Journal of Anthropological Archaeology 34 (2014) 66–77

Contents lists available at ScienceDirect

Journal of Anthropological Archaeology

journal homepage: www.elsevier.com/locate/jaa

Fishing and environmental change during the emergence of social complexity in the Lake Titicaca Basin

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ARTICLE INFO

Article history:
Received 23 August 2013
Revision received 14 February 2014
Available online 29 March 2014

Keywords:
Economic organization
Environmental change
Fish
Social complexity
Zooarchaeology

ABSTRACT

The Lake Titicaca Basin is one of the regions in the world where both primary village and state formation occurred in prehistory. Although agriculture has been discussed as the central engine fueling these processes, fish and other aquatic resources were significant but little-understood components of the region's ancient economy. In this paper, we use zooarchaeological analysis of faunal remains from 367 flotation samples recovered from five archaeological sites to discuss the interplay between fishing, environmental change, and the emergence of sociopolitical complexity in the Taraco Peninsula of Lake Titicaca. Our results suggest that fishing comprised a significant component of the local inhabitants' diet between 1500 BC and 1100 AD. The intensity of fish procurement, however, varied through time and independently of both climatic and population change. We interpret variation in fish consumption through time as a product of group and individual decisions to optimize resource use in a context of dynamic environmental and sociopolitical variability.

Introduction

Aquatic resources have had a preeminent role in facilitating population growth, sedentism, and economic specialization in many coastal regions of the world due to their nutrient density, abundance and predictability (Campbell and Butler, 2010; Casteel, 1977; Colley, 1990; Erlandson and Rick, 2008; Habu et al., 2011; Morales Muñiz and Roselló-Izquierdo, 2006; Reitz, 2004; Wheeler and Jones, 1989). Communities focused on exploiting fish and shellfish often developed along marine continental shorelines and islands, but evidence of shell mounds and fishing settlements are also common in interior rivers and lakes around the world. For instance, along the Pacific Coast of western South America the exploitation of marine resources supported specialized sedentary communities as early as the mid-Holocene (Marquet et al., 2012; Moseley, 1975, 1992; Reitz, 2001; Reitz and Sandweiss, 2001; Richardson, 1998; Sandweiss, 2008) and fishing was essential for almost every settled society in the Amazon (Erickson, 2000, 2008). Although there is increasing interest concerning the organization and environmental context of fishing economies in prehistoric societies, there is less systematic study of the ecological impact of fishing, the archaeology of fishing technology and the integration of fishing and fishing communities into broader political economies (Barrett et al., 1999, 2004; deFrance, 2009; Orlove, 2002). These aspects of fishing are particularly important in regions where fishing was one of several economic practices that could have been intensified under particular social, economic, and environmental conditions.

Located in the south central Andes, the Lake Titicaca Basin is renowned as the setting for two fundamental primary processes of social evolutionary change. Early village formation began approximately 3500 years ago (Bandy, 2004). The type site for early villages in this region, Chiripa, is one of the sites in this study (Bandy, 2006; Browman, 1989). Roughly 1500 years ago, the region also saw the emergence of the Tiwanaku state, centered on the monumental site of Tiwanaku, 15 km southwest of Chiripa, but with an influence extending as far as the Pacific coast and the warmer flanks of the Andes (Hastorf, 2008; Janusek, 2008; Stanish, 2003). Archeologists working in this region have focused on agricultural intensification and camelid pastoralism as primary factors in the cultural evolution of the region including the eventual emergence of the Tiwanaku state (500–1100 AD) (Janusek and Kolata, 2004; Kolata, 2003;

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http://dx.doi.org/10.1016/j.jaa.2014.02.001
0278-4165/

Stanish, 2003). We note that the marshlands and aquatic resources of Lake Titicaca have been underestimated in models of social and political change. Detailed studies of fish remains have been limited by the costs of systemic recovery and the absence of baseline research on the zooarchaeology of fish (Capriles, 2006; Capriles et al., 2008; Moore, 2011). Consequently, few studies have been able to measure the importance of fishing in this region or the contribution of aquatic resources to the processes of regional social change. Yet, historical and ethnographic sources emphasize the importance of aquatic resources in the economy of the people that have traditionally inhabited the shores of Lake Titicaca (Levieil and Orlove, 1990; Orlove, 2002; Portugal Loayza, 2002; Wachtel, 2001). For instance, the Uru are often depicted as a fishing specialist group settled on the shores and islands of the Titicaca Basin. However, the origin and antiquity of fishing specialization in the region has not been systematically addressed though it could go back into the Formative Period. In this paper, we use recent research to assess the changing role of fish exploitation in the Taraco Peninsula, Bolivia.

The Taraco Archaeological Project has focused on the cultural processes and environmental context associated with the emergence of social complexity in the Taraco Peninsula (Bandy and Hastorf, 2007; Hastorf, 2003, 2005; Hastorf and Bandy, 1999; Hastorf et al., 2001). The project included systematic survey of 85 km^2 and stratigraphic excavations at five sites (Bandy, 2001). The zooarchaeological component of the project sought to reconstruct the economic organization of animal husbandry, hunting, and fishing (Moore et al., 1999, 2010). Faunal remains from Formative components showed that wild resources, particularly fish (*Orestias* spp. (killifishies) and *Trichomycterus* (catfish)), were significant components of the local diet, complementing meat from domesticated (*Lama glama*, *Vicugna pacos*) as well as wild camelids (*Lama guanicoe*, *Vicugna vicugna*) (Capriles et al., 2008; Moore et al., 1999). In addition, we recognized bone tools associated with the manufacture of nets and fishing gear (Moore, 1999, 2011, 2013). In this paper, we consolidate data regarding the changing role of fish exploitation and relate it to broader processes of environmental and socio-political change. We use zooarchaeological data to address three questions: (1) how did the organization and intensity of fishing change in relation to population growth and increased social complexity? (2) How did fishing procurement and consumption respond to lake-level fluctuations? (3) How was fishing integrated into the increasingly complex agricultural landscape?

Paleoenvironmental context

Situated at 3810 m above sea level, Lake Titicaca has experienced significant environmental change during the Holocene (Fig. 1). Because of its high elevation, Lake Titicaca is less productive than most large tropical lakes but in contrast to most temperate lakes, its productivity does not plunge seasonally (Lewis, 1990; Richerson et al., 1986). Lake Titicaca covers a surface area of 8200 km^2 and is roughly divided into two parts; the northern portion (Lake Chucuito) is larger and deeper than the southern portion (Lake Wiñaymarka). Lake Wiñaymarca supports higher primary biomass densities than Lake Chucuito and has the largest littoral zones (as a percentage of total surface area) of the great lakes of the world (Vadeboncoeur et al., 2011). Because the southern profile is so shallow, it responds more quickly to changes in rainfall and temperature than the northern lake. In addition, climatic fluctuations can cause rapid change in the productivity of its subaquatic vegetation and fauna. Fluctuations in the lake's depth and the length of its shoreline influenced regional processes of cultural change (Abbott et al., 1997; Binford et al., 1997; Kolata, 2003).

Multiple paleoenvironmental proxies agree that the shoreline of Lake Titicaca fluctuated significantly during the last 15,000 years (Abbott et al., 1997, 2003; Baker et al., 2001, 2005; Cross et al., 2001; Rowe et al., 2003). For most of the late Pleistocene the lake's surface was considerably lower and its water more saline than modern conditions. During the early Holocene, increased precipitation drawn from the Amazonian lowlands coupled with glacial runoff raised the lake level enough to trigger outflow through the Desaguadero River. However, during the mid-Holocene, this trend was reversed, flow into the Desaguadero ceased, and the lake was rapidly reduced to a few shallow pools at its deepest portions. Between 4000 and 3500 years ago the mid-Holocene dry period ended with the rapid rise of Lake Wiñaymarka (Abbott et al., 1997).

Compared with the lake level history of the previous 15,000 years, the last 4000 years seem to have been characterized by relative stability with only minor fluctuations between 4000 and 3000 years ago, as Lake Titicaca approached its late Holocene stable level (Cross et al., 2000). Lake levels fluctuated more in the southern basin, including around the Taraco Peninsula which is the focus of this study. There were at least four cycles of lake-level transgression and regression between 1500 BC and 1100 AD (Abbott et al., 1997). Nevertheless, Calaway (2005) observed that the ice-core data from the Quelccaya glacier do not match the data for high and low lake levels and may indicate a more dynamic and recursive pattern of climatic cyclical change (Thompson et al., 2000, 2006). Few studies have recognized how these fluctuations affected the productivity of resources likely to have been used by humans. Our initial hypothesis is that fishing was an important economic activity for the inhabitants of the peninsula, and that fishing may have varied in intensity as a function of resource availability and environmental degradation.

Sociopolitical context

The evidence of aquatic resource exploitation in Lake Titicaca correlates with the appearance of fully sedentary agricultural village societies featuring camelid pastoralism, pottery production, and complex ritual life (Hastorf, 2008; Janusek, 2008). Although the domestication of camelids, tubers and chenopods were long-term developments, the archaeological record of the region points to a sharp change in human settlement and subsistence between the Terminal Archaic and subsequent Formative periods (Aldenderfer, 2009; Capriles and Albarracin-Jordan, 2013). The Terminal Archaic (3000–1500 BC) was characterized by mobile foraging whereas the Early Formative I (1500–1000 BC) is marked by the establishment of the first village societies in the region (Bandy, 2001). This transition also coincides with the progressive infilling of Lake Wiñaymarka (Hastorf, 2008). Village communities used both wild and domesticated plant and animals. By the Early Formative II (1000–800 BC), the peninsula witnessed the construction of trapezoidal sunken courts that included specialized structures and burials associated with community or village-level ceremonial practices that included feasting (Beck, 2004; Hastorf, 2003, 2008; Logan et al., 2012). As the first sedentary villages were established, settlements began to increase in size and internal complexity, in tandem with increasingly intensive agricultural and herding practices (Bruno, 2014; Moore, 2011; Whitehead, 2007). Processes of village growth and fissioning, possibly related to scalar stress but also to declining environmental suitability began during the Early Formative II and continued in subsequent periods (Bandy, 2004).

By the Middle Formative (800–250 BC) there is evidence for a two-tier settlement hierarchy, increased inter-regional trade, material wealth, and possible social differentiation (Bandy, 2006). The first multi-community polities were organized during the Late Formative I (250 BC–300 AD) when a few settlements, such as Kala Uyuni, grew exponentially and may have secured political control over the entire peninsula for the first time (Bandy and Hastorf, 2007). The pastoral economy of the region reflects herds kept for multiple goals (wool, meat, and transport) (Moore, 2011) and an