Archaic Fishing at Quebrada de los Burros, Southern Coast of Peru. Reconstruction of Fish Size by using Otoliths

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ABSTRACT: This paper gives a preliminary survey of the fish fauna excavated at the Archaic site Quebrada de los Burros, on the southern coast of Peru. The most abundant fish remains are from sciaenids. Reconstruction of body length and weight are made for *Sciaena deliciosa*, and mean sizes of that fish are given for the third level of the excavation dated 7735 ± 45 BP. Probable fish catching methods are nets and hook and line, both used offshore and from sand beaches of the coast.

KEYWORDS: ARCHAEOICHTHYOLOGY, ARCHAIC, OTOLITH, SCIAENIDAE, SOUTHERN PERU

RESUMEN: En este artículo se presenta una visión preliminar de la ictiofauna excavada en el sitio Quebrada de los Burros, en la costa sur del Perú. Los restos más abundantes son los de esciénidos. Se describe la reconstrucción de la longitud total y del peso para *Sciaena deliciosa*, y se calcula su tamaño medio en el nivel tres de la excavación con fechas límites 7735 ± 40 y 7195 ± 45 AP. Probablemente se pescaron con redes y líneas con anzuelos, tanto desde playas arenosas como mar adentro.

PALABRAS CLAVE: ARQUEOICTIOLOGÍA, ARCAICO, OTOLITO, SCIAENIDAE, PERÚ SUR

INTRODUCTION

Until recently, early and middle Archaic periods along the far south Peruvian coast were poorly documented (Sandweiss *et al.*, 1998; Lavallée *et al.*, 1999a, b), and the importance of marine subsistence resources was still being debated. Even though that part of the coast is covered by an extremely arid desert, the Pacific Ocean in front of it is one of the most productive ecosystems of the world. Despite this fact, very little solid archaeofaunal analysis has been carried out up to date (see E. Reitz in Sandweiss *et al.*, 1989; Wise, 1990). Since 1996, the author has been collaborating with the French Archaeological Mission under the direction of Danièle Lavallée and the first results are being published (Lavallée *et al.*, 1999a, b).

DESCRIPTION OF SITE AND METHODS

Quebrada de los Burros (QLB) is located in the southernmost department of Peru (Tacna) at 18' S, about forty kilometers north of the Chilean boundary. This small canyon, perpendicular to the coast line, slopes rather steeply: the excavation itself is 200 meters above sea level but only 1,5 kilometers from the seashore. Although the bottom of the Quebrada keeps wet almost all year long, the surrounding area is completely arid, except during strong El Niño events.

Taxa	NISP		MNI	
	#	%	#	%
Chondrichthyes	6	0,34	5	0,84
Engraulidae	54	3,05	5	0,84
Ethmidium maculatum	98	5,53	38	6,38
Sardinops sagax	48	2,71	24	4,03
Galeichthys peruvianus	20	1,13	11	1,85
Paralabrax humeralis	17	0,96	6	1,01
Trachurus murphyi	251	14,16	74	12,42
Anisotremus scapularis	19	1,07	14	2,35
Isacia conceptionis	87	4,91	46	7,72
Cheilotrema fasciatum	2	0,11	2	0,34
Cilus gilberti	58	3,27	50	8,39
Sciaena spp.	920	51,89	238	39,93
Girella laevifrons	2	0,11	1	0,17
Aplodactylus punctatus	2	0,11	2	0,34
Chirodactylus variegatus	49	2,76	34	5,70
Labrisomus philippii	1	0,06	1	0,17
Scartichthys sp.	1	0,06	1	0,17
Katsuwonus pelamis	1	0,06	1	0,17
Sarda chiliensis	73	4,12	28	4,70
Scomber japonicus	64	3,61	15	2,52
TOTAL	1773	100	596	100

TABLE 1

Species list for level 3. NISP and MNI estimates by taxon.

The main excavation consists of a broad horizontal area worked by successive "décapages". It brought to light several occupation levels, with hearths, abundant lithic tools, marine shells concentrations (*Concholepas concholepas*, *Mesodesma donacium*, *Fissurella spp.*, etc.) and many fish remains. The sample from which the analysis is presented here consists of the material recovered from 29 m^2 of level 3 of the 1997 excavation, using a 1/8" mesh screen.

The occupation of QLB took place between 9800 and 3200 BP, but radiocarbon dating on marine shells gave 7735 ± 40 (Gif-11004) and 7195 ± 45 BP (Gif-11002) as limits for the third level. For more details, see Lavallée *et al.* (1999a, b).

The identifications were carried out by the author using his own comparative skeletal collection rich of about 500 specimens from the South American Pacific. Of these more than 130 specimens are typical marine Peruvian fishes. NISP and MNI have both been used and estimated for each square meter by means of counts and symmetry or size criteria.

For constructing the model, 38 pairs of otoliths (*sagittae*) of *Sciaena deliciosa* (Tschudi, 1846), the most common Sciaenidae from central and southern Peru, ranging from 174 mm TL (62 g) to 490 mm TL (1125 g) and collected through the year, have been used. Dimensions (length, height and thickness) were measured with a resolution of 0,01 mm, and weights with a 0,01 g resolution. The relationship between otolith length or weight and body length or weight is described by the allometric equation (Le Cren, 1951; Reitz & Cordier, 1983):

$$Y = a\, X^b$$

where Y and X are the parameters we want to connect, a is a constant and b the exponent fluctuating around 1 if the parameters are of the same dimension (either lengths or weights), around 3 if one of the parameters is a length and the other a weight.

RESULTS

The site ichthyofauna

Over several thousands of fish remains, in a bad state of preservation, have been collected from each level. For the 3rd level, 20 taxa have been identified and the NISP is 1773 for a MNI of 596 (Table 1). Sciaenids are the best represented with a mean proportion of 55,3%. Second come the carangids with 14,2% and then scombrids, clupeids and haemulids oscillating between 8,2% and 6%.

The majority of the identified species belong to sand bottom or open sea biotopes (Figure 1). Even if we consider that sciaenids and carangids proportions are exaggerated because of the better preservation of some of their skeletal elements - otoliths and/or hyperostotic bones - rock bottom fishes are obviously very rarely represented. Typical rockfishes such as *Aplodactylus punctatus*, *Labrisomus philippii*, *Scartichthys gigas* or *S. viridis* are almost completely absent. Such a faunal list suggests that archaic fishermen from QLB were mostly prospecting sand beaches for fishing and were able to cross the sandbank and enter the open sea with some kind of raft. The scombrids, at least, could not be caught from the seashore. Fish catching methods were probably hook and line and nets.

The otolithometric model

Otoliths have often been used for size estimation (Witt, 1960; Casteel, 1976) but in most cases the parameter measured on the otolith was its length. It seems that recently the interest of fishery biologists in the relationship between otolith weight and the age of fish has increased (cf. Second International Symposium on Fish Otolith Research and Application, Bergen, Norway, 20-25 June 1998).

Our measurements on 38 pairs of otoliths of *Sciaena deliciosa* reveal several characteristics of that species:

– length, thickness and weight of right and left otoliths are not statistically different ($p<0,001$), so both sides can be used and joined for live fish size estimation; paradoxically, height of right sagitta is superior to the one of left sagitta in our sample (unilateral test);

– the otoliths grow slower than the rest of the body (SL or TL), the exponent of the allometric equation being superior to 1;

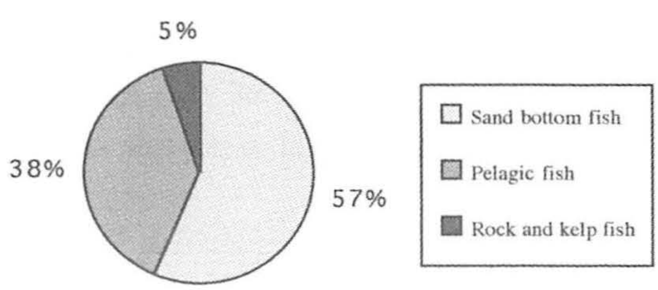

FIGURE 1

Proportions of fish remains (NISP) within each ecological group.

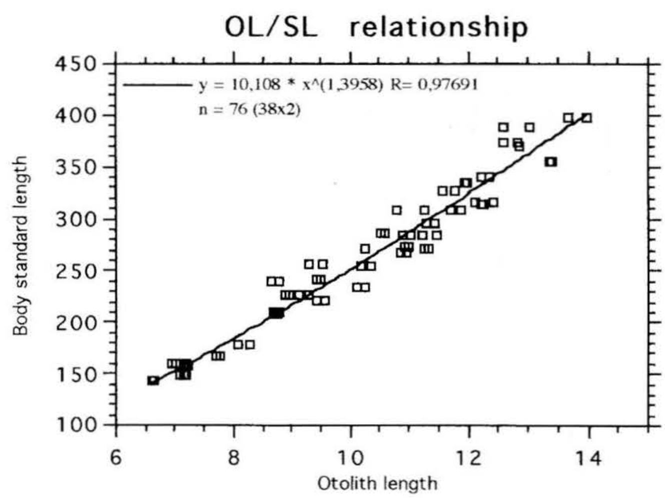

FIGURE 2

Relationship between otolith length and standard length.

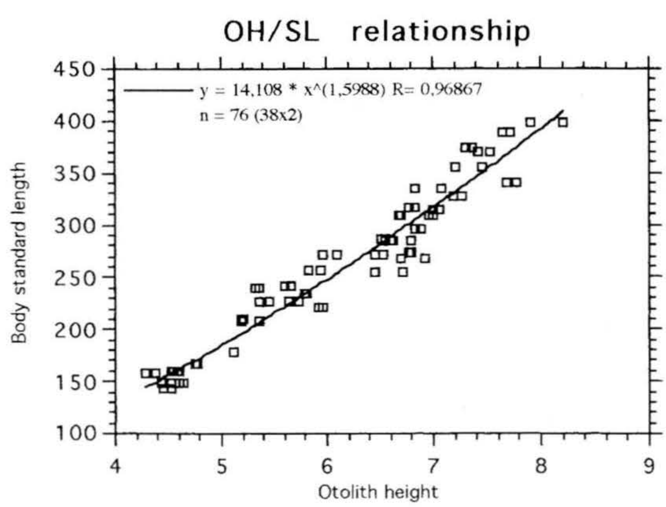

FIGURE 3

Relationship between otolith height and standard length.

– the length and height of otoliths are closely connected to body length or weight of fish (Figures 2 & 3);

– the weight of otolith is closely connected to body length (Figure 4) but moderately so to body weight (R = 0,89);

- the thickness of otoliths is not reliable, as it is poorly correlated to body length (R≤0,7); it could be due to the not well defined shape of the bump growing with age on the outer face of the sagitta;

- the reconstruction of standard length for the set of otoliths by using the model established and the parameters length, height or weight from each otolith gives three series of very similar results which are not statistically different (p<0,001).

The body weight can be predicted from the body length thanks to the relationship given in Figure 5.

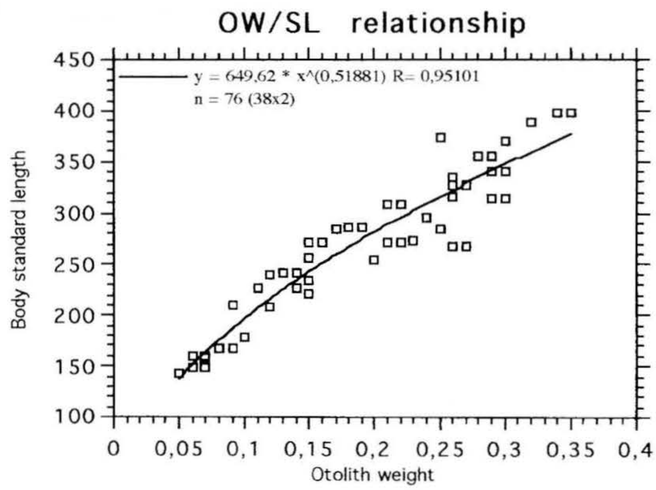

FIGURE 4

Relationship between otolith weight and standard length.

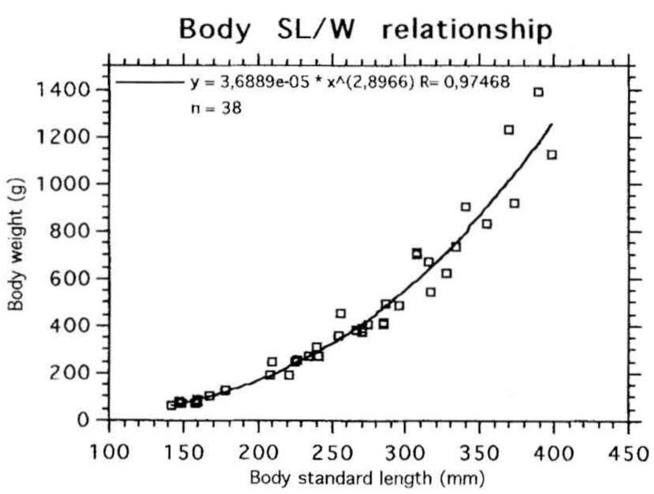

FIGURE 5

Relationship between body weight and standard length.

The reconstruction of live "lorna" size from otoliths' weight

Only complete otoliths (*sagittae*) of "lorna", *Sciaena deliciosa*, have been used for the estimations of size (Figure 6), broken ones have been discarded as their total weight would not be representative. In fact, complete otoliths represent 75,6% in number, and 78,2% in MNI, of all the otoliths found in level 3, i. e. 75,6% of 332 = 251 with a MNI of 176.

Each otolith has been weighed and the corresponding live size has been calculated using the model established. Calculations have been made separately for right and left otoliths. The 110 right otoliths gave a mean SL of 236 mm; the 141 left otoliths gave a mean SL of 242 mm (We have no explanation for the dominance of left otoliths). Intuitively, the value we should obtain using the MNI (176) for that kind of calculation would be between those two means, and, in fact, the value is 239 mm. As we were looking for an easy and rapid method to obtain a reliable estimation of the mean size of the lornas captured and as both mean SLs obtained were very close in that case, we pooled right and left data. We found that the mean length of the "lornas" involved is 240 mm (corresponding TL is 296 mm) and the mean weight is 289 g. Minimal and maximal standard lengths are 137 mm and 388 mm. The size frequency diagram is given in Figure 7.

In order to examine the validity of the model and the diagenesis and possible loss of weight of

FIGURE 6

Otoliths of *Sciaena deliciosa* from square meter C5 of the level 3 of QLB.

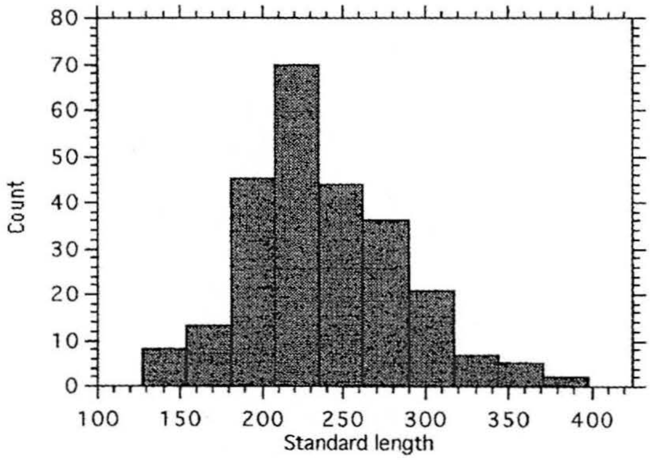

FIGURE 7
Size frequency diagram of lorna (*Sciaena deliciosa*) from level 3 of QLB.

the otoliths, the length of all the 251 otoliths has also been measured. The mean standard length obtained in this way is of 237 mm. This value is slightly, but not statistically ($p<0,001$), different than the one obtained by using weights, which is 240 mm, and does not change the result much. It shows that the model gives similar estimates using either parameter and that, in our case, otoliths have not lost weight through diagenesis processes, or if they have, this is balanced by an abrasion and/or small perimetral chips affecting the length measurement. In fact, diagenesis could affect the organic part (mainly protein) of the otolith which generally fluctuates between 0,2% and 10% of the total weight (Degens *et al.*, 1969), but we do not know its exact value for *Sciaena deliciosa*.

DISCUSSION

Very little zooarchaeological data exists for the archaic period of southern Peru. Sandweiss *et al.* (1998) briefly mention a modal standard length of 172 mm, obtained for the genus *Sciaena* and calculated from 534 otoliths. The modes are not easy to compare but our results give a mode of 220 mm, which is significantly higher. Hence, the people from QLB were fishing bigger "lornas" than those from Quebrada Jaguay situated about 300 km north-west and 2 to 3 thousand years older. Such fact seems surprising but could relate to the biotope exploited.

The wide range of sizes, with a low coefficient of variation (19,5%), obtained here (Figure 7) lead us to believe that lornas were caught with nets instead of hook and line. The shape of the curve could reflect the selectivity of the fishing gear, gillnet or hook, or a seasonal exploitation corresponding to a given size-class. Further investigations will try to address that question.

The mean weight of lornas' otoliths from the third level is of 0,15 g. If we apply the model equation for this value, we obtain a mean standard length of 244 mm, which is 4 mm higher than the one calculated before, working out the average of the standard lengths obtained from each otolith separately. The difference is due to the level of precision used for the calculations. In fact, this represents only a 1,6 % error, which in our opinion is acceptable with regard to the saving in time. By weighing a batch of selected complete otoliths from a given square meter and then dividing the result by the number of otoliths, and applying the equation, one can rapidly obtain a good idea of the mean weight of the sciaenids involved through their otoliths. High numbers of otoliths allow for this approximation without using the MNI which is always difficult to manipulate. Note that if one wants to obtain the total volume of edible meat and then the yield of protein, one must in that case multiply the mean weight by the adequate coefficient - 50% of edible meat which contains 18,5% of protein (IMARPE/ITP, 1996) - and then by the MNI estimate[1].

CONCLUSION

Otoliths are the most numerous anatomical elements and among the best preserved, not only in our site, but in several other southern peruvian sites (Sandweiss *et al.*, 1989; Sandweiss *et al.*, 1998). For such reason, they constitute appropiate material for live fish size reconstruction. Otoliths are easy to get from fresh sciaenids and once the relationship between otolith weight and total body weight has been established, it becomes easy to reconstruct the mean weight of the "lornas" caught during archaeological times in Peru and north Chile.

[1] Mean weight: 289 g. Edible meat: 145 g. Protein: 27 g. MNI = 176.
Total weight: 50,8 kg. Total edible meat: 25,4 kg. Total protein yield: 4,7 kg.

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