abound regarding the mortuary treatments of subadults, and we occasionally can detect clear material markers of important events in the lives of children such as coming-of-age rituals (e.g., sandstone boulders dotted with cupules in California). It is nonetheless true that we have discovered far less about where and when they learned how to be ordinary, productive adults and good knappers, potters, or weavers. We know just as little about the daily life of the aged in the past and how they may have been eased out of such tasks when their eyesight failed or their hands grew arthritic. In simplest terms, archaeologists in much of the world have neither routinely considered nor developed robust ways to spot the crafted remains either age class might have left behind.

It stands to reason that there are preserved artifactual materials—tools, ornaments, by-products—reflecting errors and imperfections that both age classes produced as they began to apprentice into new productive roles or reached the age to retire from old roles. Recovering and recognizing such material has implications for our understanding of household and community economies and social units of production. How do we best identify these items? Can we distinguish the work of

novices and failing but once-proficient producers from ordinary, mature, expert producers? Which artifact types and how many of them should we expect to see? Here, I focus on how best to identify the novice/expert distinctions; I must leave for another paper the finer points of distinguishing the young from the old.¹

Ethnographic observations show that apprenticing into important tasks in past societies often began at early ages. Embedded as most westerners are in an era of protective parenting that postpones children's assumptions of responsibilities, we easily forget that practices are/were different in non-industrial societies. In Samoa, for instance, children as young as five traditionally wield large knives, climb tall trees to harvest fruit, and participate in other household tasks (Elinor Ochs, personal communication). Among the Meriam of the Eastern Torres Strait, shellfish gathering by young children meaningfully augments household diets, complementing adult-gathered species. Bird and Bliege-Bird (2000) observe that shellfish targeted by Meriam adults and young collectors differ due to distinct visual ranges, hand sizes, and strength. Children's shellfishing contributions are both different and essential. This observation has facilitated interpretation of the region's archaeological sites, because only when shellfishing contributions from all ages were incorporated into analyses of ancient midden composition did they make quantitative sense.

In many traditional societies, children started simple tasks at early ages and when older started to learn to make compound tools, ornaments, large baskets, and other important gear, although the timing varied cross culturally (Kamp 2001). Mechanisms for learning include overt training, imitation, and play (Casey and Burruss 2010). Making such objects required planning, physical coordination, and valued raw materials and thus demanded some maturity and directed attention. Ultimately, the precise ages are unimportant, whereas trying to find reliable ways to detect these social actors in the past is quite important if we strive to: (1) understand the full range of past human experiences, including early life stages; and (2) document material markers associated with transitions into adulthood, the acquisition of production skills, and other key cultural transmission processes.

We should keep in mind that apprenticing can be a lengthy process, as Walleart (2001) illustrates in documenting the transmission of the complex of practices related to potting in contemporary Cameroon. Young potters in this important community of practice (Lave and Wenger 1991) develop the basic physical skills rather readily, but they require from 4 to 7 years to be fully socialized into the craft and to cultivate proper *respect* for their mothers (mentors), other seasoned potters, and the rich symbolic and social contexts associated with longstanding local potting traditions. A rich corpus of ethnoarchaeological and experimental research—especially, but not solely, on pottery making (e.g., Baxter 2005; Kamp 2001; Skibo and Feinman 1999)—makes clear that a complex set of cognitive challenges may be associated with learning a technical activity, including grasping the bodily mechanics requirements, the procedural stages, the linked social and symbolic practices, the rights and obligations that go with being a practitioner, and the latitude for innovation. Moreover, Chirikure (2006) and others have shown why the

¹ Likewise, people cycled out of ordinary productive tasks at various culturally constructed ages and/or when they could no longer do fine work or strength-sapping work associated with making certain tools or arts.

production of smelted metal is a quite different and more complex craft, and we can surmise that apprenticeship might occur at later ages due to various physical and conceptual challenges

Material Markers in Archaeological Assemblages

In order to identify children's socialization into adult tasks in the past, we need to find specific material markers. For instance, Baxter (2005) discusses *where* the activities associated with socialization of the young typically take place. She makes the simple point that daily family work and play contexts in traditional societies are largely *at and near residences*; thus, not surprisingly, domestic spaces are among the best loci to search for clues about the material record of youngsters. Keeping in mind that most but not all novices are children or adolescents (some may be adults), this observation about spatiality seems quite appropriate for shellworking and lithic production systems. Much adult-to-adult teaching and transmission of technological knowledge in the shell and stone crafts would also have occurred near residences, as proposed below. Metalworking or other crafts with special facilities that were positioned far from houses because they produced heat or noxious gases would obviously generate different spatial expectations regarding apprenticeship.

Perhaps because lithic reduction preserves mistakes, much of the research on novices in the archaeological record concerns knapping activities (e.g., Shea 2006). All such studies have as their foundation (1) a large corpus of experimental and replicative work by contemporary knappers whose production mistakes (and those of their students) are well chronicled and (b) ethnoarchaeological observations of stone-tool makers continuing to practice the craft. Similar foundational research has been done for potting, much of it ethnographic or ethnoarchaeological (Costin and Wright 1998; Crown 1999, 2001; Skibo and Feinman 1999; Stark 1995, to note just a few) and on a more limited scale for other crafts such as weaving and bead making (Kenoyer *et al.* 1991). Both stone-tool making and shellworking have preservational advantages—the durable raw material allows the survival of most production errors and reductive steps. Ceramic, textile, basket, and metal work, on the other hand, normally entails poorly preserved by-products, frequent recycling of rejected products and raw materials, and wholly different probabilities of identifying errors in the archaeological record.

John Shea (2006) suggests that many European Paleolithic sites with impressive amounts of lithic waste undoubtedly contain some that was produced by children who had graduated to the age where they could engage in simple stone-tool manufacturing. He notes that every knapper passing through the novice stage must, to become competent, make and discard literally thousands of artifacts. Consequently, the cumulative evidence ought to be both widespread and confounding to analysts, since it will be highly mixed with the by-products of experienced knappers. Shea contends that tools and debitage reflecting typical novice manufacturing errors are present at various European Paleolithic sites, and he also suspects that very *small* tools and debitage there are the handiwork of children who were learning to knap.

Nicole Pigeot has identified zones of expert and apprentice stone-tool makers at an Upper Paleolithic open-air site in the Paris Basin of France (Dobres and Hoffman

1994: 236). The debitage from retouch and core reduction work reflects notably varying technical competence levels, which Pigeot (1990) has interpreted as generated by young novices and expert knappers. The specific social identities represented there can of course be debated, but she makes a good case for the presence of producers with quite different levels of skill and experience. In an ethnoarchaeological study considering both young and aged Gamo tool makers in Ethiopia, Kathryn Weedman (2002) shows that prominent “spurs” on hide-working scrapers are the outcome of inexperienced tool retouch work by novices and by elderly producers. In another relevant study, Brooke Milne (2005) identifies novice knapping mistakes at Paleo-Eskimo sites on Baffin Island through comparison with the work of tool replicators who have described common errors attributable to the inexperienced.

So how might apprenticing typically unfold? Taking flintknapping as an example, before they started doing much tool-making themselves, children likely engaged in supporting tasks for knappers in their households, including clearing away debitage, collecting materials for hafting, and the like (Grimm 2000). Basic fetching tasks can be associated with all major technical crafts and likely provided the entrée of novices into these activities, allowing them the opportunity to watch skilled adult craftspeople for extended periods. Play in the vicinity of adults engaged in craft production can also account for an incipient interest in and affinity for the craft in children ages 3 to 8 (see Casey and Burruss 2010:67–68). Psychologist Derek Lyons and his colleagues (Lyons *et al.* 2007) identify a strong propensity in children to imitate the physical activities of adults. Indeed, Lyons demonstrates that children are masterful over-imitators, particularly when they see adults manipulating objects, and they routinely and repetitively imitate whole sequences of adult actions during their play (Lyons *et al.* 2007).

The acquisition of skills associated with decoration, style, and representational art may also be captured in the material record of the past. Ceramics, particularly the details of surface treatments, may preserve the work of novices, as Crown (2001), Hill (1977), Kamp (2001), Longacre (1999), and others have shown. Regarding the Upper Paleolithic caves of Europe, Guthrie (2005) proposes that some of the less complete and less refined rock art represents the efforts of novices who were learning carving and painting skills.

Individuals and Innovators

Efforts to identify *the individual* in prehistory also inform the problem. If we can demarcate the handiwork of the individual in the past, we might also shed light on mentor-apprentice relationships, that is, the process of skilled teachers encouraging juniors to replicate a distinct way of making a tool, pot, or ornament. Artifact assemblages occasionally preserve snapshots of these processes. Moreover, a focus on skill acquisition and the social environment in which mentoring, learning, and production took place leads to overt consideration of embodied practices such as degrees of consistency that must be achieved in motor habits in order to have success. This is closely allied to the issue of morphological standardization in finished products, a topic of great interest to many archaeologists.

Hill (1977) assumed that the *bodily mechanics* of individuals making pots or bifaces remained rather static through time and were unaffected by social learning or

socio-spatial contexts of production. The implication is that such consistency should correlate with marked standardization in the objects any given individual produces. But in cases where bustling, socially interacting communities of craft specialists regularly share designs and emulate innovators, it seems reasonable to expect individuals' standardization targets to shift through time. Also, increased age and experience ought to result in shifting skills and motor habits through the lifetime, although this notion is rebutted by suggestions that the methodical repetition that accompanies the frequent production of an artifact type minimizes the tendency to change (see Crown 1999; Longacre 1999; Skibo and Feinman 1999). John Creese (n.d.) has conducted a valuable study of these issues. Creese's experiments show that social interaction and mutual evaluation of products by co-producers can override individual differences in bodily motor function to create a community of practice with very similar material outcomes.

My interest in the analysis of the individual in prehistory is situated in its debate about the social community of production. In my view, the more social the production environment, with intervisibility of work space and exhortations and social pressures to conform to ideals, *the more difficult it will be to see the specific work of proficient individuals, but the easier it will be to spot the work of novices*. Abrupt departures in production norms by innovators also should stand out in highly social manufacturing contexts; a vibrant, interactive community of practice potentially facilitates rapid spread of a new style or object type.

It can be argued that innovations conferring strong technological or social advantages are rapidly adopted in any economic climate. Superfluous innovations may or may not be adopted under stressful economic conditions (drought, famine, epidemic, conflict, or colonial intrusion), but innovators may find success when risks or production costs are low and/or the object type in question is highly visible socially. Any of these contingencies might apply at various times in the complex and rich history of the Channel Islands bead-making industry. Beads and ornaments, like other "prestige technologies" (Hayden 1998), derive value through their visual attractiveness and social assignment and are thus malleable stylistically in ways that many other classes of artifacts cannot be. Unlike ceramics, textiles, or stone tools, their performance characteristics are completely divorced from acquiring or processing food, providing vessels for cooking, or supplying bodily warmth. Thus, the freedom to innovate is greater for purely ornamental objects than for economically functional objects.

Shellworking on the Channel Islands

The Island Chumash of southern California were among the world's great bead-making societies. From ca. 1000 AD to the early nineteenth century, specialized practitioners on the northern Channel Islands controlled this industry, making enormous quantities of beads from Olivella and the other shell species noted earlier. Notably, the mainland Chumash were not participants in this massive enterprise (Arnold and Graesch 2001). Many of the local bead types were significant for marking social statuses, whereas long strings of Olivella callus disk beads came to serve as a true currency. The term currency is not used casually by regional scholars.

Callus beads are detailed by ethnographic sources and in a wide range of oral narratives as a legitimate standard of value exchangeable for all manner of goods, foods, and services (Arnold and Graesch 2001; Blackburn 1975; King 1990).

Archaeological investigations complement the ethnohistoric data with undisputed evidence of the sustained, intensive production of millions of shell beads (mostly Olivella) at multiple households across a number of villages. Some 15 to 20 coastal villages on Santa Cruz Island and two neighboring northern Channel Islands, Santa Rosa and San Miguel islands, participated at a high level of activity (Arnold and Graesch 2001, 2004; Arnold and Munns 1994; Graesch 2004; Kennett 2005; King 1990; Rick 2007). This specialized industry continued exclusively on the islands for many centuries. Large populations of Chumash people on the mainland, as well as other groups from San Diego to the Central Valley of California, traded for and used these beads but did not make them. In short, there was a well-established and long-lasting shell bead-making community of practice on the islands (Wenger 1998). But just who was in this important community of practitioners essential to Chumash social and political reproduction?

It has never been established, even with the large body of information compiled by ethnographer John Peabody Harrington and various historic observers (see Blackburn 1975; Hudson and Blackburn 1987), whether the primary makers of beads were adult men, adult women, or both (Fig. 8). The limited ethnographic evidence regarding bead *makers* is unfortunate given the intensity of practice of this craft on the islands and its extension into the mission period. Using data mined from Harrington's hundreds of boxes of chaotically archived notes, Hudson and Blackburn (1985 and four linked volumes) have organized and published a rich array of quotes from Chumash informants on the region's material culture, but the sum total of information regarding bead-making craft *practices* and how traditional shell products were made fills just a handful of pages. Harrington interacted with his elderly informants beginning ~1910, when they were one to two generations removed from active bead-making practices. These elders were themselves recalling what their grandparents' generation told them when they were children, so most were understandably hazy or uninformed regarding producers, raw materials used for the beads, and drilling tools.

The best ethnohistoric information we have is that several decades into the mission period, a few female elders who had grown up on the islands were observed making shell beads near San Buenaventura Mission, and one man in mission records can be linked with bead making during that same period (Johnson 2001:59–67). By the 1820s–1830s, little remained of the craft that had thrived for the *longue duree* on the northern Channel Islands. The last Chumash people left the islands by 1819 to move to the missions and no longer were they using traditional stone drills, making large quantities of beads, or working in active communities of practice. These islanders transplanted to the mainland were among the very last of their culture who knew how to make beads. Amid all such disruptions to the bead-making community of practice, I do not think we can draw any specific conclusions from the gender or age of these final known shellworkers.

The archaeological record has been far more generous in giving up its secrets about the bead-making industry. Large assemblages of lithic and shell manufacturing by-products from a range of Island Chumash village sites indicate that many people



Fig. 8 Artist's conception of bead makers at a Channel Islands village. Illustration by Jon Standley (from Arnold 2001b:39). Reproduced with the permission of the University of Utah Press

living on the islands were either occupationally specialized microdrill makers (near the quarries on eastern Santa Cruz Island; Arnold 1987; Arnold *et al.* 2001; Perry 2004) or skilled, specialized bead makers (Arnold 1992, 2001a; Kennett 2005). Islanders spent a lot of time practicing these crafts, based on the prolific outputs preserved today in middens. Village after village on the eastern end of Santa Cruz Island contains tens of thousands to hundreds of thousands of microliths, flakes, and cores *per cubic meter of deposit* that are unambiguously linked to the microblade industry (Arnold 1987). Coastal villages on southern and western Santa Cruz Island and the perimeter of Santa Rosa Island yield similar densities of bead-making by-products per cubic meter.

We also have *household-specific* data from more than 30 house depressions at four western and northern Santa Cruz Island protohistoric village sites. These localities indicate that at least one person in the majority of households at those communities (but not at all island villages, and not any villages on the mainland) were bead makers (Arnold and Graesch 2004; Graesch 2004; see also Dietler 2003 for comparable data from microblade-making households at one site on eastern Santa Cruz Island). Each household participating in bead making typically focused on making two or more bead types, and no two households were alike. Despite the

absolutely critical role of these crafts in daily life on the islands, not only is it unclear whether males or females (or both) made beads, but also we lack guideposts regarding at what age people might have begun to apprentice into the craft or how they gained experience.

This study focuses on new evidence from two village sites on Santa Cruz Island with unique Olivella bead-making assemblages that may represent apprentice-produced artifacts and thus may shed light on key cultural transmission processes. I also explore the alternative proposition that this evidence could represent rejected by-products from an innovation by expert bead-making practitioners.

Apprentices in Shellworking

Shell preserves well in southern California sites, and failures of various sorts in bead-making assemblages at Channel Islands sites—beads rejected or lost before completion—have been recorded for decades (Arnold and Graesch 2001; Arnold and Munns 1994; Graesch 2004). These unfinished products fall into two primary classes: *bead blanks* (chipped perimeters; no drilling) and *beads in production* (drilling underway, but perforations may or may not be completed; perimeter grinding not initiated). Prior to the present analysis, I had not thought about these artifact classes in terms of capturing the mistakes of any category of producer beyond ordinary, trained, adult bead specialists.

Now, however, it is clear that apprenticing bead makers must have been active in the Channel Islands communities of practice, and at least some of their work should be detectable due to superb local preservational contexts and the reductive nature of shell-bead production. This investigation is important to pursue for several reasons. First, bead making was of paramount social and economic significance for the Island Chumash, constituting a large portion of their non-subsistence daily behavior. They were clear occupational specialists, rare at such a large scale among hunter-gatherers. Second, bead making was an important craft in the entire southern California regional economy, providing the great majority of currency beads and decorative beads for all Chumash subgroups and several neighboring groups extending across more than 25,000 square miles. Third, it is difficult to make shell blanks and challenging to drill these tough shell materials (especially Olivella and Pismo clam; see Arnold and Rachal 2002:193–194). Because these steps required dexterity, precision, and strength, the apprenticing process was likely fairly lengthy and thus archaeologically visible.

The Mohs hardness of Olivella shell is 5.0–5.5, exceeding the hardness of rocks such as calcite (3.0), fluorite (4.0), and apatite (5.0). Recently controlled, systematic shell-splitting experiments by Arnold and DiNapoli (unpublished data) indicate that positioning the hammerstone blow in relation to various shell orientations reliably produces good-sized wall or callus fragments. This requires moderate strength and precise hammering but is fairly simple. On the other hand, ad hoc efforts by several of my field school students over the years to chip and then perforate Olivella shell wall blanks show that, even with steel bits and nails, we are hard-pressed to pierce this material in a controlled fashion without breaking the blanks. The drilling stage is challenging and requires good tools (microdrills, anvil with small cupped areas to

hold the blank in place) and a high skill level. I venture to say that bead replication with traditional tools has not been done systematically in the region *because* it is so difficult and involves so many steps. One has to find non-archaeological island chert material to fashion microblade cores (one cannot collect from the quarries or from National Park Service land); make dozens of microblades and convert them to microdrills; haft them to dowels; make large numbers of bead blanks (most will break, thus many are needed); create a drilling anvil; do the laborious drilling; and finally string and grind the bead perimeters on sandstone slab.

So, we do not yet have good replication data to project exactly how long it takes to make a wall bead today, but considering all required steps, each bead likely took more than 10 but less than 20 min to make by Island Chumash shellworkers. The work of past apprentices, although far more competent than our stumbling efforts, ought to be apparent as they mastered these production difficulties.

Identifying Apprenticing Activities: Material Expectations

Certain material markers of apprenticing may occur regularly in archaeological assemblages derived from reductive technologies such as shell ornament/bead making and lithic tool production. I rely on findings from global ethnoarchaeological projects (as cited above) in generating a few specific material expectations. I then assess them using the Channel Islands bead data.

1. *Apprenticing should occur in close spatial proximity to key raw materials.* We ought to find most products made by apprentices within *easy transport distances* of raw material sources, since novices waste or consume considerable valued material. Such spatial proximity would have been conducive to task socialization in a relatively low-cost setting for teaching and experimentation. In short, apprentices practice where it is affordable.
2. *Apprenticing is constrained by seasonal availability of raw materials and task-scheduling conflicts.* Considering the timing of apprenticing within an annual calendar, products of novices should occur in depositional contexts generated *when* source materials were abundant. Apprenticing should *not* overlap with major ritual events or recurrent, crucial economic tasks that consume the attention of experienced practitioners. Nonessential apprenticing is unlikely at high-risk seasonal food-acquisition sites where labor is at a premium, for instance.
3. *Apprenticing routinely occurs in proximity to skilled adult mentors at and around domiciles.* In non-industrial societies, adults with expertise in making tools, pots, and beads spend many hours at home in visual contact with children who need to learn adult skills and responsibilities. Artifact manufacture is generally done at/near houses or in special workshop areas close by. Adults are multitasking: tending the fire, preparing food, repairing clothing, attending to youngsters, and making tools and ornaments as needed. Novices are active in and around houses—playing, imitating the actions of their siblings and elders, and directly helping by finding/carrying raw materials, learning how to position themselves to work, and where to dispose of by-products.

4. *Breadth of practice partially determines spatial positioning of apprenticing activity.* What I call *breadth of practice* is a simple measure of the rate of participation in a craft by members of a given society. For example, if every household customarily has a proficient adult male knapper, the breadth of practice for that skill is close to 100% of men. I suggest that *breadth of practice* predicts in part where apprenticing will take place. We thus should see an array of novice-made lithic by-products near all homes with young boys (as long as raw material is ample to support knapping at villages; see #1 above). Breadth of practice has two main constituents: how ubiquitous the task is and whether it is practical to carry out at home. Evidence for apprentice work should also be found in and around houses since novices are typically trained by close family members (Weedman 2002). Similarly, if baskets are made by most adult females (breadth of practice close to 100%), odds are high that the learning of this craft by novice girls will take place near home, where it is practical for women to prepare fibers and weave while also overseeing play, cooking, etc.

Low breadth of practice, conversely, does not necessarily correspond to a distinct spatial signature. If men or women in 5% of households specialize in a craft, there will be less overall evidence for novices, and all evidence may be at domestic or non-domestic loci. If the craft is spatially divorced from home-based activity—including work at community kilns or iron-working loci with undesirable by-products (e.g., smoke and slag from smelting)—then obviously novice products will exhibit a narrow and non-residential distribution.

Olivella Bead Making by Novices

This study draws on large shellworking assemblages from the northern Channel Islands. The data sets are precisely dated, derived from pristine (undisturbed) household contexts at several Late Holocene coastal villages, and encompass substantial Olivella wall bead collections and associated by-products (Arnold and Graesch 2001, 2004). My analysis focuses on a set of Olivella wall disk beads, wall beads in production, and wall bead blanks from the villages of *Shawa* (SCRI-192) and *Xaxas* (SCRI-240).

Shawa was a thriving, year-round village of about ten households on the southwestern shore of Santa Cruz Island. Residents lived at this location throughout the Late and initial Historic periods, enjoying access to some of the richest coastal waters in the northern hemisphere. They consumed hundreds of species of fish, marine mammals, birds, and shellfish. Even huge swordfish were captured with some frequency there; all told, fishbone densities reach 500,000 elements/m³ at the site (Arnold 2001b). Anthony Graesch (2004) has shown that each Shawa household made significant quantities of shell beads (of varying types) in and immediately around the houses.

Xaxas was an important trading village on the island's northern shore. Ethnohistoric records reveal that elite individuals, including chiefs and their relatives, resided there, although the number of houses is unknown because portions of the site were destroyed by the Army Corps of Engineers in 1929. Our data are from a buried elite structure with a partially preserved redwood-post frame that I

discovered in 1991 (Arnold 2001b). This was a locus where both microdrill making and bead making occurred on a modest scale (Arnold 2001a, c; Graesch 2004). Residents of this house had unusual access to wealth goods, prized ornaments, and high-status foods. Nonetheless, ordinary bead making was also taking place at the house with some regularity during the Late and early Historic periods.

Proficient bead makers at Shawa and Xaxas of course made manufacturing mistakes. The most common error was fracturing the blank while drilling the perforation. They also simply occasionally lost or cached small numbers of perfectly good blanks and beads in production during their sustained, high-intensity participation in this craft. I have reported on these “ordinary” errors and misplaced specimens at length elsewhere (Arnold and Graesch 2001). To convey more precisely a sense of the scale of production, we recover from 50 to 200+ Olivella wall beads in production and blanks per 5-cm level in a typical 1 × 1 m controlled excavation unit. This is equivalent to 1,000–4,000 specimens/m³. Bead-production densities are lower at Xaxas than at Shawa during the Historic period (recall that other crafts were also practiced at Xaxas). Nothing stands out in most of these levels and components as obvious work of inexperienced shellworkers.

Next, I outline what I expect novice-made Olivella shell beads to look like, and I suggest that we should find them in and around Island Chumash houses at major coastal villages. Among the many unknowns, we might ask how prevalent should novice-made products be? Perhaps not very, if the duration of apprenticing was rather short compared to a long “career” of skilled bead making. Should we expect unusual errors or unusual spatial concentrations of odd or poorly made Olivella shell artifacts?

The Sample

Small numbers of Olivella wall beads in production with two drilled holes were first reported from Shawa (Arnold 2000). The two-hole bead could be suitable for display if sewn flat (sequin like) onto clothing or baskets, and I long assumed that these rare specimens represented a short-lived innovation for that purpose at Shawa. At the time, it did not occur to me that they might represent apprenticing by-products, that is, practice specimens or not-very-skilled attempts to make beads.

Subsequently, I have identified roughly 300 additional specimens, most unfinished, during ongoing analyses of the Santa Cruz Island collections. Several variants and stages of production, including rare *finished* two-hole beads, are among these specimens, and a systematic analysis of their contexts of production is now warranted. To date, I have identified 319 artifacts unambiguously associated with making two-hole (and a few three-hole) Olivella wall beads.

Expectations—Assemblages of Bead-Making Apprentices vs. Bead-Making Experts

The full collections from bead-making villages that are housed at the UCLA Channel Islands Laboratory include more than 20,000 Olivella beads in various stages of production. These specimens provide the foundation for understanding the recurring production errors linked to making standard, single-hole Olivella beads. Material

markers consistent with the mechanics, skills, and intentions of novice bead makers learning the craft should stand out from these standard errors and should reveal basic mistakes in judgment and proficiency.

My working hypothesis is that multi-hole variants are “practice” specimens. Mentors could maximize their apprentices' drilling practice—working on perforation placement, size, and angle—and minimize the waste of bead blanks by having them drill two and occasionally even three holes per blank. If this hypothesis is correct, apprentice-made beads and beads in production should reflect modest to high rates of the following nine production problems (A1–A9) and should reveal two regional patterns (A10 and A11).

Production problems associated with apprentices

- A1. Substandard shell raw material is selected (should occur occasionally)
- A2. Sub-optimal portion of shell is selected, including portions of the spire shelf or base (should occur occasionally; poor aesthetics; tendency to fracture)
- A3. Asymmetries in bead blank chipping (should occur with some frequency; perimeters with notable flaws)
- A4. Poor placement of first and/or subsequent perforations (should occur with some frequency; specimens often abandoned with one perforation piercing the blank margin)
- A5. Blanks are too small (should occur occasionally)
- A6. Incomplete first and/or subsequent perforations (should occur with some frequency; failed to finish perforation)
- A7. Perforations overlap (should occur occasionally; poor hole-to-hole placement)
- A8. Breakage during chipping or drilling (should occur at a very high frequency; drilling is the most difficult step)
- A9. Specimens not finished and perimeters not ground (should occur at a very high frequency) and the ratios of unfinished beads to completed beads should exceed 4:1 (see below)

Regional patterns associated with apprentices

- A10. Few or no finished multi-hole beads found at other sites in regional collections
- A11. Specimens appear slightly different at various houses and villages, reflecting different mentor training methods

If alternatively we have recovered the products of experienced bead makers who were experimenting briefly with a new multi-hole Olivella wall bead form (the rarity of the finished two-hole variant both locally and regionally makes it obvious that it was not sustained and did not catch on), I expect few occurrences and low rates of the production problems A1–A9. The basic working hypothesis here is that the two- or three-hole variant represents a sequin-style bead with a high degree of difficulty that would be more valuable than the simple wall bead form. It could have been a “showy” product made by virtuoso bead makers. Even rejected specimens should reflect high levels of production skill and good decision-making consistent with the

skills and intentions of experienced bead makers who were innovating, trying out a new idea.

Thus expert-made beads and beads in production should reflect: (1) consistent selection of quality shell raw material; (2) consistent selection of good portions of the shell wall; (3) symmetrically chipped bead blanks; (4) well-placed perforations; few abandoned with a perforation near/piercing the blank margin; (5) blanks of adequate size; (6) perforations finished (not partly piercing shell); (7) perforations do not overlap (good hole-to-hole placement, and two perforations per specimen; not abandoned after one hole); (8) low to modest rate of breakage during chipping or drilling; (9) some/many specimens reach a finished, perimeter-ground state; ratios of bips to beads are roughly 1:1 to 4:1; (10) some finished multi-hole beads should have gone into circulation and should be found at other sites; and (11) specimens should be more or less the same at various houses and villages since they derive from a small number of experienced participants in the innovation. Allowing for some errors, of course, specimens derived from experts should measure up against yardsticks of mastery and technical expertise, even if they were trying out a new concept.

Results: Multi-hole Olivella Wall Beads

With generous support from NSF, UCLA recovered this assemblage of multi-hole Olivella wall beads at three bead-making households: houses 4 and 8 at Shawa and house 1, a redwood-post house, at Xaxas (see Arnold 2001a, b). Olivella shell raw material is found in the intertidal areas of sandy beaches near both villages. The empty shells are easy to collect along the shore, but they are not always abundant, particularly at Xaxas.

Finished Multi-hole Beads

From the full collections of the Santa Cruz Island Project, we have recovered just 10 completed multi-hole Olivella wall beads, those with two drilled holes and grinding around most or all of the perimeter (Fig. 7; Table 1). Eight of ten are from occupational deposits near the center of house 1 at Xaxas, firmly within the early Historic strata. The other two were recovered from Historic levels at Shawa, one at each house. Although substantial perimeter grinding places these specimens within the typological class “finished beads” (bead analysts in the region apply this criterion more or less universally), the perforations are not all complete (Table 1). Indeed, on six specimens, the second perforation is not complete, often barely breaking through the shell and thus much smaller in diameter than the first. Also, on four of the beads the second hole overlaps the first, creating a “figure-8” hole that precludes display as a sequin, and on two more, it is evident that if the second perforation had been completed, it would have broken through to overlap the first. Specimen #880-9000 (Fig. 7, second from right) also could not be displayed as a sequin since the second perforation failed to pierce the shell wall.

Two distinct morphological types are present: a round form ($n=9$) and a square, dorsally ground, perimeter-ground form with no known counterpart in the region

Table 1 Completed multi-hole Olivella wall beads, Santa Cruz Island

Site and location	Excavation unit and level	Artifact no.	Olivella wall artifact type	Perimeter grinding	No. of perforations	First complete	Second complete	Drilling location error	Broken	Curvature of blank
SCRI-240										
House 1	4N 20W 35–40	880-2591	Two-hole bead	Fully ground	2	Yes	Yes	None	No	High
	5N 17W 25–30	880-8965	Two-hole bead	Fully ground	2	Yes	No	Holes overlap	No	High
	5N 17W 30–35	880-9000	Two-hole bead	Fully ground	2	Yes	Does not pierce wall	Would overlap if finished	No	High
	5N 17W 30–35	880-9001	Two-hole bead	Mostly ground	2	Yes	No	Would overlap if finished	No	Moderate/high
	5N 17W 40–45	880-9123	Two-hole bead	Fully ground	2	Yes	No	None	No	Moderate/high
House 8	5N 18W 20–25	880-7752	Two-hole bead	Fully ground	2	Yes	Yes	Holes overlap	No	High
	5N 19W 40–45	880-XJ10	Two-hole bead	Fully ground	2	Yes	No	None	No	Moderate
	5N 17W 35–40	880-9056	Square Two-hole bead	Beveled and dorsally ground	2	Yes	No	Holes overlap	No	Moderate
SCRI-192										
House 8	7S 25W 15–20	887-6072	Two-hole bead	Fully ground	2	Yes	Yes	None	Yes	Moderate
House 4	2S 36E 0–5	887-XJ00	Two-hole bead	Mostly ground	2	Yes	Yes	Holes overlap	Yes	High

(#880-9056, Fig. 7, far right). The pieces of Olivella shell that bead makers chose for these two-hole variants exhibit pronounced cupping or curvature. I initially imagined that it was exceptionally challenging to drill two off-center perforations into a bowl-shaped blank, as opposed to a flat blank, adding to the overall degree of difficulty. I much later concluded that pronounced curvature actually increases the probability of drilling without incurring breakage. In any case, although these finished specimens reflect a number of production mistakes, they seemed initially to represent a manufacturing challenge beyond the reach of novices.

Multi-hole Beads in Production

I have thus far identified 309 multi-hole Olivella wall beads in production in the Santa Cruz Island collections (Fig. 9; Table 2). Twelve of these in-production specimens are from the same levels of House 1 at Xaxas as most of the finished multi-hole beads, and the remainder ($n=297$) are from early Historic period contexts at Shawa.

I randomly selected just over 50% of the specimens for detailed analysis of production stages and errors (Table 3), including all 12 beads in production from Xaxas and 148 beads in production from Shawa (total subsample, 160 of 309; 52%). The specimens from Xaxas include nine two-hole beads in production and three three-hole beads in production. The two-hole beads in production exhibit a litany of production errors, including breakage (eight of nine; 88%); incomplete first and/or second perforation (eight of nine); and drilling location errors such as overlap of holes, hole too close to the margin, and poor drilling angle (seven of nine; 77%) (see Table 4). Three specimens reflect suboptimal choice of shell wall area, and one has an asymmetrically chipped perimeter.

The three-hole beads in production (Fig. 9, left) are rather extraordinary—I am unaware of any others identified in California—and the rationale for making them resides, I believe, in the realm of experimentation, whether by experts or novices. They are on moderately to highly curved wall blanks, much like the rare finished two-hole beads, and this shared feature prompted my eventual realization that a curved blank configuration lowers the odds of breakage. Nonetheless, although drilling a third hole without breaking the blank or creating an undesirable “figure-8” hole would appear to require skill, I doubt that the maker(s) expected to “complete” them, nor has a finished, perimeter-ground one been found. As well, a third hole



Fig. 9 Sample of multi-hole Olivella wall beads in production from Xaxas (SCRI-240) and Shawa (SCRI-192). *Left*: three-hole variants. *Right* group: first five specimens have two partially completed perforations and other production errors; two specimens at *far right* show the first of the off-center perforations. Photo by the author

Table 2 Multi-hole Olivella wall beads in production, Santa Cruz Island

Site	House	Unit	Level	Artifact no.	Artifact type	Count
SCRI-240	House 1	3N 17W	15–20 cm	880-9361	Two-hole bip	1
		3N 17W	15–20 cm	880-15	Two-hole bip	1
		5N 17W	15–20 cm	880-8851	Three-hole bip	1
		5N 17W	25–30 cm	880-8966	Three-hole bip	1
		5N 17W	30–35 cm	880-9002a-c	Two-hole bip	3
		5N 17W	45–50 cm	880-9180	Two-hole bip	1
		5N 18W	35–40 cm	880-7407a-c	Two-hole bip	3
		5N 18W	35–40 cm	880-7407d	Three-hole bip	1
SCRI-192	Adj House 4	2N 23E	10–15 cm	882-XJ01	Two-hole bip	1
		2N 25E	20–25 cm	882-7387	Two-hole bip	1
		2N 23E	25–30 cm	882-3122	Two-hole bip	1
	House 4	2S 36E	0–5 cm	887-3561a-b	Two-hole bip	2
		2S 36E	5–10 cm	887-3793a-d	Two-hole bip	4
		2S 36E	10–15 Fea 1	887-3929a-f	Two-hole bip	6
		3S 36E	0–5 cm	887-7289	Two-hole bip	1
		3S 36E	5–10 cm	887-4402a-m	Two-hole bip	13
		3S 36E	10–15 cm	887-4438a-p	Two-hole bip	16
		1S 35E	0–5 cm	887-4485	Two-hole bip	8
		1S 35E	5–10 cm	887-7268	Two-hole bip	5
		1S 35E	10–15 cm	887-7273	Two-hole bip	4
		1S 35E	10–15 Fea 1	887-7275	Two-hole bip	3
		1S 35E	15–20 C&D	887-4853a-i	Two-hole bip	9
		1S 37E	0–5 cm	887-3092	Two-hole bip	3
		1S 37E	5–10 cm	887-3351	Two-hole bip	1
		1S 37E	5–10 Fea 1	887-7283	Two-hole bip	4
		1S 37E	10–15 cm	887-7282	Two-hole bip	2
		1S 37E	10–15 Fea 1	887-3232	Two-hole bip	8
		2S 34E	0–5 cm	887-3264a-f	Two-hole bip	6
		2S 34E	5–10 cm	887-3295a-b	Two-hole bip	2
		2S 34E	5–10 Fea1	887-3327a-d	Two-hole bip	4
		2S 34E	10–15 Fea 1	887-7307a-l	Two-hole bip	12
		2S 35E	0–5 cm	887-3414	Two-hole bip	9
		2S 35E	5–10 cm	887-7315	Two-hole bip	1
		2S 35E	10–15 cm	887-3643	Two-hole bip	1
		2S 35E	10–15 Fea 1	887-3515	Two-hole bip	5
		2S 35E	10–15 Fea 1	887-XJ04	Three-hole bip	1
		2S 38E	0–5 cm	887-4106	Two-hole bip	2
		2S 38E	5–10 cm	887-4142	Two-hole bip	1
		2S 38E	10–15 W 1/2	887-7325	Two-hole bip	2
		2S 38E	10–15 E1/2	887-4273	Two-hole bip	6

Table 2 (continued)

Site	House	Unit	Level	Artifact no.	Artifact type	Count
SCRI-192	House 8	5S 26W	0–5 cm	887-5716a-d	Two-hole bip	4
		5S 26W	5–10 cm	887-7222	Two-hole bip	1
		5S 26W	10–15 cm	887-5803	Two-hole bip	1
		7S 25W	0–5 cm	887-7248a-b	Two-hole bip	2
		7S 25W	5–10 cm	887-5904a-l	Two-hole bip	12
		7S 25W	10–15 cm	887-5942a-j	Two-hole bip	10
		7S 25W	10–15 lens B'	887-5984a-p	Two-hole bip	16
		7S 25W	10–15 lens C	887-6009a-d	Two-hole bip	4
		7S 25W	15–20 lens B	887-6037a-d	Two-hole bip	4
		7S 25W	15–20 lens C	887-6073a-j	Two-hole bip	10
		7S 25W	20–25 lens B'	887-7518a-b	Two-hole bip	2
		7S 25W	20–25 lens C	887-6145a-d	Two-hole bip	4
		6S 25W	0–5 cm	887-5670	Two-hole bip	6
		6S 25W	10–15 cm	887-5568	Two-hole bip	14
		6S 25W	10–15 lens B'	887-5536	Two-hole bip	8
		6S 26W	0–5 cm	887-6432	Two-hole bip	7
		6S 26W	5–10 cm	887-6470	Two-hole bip	7
		6S 26W	10–15 cm	887-6516	Two-hole bip	2
		7S 26W	0–5 cm	887-6264	Two-hole bip	4
		7S 26W	5–10 cm	887-6297	Two-hole bip	16
		7S 26W	10–15 lens B'	887-7263	Two-hole bip	2
		7S 26W	10–15 cm	887-6337	Two-hole bip	16
		Total				309
		Total analyzed				160

Analyzed specimens are set in bold

bips beads in production

adds nothing to function, since two holes allow the sequin form of attachment/display. Was the driller just dabbling, practicing, or possibly attempting to demonstrate virtuoso skills? In any case, these specimens reflect production errors similar to those above: two of three are broken; the third hole is not complete on two; and there are drilling location errors on all three.

The much larger assemblage of two-hole beads in production at Shawa appears to parallel the very high intensity of specialized Olivella bead production documented for this site (Arnold and Graesch 2001; Graesch 2004). Several differences in production methods and successes are evident when compared to those at Xaxas. Most important, from this site we have captured a manufacturing stage not detected (as of yet) at Xaxas. This is the step after drilling the first perforation, deliberately very off-center, and before starting the second hole. Referring to Table 3, specimens of this type consistently co-occur with more advanced two-hole beads in production

Table 3 Analyzed subsample of multi-hole Olivella wall beads in production

Site and location	Artifact no.	Olivella wall artifact type	Perimeter chipping; blank selection	No. of perforations	First complete	Second complete	Drilling location error	Broken	Curvature of blank
SCRI-240									
House 1	880-9180	Two-hole bip	Ok	2	No	No	Position and angle	Yes	Moderate
	880-9361	Two-hole bip	Ok	2	No	No	None	No	Low
	880-15	Two-hole bip	Ok; near base	2	Yes	Yes	None	Yes	High
	880-9002a	Two-hole bip	Ok; spire seam	2	Yes	No	Close to overlap	Yes	Low
	880-9002b	Two-hole bip	Ok	2	Yes	No	Close to overlap	Yes	Low
	880-9002c	Two-hole bip	Asymmetry; near callus	2	Yes	No	Would overlap if finished	Yes	High
	880-7407a	Two-hole bip	Ok	2	Yes	No	Would overlap if finished	Yes	Low
SCRI-192	880-7407b	Two-hole bip	Ok	2	Yes	No	Close to overlap	Yes	Moderate
	880-7407c	Two-hole bip	Ok	2	No	No	Would overlap if finished	Yes	Low
	880-7407d	Three-hole bip	Ok	3	Yes	Yes; 3rd no	Position; 3rd hole on margin	Yes	Moderate
	880-8851	Three-hole bip	Ok	3	Yes	Yes; 3rd complete	Two overlap	Yes	High
	880-8966	Three-hole bip	Ok	3	Yes	Yes; 3rd no	Two overlap	No	High
	882-XJ01	Two-hole bip	Asymmetry	2	Yes	No	None	Yes	Low
	882-7387	Two-hole bip	Ok; very small	2	Yes	No	On edge	Yes	Moderate
House 4	882-3122	Two-hole bip	Ok	2	Yes	No	None	Yes	High
	887-3643	Two-hole bip	Ok	2	No	No	Position and near overlap	No	Moderate
	887-3264a	Two-hole bip	Asymmetry	2	Yes	No	None	No	Low
	887-3264b	Two-hole bip	Asymmetry	2	Yes	No	On edge	Yes	Moderate
	887-3264c	Two-hole bip	Ok; very small	1	No	N/A	On edge	Yes	Moderate
	2S 34E								

887-3264d	Two-hole bip	Ok	1	Yes	N/A	On edge	No	Low
887-3264e	Two-hole bip	Ok; near callus	1	Yes	N/A	None	No	High
887-3264f	Two-hole bip	Ok	1	No	N/A	On edge	Yes	Moderate
887-3295a	Two-hole bip	Ok	2	Yes	Yes	None	Yes	Low
887-3295b	Two-hole bip	Ok	1	No	N/A	None	Yes	Moderate
887-3327a	Two-hole bip	Ok	1	Yes	N/A	None	No	Moderate
887-3327b	Two-hole bip	Ok	1	No	N/A	Position and angle	Yes	Low
887-3327c	Two-hole bip	Irregular	2	Yes	No	None	Yes	Moderate
887-3327d	Two-hole bip	Ok	2	Yes	No	None	No	Moderate
887-7307a	Two-hole bip	Ok	2	Yes	No	Overlap	Yes	Moderate
887-7307b	Two-hole bip	Ok; near spire	1	Yes	N/A	Close to edge	No	Moderate
887-7307c	Two-hole bip	Ok	1	No	N/A	None	No	Moderate
887-7307d	Two-hole bip	Ok	1	Yes	N/A	None	No	Low
887-7307e	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Moderate
887-7307f	Two-hole bip	Ok	1	No	N/A	Close to edge	Yes	Low
887-7307g	Two-hole bip	Ok	1	No	N/A	None	Yes	Low
887-7307h	Two-hole bip	Ok	1	No	N/A	None	Yes	Moderate
887-7307i	Two-hole bip	Ok	1	No	N/A	None	Yes	Low
887-7307j	Two-hole bip	Ok	1	No	N/A	Close to edge	Yes	Low
887-7307k	Two-hole bip	Ok	1	No	N/A	Close to edge	Yes	Low
887-7307l	Two-hole bip	Ok	1	Yes	N/A	None	No	Moderate
887-4853a	Two-hole bip	Ok	1	Yes	N/A	None	Yes	High
887-4853b	Two-hole bip	Ok	1	No	N/A	None	No	Low
887-4853c	Two-hole bip	Ok	1	No	N/A	None	Yes	Moderate
887-4853d	Two-hole bip	Ok	1	No	N/A	Position and angle	Yes	Low
887-4853e	Two-hole bip	Ok	1	No	N/A	Position	Yes	Moderate
887-4853f	Two-hole bip	Ok	1	No	N/A	None	Yes	Low

1S 35E

Table 3 (continued)

Site and location	Artifact no.	Olivella wall artifact type	Perimeter chipping; blank selection	No. of perforations	First complete	Second complete	Drilling location error	Broken	Curvature of blank
2S 36E	887-4853g	Two-hole bip	Ok	1	No	N/A	Position and angle	Yes	Low
	887-4853h	Two-hole bip	Ok	1	No	N/A	None	Yes	Low
	887-4853i	Two-hole bip	Asymmetry	2	Yes	No	Near overlap	Yes	Low
	887-3561a	Two-hole bip	Ok	1	Yes	N/A	Close to edge	Yes	Moderate
	887-3561b	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Low
	887-3793a	Two-hole bip	Irregular	2	No	No	None	Yes	Low
	887-3793b	Two-hole bip	Ok	2	No	No	None	Yes	Low
	887-3793c	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Low
	887-3793d	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Low
	887-3929a	Two-hole bip	Ok; at callus junction	2	Yes	No	None	Yes	High
	887-3929b	Two-hole bip	Irregular; near spire	1	Yes	N/A	None	Yes	Low
	887-3929c	Two-hole bip	Ok	1	No	N/A	Close to edge	No	Moderate
	887-3929d	Two-hole bip	Ok	1	No	N/A	None	Yes	Moderate
	887-3929e	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Moderate
3S 36E	887-3929f	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Low
	887-7289	Two-hole bip	Ok	1	Yes	N/A	Close to edge	Yes	Low
	887-4402a	Two-hole bip	Ok	2	Yes	No	None	Yes	Low
	887-4402b	Two-hole bip	Ok	2	Yes	No	None	Yes	Low
	887-4402c	Two-hole bip	Ok	1	No	N/A	None	Yes	Low
	887-4402d	Two-hole bip	Ok	1	No	N/A	Close to edge	Yes	Moderate
	887-4402e	Two-hole bip	Ok	1	Yes	N/A	None	Yes	High
	887-4402f	Two-hole bip	Ok	1	No	N/A	Close to edge	Yes	Low
	887-4402g	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Low

887-4402h	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Low
887-4402i	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Moderate
887-4402j	Two-hole bip	Asymmetry	1	Yes	N/A	None	Yes	Moderate
887-4402k	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Moderate
887-4402l	Two-hole bip	Ok	2	Yes	No	None	Yes	Low
887-4402m	Two-hole bip	Ok; dorsal grinding	1	Yes	N/A	Close to edge	Yes	High
887-4438a	Two-hole bip	Ok	2	Yes	Yes	None	No	Moderate
887-4438b	Two-hole bip	Ok	2	Yes	Yes	None	Yes	High
887-4438c	Two-hole bip	Ok	2	Yes	No	Close to edge	Yes	High
887-4438d	Two-hole bip	Ok	2	Yes	No	None	No	Moderate
887-4438e	Two-hole bip	Ok; perimeter ground; finished 1-hole bead	2	Yes	No	Would overlap if finished	Yes	Moderate
887-4438f	Two-hole bip	Ok	1	No	N/A	Close to edge and angle	No	Low
887-4438g	Two-hole bip	Ok	1	Yes	N/A	Close to edge and angle	Yes	Moderate
887-4438h	Two-hole bip	Ok	1	Yes	N/A	None	No	High
887-4438i	Two-hole bip	Ok	1	Yes	N/A	Close to edge	No	Moderate
887-4438j	Two-hole bip	Ok	1	Yes	N/A	None	No	Moderate
887-4438k	Two-hole bip	Ok	1	Yes	N/A	Close to edge	Yes	High
887-4438l	Two-hole bip	Ok	1	No	N/A	Close to edge	Yes	High
887-4438m	Two-hole bip	Ok	1	No	N/A	Close to edge and angle	Yes	High
887-4438n	Two-hole bip	Ok	1	No	N/A	Close to edge and angle	Yes	High
887-4438o	Two-hole bip	Irregular	1	Yes	N/A	Close to edge	Yes	Moderate
887-4438p	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Low
887-5716a	Two-hole bip	Asymmetry	1	Yes	N/A	None	No	Low
887-5716b	Two-hole bip	Asymmetry	1	Yes	N/A	Position	Yes	Moderate
887-5716c	Two-hole bip	Asymmetry	2	Yes	No	None	Yes	Low

House 8

5S 26W

Table 3 (continued)

Site and location	Artifact no.	Olivella wall artifact type	Perimeter chipping; blank selection	No. of perforations	First complete	Second complete	Drilling location error	Broken	Curvature of blank
7S 25W	887-5716d	Two-hole bip	Asymmetry	2	Yes	No	Position and angle	Yes	Low
	887-7222	Two-hole bip	Ok	2	Yes	Yes	None	Yes	Moderate
	887-5803	Two-hole bip	Ok	2	Yes	Yes	None	Yes	High
	887-7248a	Two-hole bip	Ok	1	Yes	N/A	None	No	Moderate
	887-7248b	Two-hole bip	Ok	1	Yes	N/A	Close to edge	No	Moderate
	887-5904a	Two-hole bip	Ok	2	Yes	Yes	None	Yes	Low
	887-5904b	Two-hole bip	Ok	2	Yes	Yes	None	Yes	Moderate
	887-5904c	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Low
	887-5904d	Two-hole bip	Ok	1	Yes	N/A	Close to edge	No	Moderate
	887-5904e	Two-hole bip	Ok	1	Yes	N/A	Close to edge	Yes	Low
	887-5904f	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Low
	887-5904g	Two-hole bip	Ok	1	No	N/A	Close to edge	Yes	Moderate
	887-5904h	Two-hole bip	Ok	1	Yes	N/A	Close to edge	Yes	Moderate
	887-5904i	Two-hole bip	Ok; near callus	1	Yes	N/A	None	Yes	High
	887-5904j	Two-hole bip	Ok	1	Yes	N/A	Close to edge	Yes	Low
	887-5904k	Two-hole bip	Ok	1	No	N/A	Close to edge	Yes	Low
	887-5904l	Two-hole bip	Ok	1	No	N/A	None	Yes	Low
	887-5942a	Two-hole bip	Ok	2	Yes	No?	None	Yes	Moderate
	887-5942b	Two-hole bip	Ok	2	Yes	No	Would overlap if finished	Yes	High
	887-5942c	Two-hole bip	Ok	2	Yes	No	None	Yes	Low
	887-5942d	Two-hole bip	Ok	2	Yes	No	Angle	Yes	High
	887-5942e	Two-hole bip	Ok	1	Yes	N/A	Close to edge	No	Moderate
	887-5942f	Two-hole bip	Ok	1	Yes	N/A	Close to edge	Yes	Moderate

887-5942g	Two-hole bip	Ok		1	Yes	N/A	Close to edge	Yes	Moderate
887-5942h	Two-hole bip	Ok		1	No	N/A	None	Yes	Low
887-5942i	Two-hole bip	Ok		1	Yes	N/A	None	Yes	Low
887-5942j	Two-hole bip	Irregular		1	Yes	N/A	None	Yes	Low
887-5984a	Two-hole bip	Ok		2	Yes	No	Would overlap if finished	No	Low
887-5984b	Two-hole bip	Ok; near spire		2	Yes	Yes	None	Yes	High
887-5984c	Two-hole bip	Ok		2	Yes	Yes	Overlap	Yes	Moderate
887-5984d	Two-hole bip	Ok		2	Yes	Yes	None	Yes	Moderate
887-5984e	Two-hole bip	Ok		2	Yes	Yes	Overlap	Yes	High
887-5984f	Two-hole bip	Ok		2	Yes	Yes	Overlap	Yes	High
887-5984g	Two-hole bip	Ok		2	Yes	No?	Overlap	Yes	Moderate
887-5984h	Two-hole bip	Ok; near suture		2	Yes	No	Near overlap	Yes	Low
887-5984i	Two-hole bip	Ok		2	Yes	No	None	Yes	Low
887-5984j	Two-hole bip	Ok		1	Yes	N/A	None	No	Moderate
887-5984k	Two-hole bip	Ok		1	Yes	N/A	None	No	Low
887-5984l	Two-hole bip	Ok; very small		1	No	N/A	At edge	Yes	Moderate
887-5984m	Two-hole bip	Ok		1	Yes	N/A	None	Yes	Low
887-5984n	Two-hole bip	Ok		1	Yes	N/A	Close to edge	Yes	Low
887-5984o	Two-hole bip	Ok		1	Yes	N/A	Close to edge	Yes	Low
887-5984p	Two-hole bip	Ok		1	Yes	N/A	Close to edge	Yes	Moderate
887-6009a	Two-hole bip	Ok		1	Yes	N/A	Close to edge	Yes	Moderate
887-6009b	Two-hole bip	Ok		1	No	N/A	None	Yes	Low
887-6009c	Two-hole bip	Ok		1	No	N/A	None	Yes	Moderate
887-6009d	Two-hole bip	Ok		2	Yes	Yes	None	Yes	High
887-6037a	Two-hole bip	Ok		2	Yes	No	None	Yes	Moderate
887-6037b	Two-hole bip	Ok		2	Yes	Yes	Near overlap	Yes	Moderate
887-6037c	Two-hole bip	Ok		1	Yes	N/A	None	Yes	Moderate
887-6037c	Two-hole bip	Ok		1	Yes	N/A	None	No	Moderate

Table 3 (continued)

Site and location	Artifact no.	Olivella wall artifact type	Perimeter chipping; blank selection	No. of perforations	First complete	Second complete	Drilling location error	Broken	Curvature of blank
	887-6037d	Two-hole bip	Ok	1	No	N/A	Close to edge	Yes	Low
	887-6073a	Two-hole bip	Ok	2	Yes	Yes; much smaller	None	No	Moderate
	887-6073b	Two-hole bip	Ok	2	Yes	Yes	Both close to edge	Yes	High
	887-6073c	Two-hole bip	Ok	2	Yes	Yes	Overlap and close to edge	Yes	Moderate
	887-6073d	Two-hole bip	Ok	1	No	N/A	None	Yes	Low
	887-6073e	Two-hole bip	Ok	1	No	N/A	At edge	Yes	Moderate
	887-6073f	Two-hole bip	Ok	1	Yes	N/A	At edge	Yes	High
	887-6073g	Two-hole bip	Ok	1	Yes?	N/A	At edge	No	Low
	887-6073h	Two-hole bip	Ok	1	Yes	N/A	Close to edge	Yes	Low
	887-6073i	Two-hole bip	Ok	1	Yes	N/A	Close to edge	Yes	High
	887-6073j	Two-hole bip	Ok; near base	1	No	N/A	At edge and angle	No	Low
	887-7518a	Two-hole bip	Ok	1	Yes	N/A	None	No	Moderate
	887-7518b	Two-hole bip	Ok	1	Yes	N/A	At edge	No	Low
	887-6145a	Two-hole bip	Ok	2	Yes	No	Overlap	Yes	Low
	887-6145b	Two-hole bip	Ok	1	Yes	N/A	Close to edge	Yes	High
	887-6145c	Two-hole bip	Ok	1	Yes	N/A	None	Yes	Moderate
	887-6145d	Two-hole bip	Ok	2	Yes?	No	None	Yes	Low

within carefully controlled stratigraphic excavations at houses 4 and 8 (see those marked “N/A” in “Second Complete” column). I infer the bead-makers’ *intent* to create two-hole beads by placing the first hole, in a calculated manner, off to one side (see Fig. 9, two specimens, far right).

Comparing the kinds of production errors evident among the multi-hole specimens at Shawa with those documented in the small Xaxas assemblage (Table 4), we find a lower proportion of shell *blank-selection errors* (about 6%) and a slightly higher proportion of *blank-chipping errors* (about 10%) at Shawa, but the incidences are small and no striking intersite or intrasite distinctions occur. The *breakage* rates are very high at all three houses: at Shawa, 117 of 148 specimens are broken (79%), very close to the 83% rate at Xaxas. So in these features, differences are minimal.

On the other hand, the rate of *incomplete first and/or second perforations* is comparatively higher at Shawa, reaching 96% at house 4 and 80% at house 8 (Table 4). The greatest difference is *between* the two Shawa households, looking at the second perforation data alone. At house 4, 86% (19 of 22) of the subset of specimens with an initiated second hole have incomplete ones, whereas at house 8, just 45% (13 of 29) do. Finally, notably lower rates of *drilling position errors* occur at Shawa (41% at house 4 and 53% at house 8) versus Xaxas (83%). A specific type of position error, the *overlapping perforation*, accounts for this disparity, as it occurs in high frequency at Xaxas (67%) and low frequency at Shawa (4% and 14% at the two houses). Most hole-location errors at Shawa are too close to blank edges or drilled at bad angles. Also, most specimens at Shawa are made on blanks with low or moderate curvature, whereas bead makers at Xaxas preferred curved blanks. Just one three-hole specimen has been found at Shawa.

Table 4 Summary of bead production features (analytic sample)

Production feature	Expectations if apprentice made	Expectations if expert made	SCRI-240 house 1 (n=12 (%))	SCRI-192 house 4 (n=78 (%))	SCRI-192 house 8 (n=70 (%))
A1. Substandard shell selected	Occasionally	Never	0	1	1
A2. Sub-optimal portion of shell selected	Occasionally	Rare	25	5	6
A3. Asymmetrical blank chipping	Common	Rare	8	12	7
A4. Poorly positioned 1st and/or 2nd perforation	High rate	Rare	83	41	53
A5. Blank too small	Occasionally	Rare	0	3	1
A6. Incomplete 1st and/or 2nd perforations	High rate	Rare	75	96	80
A7. Overlapping perforations	Common	Never	67	4	14
A8. Breakage	High rate	Common	83	78	80
A9. Specimens unfinished	High rate	Some	83	82	99

Discussion

Was This the Work of Apprentices? We find roughly one two-hole specimens for every 100 regular one-hole Olivella specimens in the Historic-era units at Xaxas where multi-hole variants occur (i.e., frequencies of Olivella two-hole wall bead variants in relation to one-hole Olivella wall beads in production and beads in the same proveniences constitute not more than 1% of that assemblage) and a few more at Shawa (about 2–10% of that assemblage). Considering the possibility that these specimens were the work of novices, we need to develop a context for evaluating the frequencies; currently we have none. Should there be more evidence of apprentice-produced errors than 1–10% of beads in production, or is this within an expectable range?

If these artifacts were the practice by-products of novices, and if the apprenticing process was short, then glaring errors and the drilling of multiple practice perforations could reasonably constitute a microscopically small percentage of preserved assemblages. Children were exposed to the bead-making process at a very young age, since this craft occurred ubiquitously around houses at most Island Chumash villages during the entire Late and Historic periods, based on voluminous archaeological data and Graesch's (2004) analysis. Children as young as ages 3 to 4 could have assisted by helping a parent collect Olivella shells along the sandy coves of western Santa Cruz Island and other locales where they were abundant. They may also have been encouraged to pick out the best fragments for conversion into blanks after adults split the shells. Splitting requires force and precision, and it is easy to waste shells through careless or poorly executed strikes, as our recent lab experiments show (Arnold and DiNapoli, unpublished data). Any able older child, however, could have quickly developed the proper approach to splitting after repeated observation, noting that the technique varies according to the wall or callus fragments to be isolated.

The later stages of bead production (perimeter chipping, drilling with dowel-hafted chert microdrills or iron needles post-1782 AD) required notable skill and coordination and were too difficult for children. Approaching adulthood, however, novice bead makers must have been allowed to execute these later steps, and perhaps they mastered perimeter preparation and drilling during a quick apprenticeship, given their years of exposure to the craft.

At Shawa, much more intensive bead-making activity occurred overall (Graesch 2004). One can envision an apprentice working with a mentor—and perhaps even a small group of apprenticing individuals working with a mentor—at both houses 4 and 8, each engaged in practice sessions amid a larger enterprise of intensive “real” production by the mentor. Since the strata in question at Shawa represent just 20 to 25 years in the early Historic period, we could indeed be witnessing only one or two generations of novice learning. In that case, the greater counts and proportions of rejected beads in production might correspond to more *apprenticing activity* and/or more *apprentices* at Shawa than at Xaxas. This is a reasonable interpretation in light of the intense focus on bead work there in contrast to the diverse range of activities (microdrill making, ornament making, bead making, trade) documented for house 1 at Xaxas (see Arnold 2001b).

Just as important, the striking ratio of multi-hole beads in production to finished multi-hole beads (around 150:1) at Shawa demands explanation (recall the ratio for Xaxas is close to 1:1). Ratios of regular Olivella beads in production to beads (ordinary single-hole specimens) are typically in the range of 1:1 to 4:1 at Santa Cruz Island bead-making communities (see discussion in Arnold and Graesch 2001). So, a 150:1 ratio is an obvious outlier.

High rates of mistakes and rejected beads could reflect inferior mentoring skills and/or lesser aptitudes of the apprentices at Shawa, but I find this implausible given the very fine work of the experienced bead makers at that village making bead blanks and *single-hole* unfinished and finished beads (Graesch 2004). The better interpretation may be the simplest one: that finished multi-hole specimens were never the objective, and the great counts of rejected multi-hole bips simply reveal intensive practice. In short, these represent a different phenomenon altogether.

Morphologically, the multi-hole specimens are consistent with the by-products of non-experts engaged in learning and practicing activities (see Tables 3 and 4). It seems fair to say that these villages were, in multiple senses, communities of *practice*. Of the nine production problems identified above, all are represented at some level—often very high levels—in the assemblages. Most beads in production reveal multiple perforation placement errors, incomplete perforations, overlapping drilling (probably deliberate reuse of a blank for practice), and breakage. Many of the beads in production also conform to my expectations regarding sub-optimal shell segment choices, blank asymmetries, and blank sizes.

Also as expected in the apprentice model, few specimens reached a finished, perimeter-ground state or circulated in the region. In the known population of these artifacts, ten (3%) are finished, and all were found at houses where they were made (most at house 1, Xaxas). The in-production specimens are different at various houses and sites, consistent with expectation A11, possibly reflecting different mentor training methods and different skill levels of apprentices. The disparity in rate of incomplete second perforations between houses 4 and 8 at Shawa strongly suggests different procedural choices or work habits.

I recently identified six red abalone multi-hole beads in production from house 4 at Shawa, and these also appear to be the mistakes of inexperienced shellworkers. I found that perforations were poorly placed, and importantly, *second holes were drilled even when the placement of the first had doomed the piece to failure*. Seemingly the only reason to drill a second hole would be to *practice drilling*. More and more it appears that the blank was a slate for practice. This constitutes independent support for the apprenticing hypothesis.

Was This the Work of Skilled Innovators? Can any case still be made that the low counts and rarity of these artifacts are consistent with what we would expect from the hands of innovators? Skilled practitioners might develop a new concept, make a few prototypes, funnel them to a high-status household (such as house 1 at Xaxas) to test interest, then abandon the idea and halt production when there is no demand. We would expect to find small numbers of multi-hole beads and beads in production at a narrow spectrum of households and in a narrow time frame. So far, so good, given the collection from Xaxas.

But the numbers at *Shawa* undermine this interpretation. Finished multi-hole Olivella beads are virtually absent in regional collections. We would not expect skilled shellworkers to have made thousands (including projected counts from contiguous, unexcavated site deposits) of badly failed specimens without leaving behind far more completed beads *somewhere*. Again, the ratios of beads to beads in production are notably out of whack with ratios of successfully finished *ordinary* Olivella beads to beads in production (and for that matter all other bead types of various materials that have been analyzed in the region; see Arnold and Graesch 2001:74–106).

Innovative work by expert craftspersons should have a morphological signature that reflects deliberate departure from production norms, accomplished with excellence. The production of multi-hole Olivella beads certainly represents a departure from norms. Do we find high-caliber production skills? In these assemblages, the three production steps that are most easily executed exhibit decent rates of success (Tables 3 and 4). Good quality shell material was selected 99% of the time; good portions of the wall were chosen in 149 of 160 cases (93%); and symmetrical perimeter chipping of the blanks occurs on 145 of 160 specimens (91%). None of the more challenging production quality expectations are met. Where we expect good success rates, we see low numbers. As discussed above, well-located perforations occur on half or fewer specimens, two perforations are completed on fewer than one quarter, and breakage during drilling was ubiquitous and often led to abandonment.

These specimens fail to reflect the skills or choices of master bead makers. Indeed, since it is clear that some of these perforations were drilled by iron needles, a tool that likely made bead making somewhat easier, it is all the more surprising that the perforation work was so ineffective. For a general discussion of Historic needle-drilling practices, see Graesch (2001:279–281).

As well, the expectation that specimens should be more or less the same across sites and households due to a small number of participants in the innovation is not supported. Notable differences occur in kinds and numbers of errors made at the two sites, particularly drilling location errors and perforation completion rates, and there are distinctions in intensity of production and the curvature of selected shell blanks. When we compile the data in a different way, by tallying all errors evident on each artifact, other inter-household differences emerge. For instance, artifact #880-9180 has two incomplete holes, a drilling angle error, a perforation position error, and a break (five errors); artifact #997-3327d has an incomplete second hole (one error). Error rates are lower at house 4 compared with houses 8 and 1. Higher proportions of specimens at house 4 display only single errors such as a break or one incomplete perforation, and drilling location mistakes are very low at house 4. At house 8, incomplete perforation errors are low, and even if the holes were badly positioned, and the piece was doomed to failure, the house 8 bead makers kept drilling. Overall, these material production distinctions appear consistent with the training of apprentices with a range of practices and aptitudes.

Conclusions

Some ambiguity remains in how best to interpret this multi-hole bead assemblage, although the compounded manufacturing errors and unusual ratio of incomplete to

complete specimens point strongly toward apprenticing activities embedded within the large bead-making enterprise, rather than the work of skilled experts. We must, however, acquire and assess comparable data from other California bead-making localities before settling on a single, rigid explanation, since this dataset could reflect evidence derived from either apprenticing alone or *both* innovating and apprenticing practices (Gero 2007). We certainly cannot yet clarify the participation of women, or men, or both, as the primary bead makers among the Island Chumash.

These data do effectively capture the participation of several sets of people at three island households who were significantly engaged in bead making and some of whom appear to have been learning the bead-making craft during the early Historic period. Bead making exhibits a high breadth of practice at selected Channel Islands villages. It was conducted by workers in virtually every household we have sampled—and training activity was situated, as predicted, in domestic contexts. It was primarily practiced near sandy beaches on the islands where participants had good access to the key raw materials. It appears to have been practiced year-round. Still, it was a very restricted craft. Certain other island villages participated notably less, and mainland villages did not participate at all in this huge bead-making enterprise that shaped Island Chumash life during the Late and Historic periods.

My final observation is that apprenticing activities should be evident in all periods and most bead-making sites. It is odd that the pattern as currently recognized is confined to the last half century or so of the thriving bead industry on the islands. A point to consider is that both experts and novices could have been better at the transfer of production knowledge in earlier periods, and their apprenticing errors are consequently more subtle and harder to identify. I also expect rejected or “practice” multi-hole specimens to appear at contemporaneous bead-making villages such as SCRI-328/330, where great numbers of Olivella and red abalone beads were made in the Late and Historic periods (Graesch 2004). Just two have recently been identified. Perhaps apprentices were trained there largely via other methods by mentors with distinct traditions. Further investigations into these issues at Pacific Coast sites are surely warranted, and I encourage scholars interested in how apprenticing and innovation are expressed in the material record to explore these phenomena.

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