

SEA FISHING AT SALANGO (MANABÍ PROVINCE, ECUADOR) DURING THE MIDDLE FORMATIVE MACHALILLA PHASE

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Formative Ecuadorian coastal societies possessed the technologies and skills necessary not only for fishing, but also for deep-sea navigation. Although marine shellfish are acknowledged as significant both for dietary and religious purposes, the importance of sea-fishing is rarely highlighted or explored. In order to help evaluate more fully the significance of the sea in the Ecuadorian Formative, this paper presents recently studied evidence, excavated at the Salango site, in the Province of Manabí, for local off-shore tuna fishing during the Middle Formative Machalilla phase (ca. 1500–900 B.C.), where Scombrids constituted 80 percent of recovered fish remains. The results are then compared with those obtained from other Machalilla sites. Finally, data from the subsequent Late Formative Engoroy phase (ca. 900–100 B.C.) indicate that while Scombrid fishing continued to predominate at Salango, species capture changed through time, with a shift from yellowfin tuna in the Machalilla phase to black skipjacks in Engoroy times. It is suggested that the decline in tuna capture reflects not so much change in fishing strategy as change in the populations of fish species reaching the local marine environment.

Las sociedades costeras del Formativo ecuatoriano poseyeron las tecnologías y las habilidades necesarias no sólo para la pesca, sino también para la navegación de altamar. Pero a pesar de que los recursos marinos se reconocen como significativos en relación a los aspectos dietéticos y religiosos, raramente se destaca o se explora la importancia de la pesca. Para evaluar con más claridad el valor y el significado del mar durante el período Formativo ecuatoriano, el presente trabajo aporta nuevas evidencias, excavadas en el sitio Salango, Provincia de Manabí, sobre la pesca de atún y especies afines durante la fase Machalilla (ca. 1500–900 a.C.). Se pone en evidencia una pesca de grandes peces pelágicos, donde los escómbridos constituyen el 80 por ciento de los restos de pescados recuperados. Luego, se comparan los resultados con aquellos obtenidos en otros sitios Machalilla del litoral ecuatoriano. Los grandes anzuelos circulares recuperados en los niveles Machalilla probablemente fueron utilizados para la pesca del atún. Para terminar, los datos de la siguiente fase a Engoroy (ca. 900–100 a.C.) indican que mientras la pesca de los Scombridae continuaba predominando en Salango, hubo un cambio en cuanto a la captura de especies: mientras el atún aleta amarilla predominaba en la fase Machalilla, fueron los barriletes negros los que prevalecieron en tiempos Engoroy. Se sugiere que la baja en la captura del atún no refleja un cambio en los patrones de pesca, sino más bien cambios en el comportamiento de los peces frente a la explotación.

The Ecuadorian coastal Formative is currently understood in terms of a complex process of uneven development contingent on a wide range of environmental and historical factors. Succeeding the Archaic Las Vegas culture (Stohtert 1985, 1988), it comprises early, middle, and late stages represented respectively by the Valdivia (4400–1450 B.C.), Machalilla (1450–800 B.C.) and Chorrera cultures (1300–300 B.C.) (Marcos 2003; Staller 2001; Zeidler 2003, 2008). The

principal pioneering study of Valdivia and Machalilla led to the initial conclusion that these sedentary pottery-making cultures were essentially supported by a sea-fishing economy (Meggers et al. 1965). Countering this interpretation, which not only based itself on a material sample derived principally from coastal sites, but also drew inspiration from a hypothesis of trans-Pacific origins for the Early Formative Valdivia, an alternative model of a tropical forest culture based on agriculture was

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then posited (Damp 1979; Lathrap et al. 1975). In an influential summary account, Lathrap made reference to the presence of sea-fish bones and shellfish at both shoreline and upriver inland sites, and placed Valdivia fishing with shell fishhooks in the context of a circum-Pacific tradition (Lathrap et al. 1975:19, 22f). Nonetheless, since then the value of the sea for Valdivia and Machililla has tended to be underexplored.

Early investigation of the Formative cultures of coastal Ecuador may indeed have been overly biased in favor of the more easily accessible shoreline sites (Marcos 2003:15). But while agriculture and hunting by land were clearly highly significant subsistence base components, there is ample evidence in favor of the importance of the sea as a source of food also (Stahl 2003; Staller 2001: 209–213). Indeed, study of pre-ceramic Las Vegas sites of the Santa Elena Peninsula shows that sea-fishing was a major subsistence activity well before Valdivia times (Stohtert et al. 2003).

In addition, it is clear that the sea was a fundamental cosmological symbol and source of sacred materials in the Formative (Stohtert 2003). Early Formative long-distance trade in *Spondylus* and *Strombus* shells and their incorporation in ritual offerings and iconography are attested most recently by finds at the Mayo-Chinchi site of Palanda, on the Atlantic watershed to the south of the Ecuadorian Andes (Valdez et al. 2005). By the time of the Spanish conquest, balsa raft navigation and long-distance maritime trade in *Spondylus* were to be defining characteristics of groups in the area (Anderson et al. 2007; Currie 1995a, 1995b; Marcos 1977–78, 1995; Marcos and Norton 1981, 1984; Norton 1986).

Meanwhile, the presence on La Plata Island of a Valdivia ceremonial structure with associated imported artifacts (Damp and Norton 1987; Marcos and Norton 1981) demonstrates not only that the skills and technology for deep-sea navigation were in place by the Early Formative, but that the sea itself had been claimed as an arena for religious practice. La Plata continued to be visited for ritual purposes by Machalilla people. By Late Formative times, mother-of-pearl fishhooks were being “sacrificed” and buried as offerings on the island, and images of fish were being crafted out of stone and buried at related mainland ceremonial sites (Lunniss 2008:Plate 7.12).

But while the coast of Ecuador is probably the best-known region of the country from an archaeological point of view (Meggers 1966; Raymond and Burger 2003), of its various precolumbian phases, the Machalilla culture has received relatively little attention. In particular, Machalilla subsistence resources have not been well studied—no published papers exist that treat the subject specifically, and few relevant data are to be found in theses, reports, or other general publications (e.g., Byrd 1976; Lippi 1983; Norton 1992; Sánchez Mosquera 1990, 1991; Stahl 2003).

One interesting exception is a report by Van der Merve et al. (1993) on an isotopic analysis of bone collagen from Machalilla human skeletons from the coastal site of Salango, in which it was concluded that diet was dominated by marine food with possibly some maize. The present analysis of fish remains recovered from the Machalilla levels at Salango now brings forward further evidence for the dietary importance of the sea, and provides the opportunity to investigate both Machalilla marine resource exploitation and its changes over time.

Archaeological Context: The Machalilla Culture and Salango

The Formative Period Machalilla culture principally occupied the central coastal strip of Ecuador, an area of dry scrub and deciduous tropical forest between the Río Chone (0° 36' S) and the Punta Arenas Peninsula (2° 44' S), during the period ca. 1450 B.C. to 800 cal B.C., with unattached settlement zones occurring also in the area of north Manabí and south Esmeraldas (Villalba et al. 2006), and in El Oro Province (Staller 2001; Zeidler 2003, 2008). Machalilla ceramics compare with those of the Cotacollao (Villalba 1988) and other highland sites, perhaps as the result of long-distance trade (Zeidler 2008:467).

First isolated at La Libertad on the Santa Elena Peninsula (Bushnell 1951), Machalilla was then defined and named after excavations at the type site at the modern fishing port of Machalilla (Estrada 1958; Meggers et al. 1965) (Figure 1). Various studies indicate that Machalilla developed directly out of the Early Formative Valdivia culture that preceded it, though its range is decidedly more restricted (Staller 2001; Zeidler 2008).

Machalilla has received much less attention than either Valdivia or the Late Formative Chorrera culture and its variants. This is in part due to the lesser frequency of Machalilla sites visited, though the chronological priority of Valdivia on the one hand, and the extraordinary brilliance and quantity of Chorrera ceramics (Cummins 2003; Lathrap et al. 1975) on the other, are also important factors.

Nonetheless, Machalilla is significant as an expression of sociocultural adaptation to the specific historical and ecological conditions of its time and place. In particular, its littoral range points to an orientation toward the sea and a likely heavy dependence on marine resource exploitation. Detailed studies of Machalilla fish remains can provide insights into the early history of this fishing specialization and coastal marine resources management.

Fieldwork since the initial definition of the Machalilla culture has been limited. But excavations have been carried out at an inland agricultural village at La Ponga (Lippi 1983) and at a fishing village on the shore at Salango (Norton et al. 1983); and sites ranging from small farms to villages of perhaps up to 6 hectares, have been documented through survey for the valleys of the Río Verde (Zeidler 1986) and the Río Valdivia (Schwarz and Raymond 1996).

While Machalilla evolved out of Valdivia, there were significant changes in settlement pattern and social structure (Zeidler 2008:467). In particular, no architecture has been discovered to date that might indicate the presence of ceremonial centers such as characterized Valdivia. However, a variety of archaeological features such as human burials, as well as artifacts such as small solid and large hollow ceramic figurines (Cummins 2003:Figure 7), and small quantities of obsidian and other semi-precious stones imported from the Ecuadorian highlands (Norton et al. 1983), constitute evidence for Machalilla religious beliefs and practices. The imported materials, of course, point to the existence of long-distance exchange networks, in which *Spondylus* and other locally gathered marine shells were most likely important outward-moving elements (Paulsen 1974).

Subsistence practices were based largely on agriculture (Pearsall 2003), hunting, and fishing (Stahl 2003), and appear to have been little different from those of the preceding Valdivia culture

(Staller 2001; Zeidler 2008). Small sets of fish remains are reported by Byrd (1976) for the La Carolina site, OGSE-46, at La Libertad (Bushnell 1951; Ferdon 1941), and for the Río Perdido site OGCh-20, in the Chanduy Valley (Lippi 1980). Lippi (1983) reported marine fish found at the inland La Ponga site. Sánchez Mosquera (1990, 1991; see also Cooke 1992) has presented data on the Machalilla fish remains for the Salango site; and Van der Merve et al. (1993) determined on the basis of an isotopic analysis of bone collagen from several Machalilla human burials at Salango that human diet was dominated by marine food.

Salango is a modern fishing community on the south coast of the Province of Manabí (Figure 1). A small but complex precolumbian site lies at the south end of its sandy bay, in an area now largely occupied by a fish-meal factory (Figure 2). Over the period from 1979 to 1989, detailed investigation there of a five meter deep sequence of cultural stratigraphy provided evidence of continuous occupation from Valdivia times in the late fourth millennium B.C. through to contact with the Spanish. One large component identified consisted of the remains of a Machalilla fishing village (Lunniss 2001:44–53; Norton et al. 1983). These Machalilla contexts overlay material relating to a small Valdivia settlement or camp, and were in turn succeeded by remains of a fishing village and then a ceremonial center of the Late Formative Engoroy culture, Engoroy (ca. 900–100 B.C.) being the local variant of Chorrera (Beckwith 1996; Lunniss 2001, 2008).

The Machalilla fishing village at Salango occupied an area of perhaps .75 ha and lay next to the beach at the base of the headland Punta Piedra Verde (Figure 3). It is represented by an approximately 75-cm thick sequence of dark grey to black sandy midden, with a base at a little over 3 m below present ground level, i.e., about 2 m asl. Occasional thin yellow clay layers are suggestive of prepared surfaces or floors, while post holes and linear features suggest house structures. Also encountered were 26 human burials, including both primary and secondary, single and multiple interments. Artifacts included abundant pottery fragments, stone and shell tools and ornaments, marine shells, and marine fish remains. Among the tools were found shellfish hooks, stone net sinkers, and a bone spearthrower hook.

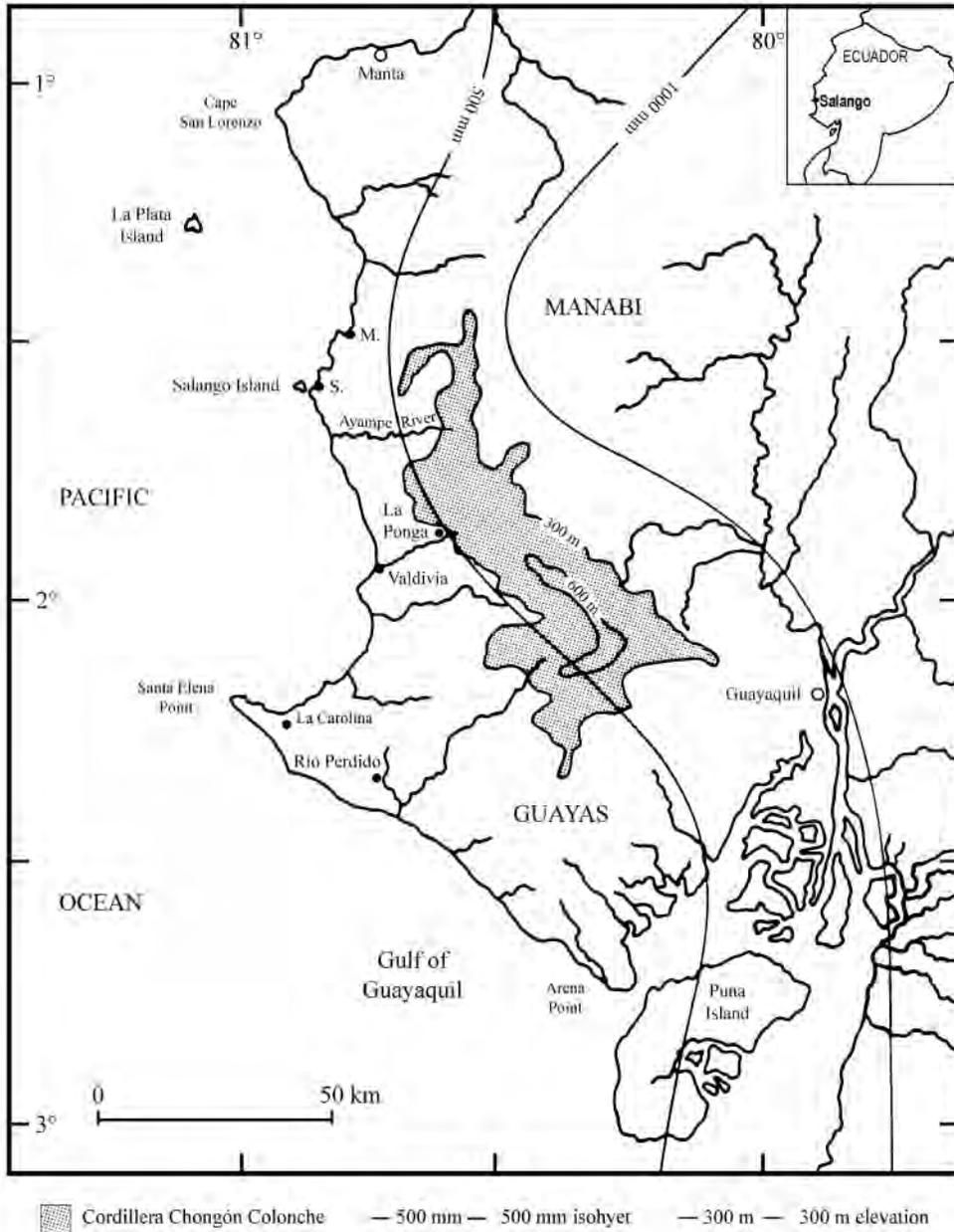


Figure 1. Map of southwestern Ecuador showing places mentioned in the text: M = Machalilla; S = Salango.

Ecological Context

Notwithstanding its position on the equator, Ecuador’s affinities are more tropical than equatorial, especially with regards to the two central coastal provinces of Manabí and Santa Elena. Due to the influence of the cold water coming from the

south, driven by the Peru or Humboldt Current, this part of the littoral is rather dry, with only one short rainy season. While the upper hill slopes support cloud forest, the lower elevations and beach zones are characterized by deciduous tropical dry forest and xerophytic vegetation (Lunniss 2008: 204–207). The mean annual precipitation on the



Figure 2. The southern part of Salango's bay, with the Punta Verde point and Salango island. The archaeological site lies under a fish-meal factory.

coast of Santa Elena and southern Manabí Provinces for the 1964–1993 period ranges between 260 and 360 mm (Figure 1). These values might be multiplied by ten or even more during El Niño years (Rossel et al. 1999). Most of the potable water is derived from the surrounding hills whose forests are sustained by *garúa* (foggy light rain).

The marine fauna mostly corresponds to that of the warm, low salinity water of the Tropical Eastern Pacific biogeographic realm (Béarez 1996). However Ecuador is situated in the southernmost part of this realm, next to the Warm Temperate Southeastern Pacific province. Indeed, the zone from Cabo San Lorenzo (1° S) to Punta Aguja (6° S, Peru), called the Gulf of Guayaquil sub-province (Jiménez-Prado and Béarez 2004) or Guayaquil ecoregion (Spalding et al. 2007), is an area of transition between the two larger biogeographic provinces. As the area of Salango is situated within this sub-province, it undergoes marked seasonal variations and is subject to high environmental variability, especially in relation with ENSO events (El Niño and La Niña), which periodically strongly affect the wildlife and the people living in the area. It is thus of special interest for studies of fish distribution and human adaptation to changing environments.

The marine fish biodiversity of Ecuador is high, with 784 species recorded for the continental (i.e., excluding Galápagos) waters (Jiménez-Prado and

Béarez 2004). Productivity is also high due to upwelling and the influence of the nearby Humboldt Current ecosystem (Bakun and Weeks 2008), one of the richest of the world (Carr 2002). The main fish species landed along the Manabí and Santa Elena coast are, for the demersal (bottom dweller) or benthopelagic group: cusk eel or *corvina de roca* (*Brotula clarkae*, Ophidiidae); snook or *robalo* (*Centropomus* spp., Centropomidae); grouper or *cherna* (*Mycteroperca xenarcha*), rock bass or *perela* (*Paralabrax callaensis*), sand perch or *camotillo* (*Diplectrum* spp., Serranidae); tilefish or *cabezudo* (*Caulolatilus* spp., Malacanthidae); snapper or *pargo* (*Lutjanus* spp., Lutjanidae); and weakfish or *corvina* (*Cynoscion* spp., Sciaenidae). Coastal pelagic fishes are represented by amberjacks or *huayaipes* (*Seriola* spp.), jacks or *burro*, *caballa* (*Caranx* spp.) and lookdown or *caras* (*Selene* spp., Carangidae); while small pelagic species consist mainly in thread herring or *pinchagua* (*Opisthonema* spp., Clupeidae). The large pelagic (open ocean) fishes include wide ranging dolphinfish or *dorado* (*Coryphaena hippurus*, Coryphaenidae); yellowfin tuna or *albacora* (*Thunnus albacares*) and skipjack tuna or *barrilete* (*Katsuwonus pelamis*, Scombridae); and sailfish or *banderón* (*Istiophorus platypterus*, Istiophoridae). All these species are typical inhabitants of the tropical eastern Pacific.

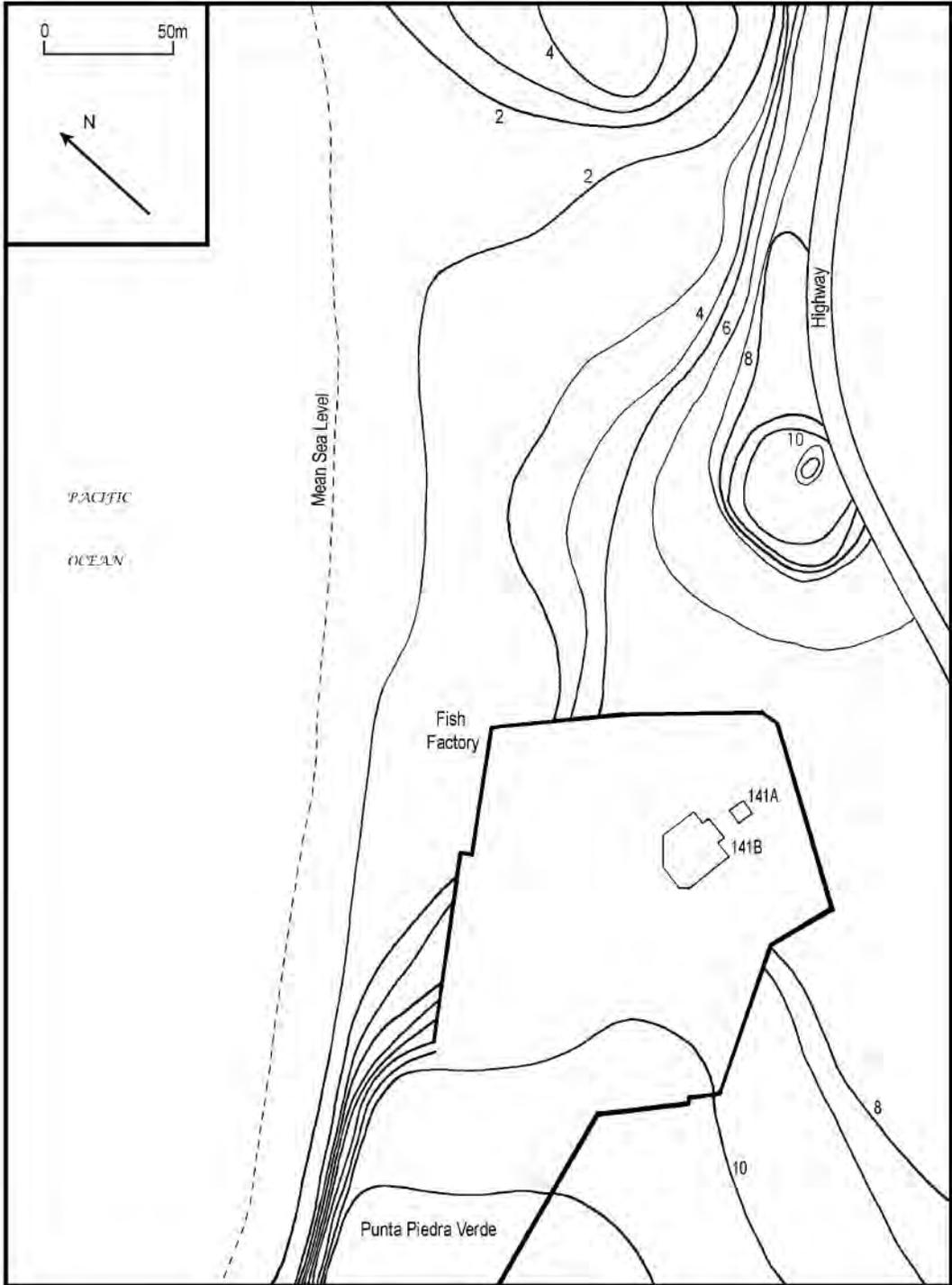


Figure 3. Place of excavation, Salango 141A.

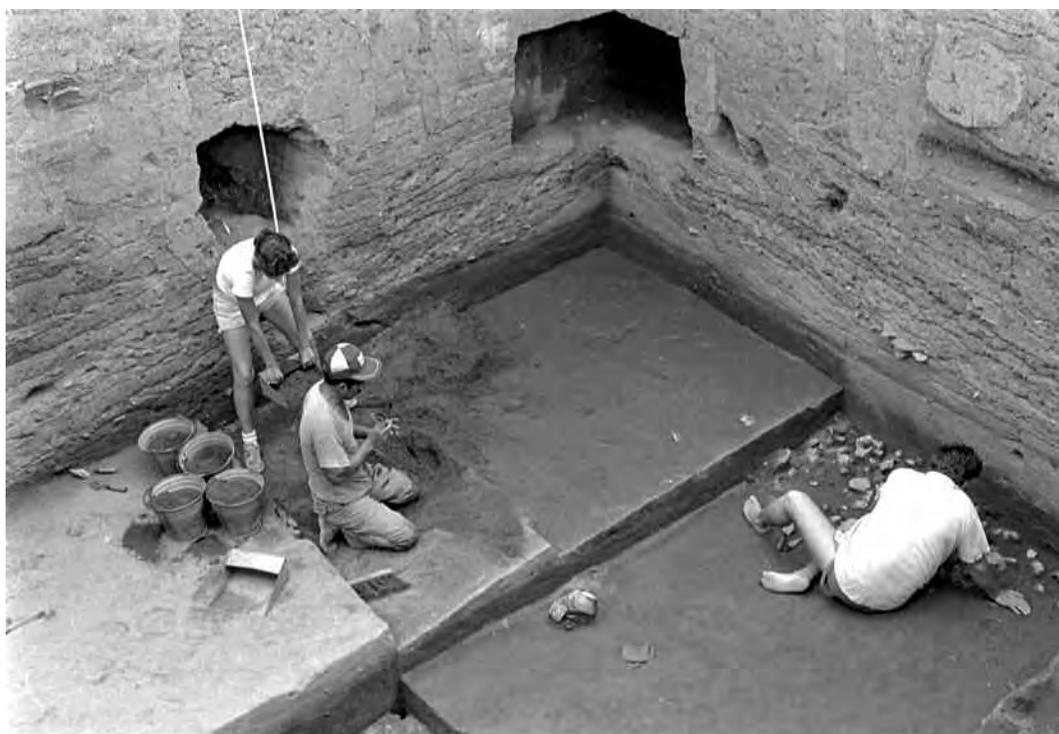


Figure 4. Sector 141A of the Salango site in 1982: excavation of the base of the Machalilla layers (corner = 2x3 m unit A82), with Valdivia material appearing beneath (unit B82).

Material and Methods

Investigation of the Machalilla levels at Salango was achieved mainly in sector OMJPLP-141A during the early months of 1982.¹ This 6 m by 6 m sector was divided into 6 units, each of 2 m by 3 m, designated units A82, B82, C82, D82, E82 and H82 (Figures 4 and 5). Full analysis of the Machalilla contexts still has to be carried out. Meanwhile, for the purposes of this paper and in order to gain an overview of the stratigraphic sequence for the area as a whole, the levels excavated in those six units were correlated on the basis of soil descriptions, levels, and other observations recorded in the field notes.² It is also worth noting that the dark gray to black sandy layers of the Machalilla village were clearly different, both from the relatively sterile clay sands of the underlying Valdivia occupation and from the overlying yellow clay Engoroy floors.

The resulting interpretative scheme was a sequence of 11 main layers that broadly fell into two stages. A lower, earlier stage is represented by four layers with an overall depth of about 25 cm,

and a higher, later stage is represented by seven layers totaling about 50 cm deep. The results of an unpublished study (Everett ca. 1990) of the pottery suggest that there were gradual transitions first from Valdivia into Machalilla, and then from Machalilla into the succeeding Engoroy phase.³ The Salango sequence probably corresponds, then, to the entire span of Machalilla history.

Eight samples of charcoal and human bone taken from one midden layer and seven human graves cut into those layers were assayed in 1982 at Cambridge (UK). The results, unfortunately, have never been published or given official laboratory numbers. However, following calibration with the OxCal Program v3.9 (Bronk Ramsey 1995, 2001), their combined ranges at 68 percent probability are 1520–1010 cal B.C., and at 95.4 percent probability, 1610–970 cal B.C. (Table 1). It is interesting that these results suggest start and end dates slightly earlier than those proposed by Zeidler (2003). Further analysis is required before these differences can be properly assessed.

The sample consisted initially of all fish bones recovered from layers excavated within the 6 units

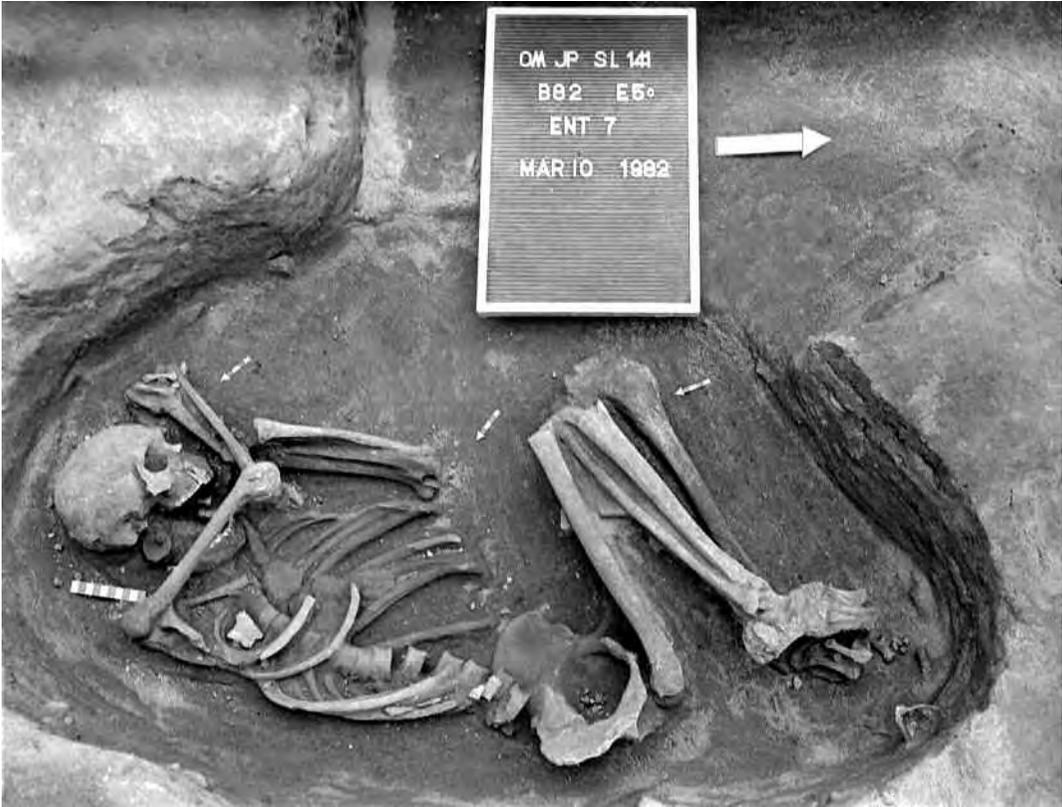


Figure 5. Machalilla burial No. 7 from unit B82 of sector 141A, Salango.

of sector OMJPLP-141A. Material recovered from features such as burials and other pits was not included in the study. These bones, along with all other excavated materials and the field register, are stored in the Centro de Investigaciones y Museo Salango (CIMS). All excavated deposits were sieved in the field with a ¼ inch mesh, but in the laboratory all bone remains were sieved again with a 3 mm mesh prior to examination, to eliminate small unidentifiable fragments, and only the frac-

tion over 3 mm was finally included in the study. The sample was then organized for analytical purposes according to the two-stage stratigraphic scheme earlier developed.

Fish identifications were carried out at CIMS using the reference collection housed there. All fish bones were counted and weighed. Numbers of identified specimens (NISP) and element weights were used as indicators for relative abundance. The estimate of the Minimum Number of Individuals

Table 1. Radiocarbon Dates from Machalilla Contexts at OMJPLP-141A, Salango.

Lab #	Context	Uncalibrated RCYBP	68.2% (cal B.C.)	95.4% (cal B.C.)
S-9	Ent 6	2910 ± 40	1210-1010	1260-970
S-6	Ent 2	2990 ± 40	1310-1120	1380-1050
S-8	Ent 5	3010 ± 40	1370-1130	1390-1120
S-7	Ent 4	3025 ± 40	1380-1130	1400-1120
S-10	Ent 7	3050 ± 40	1390-1260	1410-1130
S-12	Ent 13	3080 ± 40	1410-1260	1440-1210
S-11	Ent 10/11	3165 ± 40	1500-1400	1520-1310
S-13	CD82 N17/18	3200 ± 50	1520-1425	1610-1320

Note: Ent 6 = Burial 6 ; CD82 N17/18 = Unit CD82, Level 17-18.

(MNI) was not performed, as a relatively high abundance of vertebrae (79.2 percent of NISP) would render its application overly uncertain.⁴ Also, the MNI calculation strongly relies on the stratigraphic scheme adopted (Grayson 1984:91) while NISP would remain unchanged in case of level/phase rearrangement. Size estimates were carried out through direct comparison with the specimens of the reference collection, which contains several specimens for each taxon. Approximate average weights were calculated for the ten best-represented taxa on the basis of these estimates, assuming that, statistically, all sizes were equally represented in terms of NISP inside each given taxon.

Several diversity indices were calculated to measure the biodiversity represented in the different stratigraphic levels (Cruz-Urbe 1988). They are here based solely on taxa identified to species level. First, species richness (S) is the number of different species in the sample. Diversity is then quantified through the Shannon index H' , where p_i is the relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the sample.

$$H' = -\sum p_i \text{Log } p_i$$

When all species are present in equal numbers,

$$H' = H_{\max} = \ln S.$$

Third, equitability (E) evaluates the manner in which individuals are distributed among the different species.

$$E = H'/H_{\max}$$

Equitability assumes a value between 0 and 1 with 1 being complete evenness.

Two main categories of fish defined by habitat and behavior will be considered from here on:

- Demersal fish that live close to the bottom and generally feed on it;
- Pelagic fish that live in the upper waters or in the water column of the open sea.

Results

A total number of 92,322 fish bones, weighing 40,855.7 g, were examined. Of these, 31,396 could be identified to family (except for sharks and rays), with a large majority taken to species level (82 per-

cent of NISP). This gives a rather good identification ratio of 34 percent, partly due to the abundance of scombrid vertebrae, which are easily recognizable (Figure 6). Proportions of vertebrae are very high among identified scombrid remains, but similar in both levels: 11,128 (83.2 percent) in the lower level, 9,959 (86.1 percent) in the upper level.

Almost all the identified taxa are bony fishes belonging to 30 families, 61 genera, and at least 73 species (Table 2). Three families represent 90 percent of the fish remains identified: the Scombridae with 79.4 percent, the Carangidae with 6.1 percent, and the Tetraodontidae with 4.4 percent. Cartilaginous fishes are almost entirely absent, being represented by only 12 elements, one from a ray and 11 from sharks.

The scombrids strongly dominate, and are themselves mainly represented by the yellowfin tuna, the black skipjack (*Euthynnus lineatus*), and the skipjack tuna (Table 3). These pelagic species are known to swim together in multi-species schools, and might have been fished simultaneously.

Among the other important families (> 1 percent NISP), we find both pelagic and demersal fishes. Jacks or lookdown (carangids) and needlefish (belonids) are coastal pelagic fishes, generally living inshore and forming small to big schools, as is the case for *Selene brevoortii*, *Caranx caballus*, *Caranx caninus*, and *Strongylura exilis*. Puffer fish (tetraodontids) are soft-bottom dwellers in shallow water living generally in small groups. Tilefishes (malacanthids) and snappers (lutjanids) are bottom dwellers, the former over soft bottoms at a depth of at least 30 m, the latter mostly over reefs and rocky substrates, from 3 to 60 m.

Since the three main species, yellowfin tuna, black skipjack and skipjack, count for 96.5 percent of all the identified scombrids, we will focus on the Thunnini tribe, which also includes the *Auxis* species. Of the latter, two are present in Ecuadorian waters (Jiménez-Prado and Béarez 2004), and are also probably present in the archaeological samples, but only frigate tuna (*Auxis thazard*) could be identified with certainty.

A closer look at the distribution of NISP in the two different sequences (Tables 2 and 3) reveals some overall tendencies towards change:

- the proportion of scombrids among total NISP increases through time (early to late): the pro-



Figure 6. Vertebrae of scombrids from the Salango archaeological site.

portion of scombrids in the upper level (83 percent) is significantly higher than that of the lower level (76.5 percent; standardized data = $z = 14, p < .000$). This figure is also statistically true within individual units, except for D82 (Figure 7);

- among identified Thunnini scombrids, *T. albacares* and *E. lineatus* increase with time, while *K. pelamis* and *Auxis* spp. decrease (Figure 8). The proportions are significantly different within all four species ($z > 3.9, p < .000$).

At this stage, the low precision of our method for estimating size does not allow a comparison between the two stages, early and late (Table 4). Allometric estimates of original live weight and size are meanwhile being conducted. The most abundant species, the yellowfin tuna, is also the one that grows bigger, and hence contributes the largest quantity of available meat. The wide range in size of the different species caught likely indicates the use of a large set of fishing gears: hooks of different sizes and gill nets of different mesh sizes.

The biodiversity among the two samples is not very high, but this is partly due to a bias in the sample in which the abundance of a few species (scombrids) drags down the index value (Table 5). Equitability is also rather low. Nevertheless, diversity is higher during the early stage of the sequence. Likewise, some taxa, for example surgeonfishes (acanthurids), needlefishes, jacks, tilefishes, and puffers (tetraodontids), are much more abundant in the early stage (Table 2).

Discussion

The faunal lists published to date (Byrd 1976; Lippi 1983; Sánchez Mosquera 1991) indicate that marine resources were of primary importance and that the consumption of scombrids was a common trait among Machalilla people north of the Santa Elena Peninsula. Nevertheless, ariids (marine catfishes) rather than scombrids are the dominant fish at sites close to or east of the Santa Elena Peninsula, La Carolina and Río Perdido, as is observed also for the Valdivia period occupation (Byrd 1976).

Table 2. Distribution of Taxa Among the Fish Fauna Recovered at Site 141a. Families Ordered by Rank of Importance.

Taxa	NISP				Grand Total	% Total ID	
	Lower level	% Total ID	Upper level	% Total ID			
Scombridae	<i>Auxis thazard</i>	224	1.28	14	.10	238	.76
	<i>Auxis</i> spp.	240	1.37	77	.55	317	1.01
	<i>Euthynnus lineatus</i>	3436	19.67	4194	30.10	7630	24.30
	<i>Katsuwonus pelamis</i>	2569	14.71	1254	9.00	3823	12.18
	<i>Sarda orientalis</i>	1	.01	6	.04	71	.23
	<i>Scomberomorus sierra</i>	100	.57	97	.70	197	.63
	<i>Thunnus albacares</i>	4927	28.21	4697	33.71	9624	30.65
	UID	1870	10.71	1227	8.81	3097	9.86
Carangidae	<i>Alectis ciliaris</i>	0	.00	2	.01	2	.01
	<i>Caranx caballus</i>	273	1.56	105	.75	378	1.20
	<i>Caranx caninus</i>	281	1.61	174	1.25	455	1.45
	<i>Caranx otrynter</i>	60	.34	30	.22	90	.29
	<i>Caranx</i> spp.	50	.29	16	.11	66	.21
	<i>Chloroscombrus orqueta</i>	1	.01	1	.01	2	.01
	<i>Decapterus</i> spp.	2	.01	0	.00	2	.01
	<i>Elagatis bipinnulata</i>	1	.01	0	.00	1	.00
	<i>Selene brevoortii</i>	363	2.08	281	2.02	644	2.05
	<i>Selene peruviana</i>	17	.10	4	.03	21	.07
	<i>Selene</i> spp.	65	.37	59	.42	124	.39
	<i>Seriola rivoliana</i>	5	.03	0	.00	5	.02
	<i>Seriola</i> spp.	0	.00	2	.01	2	.01
	<i>Trachinotus kennedyi</i>	10	.06	6	.04	16	.05
	<i>Trachinotus rhodopus</i>	32	.18	16	.11	48	.15
	<i>Trachinotus</i> spp.	4	.02	5	.04	9	.03
UID	38	.22	23	.17	61	.19	
Tetraodontidae	<i>Spherooides</i> spp.	987	5.65	406	2.91	1393	4.44
Malacanthidae	<i>Caulolatilus affinis</i>	545	3.12	304	2.18	849	2.70
Belonidae	<i>Ablennes hians</i>	2	.01	0	.00	2	.01
	<i>Strongylura exilis</i>	240	1.37	130	.93	370	1.18
	<i>Tylosurus</i> spp.	75	.43	51	.37	126	.40
UID	22	.13	4	.03	26	.08	
Lutjanidae	<i>Hoplopagrus guentherii</i>	1	.01	0	.00	1	.00
	<i>Lutjanus aratus</i>	3	.02	0	.00	3	.01
	<i>Lutjanus argentiventris</i>	16	.09	8	.06	24	.08
	<i>Lutjanus guttatus</i>	170	.97	228	1.64	398	1.27
	<i>Lutjanus novemfasciatus</i>	1	.01	0	.00	1	.00
	<i>Lutjanus peru</i>	1	.01	0	.00	1	.00
	<i>Lutjanus</i> spp.	46	.26	25	.18	71	.23
Haemulidae	<i>Anisotremus interruptus</i>	24	.14	11	.08	35	.11
	<i>Anisotremus</i> spp.	4	.02	1	.01	5	.02
	<i>Haemulon steindachneri</i>	4	.02	1	.01	5	.02
	<i>Haemulon</i> spp.	2	.01	0	.00	2	.01
	<i>Haemulopsis</i> spp.	2	.01	1	.01	3	.01
	<i>Orthopristis chalceus</i>	9	.05	0	.00	9	.03
	<i>Pomadasys branickii</i>	1	.01	1	.01	2	.01
	<i>Pomadasys</i> spp.	4	.02	0	.00	4	.01
UID	113	.65	59	.42	172	.55	
Acanthuridae	<i>Acanthurus xanthopterus</i>	17	.10	0	.00	17	.05
	<i>Prionurus lacticlavius</i>	158	.90	52	.37	210	.67
	UID	6	.03	0	.00	6	.02
Serranidae	<i>Dermatolepis dermatolepis</i>	1	.01	0	.00	1	.00
	<i>Diplectrum maximum</i>	1	.01	0	.00	1	.00
	<i>Epinephelus analogus</i>	9	.05	2	.01	11	.04
	<i>Epinephelus itajara</i>	4	.02	5	.04	9	.03
	<i>Epinephelus labriformis</i>	22	.13	7	.05	29	.09

Table 2. (continued) Distribution of Taxa Among the Fish Fauna Recovered at Site 141a.
Families Ordered by Rank of Importance.

Taxa	NISP				Grand Total	% Total ID	
	Lower level	% Total ID	Upper level	% Total ID			
	<i>Epinephelus</i> spp.	33	.19	23	.17	56	.18
	<i>Hemanthias</i> spp.	1	.01	0	.00	1	.00
	<i>Mycteroperca xenarcha</i>	60	.34	31	.22	91	.29
	<i>Paralabrax callaensis</i>	3	.02	3	.02	6	.02
	UID	12	.07	16	.11	28	.09
Triglidae	<i>Prionotus ruscarius</i>	0	.00	1	.01	1	.00
	<i>Prionotus stephanophrys</i>	54	.31	59	.42	113	.36
Sparidae	<i>Calamus brachysomus</i>	51	.29	47	.34	98	.31
Ariidae	<i>Arius</i> spp.	33	.19	44	.32	77	.25
	<i>Bagre</i> spp.	5	.03	3	.02	8	.03
Labridae	<i>Bodianus diplotaenia</i>	32	.18	33	.24	65	.21
	<i>Halichoeres nicholsi</i>	0	.00	2	.01	2	.01
Sciaenidae	<i>Cynoscion</i> spp.	2	.01	0	.00	2	.01
	<i>Micropogonias altipinnis</i>	16	.09	19	.14	35	.11
	<i>Umbrina dorsalis</i>	1	.01	0	.00	1	.00
	<i>Umbrina xanti</i>	7	.04	0	.00	7	.02
	UID	5	.03	3	.02	8	.03
Balistidae	<i>Balistes polylepis</i>	23	.13	16	.11	39	.12
	<i>Pseudobalistes naufragium</i>	6	.03	4	.03	10	.03
Coryphaenidae	<i>Coryphaena hippurus</i>	9	.05	15	.11	24	.08
Diodontidae	<i>Diodon</i> spp.	9	.05	6	.04	15	.05
Scaridae	<i>Scarus perrico</i>	7	.04	2	.01	9	.03
	UID	5	.03	0	.00	5	.02
Selachimorpha		6	.03	5	.04	11	.04
Pomacanthidae	<i>Holacanthus passer</i>	5	.03	2	.01	7	.02
Ephippidae	<i>Chaetodipterus zonatus</i>	6	.03	0	.00	6	.02
Muraenidae	<i>Muraena</i> spp.	4	.02	2	.01	6	.02
Cirrhitidae	<i>Cirrhitus rivulatus</i>	1	.01	2	.01	3	.01
Kyphosidae	<i>Kyphosus</i> spp.	1	.01	0	.00	1	.00
	<i>Sectator ocyurus</i>	2	.01	0	.00	2	.01
Nematistiidae	<i>Nematistius pectoralis</i>	0	.00	3	.02	3	.01
Elopidae	<i>Elops affinis</i>	2	.01	0	.00	2	.01
Scorpaenidae	<i>Scorpaena</i> spp.	1	.01	1	.01	2	.01
Sphyraenidae	<i>Sphyraena ensis</i>	1	.01	1	.01	2	.01
Uranoscopidae	<i>Astroscopus zephyreus</i>	0	.00	2	.01	2	.01
Mugilidae	<i>Mugil</i> spp.	1	.01	0	.00	1	.00
Pomacentridae	<i>Microspathodon dorsalis</i>	1	.01	0	.00	1	.00
Batoidimorpha		0	.00	1	.01	1	.00
Total		17464		13932		31396	
Osteichthyes	UID	32637		28289		60926	
Grand Total		50101		42221		92322	

At La Ponga, a site situated 15 km inland, there is a preponderance of scombrids, suggesting a marked degree of dietary selectivity (Lippi 1983:184–185). The fish remains were only rarely identified to the level of species, making it difficult to assess the results. Nevertheless, the author mentions an interesting pattern, with *Euthynnus* spp. (probably including both black skipjack and skipjack tuna) confined to lower levels (early to

middle Machalilla) and *Acanthocybium solandri*, the wahoo, confined to upper levels (middle to late Machalilla). The wahoo remains in a late Machalilla context at the La Ponga site encouraged Lippi (1983:374) to suggest that the Equatorial Countercurrent may have shifted farther south during that period, not only resulting in more humid terrestrial conditions but also encouraging the presence of wahoo, a warm-water species.

Table 3. NISP and Proportions of the Different Species of Scombrids.

Taxa	Lower level	%	Upper level	%	Grand Total	%
<i>Thunnus albacares</i>	4927	42.85	4697	45.43	9624	44.07
<i>Euthynnus lineatus</i>	3436	29.89	4194	40.56	7630	34.94
<i>Katsuwonus pelamis</i>	2569	22.34	1254	12.13	3823	17.51
<i>Auxis</i> spp.	464	4.04	91	.88	555	2.54
<i>Scomberomorus sierra</i>	100	.87	97	.94	197	.90
<i>Sarda orientalis</i>	1	.01	6	.06	7	.03
<i>Scombridae</i> UID	1870		1227		3097	
Total	13367		11566		24933	

Note: represents the percentage of identified scombrids.

Table 4. Estimation of Weight (total live weight in g) from the Remains of the Ten More Abundant Taxa.

Taxa	Total NISP	Minimum size	Maximum size	Average size
Yellowfin tuna (<i>T. albacares</i>)	9624	500	60000	10700
Black skipjack (<i>E. lineatus</i>)	7630	300	9500	3300
Skipjack tuna (<i>K. pelamis</i>)	3823	200	12000	2600
Puffer fish (<i>Sphoeroides</i> spp.)	1393	200	4000	1100
Tilefish (<i>Caulolatilus affinis</i>)	849	250	3000	1200
Lookdown (<i>Selene brevoortii</i>)	644	200	1000	500
Crevalle jack (<i>Caranx caninus</i>)	455	400	16000	3300
Rose snapper (<i>L. guttatus</i>)	398	250	7000	1500
Green jack (<i>Caranx caballus</i>)	378	100	2800	700
Needlefish (<i>Strongylura exilis</i>)	370	-	2000	-

Table 5. Diversity Indices among Early and Late Machalilla Samples.

	Abundance	Species richness	Shannon index	Equitability
Early Machalilla	13816	55	1.927	.481
Late Machalilla	11872	43	1.637	.435

Note: Abundance represents the total number of individuals of all identified species.

The presence of the wahoo is in fact surprising as this species is rarely abundant in the area, either in modern landings or in archaeological material. All scombrids occurring today in Ecuador are normally present in the entire tropical eastern Pacific, from California to Peru. During ENSO episodes (El Niño, La Niña), some changes in oceanic distribution patterns of tunas occur (De Anda-Montañez et al. 2004), but too little is known about wahoo, not considered a commercial species, to allow an assessment of its behavior in relation to ENSO. Hence any explanation of the presence/absence of one of the scombrid species that relies on climate warming or El Niño events is likely to be unsustainable.

Meanwhile, skipjack tuna and yellowfin tuna both occur in large schools in oceanic waters and are cosmopolitan in tropical and subtropical seas

(Collette and Nauen 1983). Black skipjack form schools in coastal waters and around offshore islands, but are also found in oceanic waters. The wahoo, in turn, is a cosmopolitan warm-water species usually found well offshore, but frequently taken around islands, or as close as 8 to 10 km from land (Iversen and Yoshida 1957). This last species, however, is solitary or tends to form small, loose aggregations, and is never abundant. A very interesting testimony about wahoo, made by C. M. Breder, Jr., in December 1942 (non-El Niño year), is quoted by Nichols and Murphy (1944): "Common [at La Plata Island, Ecuador]. Frequently seen at the surface in schools of up to about eight, with dorsal and upper caudal lobe protruding through surface. At a little distance they look somewhat shark-like in this aspect. Generally of large size." Today La Plata Island is still a good fishing spot for wahoo.

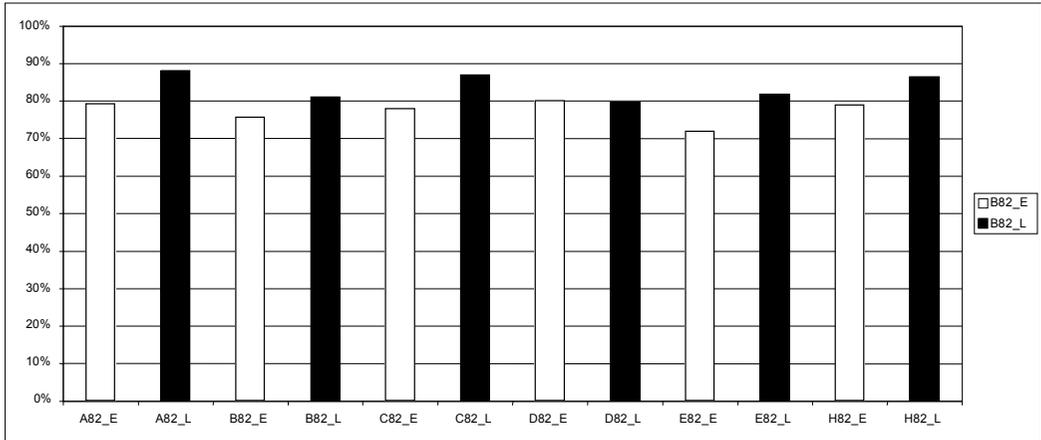


Figure 7. Evolution of scombrids proportions (E for early; L for late).

It is interesting then that just in front of Valdivia, downriver from La Ponga, lies a small island called “El Pelado,” at ca. 7 km from the mainland. Did the wahoo frequent this island as it does now at La Plata? The wahoo is a fast swimmer and strong fighter usually caught by trolling, a technique evidently not reliable for precolumbian fishing. Breder might also give a clue for this aspect: as the wahoo swim close to the surface it might be possible to harpoon it. Harpooning has already been documented for scombrids (Crockford 1994). Byrd (1976), in her extensive diachronic review of the archaeofauna of the Southwest Ecuador sites, does not report any bone of wahoo—neither do we at Salango (Béarez 1996; present study), or Reitz and Masucci (2004) at El Azúcar for the Guangala period. We thus suggest that La Ponga people deliberately selected wahoo for their use, and that the fishermen, likely from Valdivia, knew the specific place and technique to catch them in order to satisfy that requirement.

At Salango, Sánchez Mosquera (1991) also determined that scombrids predominated among the material from unit C of site 141A. She stated that *Euthynnus lineatus*, *Thunnus albacares*, and the Pacific crevalle jack (*Caranx caninus*) were the most represented fish species in the unit C sample. Our results both confirm and establish more precisely the importance of fishing for pelagic species. As Salango is a coastal site, situated on the beach, its faunal remains cannot be interpreted as the result of selection of supplied fishes, as is

inferred for La Ponga (Lippi 1983). The three more abundant species at Salango are all scombrids (Table 4), and tunas were clearly the major source of fish protein for Machalilla people. This picture rather suggests selective fishing. It is worth mentioning here that yellow-fin tuna, black skipjack, and skipjack frequently tend to school together (Collette and Nauen 1983), a fact that might explain the dominance of this trio among captures. This is confirmed by the low frequency in the sample (Table 3) of the Pacific sierra (*Scomberomorus sierra*), a near-shore pelagic schooling scombrid, common in modern local fisheries, but which does not mix with Thunnini. It is not clear whether it was less present during the Machalilla period or was simply neglected.

Fishing was not directed exclusively toward specific pelagic fishes, however, as is demonstrated by the presence of many demersal fishes and the huge diversity of taxa. Among the demersal shorefishes, the contribution of pufferfishes (4.4 percent of NISP) is noteworthy and raises questions, even if we consider that they may be overrepresented due to the preferential survival of their robust premaxilla and dentary bones. The tetraodontids and their main local representatives, the “tambuleros” (*Sphoeroides* spp.), are known to be toxic (Goe and Halstead 1953, Núñez-Vázquez et al. 2000). However the biotoxins are concentrated in the internal organs, mostly the liver (Núñez-Vázquez et al. 2000), and the skin, hence it is likely that pufferfish were very carefully pre-

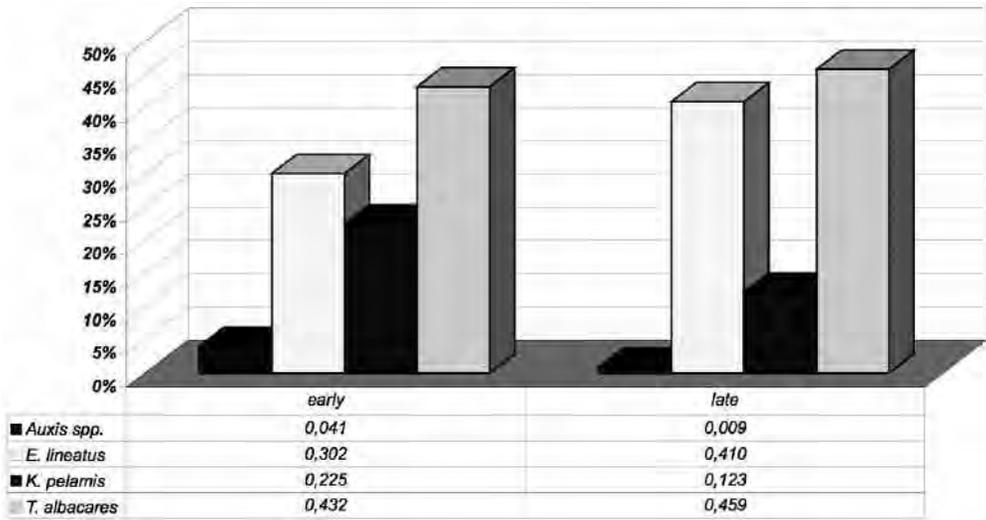


Figure 8. Evolution of Thunnini species proportions from early to late stages.

pared before use for human consumption (Béarez 1996; Cooke 1992).

While it is open to debate whether tuna and non-tuna fishing were practiced differently, several arguments lead us to think this in fact to have been the case. First, many of the taxa represented have very different patterns of ecological behavior. For example, if we consider tilefishes (demersal, depth > 30 m), pufferfishes (demersal, 0–10 m), and needlefishes (subsurface pelagic), it would be impossible to fish them all at once. Second, the fishing artifacts retrieved in the different layers of the excavation are mainly shellfish hooks, and these could not explain all the catches (e.g., pufferfishes, surgeonfishes, parrotfishes would hardly be able to take a baited hook).

Made of pearl oyster shell (*Pinctada mazatlanica*) hooks are almost circular but have different diameters and thickness (Figure 9). Some are especially thick and seem to be characteristic of the Machalilla period (Lippi 1983:203; Meggers 1966:48). These circular hooks were probably used without adding bait, their bright shine acting as a lure. However, some artifacts that have not been preserved, like feathers or vegetal or textile fibers, might have been added just above the hooks, on the line, to enhance the attractiveness of the lure. The circular form makes them act by rotating, once swallowed, and then grabbing the gill arches rather than the jaws (Garanger 1965). Furthermore, the points of the bigger hooks retrieved were cut and

polished smooth (Figure 9), indicating that they probably would not be intended to pierce the flesh of the fish.

Obviously, hook size relates to the size and the kind of prey one wants to catch (see Allen 1996), and circular fish-hooks with a big gap between hank and point might have been large and thick enough to catch big tunas in the size range of 20 to 60 kg. Other large carnivore fishes might have been caught with those large hooks, but their remains are rare: for example, only nine bones of the big grouper *Epinephelus itajara* were identified. We suppose, then, that large hooks were mostly designed to catch large scombrids.

Lathrap et al. (1975) mention a pair of harpoon barbs of bone from an unknown Machalilla site. No harpoon or composite fishhook has been recovered at Salango, but one bone spearthrower hook found there might have been part of a harpoon kit. Weights or net sinkers, meanwhile, are very rare in the Machalilla levels of Salango: only two have been retrieved (Figure 10), a significant fact in view of the proximity of the site to the beach. It seems possible, then, that net fishing was only of minor importance for Machalilla people. Nonetheless, a non-selective technique like beach seining in shallow water might also have been practiced, and would explain the concomitant capture of near-shore pelagic and sandy bottom dweller species. In this connection, it is notable that Salango was a renowned site for black skipjack fishing with seine



Figure 9. Machalilla fish hooks made from *Pinctada mazatlanica* shell (units A and E).

during the first half of the twentieth century (Béarez 1996; Southon 1987). This local small scale fishery collapsed in the 1960s.

The pattern of pelagic fishing indicated by our results raises the question of the kind of craft that may have been used by Machalilla fishermen. Very few directly relevant data are available but small balsa rafts as used by both the Manteños (Benzoni 1985 [1565]) and today by the poorer fishermen at Salango, or dugout canoes (Lathrap et al. 1975) were probably used, and possibly also reed vessels made with some sedge, like the Peruvian *caballito* (little horse) made of *tatora* (*Schoenoplectus californicus*, Cyperaceae) bundles. Off-shore navigation is also confirmed by the record of Valdivia and Machalilla material on La Plata Island, some 25 km off the mainland coast (Marcos and Norton 1981).

If we now compare the present results with the data obtained for the subsequent Engoroy phase at Salango (Béarez 1996; Béarez and Lunniss 2003), it appears that diversity of catch was higher during Machalilla phase (75 taxa vs. 65), and, even more, that the proportion of scombrids was higher (79.4 percent vs. 62.2 percent; $z = 21, p < .000$). The evolution of each species of scombrid over time is particularly interesting: the yellowfin tuna dominates the assemblage during the Machalilla phase whereas it becomes a minority element among the scombrids of the Engoroy phase. In addition, there is a progressive replacement of the skipjacks by the black skipjacks.

Changes in relative frequencies among the remains found at Salango could reflect overfishing of the skipjacks and tunas. However, fishing down such abundant tuna stocks is rather unlikely; thus

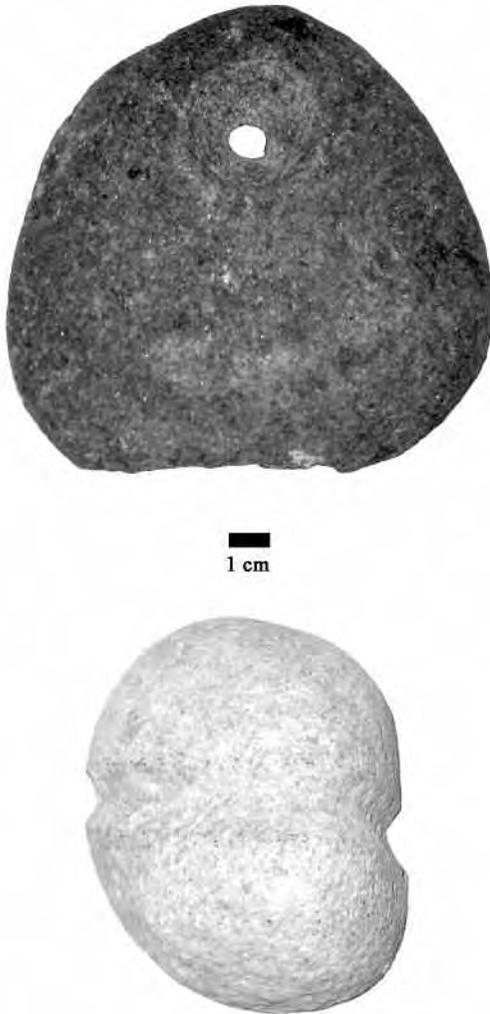


Figure 10. Machalilla stone sinkers, Salango 141A.

changes in the fish populations exploited in the local marine environment might be better explained through consideration of the behavior of these pelagic fishes. Specifically, tunas and skipjacks are more oceanic (open ocean pelagics) than black skipjacks (migratory coastal pelagics). Thus it can be suggested that coastal schools of tunas might have moved further offshore after repeated years of human exploitation, while black skipjacks kept on coming inshore, because of their instinctive tendency to favor coastal habitats.

Conclusion

The fish remains of the Machalilla component of

the Salango archaeological site are a valuable source of information on Formative period off-shore fishing practices of Pacific coastal South America, and contribute to understanding of the early history of the wide set of relations with the sea that was later to be more fully developed on the central coast of Ecuador. The site demonstrates in particular that the Machalilla people of Salango not only relied on marine food, but were skilled fishermen, well adapted to the marine environment, and capable of catching abundant quantities of large pelagic fish. It is likely that their methods were diverse but already specialized, with a main focus on the pursuit of scombrids in the open sea.

Machalilla people adapted specifically and differentially to the conditions of different sites, obtaining marine fish for their subsistence directly from the sea (Salango) or through a process of selection (La Ponga). This aspect would need to be addressed in deeper details in future Machalilla culture studies, but this sort of behavioral and technical diversity is already important as an observation on early fishing in general.

We suggest that fishing strategy and tactics were in large part developed in order to take advantage of the particularities of Salango's coastal physiography, including, especially, Salango Island, a spot favored by schools of tuna and skipjack, and therefore ideal for their capture. Scombrid schools might later have reacted to exploitation or fishing impact by changing their schooling patterns, with the tunas abandoning inshore waters.

Finally, it is worth noting that Salango in the second millennium B.C. presents one of the earliest examples of intensive tuna fishing not just in the Americas but in the world.

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Notes

1. Fish remains from an adjacent but earlier exploratory pit excavated into this sector in 1980 were not included in the study.
2. This post-excavation work was carried out in the first place in 1988 by Andy Mudd and Rachel Everett. The third author (RL) subsequently re-examined the field data and made some modifications to the scheme obtained earlier.
3. A full treatment of Machalilla pottery is still required. The Salango material will be very important in this respect.
4. Vertebral counts include the last vertebra or hypural plate.

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