Holocene Climate Change and Cultural Adaptation: Case Study from the Saloum Delta, Senegal, West Africa

Article · February 2023

DOI: 10.32474/JAAS.2023.07.000273

1 author:

Augustin F.-C. Holl
Xiamen University
139 PUBLICATIONS **949** CITATIONS

SEE PROFILE

LUPINE PUBLISHERS

Journal Of Anthropological And Archaeological Sciences

DOI: 10.32474/JAAS.2023.07.000273

ISSN: 2690-5752

Research Article

Holocene Climate Change and Cultural Adaptation: Case Study from the Saloum Delta, Senegal, West Africa

Augustin F. C. Holl*

Department of Anthropology and Ethnology, Xiamen University, PR China

***Corresponding author:** Augustin FC Holl, Africa Research Center, Belt and Road Research Institute, Department of Anthropology and Ethnology, School of Sociology and Anthropology, Xiamen University, Xiamen, Fujian, PR China

Received: February 01, 2023 **Published:** February 21, 2023

Abstract

Islands and coastal areas tend to be hyper-sensitive to climate change at different magnitude and time scales. Building on previous research conducted from the first half of the 20th century to the present, the Saloum Delta anthropological archaeology project launched in 2017 aims to investigate the onset and development of intensive exploitation of deltaic resources as well as patterns of cultural adaptation in the context of global Holocene climate change along coastal West Africa. The Saloum delta is located in coastal Senegal at the western end of West Africa. It is today the northernmost mangrove along the West African coast, a UNESCO listed mixed biological preserve and world Heritage site, with birds' sanctuaries and hundreds of shell-middens.

Hypothetically, fluctuating species compositions of the collected shells' samples may have reflected the interplay between anthropic action and natural phenomena triggered by climate change. Middens size differences and location are key cultural variable to be investigated. For the first time some activities areas, beside burials, were recorded in one of the tested midden. Complete shells size (length and width) is relied upon to monitor cycles of exploitation in the largest tested midden of Oudierin – Boumak and used as proxy for either climate or anthropic induced changes. The formation of the tested midden spans the entire Holocene period from 8500 BCE to 1350 CE, visited intermittently for short periods of intensive shellfish processing followed by long periods of abandonment. This paper investigates the most probable causes of the documented punctuated nature of shellfish exploitation and by extension the formation of the shell-midden under consideration.

Keywords: Shell-middens; mangrove; delta; shellfish exploitation; bloody cockles; mangrove oysters; holocene; climate change; cultural landscape; senegal; West Africa

Introduction

The Saloum estuary, located between Joal in the north and the Gambia River in the south, is an original mangrove environment traversed by multiple arms and tidal channels called Bolon in local wolof language. The delta stricto-sensu is located between 13o 40' and 14o 20' north latitude. The Saloum estuary was an open bay around 4000 years BCE. It was gradually filled in by sediments deposited by the Saloum River, with a geomorphological configuration close to the current situation reached between 2000 and 1500 BP [1]. The last aggradation phase took place between 1500 and 600 BP. The mangrove, so characteristic of the delta landscapes, essentially comprises three species: *Rhizophora mangle, Avicennia nitida*, and more rarely *Rhizophora racemosa*. The shell middens as well as old and current villages are colonized by *Adansonia digitata* (baobabs), with in some cases oil palms (*Elaeis guineensis*). The herbaceous layer is made up of bands of different species depending on the salt content. "The borders are populated by halophile (*Sesuruma*), the sandy soils with little salt concentrate the Andropogonae. The dominant soils under mangroves are acid sulphate soils whose acidification is due to the oxidation of sulphides" [2]. The Saloum delta, which covers an area of more than

2,500 square kilometers, has three main arms, the Saloum in the north, the Diombos in the center, and the Bandiala in the east. These three large rivers are linked to each other by an extremely dense network of braided channels, the bolons. The delta has two large groups of islands separated by the Diombos, the islands of Gandoul to the northwest and the islands of Betanti to the southeast, with the islets of Gouk and Poutak in the Diombos. Cockles and oysters are still exploited today but less intensively than in the past [3-8]. The shell middens that make the Saloum Delta special are majestic for some and without comparison with the neighboring regions near or far. This is indirectly the indication of a particularly rich biotope, a biodiversity reserve, part of which has been erected as a national park of the Saloum delta listed as world cultural heritage and biodiversity reserve.

The Data Base

The first archaeological excavations were carried out at Dioron-Boundaw and Dioron-Boumak in 1939 by M. Yvetot, T. Monod, and J. de Saint-Seine. H Bessac, R. Mauny, and J. Figuie excavated the same sites in 1951 and 1956. G. Thilmans and C. Decamps conducted complementary and larger-scale research there in 1971-73. More recently, these two researchers carried out excavations on the site of Ndiamon-Badat near the village of Dionewar in the Gandoul islands. Additional excavations, sometimes for purposes other than archaeological, have been carried out at Faboura [9], Bangalere [10], and Soukouta [11] in the Nombato, the continental portion of the delta. A regional project conducted in the Oudierin Drainage from 2012 to 2018 (Holl 2021, 2022) as well as [5] in the Gandioul Islands provide additional high-resolution data. In general, however, very few sites have been excavated in all the islands of the Saloum delta to allow a satisfactory interpretation of the ancient history of this portion of Senegal. Despite their limitations, the available archaeological and environmental data shed new light on the interplay of climate change and cultural adaptation. The assembled data are arranged into chronological cohorts starting from the earliest occurrences to the present, ranging from the Early Holocene to the Late Post-Holocene period (ca. 1500-1900 CE). The number of dated sites per chronological period varies considerably, from 1, respectively in the Early Holocene and Middle Post-Holocene to 7 in the Late Post Holocene (Table 1).

Table 1: Outline of the Saloum Delta shell-middens chronology based on lumped available radiocarbon dates from archaeologically tested sites.

Period	Site	Time Range	Number of sites
Holocene			
Early Holocene	Oudierin Boumak	8551-8329 – 6956-6791 BCE	1
Mid-Holocene	Oudierin-Boumak	4343-4151 – 3010-2779 BCE	2
	Sipo	3953-3714 BCE	
Late Holocene	Oudierin-Boumak	763-546 BCE	4
	Dionewar	465-225 BCE	
	Ndiar	341-328 BCE	
	Nguior	180 BCE-20CE	
Total			**7**
Post-Holocene (PH)			
Early PH	Bangalere	300 CE	4
	Dionewar	462-643 CE	
	Dioron-Boumak	432-600 CE	
	Faboura	10-635 CE	
Mid-PH	Ndafafe	654-791–668-866 CE	1
Late PH	Diafandor	1429-1618 CE	7
	Dioron-Boumak	1179-1265 CE	
	Dioron-Boundaw	1000-1300 CE	
	Nguior	1366-1592 CE	
	Oudierin-Boumak	945-1029 – 1193-1268 CE	
	Oudierin-Boundaw	1036-1158 – 1266-1297 CE	
	Tioupane	986-1153 – 1262-1390 CE	
Outlier	Diafandor	1695-1955 CE	1
Total			**13**

The main outlines of West Africa Holocene climate variations are relatively well established with however important regional and local variations [12,13]. Sustained paleo-environmental research, either palaeo ecological or palaeo-climatological, features the extensive impact of the African Humid Period (AHP) that lasted from the Early to the Mid-Holocene. Most of tropical Africa then experienced a significant increase in rainfall, triggering the formation of extensive lakes, river systems and wetlands. Ndiaye et al (2022) study based on stable carbon isotopic composition, rock eval thermal and charcoal analyses points to "a more-woody landscape and a higher water table, related to the increased monsoonal rainfall during the AHP between 9.500 and 5.500 cal yr BP". The AHP was however interrupted around 8.200 cal yr BP by a short dry event that initiated the formation of a predominantly grassy landscape. The Late Holocene dry period started around 4.800 cal yr BP after a transition period. In conclusion, "in West Africa, the Northern subtropics experienced a wet climate between 11500 and 6500 cal yr BP and then a trend toward dryness, which culminated after 2200 cal yr BP" (Nguetsop et al 2004: 591).

As far as the Saloum delta is concerned, Carre et al (2022) study based on shell middens analyses reveals in fact that the Sahel is more arid today than at any other period in the past due to a sudden and sharp decrease in rainfall in the past 200 years. The climate was generally humid with high rainfall during the AHP (9.500 – 5.500 BP), transitioning to drier condition in the Late Holocene. The post-Holocene last 2000 years characterized by sustained drying trends witnessed successive wet/dry centennial fluctuations, with on the average increased rainfall in 1500-1800 CE (Figure 1).

Figure 1: The Saloum Delta: Location Map and distribution of shell-middens.

Patterns During the Holocene

Field methodology

To probe the causes of changes in the shellfish population represented in some of the tested shell middens, more or less equal size shell samples were collected at Oudierin - Boumak in a 2.00 m thick sediment deposit, every 10 cm along the human-made deposit. The samples were sorted in the laboratory and complete shells-at least 100 per sample - of all represented species were selected for further measurements, essentially width and length. The analytical rationale is anchored on shellfish – here bloody cockle and oyster – biology and growth patterns. In West Africa, bloody cockle lives generally in the top 5-10 cm layer of sandy mud or mud of lagoons and estuaries [14]. Their maximum length ranges between 100 and 150 mm. Mangrove oysters are seasonal breeders in estuaries and continuous ones on lagoons, with size at maturity ranging from 8 mm for male and 10 mm for female. There are however, many factors that may influence shellfish size. "Water temperature, salinity, turbidity, nutrient availability, species population density, and overall community composition all affect intertidal molluscan growth rates and may contribute to geographic or temporal variation in average size within a molluscan species" [15].

It is important to emphasize that each of the sample collected, weighing 0.7 to 2 kg, very likely represents a "snapshot" of an actual discrete episode of shellfish processing, providing an insight into the exploited shellfish population structure. A total of 16 samples weighing 0.7 to 2 kg were collected along the stratigraphic column. Overall, oysters' shells are largely predominant in the site deposit (Figure 2 & Table 1). In summary, the collected shells samples point to a predominant exploitation of mangrove oysters, complemented along most of the depositional sequence by the collection of bloody cockles. The latter became dominant in the top latest Early 2nd millennium CE depositional unit. Measurements of maximum length and width of complete oyster and bloody cockles' shells are relied upon to assess size fluctuations and their relation to cycles of use and abandonment of shellfish processing sites. "Smaller size implies more intense collection, and more intense collection is most readily attributed to growth in the number of human collectors" [14]. It is assumed that sustained collection affects shellfish population growth patterns with variations in the represented shellfish species spectra indicative of either shift in collection zones or environmentally induced habitat changes.

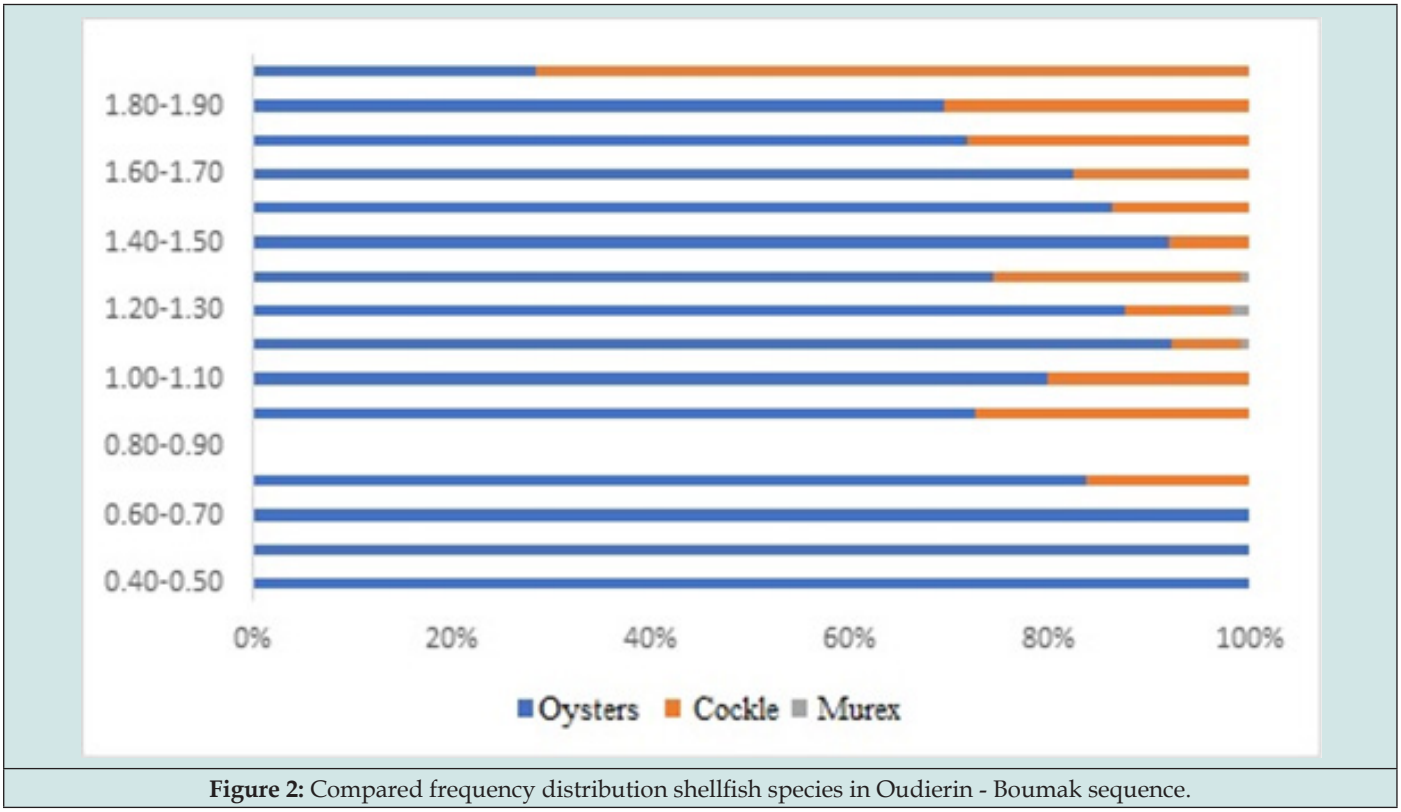

Figure 2: Compared frequency distribution shellfish species in Oudierin - Boumak sequence.

The Early Holocene

Early Holocene samples dated from 8551-8329 - 6956-6791 BCE collected at a single locality, Oudierin-Boumak 0.40-0.80 m bottom deposit, are predominantly made of oysters' shells (Table 1, Figure 3). Oysters' length and width ranges from 1.5-6 cm and 0.5-3.5 cm, clustered at 2-5 and 1-3 cm at 0.40-050 m; then 1.5-4.5 and 0.5-4.5 cm at 0.50-0.60 m; 2-7 and 0.5-3 cm at 60-0.70 m, and finally, 2-4 and 0.5-4 cm (oysters) and 1.5 and 2.7 cm (cockles) at 0.70-0.80 m (Figure 3). Sample 4, featuring the situation at the end of the Early Holocene displays an overall drop in oysters' average size that ranges from 2-4 cm (length) and 0.5-4 cm (width). Data from cockles' shells supports the inference from the oysters one.

Most of the recorded specimens measure 1.5 to 2.7 cm in length and width, pointing to the collection of very young specimens (Figure 3). The abandonment of the tested processing locality at the end of the Early Holocene appears to be a logical consequence of the depletion of shellfish population in the visited actual collection zones.

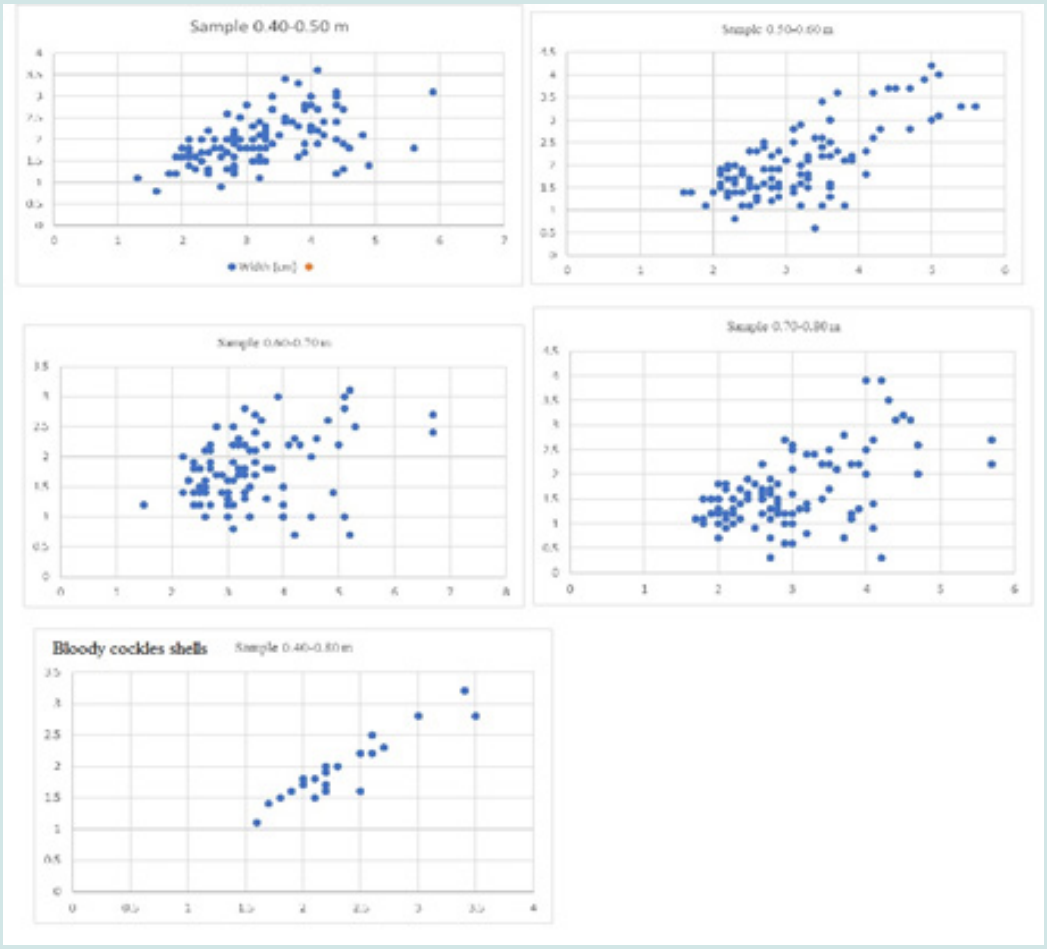

Figure 3: Scatter-diagrams of Early Holocene oysters and cockle's shells (source: Holl 2022).

The Middle Holocene

Middle Holocene deposits dated 4343-4151-3010-2779 BCE have been recorded at two shell-middens: Oudierin-Boumak and Sipo. Shellfish shells measurements are not available for Sipo. At Oudierin-Boumak, shellfish processing resumes a few thousand years later after the Early Holocene. The collected oysters and cockles are relatively larger with significant proportion of 4-6 and 2.5-5 cm long oysters and cockles' shells (Figure 4). On the average, oysters and cockle's shells size improves in the 1.00-1.10 m sample, with 5-7.5 cm oysters and 2.5-4 cm cockles (Figure 4). The last 1.10-1.20 m Mid-Holocene sample presents a broader oysters' size range at both spectrum ends. The majority of the cockle population range from 2 to 4 cm in length. The trends documented in sample 1.00-1.10 m persists in the 1.10-1.20 m deposit. Overall, there is an interesting contrast between oysters and cockles' size. It is as if the mangrove had expanded and colonized the intertidal zones, impacting the local bloody cockle habitat, suggesting a climatically induced micro-environmental change.

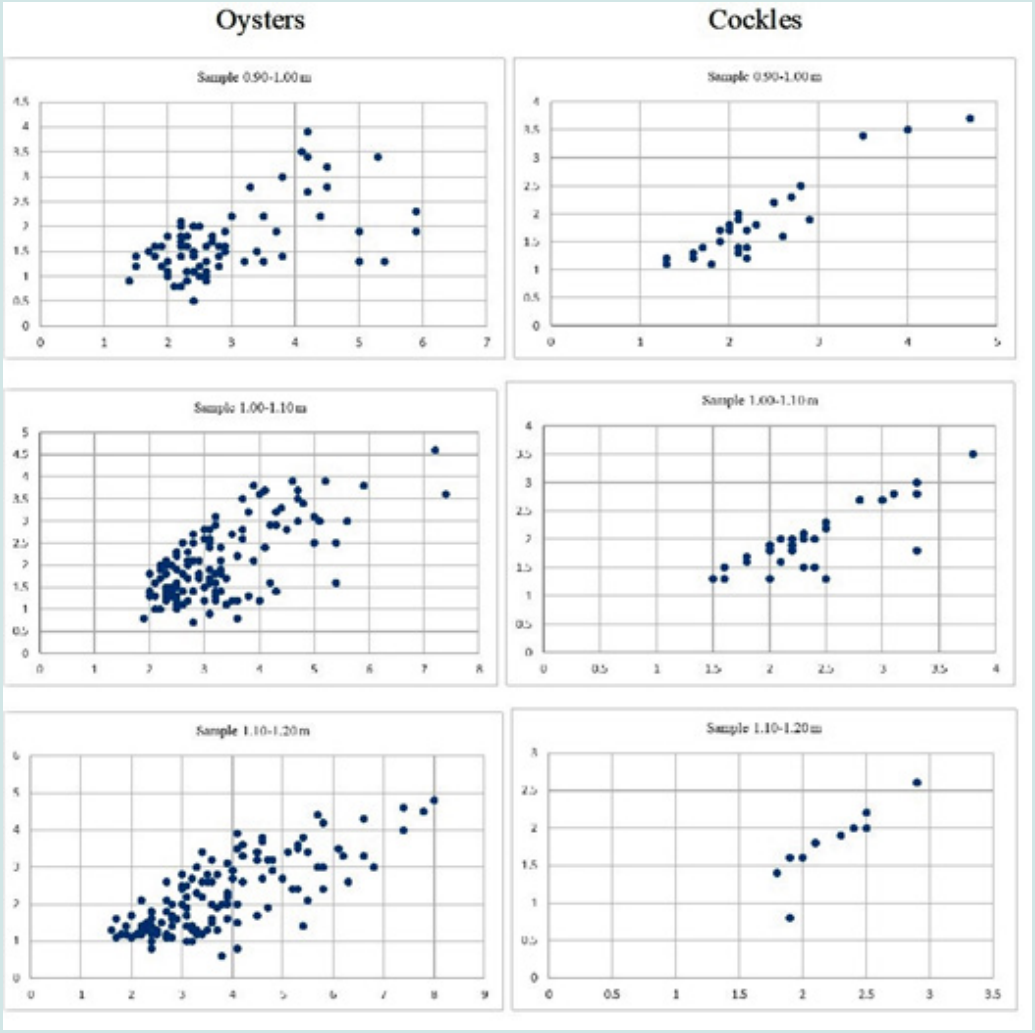

Figure 4: Scatter diagrams of Middle Holocene oysters and cockles' shells size (Source: Holl 2022).

The Late Holocene

For sake of simplicity, Late Holocene period covers the last millennium BCE, from 763 BCE to 0 CE. Late Holocene deposits are documented at 4 shell-middens: Oudierin-Boumak, Dionewar, Ndiar and Nguiar. Dionewar, Ndiamon Badat (13o 53' 85" N/ 16o 43' 49" W) site - features the only known site of a mixed farmer-herder-fishing community. It is a shell midden part of the 4 middens Dionewar group. It is a large accumulation, about two kilometers long and 3 to 5 m thick, consisting mainly of cockle's shells. It is probably the largest shell mound in the Saloum delta: "it runs along a winding course for nearly 2 km, over a hundred meters at the base, and about ten meters high" (Mauny 1961: 158). It is located 1.5 kilometers northeast of the village near Bolon Gokehor and has 149 burial mounds. The excavation focused on a medium-sized tumulus, located in the central part of the site, which has 13 such tumuli within a radius of 70 m [16]. The explored tumulus measures 20 m in diameter and 1.40-1.50 m in height. The dome of the tumulus was stripped up to 1.40 from the top and a trench 4 m wide and 20 m long was opened at the base of the monument. A central burial was unearthed at 1.10-1.30 m below the surface m and the top of the overlying mound was exposed 1.40-1.50 m below the top of the tumulus.

The state of preservation of the bones is particularly poor. Some information could nevertheless be obtained from the available data. The unearthed skeleton is that of a middle-aged adult male, measuring approximately 1.68 m. This individual was buried in a left dorso-lateral position, oriented East-West, and facing south. The funerary furniture is quite eclectic. It includes four iron objects: a spear point, a socket palette, a cylindrical piece, and a sheet metal disc; a copper bracelet; and two beads: one in carnelian and the other in cockles shell [16]. Additional objects were found in the body of the tumulus but without direct relation to the skeleton. No whole pottery has been unearthed but the shards collected belong to the so-called "Palmarin family" tradition [16].

The fauna collected during the excavation is subdivided into two sets: the material from the tumulus which is reworked. And the one in place taken from the summit part of the cluster which dates from ca 350-400 of the common era. The Ndiamon-Badat cluster

was formed from 2370 +/- 50 BP to 1555 +/- 80 BP, i.e. from 420 BCE to 400 CE. The tumulus was built much later, at an unknown date. The tumulus faunal sample includes 53 pieces distributed among 11 species [17]. Five species of fish are represented: the machoiron (*Arius sp*.), the pompaneau (*Trachinotus sp*.), the sea carp (*Haemulidae*), the bobo otolith (*Pseudotolithus elongatus*), and the fat captain (*Polydactylus quadrifilis*), with frequencies varying from 1 to 8. There are two species of reptiles, the loggerhead (*Carretta carretta*) and an indeterminate sea turtle; two species of wild mammals, the manatee (*Trichechus Senegalensis*) and the dolphin (*Sousa teuszii*), and finally, two species of domestic mammals: sheep/goats (*Ovis/Capra*) and cattle (*Bos taurus*), with respectively 7 and 23 bones .

The sample of the cluster in the strict sense reflects much more directly the activities of the inhabitants of the Ndiamon-Badat region at the end of the first half of the first millennium of the common era. Twelve species of fish are represented, with, in addition to the species already mentioned above, the shark (*Carcharhinidae*), the hammerhead shark (*Sphyrna sp*.), the sawfish (*Pristis sp*.), the guitarfish (*Rhinobatos sp*..), etc., 3 species of reptiles, one species of wild mammal (the manatee), and 3 species of domestic mammals, including dogs (*Canis familiaris*) in addition to sheep/goats and cattle. In summary, the inhabitants of Ndiamon-Badat practiced the collection of shellfish, mainly cockles, fished with nets, hunted other aquatic vertebrae, and raised goats, sheep, and cattle. "The choice of habitat, on the edge of the lagoons, has strongly influenced the way of life of the occupants. This kind of place, favorable to the harvesting of molluscs, and to the exploitation of other aquatic resources, was highly sought after not only in the Saloum delta, but also in the estuarine zone of the Senegal River" [17].

The shell midden located below the tumulus is 2.5 m thick. It was accumulated by peasants with diversified subsistence practices and was formed from 2370 +/- 50 BP to 1555 +/- 80 BP (420 BCE to 400 CE), i.e. nearly 800 years for 2.5 m of deposit. The average rate of accumulation of around 31 cm per century is particularly low. This particularity is explained by the impressive dimensions of the site, which is nearly two kilometers long. The tumuli were built much later on top of the initial mass, at an unknown date which should probably be in the second half of the first millennium of the common era. The Ndiamon-Badat cluster is to date the village site in the Saloum delta. It was formed in two successive stages. The initial cluster, which is 2.5 m thick, accumulated from ca 450 BCE to 400 CE. The construction of the 149 tumuli then began at an unknown date but later than 400 CE. The excavated grave in the center of the tumulus is that of a middle-aged adult male, oriented east-west, facing south, and buried with an interesting array of grave goods. Only the cockle shell threading grain is of local origin. The rest of the materials represented, the four iron objects, the copper bracelet, and the carnelian bead come from elsewhere and were probably obtained through the long-distance exchange networks that connected the delta to the rest of the West Africa.

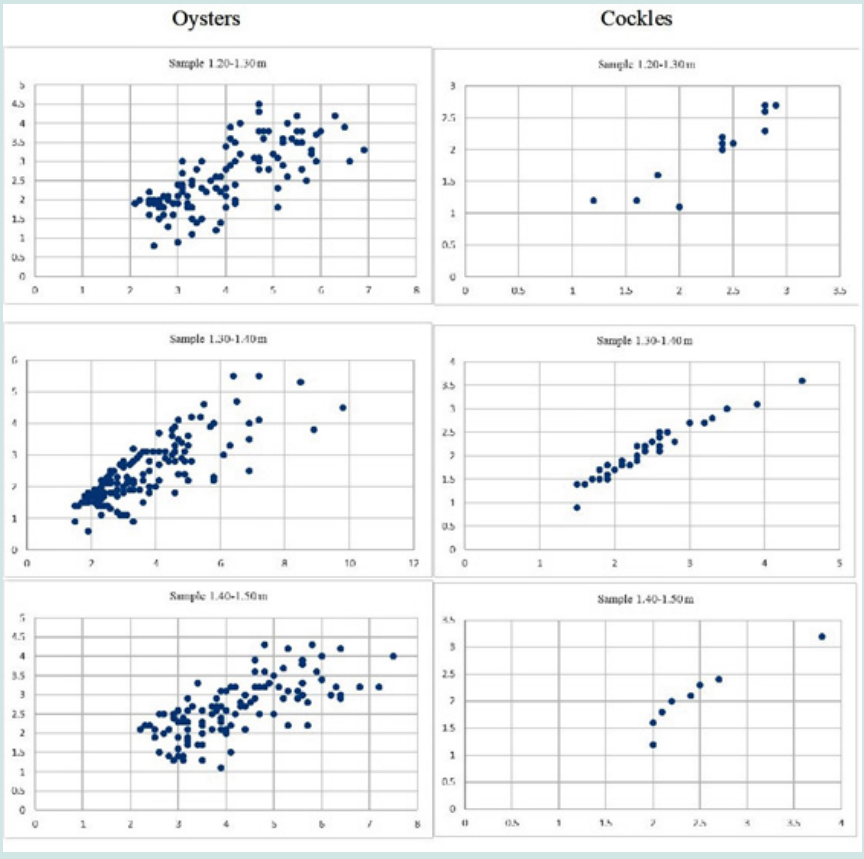

Figure 5: Scatter diagrams of Late Holocene oysters and cockles' shells size (Source: Holl 2022).

At Oudierin-Boumak, shellfish collection and processing resumed again on the sampled spot some 2500 years later. The 1.20-1.30 m sample oysters size ranges from 2-7 and 0.5-4.5 cm, distributed into two distinct but relatively equal sub-sets, below and above the 2.5 cm width line (Figure 5). The lower sub-set includes specimens 2-4.1 cm long and 0.7-2.5 cm wide. The upper is made of 4-7 cm long and 2.5-4.5 cm wide shells. There is a significant increase in oysters shells size range in the 1.30-1.40 m sample. Finally, the average oyster shell size increases in the final 1.40-1.50 m Late Holocene sample with a relatively even distribution. Cockle shells are small on the average. Oyster shells are comparatively larger, pointing to a preferential exploitation of richer mangrove areas at the expense of interstadial sandy mud and confirming a climatically induced environmental change.

The Early Post Holocene: 0-500 CE

Early Post Holocene deposits dated from 0 to 500 CE have been recorded at 5 middens: Dionewar and Ndafafe in the Gandioul Islands, Dioron-Boumak in the Betanti islands, and Faboura and Bangalere in the continental Nombato. No shells measurements are available for any of these middens but they feature complementary aspects of shell-midden formation and provide sustained evidence of significant integration of the Saloum delta in the West Africa long-distance trade network during the 1st millennium CE. Imports of cooper and iron artefacts as well as carnelian beads were probably obtained through exchange of "processed" shellfish products exported in unique bevelled-rim vessels named "Dioron-Boumak ware". Dionewar Ndiamon-Badat cluster was formed in two successive stages. The initial cluster, which is 2.5 m thick, accumulated from ca 450 BCE to 400 CE. The construction of the 149 tumuli then began at an unknown date but later than 400 CE. The excavated grave in the center of the tumulus is that of a middle-aged adult male, oriented east-west, facing south, and buried with an interesting array of grave goods. Only the cockle shell threading grain is of local origin. The rest of the materials represented, the four iron objects, the copper bracelet, and the carnelian bead come from elsewhere and were probably obtained through the long-distance exchange networks that relay the delta to the rest of the West Africa.

Dioron-Boumak (13o 50' 041" N/ 16o 29' 823" W) shell midden was formed from 1580 +/- 80 BP (MC 581) to 1140 +/- 80 BP (MC 590), i.e. from the 4th to the 9th century CE. The tumuli were built between the 8th and 14th century. Burial procedures present a certain diversity. Excavations have brought to light various practices, skull burial, individual burial in small tumuli, successive more or less superimposed burials, and collective burials in large burial mounds. The assessment of the midden formation pace presented in certain works are heuristic and artificial indications without any real historical or social value. Azzoug et al [1] estimates have detected two phases in the formation of the large Dioron-Boumak shell-midden: initially a first accumulation phase at the rate of 200 cm per century which resulted in the formation of the 0 to 8 m segment of the deposit. It is followed by a much slower accumulation phase, 40 cm per century, for the 2 m thick top deposit, from 8 to 10m. The Impressive Dioron-Boumak shell-midden combines three distinct, more or less successive formative histories. The first is the accumulation of cockle's shells that died of natural causes in their sedimentary context. The second derives from shellfish exploitation operating at different periodicities, frequencies, and intensities over the long-term formation of then site. Shellfish exploitation and processing activities produce waste that accumulates on the bottom natural deposits. Vegetation helps stabilize and protect accumulations. Dioron-Boumak was later transformed in to a cemetery with hundreds of burial mounds, from the 8th to the 14th century CE. The shells accumulated during sequences 1 and 2 were then remobilized for the construction of more or less imposing burial. Shells did not accumulate any longer but were re-arranged in mound mounds of different size and shape on the surface of the selected localities.

The approximately 125 generally large burial mounds, spread over a site 500 m long and 250 m wide, give a hilly appearance to Dioron-Boumak. From the landing stage, one takes a path that winds up towards the center of the site, in the shade of giant baobabs. The north face of the site exploited for the extraction of construction materials presents an impressive section several meters thick. The eastern escarpment, 6 to 8 m high, is the result of storms and the backwash of the Bandiala waters. The midden has a total thickness of 10 m. consisting almost exclusively of cockle shells (*Anadara senilis*). Sedimentary fills consist of fine sand, silt, ash and charcoal from hearth pits used to process bivalves [1]. Bangalere shell-midden is located on the bank of the Bolon Irragago about ten kilometers NNE of Sokone. It is 100 m long, 3 to 4 m high, and 50 m wide [10]. Two trenches were sunk in the midden to trace its formation history.

Trench 1 presents a 1.90 m thick accumulation with a succession of six layers starting with small cockles in a black soil as follows:

a) 1.90 - 1.60 m: Black bottom deposit with small cockle shells.

b) 1.60 - 1.27 m: Oyster shell layer.

c) 1.27 - 1.10 m: Broad spectrum layer including 9 species: *Anadara senilis, Crassostera gasar, Mytilus perna, Tagelus angulatus, Tympanotonus fuscatus*, etc.

"The patterns of breakage of *Semiofusus morio* and *Cymbium porcinum* clearly indicate a consumption by humans" [10].

d) 1.10 - 0.57 m: Layer of oyster shells.

e) 0.57 - 0.40 m: Layer with oyster shells in a clay-ash sediment.

f) 0.40 m: Gray soil marking a pause in the accumulation of shells.

g) 0.40 - 0.00 m: Resumption of shell accumulation with small cockles and oysters.

Trench 2 located about twenty meters south of the previous

one is 3.20 m thick. It consists of six layers: The cluster was formed between 1650 +/- 130 BP and 580 +/- 125 BP, i.e. from 300 to 1400 AD. Does the succession of species reflect changes in the local environment or that of the collection areas which may be several kilometers from the places where the molluscs are processed? The relative predominance of oysters is, however, logical in a well-developed mangrove area.

Faboura site (14o 07' N/ 16o 45' W) located a few kilometers east of Joal was studied by C. Descamps, G. Thilmans, J and Y. Thommeret and E.F. Hauptmann [9]. During the years 1975-1977, half of this gigantic shell mound was used for the construction of the Dangane road. The rest are probably endangered. Descamps' team focused on measuring the rate of formation of shell mounds. The cluster studied measures about 400 m in diameter for a height of about 10 m. The shell deposit is predominantly made of cockles with three layers of oysters highlighted at 5.90 - 7.00 m for the oldest, 4.75 - 5.30 m for the intermediate layer, and 2.00 - 2, 50 m for the most recent layer. The 8 m of the accumulation of shells formed between 1940 +/- 80 BP (MC-1390) and 1360 +/- 80 BP (MC-1382), from 10 to 635 CE, i.e., six centuries, have different rhythms. On average, the rate of accumulation is around 1.25 m per century. The settling of shells and the lateral changes of in the location of shellfish processing areas considerably modify the estimates in the formation rates of shell mounds. In the case of the Faboura midden, there is a first phase of slow accumulation with a 2 m thick shells deposit over a period of about 350 years [9]. There is then a phase of accelerated accumulation which corresponds to an intensification of shellfish exploitation, both cockles and oysters, with 3 m thick deposit in half a century. And finally, a new phase of slow accumulation, generating a 2 m thick deposit for a period of two centuries.

The Mid-Post Holocene: 500-1000 CE

A profound cultural change occurred at the end of the 1st millennium-beginning of the 2nd millennium CE. At Dioron-Boumak, surveying and excavation methods have changed considerably since R. Mauny's visit in 1956. During the Colonial Period, "the island was set on fire, where the grass hid the ground, revealing in the center a large number of burial mounds, some reaching 4 m in height" (Mauny 1961: 161). The cemetery with hundreds of tumuli was formed from the end of the 1st millennium to the 1st tier of the 2nd millennium CE. Two of the smaller tumuli were excavated. A poorly preserved skeleton was unearthed in a small tumulus 1 m high, 1 m deep. Oriented E-W, and facing the sky, the dead man was buried with an iron spear on his left and a copper bracelet at the level of the hip. The second excavated tumulus, located about ten meters east of the previous one, is 1.5 m high. A tomb containing disintegrated bones in bulk, an unidentified iron instrument, 2 stone beads (agate?), and 3 copper bracelets, were unearthed at a depth of 0.30 m. A second tomb was discovered "deeper" (Mauny 1961: 161), without grave goods and oriented N-S. Finally, a skull lying on its side and facing NNE was unearthed 0.30 m below the second skeleton.

G. Thilmans and C. Descamps [18] organized new archaeological excavations at the Dioron-Boumak site in 1971-1972. The research focused on three tumuli called A, B, and C. Tumuli A and B are made up exclusively of cockle shells. They are neighbours, located near the eastern limit of the site and have identical funerary procedures. The 41 and 68 burials unearthed in tumuli A and B are divided into three groups, a deep central group, a superficial group above the sterile layer of arch shells, and a final peripheral group. These burials were set up in three episodes of unknown duration.

a) Initially, the deadwere buried under small well - delineated mounds located in the center and part of the bottom group. These mounds were then merged into a first large tumulus.

b) A second group of burials - superficial group - was set out above the first tumulus. Graves were inserted into the sides and at the base of the large mound formed at the end of episode 1.

c) The tombs of the peripheral group, probably more recent, were then "placed tangentially at the bottom of the slope of the existing tumulus" [18].

The distribution of grave goods varies considerably between groups of tombs. The initial group presents only iron objects. The superficial group includes most of the funerary goods, iron weapons, copper and copper alloy jewelry, funerary pottery. The peripheral group also includes some copper objects. In addition to a large quantity of funerary goods, the remains of about ten dogs were unearthed in tumulus B. The animals, presumably sacrificed, were generally buried near humans, but in two cases, dogs and humans were buried together. Tumulus C with 40 skeletons presents another funerary program. 14 of the graves are located in the center of the monument. The other 26 are distributed at the base of the tumulus. Grave goods are scarce and pottery absent. Overall, the excavations of the three Dioron-Boumak tumuli have revealed significant and spectacular archaeological material. The 135 funerary pottery belong to a refined craftsmanship tradition. The adornment elements break down into shell beads (3981), copper beads (184), glass beads (132), chalcedony beads (39), and gold (1), copper bracelets and anklets (38), iron (13), bones (12), various rings and rings of copper and iron, and among the weapons, 36 spearheads and three iron arrowheads. The pottery of the Dioron-Boumak family is unique and easily recognizable. The opening of the container is fitted with bevelled rim, thus creating a support for the lid. Most of the containers unearthed in tumuli A and B are carefully polished and then painted with a red-ocher slip. Furthermore, the analysis of human skeletons has revealed interesting medical practices; a case of partially healed trepanation on an individual from the initial group of tumulus A and a case of consolidated fracture of the right radius and ulna of an individual from tumulus C.

The Late Post Holocene: 1000-1500 CE

Late Post-Holocene deposits have been recorded at the highest number of archaeologically tested shell-middens. It is the case at Dioron-Boumak (1179-1265 CE), Dioron-Boundaw (1000-1300

CE), Nguior (1366-1592 CE), Oudierin-Boumak (945-1029 – 1193-1268 CE), Oudierin-Boundaw (1036-1158 – 1266-1297 CE), and Tioupane (986-1153 – 1262-1390 CE). The Late Post-Holocene period from 1000 to 1400 CE witnessed the routinization of the creation of cemeteries with burial mounds, signaling the kick-off of territorialization processes. The regional distribution of burial grounds is far from random, with on the average one cemetery per important bolon drainage (Holl 2021, 2022) (Figure 6). The Dioron-Boundaw site (13o 49' 171" N/ 16o 29' 759" W) has a dozen tumuli measuring 6 to 10 m in diameter and 1 to 2 m high on the right bank of the Bandiala River. The funerary monuments are confined to the eastern end of the shell-midden over an area approximately 60 m in diameter and 3 to 4 m in height. Th. Monod and J. de Saint-Seine carried out excavations there in 1939 [19]. H. Bessac carried out a new excavation there in 1951 and brought to light 5 burials forming part of a much more elaborate tumulus structure. Tumulus A is at the center of a group of six tumuli located by in the east of the site. Its exact dimensions are not specified in the published note. The tumulus was built above a shell midden with an average thickness of 1.5 m. The excavation covered 1/6 of a tumulus 4 m in diameter and 1 m high. According to the projections made on the basis of 5 burials multiplied by 6, there would be around thirty individuals buried in this structure, a projection which is within the range of validity of the Dioron-Boumak tumuli. Precise data on each of the excavated tombs is rare in the publications on the shell middens of the Saloum delta. The information published by Bessac [19] is therefore important and deserves to be analyzed rigorously. This analysis highlights the specific aspects of funerary practices at the Dioron-Boundaw site.

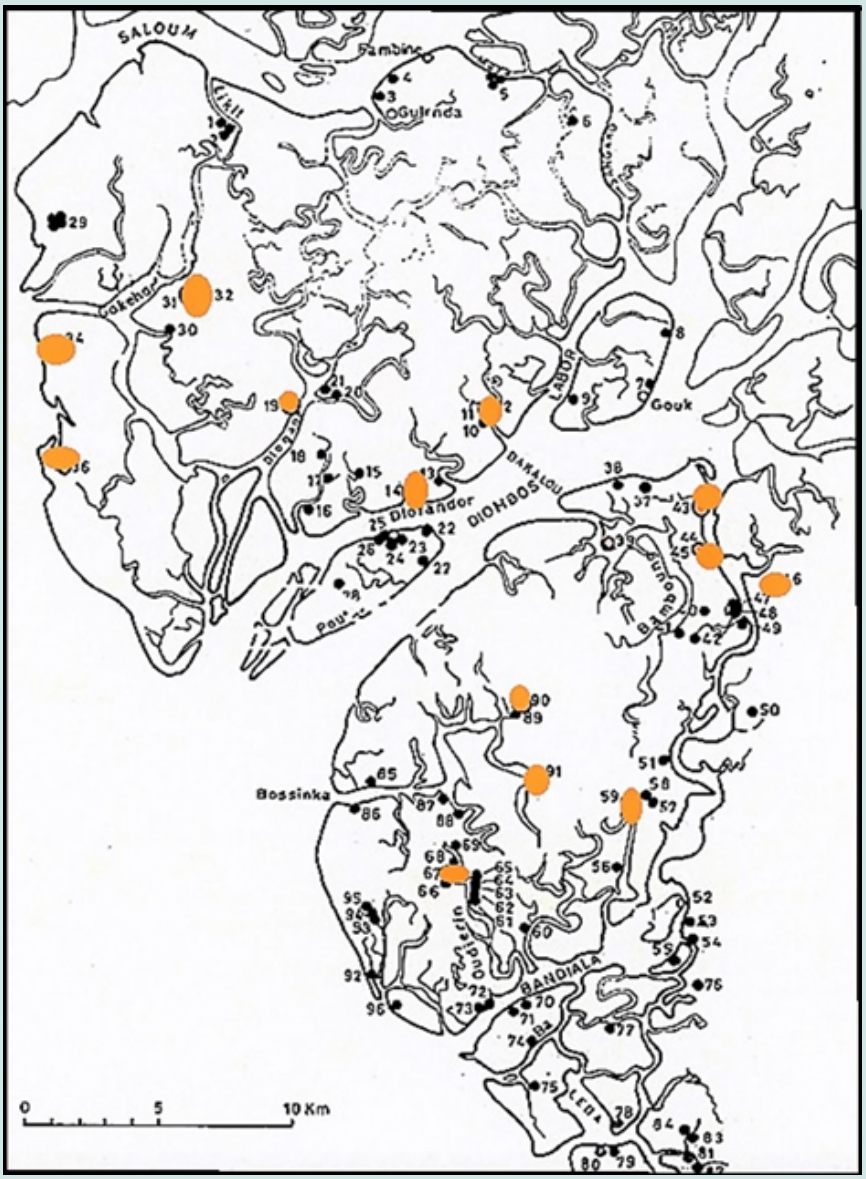

Figure 6: Regional distribution of Late Post-Holocene Cemeteries (Source: Holl 2021).

Burial 5 is the oldest in the uncovered sequence. It was about 1 m deep below the top of the tumulus. The skeleton, buried with a necklace of 19 shell beads, is oriented SE-NW, facing west. Burial 4 was unearthed at a depth of 0.70 m. The badly preserved and very fragmented skeleton was lying on a layer of potsherds, oriented NW-SE, facing west. Funerary furniture consists of a spherical container with a base and its lid. The latter measures 15 cm in diameter at the opening, 22 cm in maximum diameter, and 9 cm in total height. It is decorated with scalloped horizontal lines made with a large cockle shell relayed at the base by twisted roulette impression [19]. The shards on which the dead man rested belong to an ovoid vessel, without a lid, a "black and very elegant" pottery according to Bessac [19]. It measures 10 cm in diameter at the opening, 16 cm in maximum diameter, and 18 cm in total height, decorated with two bands of horizontal and parallel lines, the intermediate space filled with alternating triangles [20-25].

Burial 3, discovered at a depth of 0.50 m, is also heavily fragmented. The deceased was lying on a layer of potsherds, facing N-S, his face facing northeast. The funerary furniture consists exclusively of copper jewelry: 2 bracelets, one of which is elaborately decorated, 3 flat rings, and 4 other rings. Burial 1, unearthed at a depth of 0.40 m, contains a fragmented skeleton lying on shards of ovoid pottery, oriented NW-SE, face facing south-west. The funerary furniture consists of a container with lid, measuring 8 cm in diameter at the opening, 14 cm in maximum diameter, and 9 cm in height, with red slip on the upper portion. The decoration is identical to that of the container of burial 4. The ovoid pottery found below the skeleton measures 6 cm in diameter at the opening, 20 cm in maximum diameter, 25 cm in height, with black slip and decorated with three horizontal and parallel lines on shoulder, with horizontal bands of crossed incised lines. Burial 2 was found at 0.3 m below the surface. The fragmented skeleton was lying on a layer of shards, oriented SE-NW, facing west. The funerary furniture consists exclusively of iron weapons: 3 spears with double rows of barbs, and one with a leafy blade, measuring 40 to 45 cm in length [26-30].

The series of tombs found in Dioron-Boundaw tumuli presents interesting variations which would have been easier to interpret if the sex and age of the individuals buried in this "monument" were known. In all the cases listed, the shards found under the skeleton belong to one and the kind of container, generally of medium size, 18 to 25 cm in height and 16 to 20 cm in maximum diameter. It is not really a litter of shards, but more likely a container placed below the deceased which would then have collapsed and fragmented into several shards under the pressure of the body. The fragmentation and disarticulation of the skeletons are due to the vertical and lateral movements of the cockle shells that constitute the tumulus. Grave goods have some interesting differences. Individual 2 has his weapons, four iron spearheads. Individual 3 has his copper jewelry. Tombs 1 and 4 are almost identical, both are oriented NW-SE, and have pottery, ovoid without lid and spherical with a flat base and a lid. Finally, individual 5 has his pearl necklace probably from cockles. It is tempting to see the remains of a "prestigious" couple there, a man with his hunting and/or war weapons in tomb 2, a woman with her copper jewelry, with relatives and/or allies. Copper jewelry and iron weapons were not local handicrafts. They were obtained through the long-distance exchange networks that linked the islands of the Saloum delta to the rest of West Africa [31,32].

In summary, the burials discovered at Dioron-Boundaw were superimposed in the body of the tumulus. The dead were on the whole oriented differently and each rested on a container reduced to shards. H. Bessac summarizes his discoveries as follows: "The burials are superimposed and represent a small volume, much smaller than the size of the skeleton which lies, in bulk, broken and disarticulated limbs, on a bed of fragmented pottery with sometimes weapons. and the jewelry of the deceased. It is occasionally accompanied by another spheroid pottery with a lid that must have contained the viaticum of the deceased. [19].

Soukouta is located on the left bank of the Bandiala, almost at the height of Dioron-Boundaw, features the lifeways of the former peasants of Nombato. One tumulus was excavated among the 33 recorded on the site. It contained the remains of 13 individuals buried in the body of the tumulus. The grave-goods are few in number, divided between five clay vessels from the "Dioron-Boumak family", five other barrel-shaped containers, 2 shell beads, 3 copper alloy beads, 13 iron beads, and an iron arm-ring.

The exploitation and processing of shellfish resumed at Oudierin-Boumak at the beginning of 2nd millennium CE after more than one and half millennium interruption, along with the formation of cemeteries at Dioron-Boumak, Dioron-Boundaw and Oudierin-Boundaw. The oyster shells from the 1.50-1.60 m sample present an important size range, 2 to 10.2 cm for length and 1 to 5 cm for width (Figure 7). Most of the shells cluster between 2-5.5/1-4 cm, with in addition, an outlier set of 4 measuring 8.1 to 10.2 cm in length and 2 to 4.7 cm in width, and an intermediate one of 4.5-6.5 cm long and 3-5 cm wide specimens. The length range shrinks to 2.2-8 cm and the width one increases to 1-6 cm in the 1.60-1.70 m sample. A shorter length range - 3-8 cm - is documented in the 1.70-1.80 m sample with however an even distribution. The width range remained constant but the length range increased to 1.8-8 cm in the 1.80-1.90 m sample, featuring a shift toward smaller oysters. And finally, while the width range remained constant once again, the length range shrunk to 2.1-7.1 cm, with the bulk of collected specimens in the 2.2-4.5/1-3 cm size range (Figure 7). All the recorded samples of cockle shells present the same characteristics and distribution patterns. They are small, range from 1.2 to 4 cm in length and overwhelmingly from 1 to 4 cm in width (Figure 7).

The shellfish population from the exploited area points to clear signs of over-exploitation and depletion in the middle of the first half of the 2nd millennium CE, leading to the final abandonment of the tested part of Oudierin-Boumak shell-midden. In summary and keeping in mind that each of the studied sample is likely a

snapshot of discrete subsistence episode, the detailed analysis of the collected shells populations suggests different scenarios for the multiple millennia-long interruptions in shellfish processing in the tested part of Oudierin-Boumak shell-midden. The inferred scenarios range from environmentally triggered processes like the extension of mangrove habitat of oysters at the expense of intertidal sand mud habitat of bloody cockles to human enhanced shellfish resources depletion. There are converging evidence from shells size and territorialization processes unhinged during the Late Post-Holocene pointing to radical cultural adjustment to drier climate shift. On current available data, the Saloum delta appears to have been emptied of its populations during the 2nd half of the 2nd millennium CE that was paradoxically a period of increased rainfall. Shelfish exploitation is documented at a single site of Diafandor of Poutak islet in the Diombos River.

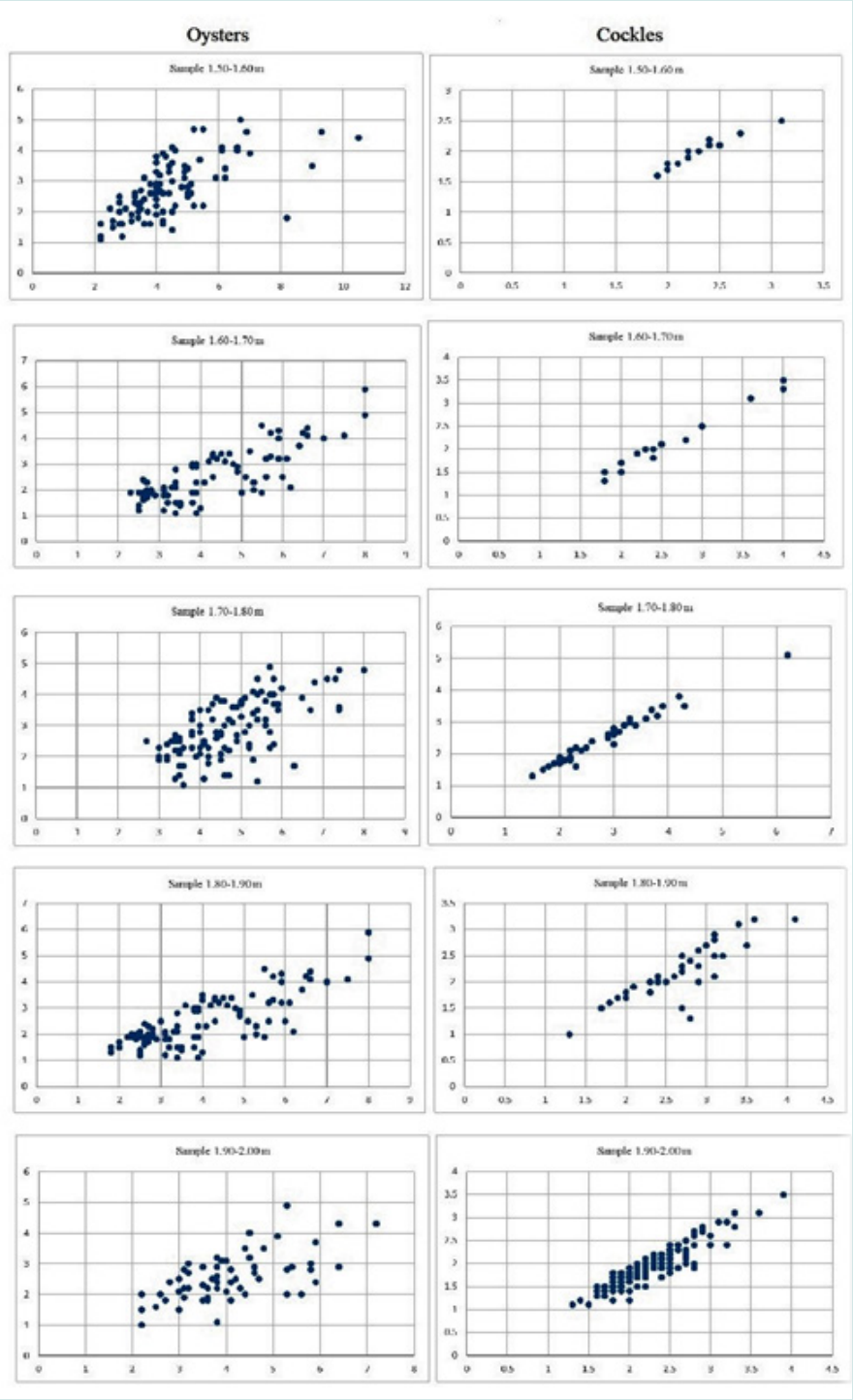

Figure 7: Scatter diagram of Late Post Holocene oysters and cockles' shells size (Source: Holl 2022).

Conclusion

Overall, archaeological research has been conducted on a relatively small number of shell middens. Three of the excavated sites, Faboura, Bangalere, and Soukouta are located in the continental portion of Nombato. Four sites have been tested in the Betanti Islands: Oudierin-Boumak and Oudierin Boundaw along the Oudierin drainage in the southeast, and Dioron-Boumak and Dioron-Boundaw, part of a twin-site complex and located in the northeast tip. Finally, Damon-Badat near Dionewar constitutes to date the only habitation site excavated and published in Gandoul islands. The chronological spectrum represented by the Saloum delta shell midden phenomenon extends over a period of 10,000 years, from 8500 BCE to 1400-1500 CE. The impact of fluctuating climate parameters on wetlands is paramount. It affects its bio-diversity and subsistence/economic sustainability. The resolution of the data assembled in this discussion varies considerably from one case to the next. High resolution data based on shells measurements are confined to the single case of Oudierin-Boumak. The conducted analysis reveals a punctuated cycling of short period of exploitation followed by long periods of abandonment, from the viewpoint of the sampled unit. For most the AHP captured in the Oudierin-Boumak record, changes in relative species compositions and shell size appeared to derive either from local micro-ecological adjustment and/or human predation pressures. The latter is particularly well documented during the Late Post-Holocene period (1000-1500 CE) through the onset of territorial marking strategies articulated on non-random distribution of cemeteries. That variable is backed by the sustained decrease in shell size pointing to over-exploitation, in the top and last deposit of Oudierin-Boumak shell-midden.

The archaeological remains unearthed, including, among other things, weapons and items of adornment in iron and copper alloy, as well as glass and carnelian beads, attest to the insertion of the islands of the Saloum delta in the West African long-distance exchange systems over the past two millennia, particularly between 800 and 1300 CE coinciding with the emergence and rise to regional primacy of the earliest West African state formations, the Wagadu-Ghana-and Tekrur kingdoms.

Acknowledgements

Part of the research conducted within the frame of the Oudierin Drainage Archaeological Project (ODAP) was supported by “Instructional Funding” of Xiamen University College of Humanities to the Department of Anthropology and Ethnology “Field Studies” Course in Senegal in 2018. The author is grateful to Professor Hamady Bocoum, Director-General of the Museum of Black Civilizations, (Dakar, Senegal) for his constant and reliable administrative and logistic support. Dr. Aime Kantoussan (Museum of Black Civilizations) Dr. Khady Niang (Cheikh Anta Diop University) and Dr. Matar Ndiagne (IFAN-Cheikh Anta Diop) assisted in shell-midden sampling and participated to fieldwork and Dr. Maurice Ndeye, director of the IFAN Radiocarbon laboratory processed samples from the project. Heartfelt thanks to all the students, undergraduate and graduate, from Xiamen university (China) and Cheikh Anta Diop University (Senegal), too many to be mentioned by names, who enrolled in the Field Studies course and contributed to the ODAP program.

References

1. Azzoug M, Carré M, Chase BM, Deme A, Lazar A, et al. (2012) Positive precipitation-evaporation budget from AD 460 to 1090 in the Saloum Delta (Senegal) indicated by mollusk oxygen isotopes. Global and Planetary Change 98-99(1): 54-62.
2. Leprun JC, C Marius, et E Perraud (1976) Caractérisation de la pédogénèse durant le dernier millénaire sur les amas coquilliers des îles du Saloum (Sénégal). Bulletin de l’Association Senegalaise d’Etude du Quaternaire Africain 49(1): 13-25.
3. Descamps C (1989) La collecte des arches (Anadara senilis L) dans le Bas Saloum (Sénégal): Une Approche ethno-archéologique des amas coquilliers. Travaux du Laboratoire d’anthropologie et prehistoire de la Mediterranee Occidentale (LAPMO) pp. 131-149.
4. Descamps C (1994) La Collecte des arches, une activité bi-millénaire dans le Bas Saloum (Sénégal). In Dynamique et usages de la mangrove dans les pays des rivieres du sud (du Sénégal a la Sierra Leone). MC Cormier Salem, editor. Editions ORSTOM, Paris pp. 107-113.
5. Diouf MW (2010) Les amas coquilliers des îles du Gandoul (Falia, Dionewar et Niodior): approche ethnoarchéologique et culturelle. Memoire de Maitrise. Universite Cheikh Anta Diop, Dakar.
6. Kantoussan A (2006) Recherche sur les amas coquilliers de Joal-Fadiouth. Mémoire de Maitrise. Universite Cheikh Anta Diop, Dakar.
7. Kantoussan A (2007) Recherches sur les armatures de pêche dans les amas coquilliers du delta du fleuve Sénégal. Memoire de DEA. Universite Cheikh Anta Diop, Dakar.
8. Mbow MA (1997) Les Amas Coquilliers du delta du Sénégal: Etude Ethnoarcheologique. Thèse de Doctorat; Université de Paris I: Pantheon-Sorbonne.
9. Descamps C, Thilmans G, Thommeret J, Hauptmann E (1977) Données sur l’âge et la vitesse d’édification de l’amas coquillier de Faboura (Sénégal). Bulletin de l’Association Senegalaise d’Etude du Quaternaire Africain 51(1): 23-32.
10. Elouard P, J Evin, V Martin, C Becker (1974) Kjokkenmodding de Bangalere: Région du Saloum, Sénégal. Bulletin de l’Association Senegalaise d’Etude du Quaternaire Africain 41(1): 85-87.
11. Descamps C, Thilmans G (1979) Les tumulus coquilliers des îles du Saloum (Sénégal). Bulletin de l’Association Senegalaise d’Etude du Quaternaire Africain 54-55: 81-91.
12. Camara A, K Hardy, E Dioh, M Gueye, R Piqué, et al. (2017) Amas et sites coquilliers du Delta du Saloum (Senegal): Passe et Present. L’ Anthropologie 121(1): 204-214.
13. Hardy K, Camara A, Piqué R, Dioh E, Guèye M, et al. (2016) Shellfishing and shell midden construction in the Saloum Delta, Senegal. Journal of Anthropological Archaeology 41(1): 19-32.
14. Otchere FA (2020) Populations patterns, biology and ecology of bivalves from lagoons and rocky shores in Ghana. International Journal of Research Granthaalayah 8(4): 53-66.
15. Klein RG, TE Steele (2013) Archaeological shellfish size and later human evolution. Proceedings of the National Academy of Science 110 (27): 10910-10915
16. Ba M, C Descamps, G Thilmans (1997) Fouilles d’un tumulus a Ndiamon-Badat (Îles du Saloum, Sénégal). In Fouilles et Degradations dans les Îles du Saloum. Saint Louis, Lille, Liege 3(1): 1-15.

17. Van Neer W (1997) Etude des ossements animaux de l'amas coquillier de Ndiamon Badat (Delta du Saloum). In Fouilles et Dégradations dans les Îles du Saloum. Saint Louis, Lille, Liege 3 - Janvier 1997 pp. 16-21.

18. Thilmans G, Descamps C (1982) Amas et tumulus coquilliers du delta du Saloum. In: Challier A, Bodian M (Eds.), Recherches scientifiques dans les parcs nationaux du Sénégal, 92. Mém. IFAN, Dakar pp. 31-50.

19. Bessac H (1953) Contribution a l'étude des buttes à coquillages du Saloum (Sénégal). Notes Africaines 57(1): 1-4.

20. Ausseil Badie J, JP Barusseau, C Descamps, EHS Diop, P Giresse, et al. (1991) Holocene deltaic sequence in the Saloum estuary, Senegal. Quaternary Research 36(2): 178-194.

21. Bailey G, Hardy K, Camara A (2013) Shell Energy. Molluscs Shells as Coastal Resources. Oxbow Books, Oxford, England.

22. Bovill E W (1968) The Golden Trade of the Moors. Oxford University Press, Oxford, USA.

23. Camara A (2010) Shell middens of the Saloum Delta, Senegal. In: Hardy, K. (Ed.), Archaeological Invisibility and Forgotten Knowledge. BAR International Series, Oxford, USA pp. 53-59.

24. Chenorkian R (1983) Ivory Coast prehistory: recent developments. African Archaeological Review 1(1): 127-142.

25. Descamps C, Thilmans G, Thommeret J (1974) Données sur l'édification de l'amas coquillier de Dioron Boumak (Sénégal). Bulletin de l'Association Senegalaise d'Etude du Quaternaire Africain 42(1): 67-83.

26. Descamps C, Thilmans G (2006) Fouille de tumulus coquilliers à Djouta (Îles du Saloum, Sénégal). Oxford; BAR Int. Series 1522(1): 135-146.

27. Diara M (1999) Formation et évolution fini-holocènes et dynamique actuelle du delta Saloum-Gambie (Sénégal-Afrique de l'ouest). Thèse de Doctorat Université de Perpignan, Perpignan.

28. Linares de Sapir O (1971) Shell middens of Lower Casamance and problems in Diola Prehistory. West African Journal of Archaeology 1(1): 23-54.

29. Martin V, C Becker (1979) Documents pour servir à l'Histoire du Saalum. Bulletin de l'IFAN 41 (ser. B) 4(1): 722-772.

30. Piqué R, Gueye M, Sall M (2013) Ethnoarchaeology of Senegambian shell middens. In: Bailey GN, Hardy K, Camara A (Eds.), Shell Energy: Molluscs as Coastal Resources. Oxbow Books, Oxford, USA pp. 183-190.

31. Thiam M (2013) Senegambian shell middens and burials: a heritage in danger. In: Bailey GN, Hardy K, Camara A (Eds.), Shell Energy: Molluscs as Coastal Resources. Oxbow Books, Oxford, USA pp. 191-198.

32. Vernet R, P Tous (2004) Les amas coquilliers de Mauritanie occidentale et leur contexte paléoenvironnemental (VIIe-IIe millénaires BP). Prehistoire Mediterraneenne 13(1): 55-69.

DOI: 10.32474/JAAS.2023.07.000273