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Big Fish or Small Fish? Differential Ichthyoarchaeological Representation Revealed by Different Recovery Methods in the Atacama Desert Coast, Northern Chile

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ABSTRACT

Recovery methods and techniques for archaeological sampling can yield major differences in abundance and anatomo-taxonomical representation of animals, affecting past social and ecological reconstruction. Despite being a common organic material in archaeological sites, faunal remains typically exhibit differential preservation of species and skeletal elements due to pre- and post-depositional processes. This is particularly true for small-sized animals such as certain species of fish, whose often small and fragile fragments are difficult to recover and identify. Here, we present the results of a comparative analysis between two ichthyoarchaeological assemblages from Caleta Vitor 3 in northern Chile (CV3, 18°45'09" S), an Early to Middle Holocene (9.2–7.6 ka cal BP) Chinchorro shell midden site. We compare samples obtained and processed, both in the field and the lab, using different recovery techniques. We developed a data standardisation procedure to compare and evaluate skeletal representation, taxa distribution and variations throughout the stratigraphic sequence. Our results show that mesh screen size affects not only the abundance and density of fish but also species representation. Moreover, the identification of small pelagic fish at CV3 sheds further light upon prehistoric fishing strategies and social organisation during the site's early occupation.

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Introduction



Reproducible sampling and recovery methods are still open questions in archaeology, as they depend on fieldwork limitations, methodological and theoretical backgrounds, which are often conditioned by the emphasis placed on spatial or temporal approaches (Mueller 1974; Schiffer, Sullivan, and Klinger 1978; Orton 2000; Peregrine 2002). Thus, differences in field recovery sampling and lab processing can be expected depending on the methodological and theoretical focus of the study, and its research questions. The aforementioned differences introduce biases that could affect the analysis and interpretations of archaeological evidence, particularly in the case of animal remains.

Recovery Methods in Zooarchaeology: The Case of Fish Remains

In zooarchaeology, experimental and fieldwork studies have demonstrated that field sampling recovery and

lab-processing techniques may affect anatomical and taxonomic taxa representation, depending on specimen size, bone density and pre- and post-depositional processes (e.g. Payne 1972; Watson 1972; Meadow 1980; Shaffer 1992; Shaffer and Sanchez 1994). Aside from these biases, the cultural value given to each animal must be considered alongside socio-cultural interpretations (Russell 2011; Hill 2013). For hunter-gatherer societies, an overrepresentation of large animals has influenced the prevalence of a big-game hunting paradigm (Hildebrandt and McGuire 2003; Gurven and Hill 2009; Konner and Eaton 2010; Buckley and Buikstra 2019), although since the middle of the twentieth century other smaller animals have been considered when analysing the archaeological record (Struever 1968; Stahl 1996; Landon 2005). Thus, intensive analysis of fish remains only really began in the early 1970s (Casteel 1976b; Wheeler and Jones 1989; Colley 1990).

The morphology and preservation of specific fish bones such as vertebrae (sometimes even from

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particular taxa) may generate biases in the ichthyoarchaeological record as they are easily recognised even by non-specialists. Furthermore, several studies have also demonstrated how recovery methods, especially mesh screen size, can affect anatomical representation and abundance of fish remains from archaeological sites (Casteel 1972, 1976a; Garson 1980; Wheeler and Jones 1989; Butler 1993; Nagaoka 1994, 2005; Matsui 1996; Barrett 1997; Ross and Duffy 2000; McKechnie 2005; Zohar and Belmaker 2005; Partlow 2006). Problems associated with logistical fieldwork issues – such as time and resources available – can affect the methodological decisions taken when developing an excavation. Despite recent efforts by zooarchaeologists to standardise faunistic recovery methods (Reitz 2009; Albarella 2017), there are still important differences between these, especially those concerned with the recovery of ichthyoarchaeological material. In the case of the Atacama Desert, the early and permanent human occupations in the coastal area have been studied for many years by different research teams, resulting in a variety of recovery methods and analytical procedures of fish bones and otoliths.

Fishing Along the Atacama Desert Coast, Northern Chile: The Chinchorro Culture

Regarding the fisher-hunter-gatherer societies that lived in the Atacama Desert coast of northern Chile, the study of coastal resources has been mainly focused on mollusks, even though the contribution of fish species is recognised (Santoro et al. 2017). This is partly due to the visibility of malacological material in archaeological shell middens, and also because they are easier to identify at a taxonomic level. Fish remains are much less visible and in some cases highly fragmented, all of which can make taxonomic identification difficult. Paradoxically, fishing gear found at these sites are much more diverse and they have been largely studied in relation to the tools used to collect mollusks. Indeed, even the earliest technologies (11–9 ka cal BP) included fishhooks made of cactus spines and composite fishhooks made of bone (Standen and Santoro 2004; Arriaza et al. 2005).

In the northernmost area of the Chilean coast, between what is now Arica (18°S) and Patillo (20°S), Chinchorro communities developed a predominantly maritime economy (Standen and Santoro 2004; Arriaza et al. 2008; Santoro et al. 2012, 2020; Carter 2016). During the Early to Middle Holocene (9.2–4 ka cal BP), these groups used a number of fishing technologies, including a variety of fishhooks made from shell, bone, rocks and plants; along with harpoons and spear throwers (Arriaza 1995). Recent stable isotope studies (Roberts et al. 2013; Standen et al. 2018) provide further evidence of the important

contribution of coastal resources in the diet of these populations. Finally, it is interesting to highlight the apparent absence of watercraft, which in areas slightly further south (26°S) allowed local populations access to pelagic fish (Llagostera 1989; Olguín, Salazar, and Jackson 2014; Béarez et al. 2016; Salazar et al. 2018, 2020; Santoro et al. 2020).

Further evidence for the exploitation of fish species comes from studies on vegetal and animal fibres found at the Caleta Vitor site. In this regard, Martens and Cameron (2019) suggest its use, among other activities, as fishing nets. Even though the authors and other researchers (Carter 2016; Disspain et al. 2016b) have suggested the use of these fishing strategies for small (sardines and anchovetas) and middle size fish species (Sciaenidae), there is no in-depth discussion about taxonomical distribution and variation through time. Furthermore, discussion of methodologies for field and lab recovery of fish remains as well as their analytical procedures is also lacking.

Recovery Methods of Fish Remains in Caleta Vitor

Caleta Vitor (18°45′09″ S) is situated in the mouth of Quebrada Vitor, 30 km south of the city of Arica. A key wetland environment occurs as water from the Cordillera de los Andes meets the Pacific Ocean, generating a phreatic prism. Coastal resources are further enriched by upwelling of subsurface nutrients; a combination that creates an unusually high marine biomass. This highly productive ecosystem, coupled with terrestrial resources yielded by the wetland provides an abundance and variety of terrestrial and marine fauna and flora, all within the context of an extreme hyperarid environment (Herreros 2011; Fariña and Camaño 2012; Hernández et al. 2014; González and Molina 2017; Latorre et al. 2017). Interdisciplinary analyses of Caleta Vitor shell middens show long-term subsistence systems and socio-cultural structures based on terrestrial and maritime resources since the beginning of human occupation early in the Holocene (Roberts et al. 2013; Carter 2016; Disspain et al. 2016b; Santoro et al. 2017; Martens and Cameron 2019; Santoro et al. 2020).

Archaeological surveys in the Caleta Vitor archaeological complex started in the early 2000s and these quickly divided the site into seven areas, named CV1–CV7 (Carter 2016; Santoro et al. 2017) (Figure 1). While some areas were synchronically occupied, other areas correspond to different time periods. The earliest occupational sequence corresponds to Caleta Vitor 3 (CV3) (18°45′09.94″ S, 70°20′08.65″ W), which is located at ~25 m above sea level and 0.3–0.4 km from the present-day shoreline. It comprises an area of 9000 m² and is composed of



Figure 1. Caleta Vitor archaeological shell midden sites located at the mouth of Quebrada Vitor.

three anthropogenic shell middens associated with human burials (Carter 2016). Radiocarbon dates established its stratigraphic sequence between 9.2 and 7.6 ka cal BP, during the Early and Middle Holocene (Carter 2016; Santoro et al. 2017). Fish data in CV3 were first obtained as part of a larger economic study of the site (Carter 2016). Later, CV3 was analysed for paleoenvironmental data. In both cases, neither of these studies performed an exhaustive ichthyoarchaeological analysis.

The present study consists in a comparative analysis of two ichthyoarchaeological assemblages recovered using different retrieval methods in CV3. We aimed to contribute to the recovery techniques of fish remains, as well as enabling discussion on archaeological interpretations derived from the

ichthyoarchaeological analysis, exemplified in this case study focused on Early to Mid-Holocene human occupations at Caleta Vitor archaeological complex. We also aimed to provide new insights regarding fish and the role of fishing within the Chinchorro communities at the local scale, while also considering regional patterns and the implications for the coastal archaeology of the Atacama Desert.

Materials and Methods

The ichthyoarchaeological assemblages from CV3 come from a trench and two column samples. The first assemblage, here defined as Sample 1, was collected from a trench excavated during the Anillo SOC 1405 project. The second one, corresponding to

Sample 2, was collected from two column-samples (CV3/P1 and CV3/P2) as part of the FONDECYT 1150763 project.

The following paragraphs describe the recovery objectives, techniques and analysis of fish remains in each assemblage, establishing comparable categories between both samples. Table 1 summarises the recovery techniques and analysis methods considered in this comparative analysis.

Sample 1

The first survey of CV3 aimed to contribute to the interpretation of the broad temporal range of the Caleta Vitor archaeological complex, identifying its stratigraphic position and cultural materials (Carter 2016). Excavation trench CV3/1 covered an area of 100 × 50 cm, with a depth of 180 cm, divided into 31 archaeological stratigraphic levels (Carter 2016; Dispain et al. 2016b) (Figure 2). Archaeological remains were sieved using a 1.7 mm mesh screen, collected by hand and bagged according to type. Fish remains were weighed and separated according to the following skeletal elements: jaws (dentary, premaxilla and maxilla), vertebrae, otoliths, shark bones and general items (indeterminate) (Carter 2016). Otoliths and fish teeth were considered for taxonomic identification, using published comparative material and ichthyological reference collections (Carter 2016).

Sample 2





Once the CV3 chronological sequence was established, new surveys aimed to obtain more detailed information about the relationship between local cultural

and environmental variations. For these, sediment was recovered from two different sections of 20 × 15 cm and 25 × 15 cm (P1 and P2, respectively), with a depth of 130 cm, divided by 5 cm artificial levels (Figure 2). These sections are located c. 10 m apart, with one profile (P1) done on the south-facing slope of the north mound, whereas P2 was on the north-facing slope of the south mound. Intact sediment sample bags were shipped to the Paleoecology and Paleoenvironmental Laboratory of the *Pontificia Universidad Católica de Chile* and sieved using different mesh screen sizes (2, 1 mm, <1 mm). All fish remains were recovered, weighed and counted to distinguish the skeletal elements of cranial and postcranial skeletons alongside a reference collection of known taxa (Rebolledo 2019). In contrast with the previous analysis, taxonomic identification of the column samples considered all specimens with diagnostic features, and bones of <5 mm were observed using a Zeiss Stemi-C binocular microscope. Finally, considering that taphonomic and anatomo-taxonomic information did not reveal significant differences between P1 and P2 (Rebolledo 2019), we considered assemblages from both sections as part of Sample 2.

Comparative Analysis

The comparison between ichthyoarchaeological assemblages comprised a quantitative approach that considered common variables of Samples 1 and 2, along with information relating to the specific characteristics of each assemblage. Considering bone and otoliths weight was the common variable between both samples, we used it to estimate the fish density (grams per litre). Having this, we subsequently

Table 1. Comparison of recovery techniques and analyses for Samples 1 and 2.

Methods	Characteristics	Sample 1 (Carter 2016)	Sample 2 (Rebolledo 2019)
Recovery technique	Dimensions (cm)	Area = 100 × 50 cm; Depth = 180 cm	Profile 1: Area = 20 × 15 cm; Depth = 130 cm Profile 2: Area = 25 × 15 cm; Depth=130 cm
	Volume excavated (L)	900	71.125
	Stratigraphic division	31 archaeological arbitrary levels sifted <i>in situ</i>	27 arbitrary levels sifted in the lab
	Lab recovery technique	1.7 mm mesh field screen Collected by hand in the field	2 mm; 1 mm; <1 mm mesh lab screens Collected by hand and tweezers in the lab
Analysis	Total quantification	Weight (g)	Weight (g) Number of remains
	Skeletal identification		
	Taxonomic identification		

Note: Fish illustrations modified from Cuvier and Valenciennes, 1828 (available at osteobase.mnhn.fr).

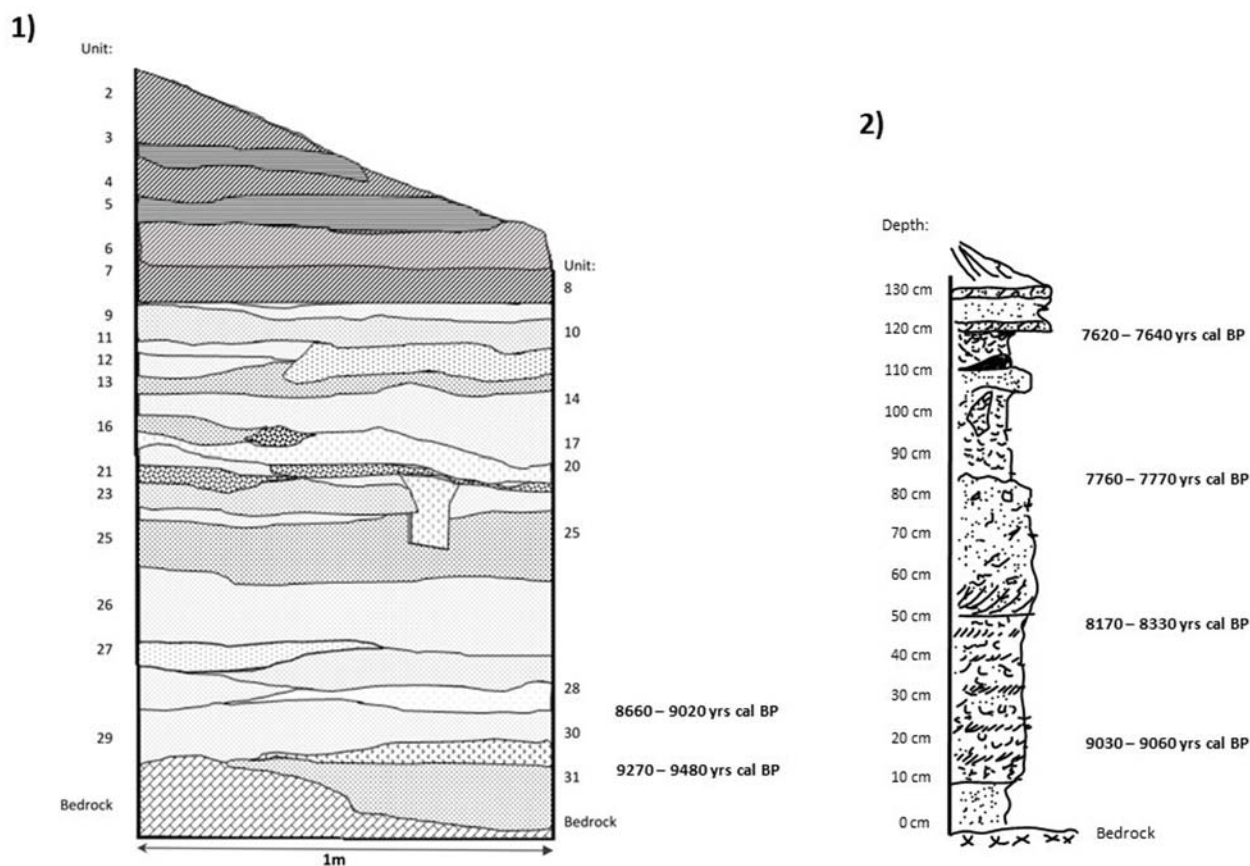


Figure 2. Trench profile of CV3/1 (Sample 1) (from Carter 2016) and CV3/P2 (Sample 2).

calculated absolute and relative frequencies in the total number of specimens (NSP), number of unidentified specimens (UID), number of anatomically identified specimens (NAISP), number of specimens identifiable to taxon (NISP) and minimum number of individuals (MNI) (Grayson 1984; Reitz and Wing 1999). Finally, we presented distributions of the most relevant species along the stratigraphic sequence of CV3. Fish systematic nomenclature follows Fricke, Eschmeyer, and Van der Laan (2020).

We also included a qualitative perspective to assess the effect of sampling techniques and analytical decisions in data interpretation and discussed skeletal representation in both samples, considering categories previously established in Sample 1 (Carter 2016), and its relation to taxonomic identification. The latter also considers the presence of fish species linked to habitat and possible fishing strategies employed.

Results

As shown in Table 2, the data available for Samples 1 and 2 do not allow for global comparisons of both assemblages (as already mentioned, data from Sample 1 were not produced within a proper ichthyoarchaeological analysis). As fish weight is the quantitative variable present in both samples, we decided to use this variable to evaluate similarities and variations in fish density between samples.

In CV3, Sample 1 is composed of 1207.41 g of fish remains, whereas Sample 2 shows a total weight of 420.25 g. In terms of fish density, Sample 2 shows a higher value (4.77 g/L) than Sample 1 (1.34 g/L) (Figure 3(A)). When comparing fish density proportions of identified (NAISP) and unidentified fish (UID), Sample 1 shows a lesser percentage of NAISP (26.83%) than Sample 2 (61.54%) (Figure 3(B)). Also, NISP density is higher in Sample 2 (17.05%) than in Sample 1 (0.05%).

The differences between NAISP and NISP densities can be explained by pre- and post-depositional processes, as well as by the identification of diagnostic features in specimens. In this regard, there is no evidence of butchery marks, and the percentage of burned bones is particularly low in Sample 2 (1%) (Rebolledo 2019). The level of fragmentation is the most important taphonomic variable due to its high percentage in Samples 1 and 2, even though both assemblages present bones and otoliths in a very good condition (Carter 2016; Rebolledo 2019). The presence of mineral and/or calcareous concretions was also observed on some remains. In fact, the latter affected the taxonomic identification of some bones and otoliths in Sample 2 (Rebolledo 2019).

In contrast, divergences in %NISP density between assemblages can be explained by analytical decisions: in Sample 1, we considered mostly otoliths for taxonomic identification, whereas in Sample 2, we

Table 2. Quantitative ichthyoarchaeological data for Samples 1 (Carter 2016) and 2 (Rebolledo 2019).

	Sample 1						Sample 2					
	NR			Weight (g)			NR			Weight (g)		
	<i>n</i>	<i>d</i> (n/L)	%	<i>g</i>	<i>d</i> (g/L)	%	<i>n</i>	<i>d</i> (n/L)	%	<i>G</i>	<i>d</i> (g/L)	%
NSP	–	–	–	1207.41	1.34	–	15,992	181.5	–	420.25	4.77	–
UID	–	–	–	883.42	0.98	73.17	12,387	140.6	77.46	258.62	2.93	61.54
NAISP	–	–	–	323.99	0.36	26.83	3605	40.91	22.54	161.63	1.83	38.46
NISP	65	0.07	–	0.58	0.00	0.05	899	10.2	5.62	71.64	0.81	17.05
MNI	–	–	–	–	–	–	205	2.33	1.28	–	–	–

included a larger proportion of skeletal elements. Despite this, absolute frequencies in the second assemblage present an NISP of 899 specimens: only 5% of the Sample 2 total. This could be attributed to the recovery of minute fragments which cannot be identified.

Concerning the taxonomic composition, Sample 1 presents four identified taxa, whereas Sample 2 exhibits 15 fish taxa (Figure 4). Regarding the species represented in Sample 1, three are included in Sample 2: *Callaus deliciosa* (syn. *Sciaena deliciosa*)

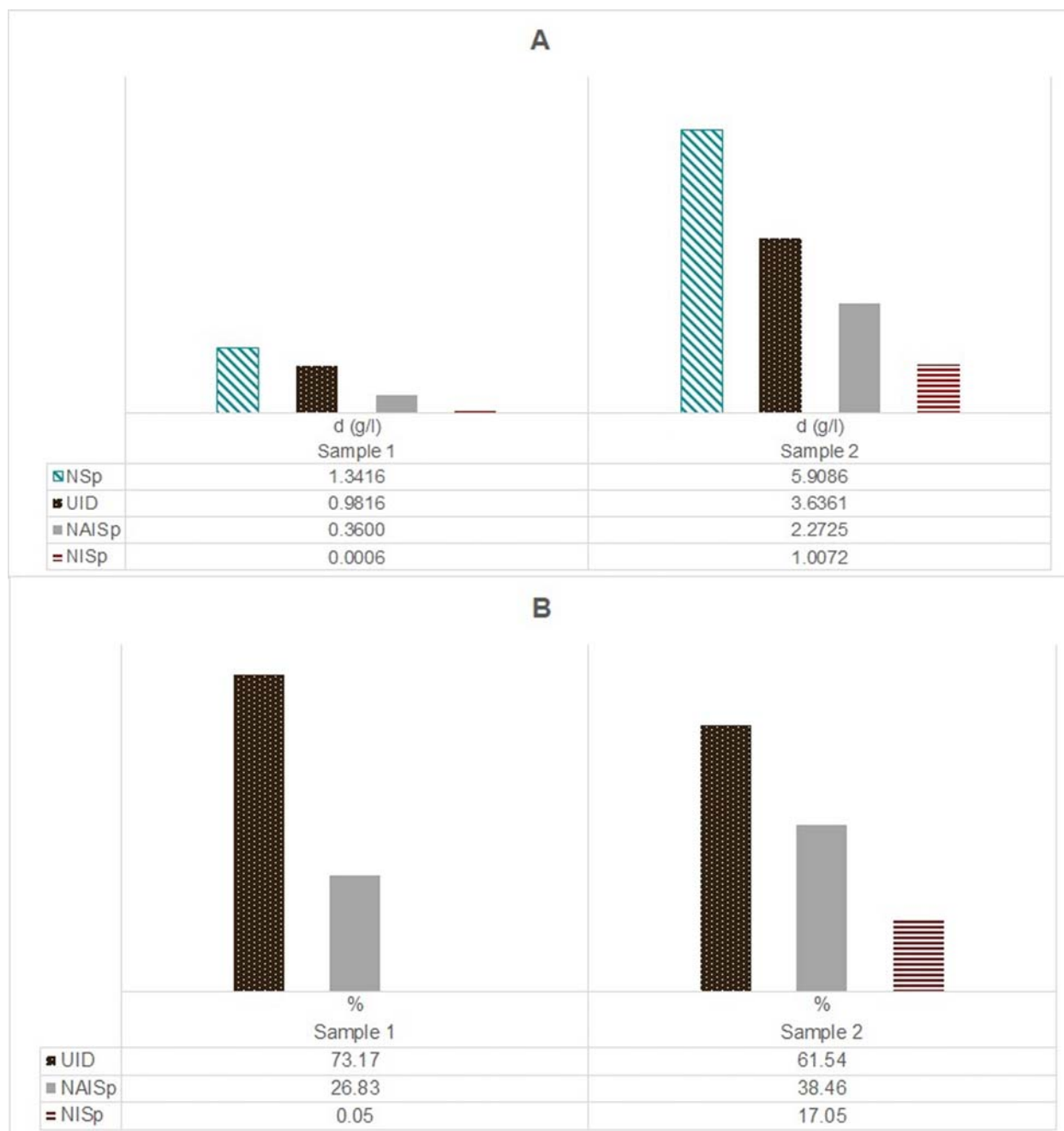


Figure 3. Distribution of fish remains and zooarchaeological indices according to: (A) Density (g/L); and (B) Relative abundance (% of weight) of unidentified and identified specimens.

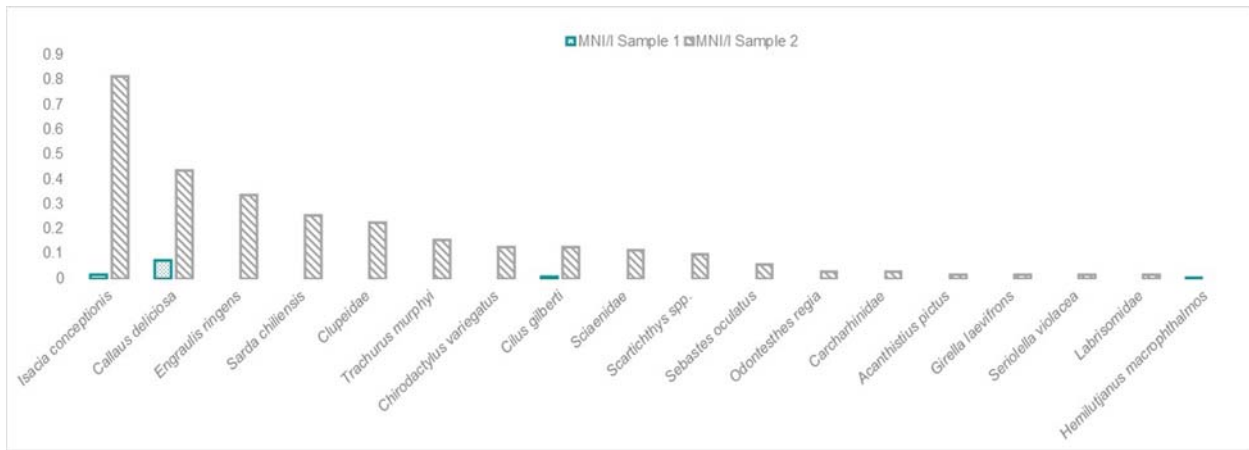


Figure 4. Taxa distribution (MNI/l) in Samples 1 and 2.

(lorna drum), *Isacia conceptionis* (cabinza grunt) and *Cilus gilberti* (corvina drum). In terms of MNI/l, *C. delicosa* and *I. conceptionis* are the most represented species in Sample 1, whereas *I. conceptionis* and *Engraulis ringens* (anchoveta) are the most numerous in Sample 2. We observed a different situation when considering the NISP/l in Sample 2 (Figure 5), where the small pelagic fish *E. ringens* was the most common.

Considering habitat representation according to taxa in Sample 1, *C. delicosa*, *I. conceptionis*, *C. gilberti* and *Hemilutjanus macrophthalmos* (grape-eye seabass) are all benthopelagic fishes which live over sandy and rocky bottoms (Figure 6(A)). With the exception of *H. macrophthalmos*, Sample 2 presents the same coastal species, alongside *Chirodactylus variegatus* (Peruvian morwong), *Acanthistius pictus* (brick seabass), *Girella laevisfrons* (nibbler), *Scartichthys* spp. (blennies), *Sebastes oculatus* (Patagonian redfish) and Labrisomidae (labrisomid blennies), suggesting the exploitation of the Caleta Vitor rocky surroundings (Figure 6(B)). Additionally, small pelagic fish are well represented in Sample 2: *E. ringens*, Clupeidae (herrings) and *Odontesthes regia* (Chilean silverside), specifically. Medium-size fish such as *Seriolella violacea* (palm ruff),

Trachurus murphyi (jack mackerel), and other larger fishes, such as *Sarda chiliensis* (bonito) and Carcharhinidae (requiem sharks) were also identified.

To examine how different habitats were represented, we compared the tendencies of *C. delicosa* in Sample 1 with *E. ringens* and *I. conceptionis* in Sample 2 (Figure 7). The former showed a decrease of *C. delicosa* MNI/l whereas the opposite situation occurred in Sample 2. An increase of *I. conceptionis* and *E. ringens* was also observed. Indeed, the percentage of both species is highly represented when considering NISP/l, with *E. ringens* being the most abundant taxon since the Early–Middle-Holocene transition (70–75 cm). This coincides with a slight increase in taxa richness during the Middle Holocene, especially of pelagic species (Rebolledo 2019).

Discussion

This comparative analysis exemplifies how contrasting ichthyoarchaeological data arise when different recovery techniques are used. Our results take into account the importance of exhaustive recovery techniques to obtain accurate information on fish remains and

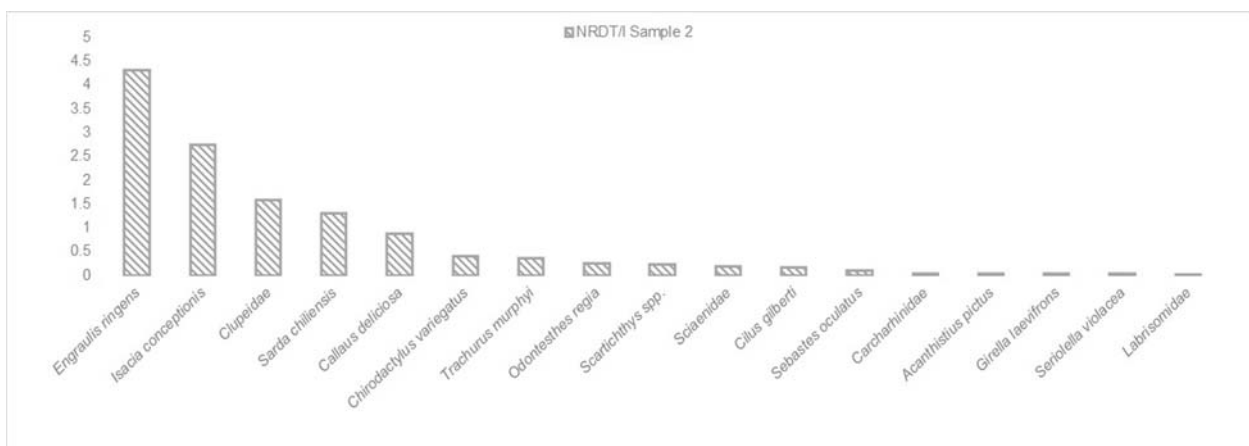


Figure 5. Taxa distribution (NISP/l) in Sample 2.

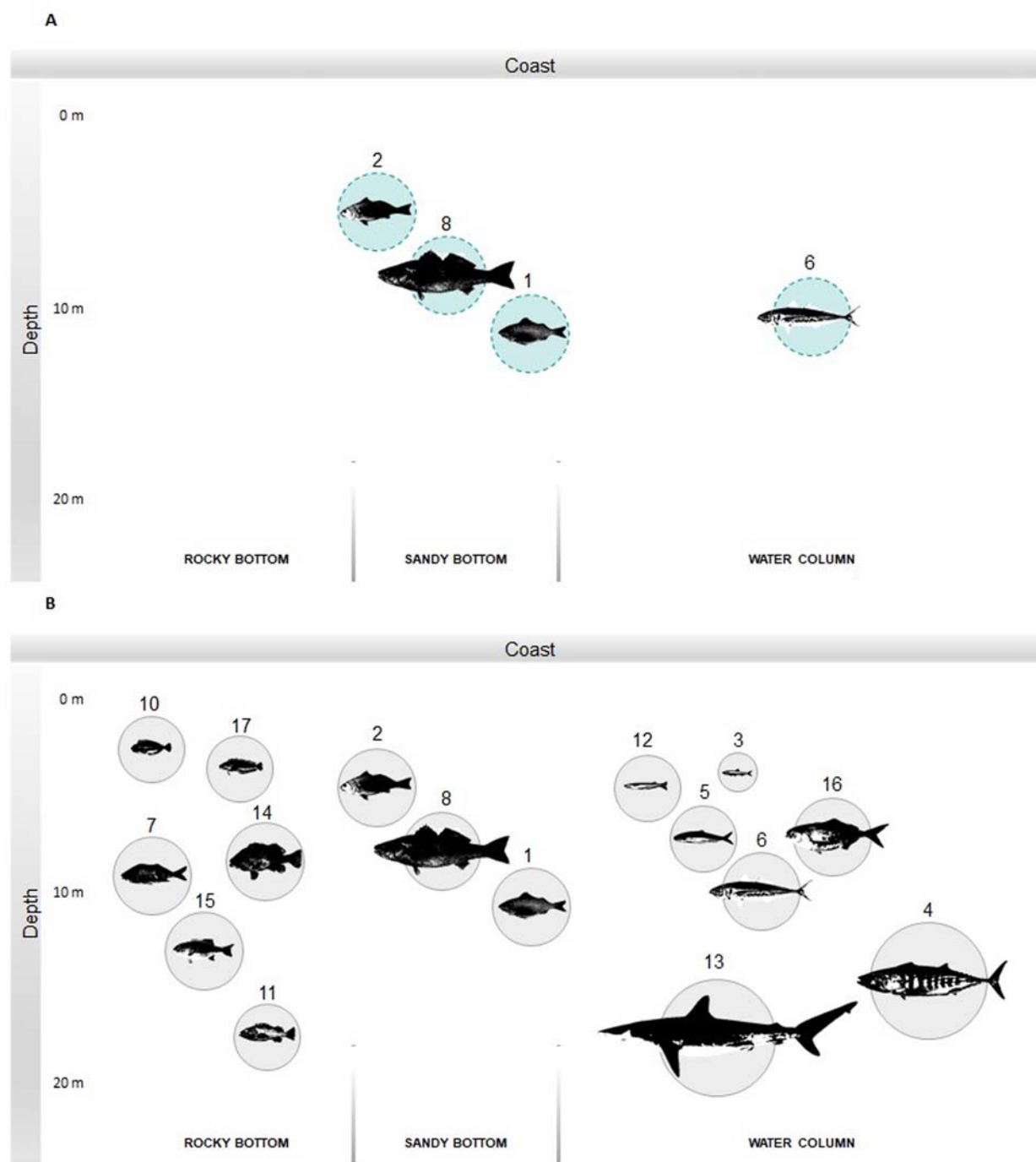


Figure 6. Fish species identified in CV3 according to habitat in (A) Sample 1; and (B) Sample 2. Shoreline is divided into rocky (left) and sandy (right) bottoms. 1: *I. conceptionis*, 2: *C. deliciosa*, 3: *E. ringens*, 4: *S. chiliensis*, 5: Clupeidae, 6: *T. murphyi*, 7: *C. variegatus*, 8: *C. gilberti*, 10: *Scartichthys* spp., 11: *S. oculatus*, 12: *O. regia*, 13: Carcharhinidae, 14: *A. pictus*, 15: *G. laevisfrons*, 16: *S. violacea*, 17: Labrisomidae, 18: *H. macrophthalmos*. Fish species are illustrated according to size proportions.

increase available data, which in turn can provide further interpretations of fish captures and fishing dynamics. Comparative ichthyoarchaeological samples in CV3 have provided valuable information about fishing dynamics during Early to Middle-Holocene Chinchorro occupations but also have exposed scopes and inconsistencies of comparative analysis when dealing with sets recovered using different techniques. In this regard and before any archaeological interpretation, it is important to evaluate the

advantages and limitations of excavation trenches versus column samples.

Excavation Trench or Column Sample?

As a fieldwork archaeological method, big areas but also excavation trenches provide a wider perspective on the archaeological reality under study, thus giving more possibilities to compare with other previously studied regional archaeological sites. Trench

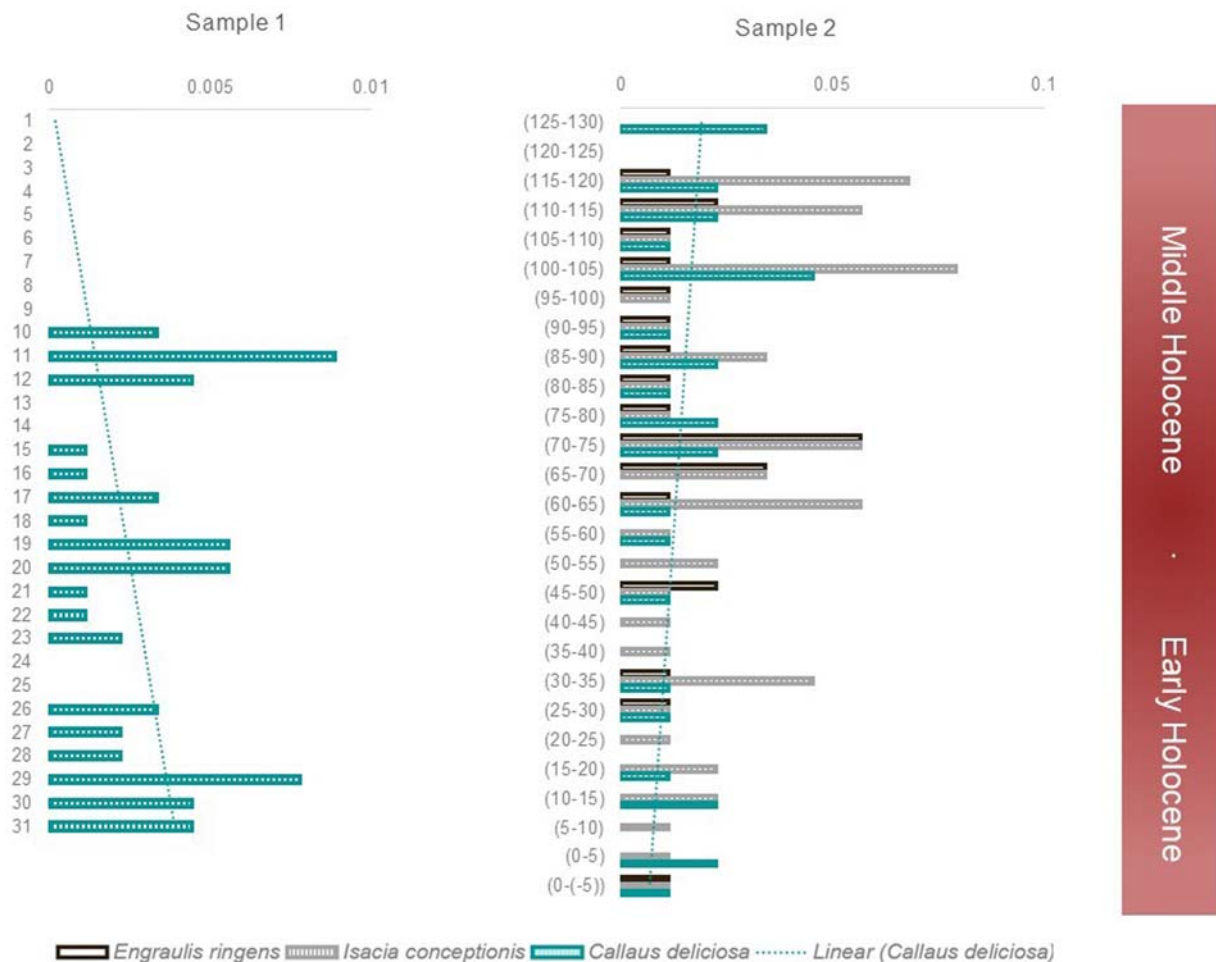


Figure 7. Taxa distribution through the sequence in Sample 1 (MNI/I *C. deliciosa*) and Sample 2 (MNI/I *E. ringens*, *I. conceptionis*, and *C. deliciosa*).

excavations provide evidence not only about the cultural materials but also of activity areas, considering the association between artefacts, ecofacts, structures and other spatial features. This is especially important in the case of fish remains, which are intrinsically related to other archaeological evidence such as fishing technology, food processing and other marine resources.

In contrast, the column (or section) sample enables a more detailed study due to its fixed, exhaustive and stratigraphically precise method. It allows for increased understanding of the structure of an archaeological site, providing a detailed understanding with increased chronological and stratigraphical control. Additionally, it is a useful tool for non-archaeological questions associated with other disciplines such as paleoecology, geology, among others. Concerning disadvantages, a column sample does not provide an archaeological spatial perspective, thus hindering interpretations at a local or regional scale.

For the study of fish remains, some authors have proposed to develop pre-excavation analysis using column samples (Nagaoka 1994; McKechnie 2005) and/or multi-mesh screens (Thomas 1969; Nagaoka 1994; Partlow 2006). In line with Wheeler and Jones

(1989), we agree on the necessity of flexibility in recovery techniques, but also that research and fieldwork objectives must consider previous studies to improve regional data and advance beyond just studying archaeological material from single sites.

In the case of CV3, comparative inconsistencies associated with sample size, research objectives, recovery methods and analytical procedures were partially solved thanks to the fish density index. Although none of the aforementioned projects in CV3 were exclusively focused on fish remains, it has still been possible to discuss methodological procedures and to analyse the ichthyoarchaeological materials from this site.

Fish Data Standardisation

The importance of data standardisation to perform comparative analyses from a local to a macro-regional scale should also be stressed. Several archaeofaunal studies have used density to assess the spatial and temporal distribution of animal remains (e.g. Jerardino 2016), and the use of weight in density estimation has already been highlighted for its advantages in standardising archaeological information (Orton 2000). In our case, and considering the information available,

we used weight to compare fish density in Samples 1 and 2. The results showed higher values in Sample 2, although the volume excavated was much smaller than for Sample 1. The increase of fish density in this sample suggests an increase in abundance per volume excavated, possibly explained by the recovery techniques employed. But how advantageous are these procedures for anatomical and taxonomical identification?

Regarding anatomical representation, there was a large proportion of unidentified remains (UID) possibly due to the level of fragmentation of some specimens and to a lesser extent to other post-depositional processes (e.g. presence of concretions, weathering). In contrast, the NAISP includes cranial and postcranial parts in both samples, although the use of skeletal elements in taxonomic identification differed. In Sample 1, otoliths were the main element used in fish identifications. Otoliths have been widely used in ichthyoarchaeological analysis due to their density and diagnostic features (e.g. Llagostera 1979; Falabella, Vargas, and Meléndez 1994; Llagostera, Kong, and Irachet 1997; Béarez 2000; Disspain, Ulm, and Gillanders 2016a, 2016b). However, their preservation potential in an archaeological context is highly dependent on depositional processes, soil pH and, most importantly, on the species. In the case of CV3, the largest proportion corresponds to Haemulidae and Sciaenidae, both medium-sized fishes with well-developed otoliths compared to other species represented in Sample 2. In this sample, postcranial elements and other cranial bones contributed to the taxonomic identification of different fish species.

Even though we observe an increase in the richness of species, this is not proportional to the percentage of taxonomic identification considering the total number of specimens in Sample 2. This problem has already been discussed by several researchers (e.g. Watson 1972; Casteel 1976a; Nagaoka 1994, 2005; Orton 2000), who pointed out the importance of constant revision regarding an archaeological site features, recovery techniques and laboratory procedures when working with ichthyoarchaeological material.

The variety of pelagic fish in Sample 2 is an important feature that stands out, especially because the identification of so many fish species would not have been possible using the recovery techniques and analysis methods used for Sample 1 (Figure 6). This actually has important consequences regarding how ichthyoarchaeological evidence is used for archaeological interpretations, and hence archaeological reconstructions regarding fishing dynamics for the Chinchorro culture.

Big Fish or Small Fish?

Although fish remains have been recorded in northern Chile since the beginning of excavations (Bird 1943),

these materials have not been part of a systematic anatomo-taxonomic analysis. Contemporary archaeological sites close to Caleta Vitor 3 show differences based on a variety of recovery techniques and analyses that often do not allow for comparisons from published data. According to published data from Acha-2 site, only fish vertebrae were considered (Muñoz, Arriaza, and Aufderheide 1993), whereas at Tiliviche 1B site total fish remains were counted (Hesse 1984). There is little information about the types of fish present in both archaeological sites: at Acha-2, authors proposed the capture of different sizes of fish, as well as the presence of pelagic species captured after stranding during the summer months (Muñoz, Arriaza, and Aufderheide 1993). At Tiliviche 1B site, the presence of small freshwater fish such as Trichomycteridae, Characidae and Atherinidae is mentioned (Núñez and Hall 1982). Meanwhile, nine taxa from coastal waters were identified at Camarones 14 site: *S. chiliensis*, *T. murphyi*, *Paralichthys* sp., *Semicossyphus* sp., *Cilus gilberti*, *Sciaena* sp., *Scomber japonicus*, *Mugil cephalus* and *Myliobatis peruvianus* (Schiappacasse and Niemeyer 1984).

At CV3, we observed that coastal species were well represented in both assemblages. The difference lies in pelagic fish, which are most represented in Sample 2 (Figure 6). Among the species of the different size found in this sample, the presence of small fish species stands out. Furthermore, fluctuations in the abundance of Clupeiformes through the occupational sequence suggest temporal variations in fishing activity. This could indicate access to other habitats farther from the shoreline, and/or environmental fluctuations that affected some species in the coastal area. In any case, this information will add to discussions on fishing strategies of Early and Mid-Holocene occupations in the area.

Previous studies have proposed the use of nets from the Caleta Vitor shoreline since the beginning of human occupation (Carter 2016; Disspain et al. 2016b; Santoro et al. 2017, 2020; Martens and Cameron 2019). Moreover, Martens and Cameron (2019) have proposed a long fibre technology tradition in Chinchorro and later coastal communities, among other productive activities. The earliest archaeological evidence of fibre technology is present in the Middle Holocene occupations in Caleta Vitor 1, where use of vegetal and animal raw materials for producing fibres have been identified. In CV3, indirect evidence from a shell bead from an Early Holocene layer and large amounts of small fish support the idea of cordage and fishing nets, respectively (Carter 2016; Martens and Cameron 2019). Additionally, Disspain et al. (2016b) have suggested the use of nets since the Early Holocene due to the presence of Sciaenidae, a fish family that can be easily caught using nets due to their proximity to the shoreline.

Nets can be very diverse both in their construction and in the way they are used. They can be passive (gill-net) or active (beach seine), and their mesh size can be adapted depending on the species targeted. Indeed, variations in habitat exploitation or in the size or behaviour of fish may have implied the use of one or the other type of net/mesh to capture a wide variety of species. The handling of nets often further requires the investment of several people, and their use could have implied another type of cooperative work related to the acquisition of raw materials, construction, fish procurement and gear maintenance, thus modelling the social organisation of the communities (Hilger 1951; Smith 1957; Antropova 1964; Newton 1985; Parmentier 2011; Beresford-Jones et al. 2018).

Direct and indirect evidence of the use of fishing nets is present throughout the arid Pacific coast, from southern Peru (Sandweiss et al. 1989, 1998; deFrance and Umire 2004, 2009; Béarez 2012; Reitz et al. 2017), to the southernmost part of the Atacama Desert (Llagostera 1989; Casteletti 2007; Rebolledo et al. 2016; Salazar et al. 2018). These authors also highlight important fluctuations in fish composition between the Early and Mid-Holocene human occupations, strongly related to the change of fishing strategies. In most cases, this is explained by the appearance of large pelagic species (see Olguín, Salazar, and Jackson 2014; Béarez et al. 2016), and even though small fish species are present at these sites, these remains are often hardly discussed.

Along with changes in fishing strategies, these fluctuations could also be explained by a seasonal use of archaeological sites. At CV3, the species most represented in Samples 1 and 2 such as drums and rock fish allow year-round access, and although anchoveta approach shorelines in summer, it is not possible to infer seasonality patterns in fishing practices from available data.

Understanding variations and continuities of fishing dynamics require that we consider all fish species and the whole spectrum of devices used to capture them. Specific to ichthyoarchaeological studies, interpretations tend to focus on a particular kind of fish, which obscures fishing strategies associated with other species and habitats (Matsui 1996; Partlow 2006). In the Atacama Desert Coast, the discussion has centred on medium- and large-sized fishes that inhabit waters farther from the shoreline, and the study of fishing technologies such as fishhooks, harpoons, and watercraft. As a consequence, the archaeological narrative tends to emphasise the importance of large-size resources, reproducing the terrestrial paradigm of big-game hunting. Establishing new research questions through the study of different fish species and fishing strategies could shed new light on fishing and its implications for coastal communities.

Conclusion

The 9000-year-old historical sequence present at Caleta Vitor constitutes a promising example to evaluate fishing practices in northern Chile. Comparative analysis of samples from CV3 Early to Middle Holocene occupations reveals how recovery techniques and methods of analysis influence ichthyoarchaeological data production. In this sense, small mesh screen size allows for a more comprehensive retrieval of fish remains, including a broader skeletal and taxonomical representation. Furthermore, Sample 2 contributes new fish species which advocates for a reinterpretation of fishing dynamics by the earlier occupations in Caleta Vitor.

Despite their small spatial representativity, both samples established preliminary approaches to fishing strategies through time. Further research must consider a spatial and synchronic perspective to provide a more complete interpretation of cultural processes associated with fishing during the earlier occupations of Caleta Vitor. Access to open data sources will be necessary to develop new research dynamics and to perform comparative analysis at a macro-regional scale using statistical software. Such studies have the potential to reveal a new level of aspects linked to fishing by the prehistoric coastal communities and the inhabitants' relationship with the Pacific Ocean.

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