ARTICLE IN PRESS

Quaternary International xxx (xxxx) xxx

Contents lists available at ScienceDirect

Quaternary International

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

# Reconsidering chronologies and cultural change on the south coast of Peru: A compilation and analysis of radiocarbon dates from Nasca, Ica, and Paracas

Christina A. Conlee [a,*], Daniel A. Contreras [b], Ann H. Peters [c], Kevin J. Vaughn [d]

[a] Texas State University, Department of Anthropology, 601 University Drive, San Marcos, TX, 78666, USA
[b] University of Florida, Department of Anthropology, Gainesville, FL, 32611, USA
[c] Penn Museum, American Section, Philadelphia, PA, 19104, USA
[d] University of California, Department of Anthropology, Riverside, CA, 92521-0418, USA

ARTICLE INFO

*Keywords:*
South coast
Peru
Central Andes
Radiocarbon date compilation
Archaeological chronologies

ABSTRACT

The South Coast of Peru, the location where Peru's widely used period/horizon relative ceramic chronology was established and where archaeological samples were obtained for the earliest radiocarbon studies, has figured prominently in the development of chronologies in the Central Andes. We examine the current state of chronology in the region with a compilation of 770 published and unpublished radiocarbon dates from >60 sites in the Nasca and Ica drainages and on the Paracas Peninsula, spanning a period of approximately 8000 years, to evaluate the relative ceramic chronologies and explore the timing and duration of major cultural changes. Kernel Density Estimate (KDE) summaries of Bayesian phase models demonstrate the following aspects of regional cultural dynamics: the earliest settlements began in the Preceramic ca. 6000 BCE and are found on the coast; the Paracas culture was established ca. 900 BCE and cultural development was first focused in the north and then spread south; a reverse direction of cultural influence is found during the Nasca culture when innovation began in the south and spread north; an early mixture of Late Nasca/local Loro culture is found in Nasca (510–720 CE) followed by the spread of Loro elsewhere and the establishment of intrusive highland Wari colonies that peaked in the mid-9th century CE; and the Late Intermediate Period was variable throughout the region in terms of timing and duration, reflecting a turbulent period. The results of the study reveal strong temporal overlap in the ceramic styles indicating they are not purely sequential and consequently are inadequate as chronological markers on a regional level. The research highlights the potential of radiocarbon evidence to reveal sub-regional temporal heterogeneity and to help us better understand the dynamics of cultural change.

## 1. Introduction

Research on the South Coast of Peru has been central to the formation of Central Andean chronologies since the 1950s, when John Rowe and colleagues developed the "Master Sequence" from ceramics found in grave lots in the Ica Valley (Menzel, 1964; Menzel et al., 1964; Rowe, 1962, 1963). This chronology established the alternating sequence of horizons and intermediate periods still widely used today and built on work from the earliest days of archaeology on the South Coast that focused on the development of relative chronologies based on diagnostic ceramics (Gayton and Kroeber, 1927; Kroeber and Duncan Strong, 1924; Tello, 1959; Uhle, 1914). The sequence established by Rowe and colleagues (Preceramic, Initial Period, Early Horizon, Early Intermediate Period, Middle Horizon, Late Intermediate Period, Late Horizon) has framed much of the archaeological research in the Central Andes and allowed comparisons across broad regions. This was Rowe's explicit intent: "Archaeological units from other parts of Peru are dated to one or another of these periods or their subdivisions on the basis of evidence that the units in question are contemporary with a particular unit of pottery style at Ica. Direct evidence for dating of this kind is available in those periods labelled "horizons," because in these periods there was an expansion of trade; certain highly distinctive pottery styles were distributed over large areas, and imported vessels in these styles are found associated with ones in the local traditions (Rowe, 1963:2)." However, the dating of horizons and applying the concept across regions can be problematic because horizons represent sociopolitical, historic,

* Corresponding author.
*E-mail address:* cconlee@txstate.edu (C.A. Conlee).

https://doi.org/10.1016/j.quaint.2024.06.014
Received 5 October 2023; Received in revised form 20 June 2024; Accepted 28 June 2024

and geographic processes that are the results of innovations, interactions, and influences, and consequently they do not work as bounded chronological markers, even though that is often how they are used.

As everywhere in the Central Andes, archaeological research on the South Coast is shaped by the practical necessity of dividing time into periods (Ramón Joffré, 2005), which reflect time spans of cultural continuity punctuated by rapid change. The identification of material culture associated with these periods often is used for chronological diagnosis, creating three challenges: 1) temporal and spatial dynamics internal to periods become difficult to identify and analyze, 2) punctuated equilibrium of neatly chronologically separated phenomena becomes the default assumption, and 3) once proposed, these periods can easily ossify. The problem is only complicated when a region large enough to allow spatial variation in change and rate of change is the object of study, and when the complexity and variety of behaviors underlying changes in material culture are subsumed under a simple assumption of change over time. Ceramic types, in particular, are reflections of the making, using, and sharing of objects that may be widespread in space or persistent in time, or may instead be highly local and special purpose, associated with particular events or processes in certain places. Recognition of these complications is not novel: the South Coast has been in the forefront of not only the development of periods based on ceramic seriation, but also of reflexive attention to those periods (e.g., Carmichael, 2019; Eerkens et al., 2008; Peters and Tomasto-Cagigao, 2018; Vaughn et al., 2014). One of the products of that reflection is the recognition of temporal overlap of many ceramic phases, indicating that ceramic variability reflects drivers other than change over time, including for example sub-regional differences, expression of family or social group style, and functional differences (e.g., ritual vs utilitarian) (Silverman and Proulx, 2002:37). In theoretical terms this is not surprising, and radiocarbon dates associated with ceramic types offer a means of diagnosing when variation does in fact represent change over time. This study is intended to shift the emphasis away from the traditional period/horizon/phase typologies and instead focus on the dynamics of when cultural material is used in different places across the region.

This paper examines the current state of chronology on the South Coast with a compilation of 770 radiocarbon dates taken from >60 sites that span the Preceramic through the Late Intermediate Period, a period of over 8000 years. The goal here is to provide an overview of the dynamics during this long time-span and not to give an in-depth analysis of each cultural period. This compilation of dates makes it possible to evaluate the relative chronologies upon which many interpretations of South Coast archaeology are based and will aid in the future to more precisely situate developments on the South Coast with respect to other areas of the Central Andes.

Some critical questions reviewed in this paper are.

- When and where were the earliest settlements of the region?
- What is the sequence of the appearance and spread of ceramics and other materials diagnostic of the Paracas and Nasca peoples?
- How does the long-established ceramic phase chronology of the Nasca culture compare with the associated radiocarbon dates?
- When did the Wari state establish colonies in the region and how variable was the impact of its collapse?
- What type of settlement variability existed across the region in the Late Intermediate Period?
- Were cultural changes impacted by climate change?

These questions are not fully answered here but the data provide a baseline for further investigation and in-depth analysis of particular time periods. We view this study as a necessary review that builds on previous research by taking stock of the current chronological evidence in an area of the South Coast of Peru. As such, it sets the stage for additional research by raising new questions and establishing in which areas and time periods new dates will have the most impact on interpretation.

## 2. Regional setting and archaeological background

The South Coast cultural area consists of the river valleys (from north to south) of Chincha, Pisco, Ica, Nasca, and Acarí, and extends from the Pacific coast to the headwaters of the rivers. In this study we only include a portion of the South Coast; the Paracas Peninsula (located between the Pisco and Ica Valleys), the Ica River drainage, and the Nasca River drainage (consisting of the Palpa and Nasca subregions), which are the areas where the authors have focused their collective research. While dates from Chincha, Pisco, and Acarí would broaden the scope of this paper to the entire South Coast, correlations between absolute dates, material culture, and context are most accurately assessed at the core of our regional expertise. For the analysis presented in this paper the dates were considered as a whole and by geographic subregion: Paracas/Ica, Palpa (northern Nasca drainage) and Nasca (southern Nasca drainage) (Fig. 1).

The entire South Coast is a hyperarid desert region that has little annual precipitation. The Nasca drainage, for example, today averages 10 mm rainfall per annum, with most of the water coming from seasonal highland runoff (Mächtle et al., 2009). Despite the difficulty of the water regime, and the restricted nature of agricultural land compared to coastal areas to the north, the South Coast was well-suited for farming and settlement. The alluvial sediments are very fertile when irrigated, and the interior Ica and Nasca valleys have 350–360 days of sunshine a year that can produce between two and four harvests depending on the crop (Beresford-Jones, 2011).

Of the subregions examined here, the Ica Valley is the largest with the most water and agricultural potential (ONERN, 1971). At the low end of agricultural potential is the Paracas Peninsula, which has no significant surface water sources, though the aquifer has been linked to an abundant spring by the Bay of Paracas (Peters, 2013). A large stretch of desert divides the Ica and Nasca valleys, although the mouths of the two rivers at the Pacific are only about 18 km apart. The Nasca drainage consists of eight rivers that merge into the Grande River before reaching the Pacific. Between the northern (Palpa) and southern (Nasca) valleys is a large plain but it is much less of a barrier than the desert expanse between Ica and Nasca. The extreme arid environment in the region has led to excellent preservation of organic material and provides a variety of possible materials for radiocarbon dating. Although charcoal has been the most used sample type, short-lived plants such as corn, or textiles made from cotton, are preferred for radiocarbon dating and are well-preserved in many archaeological sites.

### 2.1. Archaeological context

The chronological terms used in this study do not strictly follow any one established terminology (either period/horizon [Rowe, 1962, 1963] or developmental [Lumbreras, 1974]) reflecting the unsatisfactory nature of the developed typologies to reflect cultural change on a regional level (Fig. 2). Instead, we use culture names for time periods that are well established and have corresponding distinct material culture such as Paracas, Necropolis, Nasca, and Loro/Wari, and we use period designations for times when the material culture is less defined and/or multiple cultural groups were possibly present, such as Preceramic, Initial Period, and Late Intermediate Period. All the terms are descriptive and reflect cultural material that is used to group radiocarbon dates and are not primarily chronological.

The first known occupation of the South Coast was during the Preceramic, with the earliest well documented sites falling into what is considered the Middle Preceramic, beginning after 6000 BCE. This is significantly later than the earliest sites elsewhere on the Central Andean coast, which date to around 12,000 BCE on the north coast of Peru (Dillehay et al., 2012) and 11,000 BCE on the far southern coast

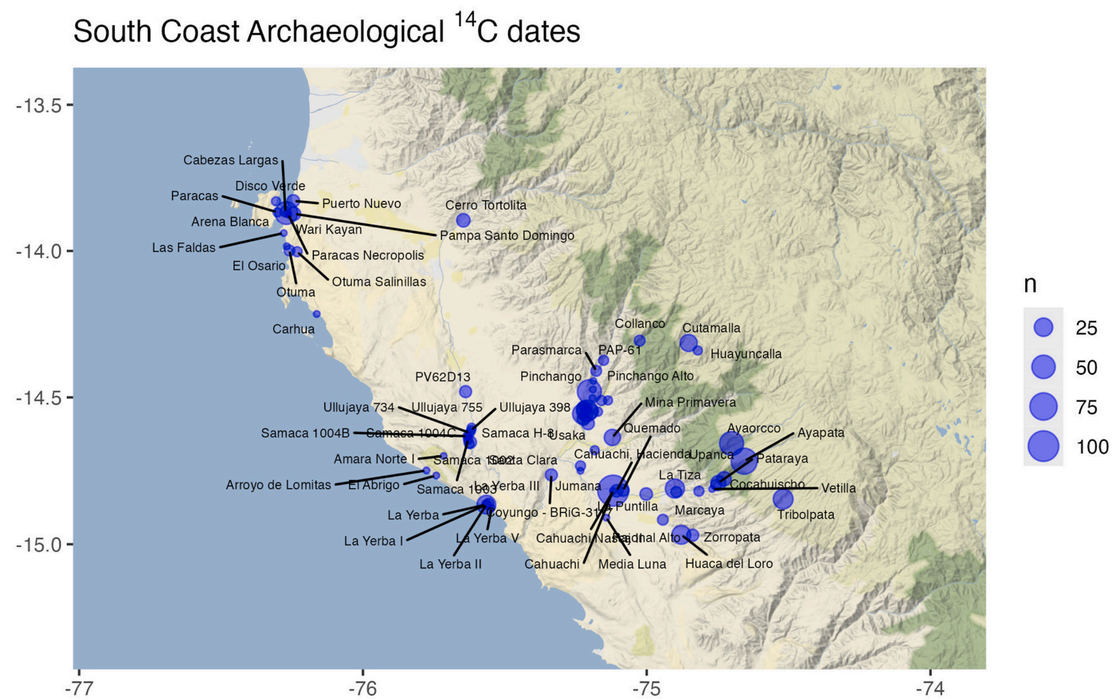


**Fig. 1.** Map of the South Coast with the sites included in the study. Points are scaled to the number of radiocarbon dates included in the analyses.

(Sandweiss et al., 1998). During the Preceramic, hunter-gatherer occupation of the South Coast coexists with evidence of early plant cultivation, domesticated camelids, substantial shell middens, and permanent villages in some places (Beresford-Jones et al., 2022; Conlee, 2016; Engel, 1981; Gorbahn, 2013). In the Late Preceramic the cultural pattern continued (Isla, 1990; Vaughn and Grados, 2006) and the region lacks the monumental architecture and dramatic changes in sociopolitical complexity evident in coastal areas to the north (e.g., Pozorski and Pozorski, 2017). Sites and contexts in this study were identified as Preceramic because of their lack of ceramics and the presence of other diagnostic materials such as projectile point types. Research at the site of Pernil Alto in Palpa, occupied beginning in the Middle Preceramic, documented a hiatus of about 1600 years in the Late Preceramic until it was re-occupied in the Initial Period at ca.1460 BCE (Unkel et al., 2012) (see Supplementary Material for list of sites included in this study, radiocarbon dates, and date sources).

The Initial Period on the South Coast generally coincides with farming and the first production of ceramics (Engel, 1991; Reindel, 2009; Riddell and Valdez, 1987–1988; Robinson, 1994; Rowe, 1967; Silverman, 1996). Material culture associated with Paracas (considered part of the Early Horizon in the Rowe sequence), considered the first complex society on the South Coast, is found on the coast from the Cañete to Nasca valleys (e.g. Carmichael, 2016; Tantaleán et al., 2016). Paracas used to be thought of as primarily a coastal culture, but sites have now been documented up to approximately 3500 masl in the Palpa subregion (Mader et al., 2023; Reindel and Isla, 2018). This period is associated with a variety of social changes, including an increase in settlements, shifts in economic relationships, and new types of material culture most evident in the production of elaborate textiles, new types of pottery, and the first construction of mounds and geoglyphs (e.g., Mader et al., 2023; Stanish et al., 2014). Large sites and elaborate material culture were present in many areas of the South Coast, indicating a high degree of centralization and complexity, while in the Nasca drainage settlements were small and material culture less elaborate, especially in the southern drainage (Reindel, 2009; Schreiber and Lancho, 2003; Van Gijseghem, 2006).

A chronology of the Paracas culture was developed using the Ocucaje pottery sequence (Menzel et al., 1964), which is divided into Early Paracas (Ocucaje 3–4), Middle Paracas (Ocucaje 5–7), and Late Paracas (Ocucaje 8–9) (Tantaleán, 2021; Unkel et al., 2012). Ocucaje 10 is sometimes considered to be part of Late Paracas and sometimes part of Necropolis (discussed below). Previous research documented the co-development of regional Paracas styles and settlements in much of the northern part of the study region associated with Early and Middle Paracas material, followed by a population explosion associated with Late Paracas material in the south in Palpa, while the first Paracas settlements in Nasca are associated with very late Late Paracas material (DeLeonardis, 2005; Dulanto, 2013; Dulanto and Accinelli, 2013; Kaulicke et al., 2009; Reindel, 2009; Schreiber and Lancho, 2003; Sossna, 2014). Analysis of mitochondrial DNA of 218 individuals dating 800 BCE-800 CE from the Paracas Peninsula, the Palpa Valley, and the highlands east of Palpa demonstrated that people from Palpa and the Paracas Peninsula were genetically similar to people of the subsequent Nasca culture (Fehren-Schmitz et al., 2010). These results suggest people of the larger region were biologically related and that migrations from the north into the Nasca drainage began by the beginning of the Paracas culture at least in the Palpa subregion, and that the Nasca culture was an indigenous development.

The period during which Paracas ceramics were replaced by Nasca ones, termed the Transition Period (Unkel et al., 2012), or the Paracas-Nasca Transition (Bautista, 2018; Orefici, 1996; Peters and Tomasto-Cagigao, 2018; Van Gijseghem, 2006), was a dynamic period of cross-cultural interactions and innovations, characterized by the coexistence of Late Paracas, Topará, and Early Nasca ceramic traditions. Carmichael (2019) proposed calling this period the Necropolis Era, since he felt the name provided a pan-regional term that could be used for comparison across the South Coast, and following his lead we call it Necropolis, although without Era since we use the term to signify a type of material culture and not a time period. Recent research that included Bayesian analysis of new and previously published radiocarbon dates in Chincha and Palpa argued that in Chincha the Topará tradition did not emerge until after Paracas sites were ritually closed, indicating that the intrusion of the Topará tradition did not cause the decline of the Paracas culture as had long been proposed (Osborn et al., 2023). In contrast, the authors found that in Palpa (as documented in other areas such as Ica and Paracas) Topará and Paracas populations coexisted. This research

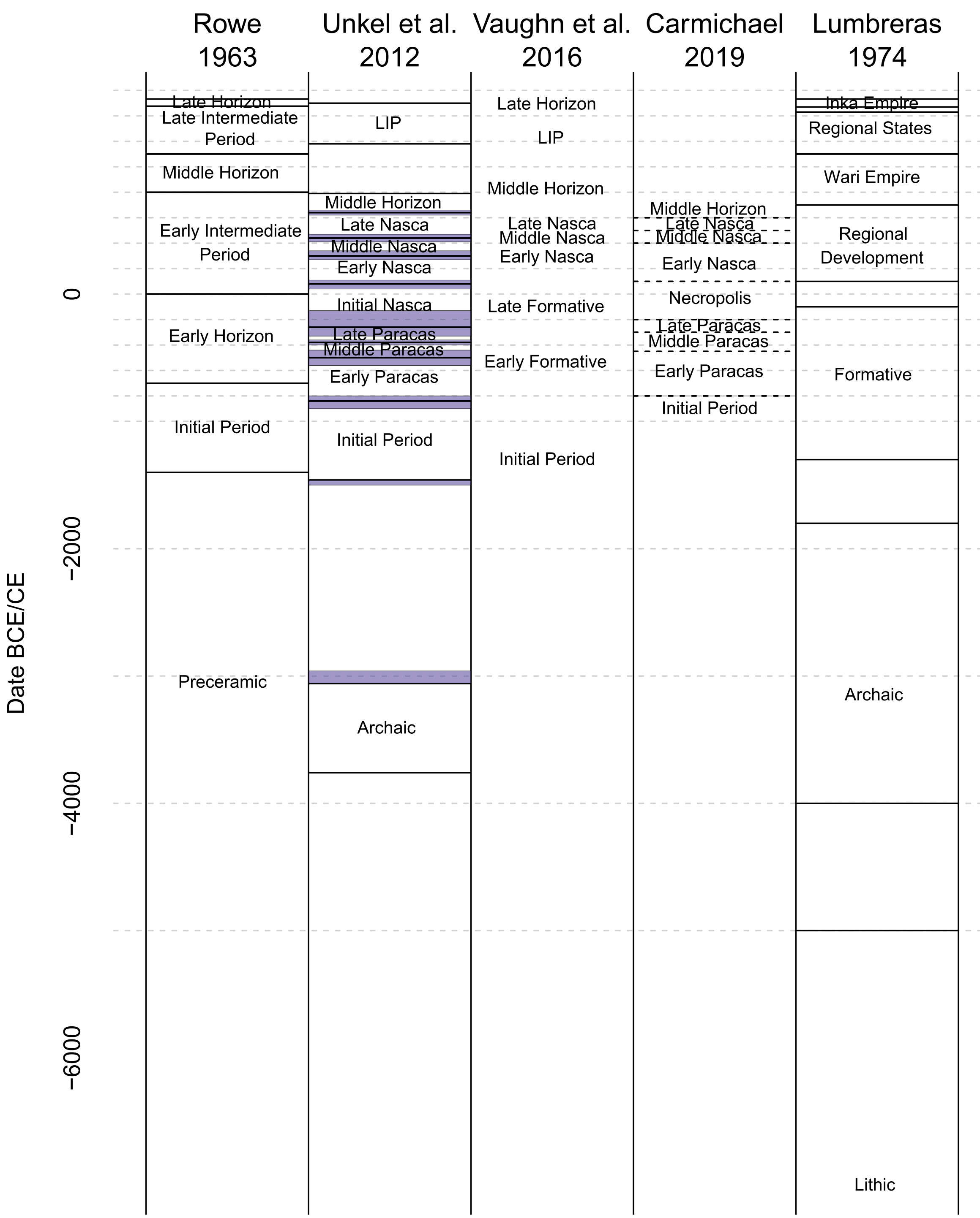


**Fig. 2.** Chronologies used on the South Coast.

supports a model of Topará style emerging north of Ica and spreading south.

Necropolis is best known for the elaborate tombs of the Necropolis of Wari Kayan excavated on the Paracas Peninsula in 1927–1928 by Julio C. Tello and his colleagues (Tello, 1959). Necropolis ceramic assemblages have many different names: Ocucaje 10 (Menzel et al., 1964), Jahuay, Chongos, and Campana (Wallace, 1986), Proto-Nasca (Strong, 1957), Initial Nasca (Unkel et al., 2012), Montana Period (Schreiber and Lancho Rojas, 2003), La Peña (Cook, 1999), and Nasca 0 (Orefici, 2011). The variety of terms reflects differences between subregions. Across many of these subregions, Necropolis is associated with an increase in the number of settlements, most strikingly in Pisco (Peters, 2013), Ica (Massey, 1986), and Palpa (Reindel, 2009; Silverman, 2002; Sossna, 2014).

Material culture classified as Nasca (considered part of the Early Intermediate Period in the Rowe sequence) is associated with a shift of the center of cultural development south to the Nasca drainage. Hallmarks of Nasca are the creation of thousands of geoglyphs (Nasca lines) on plains and mesas, the large site of Cahuachi with several pyramid mounds, and elaborate polychrome pottery. Archaeologists working on Nasca have relied heavily on a relative chronology based on pottery styles that consists of three sub-periods that correspond with ceramic phases - Early Nasca (Nasca 2–4), Middle Nasca (Nasca 5, or Nasca 4–5), and Late Nasca (Nasca 6–7). The ceramic phases were developed in the 1950s using similarity seriation based primarily on pottery found in grave lots; the chronology is known as the Dawson seriation (Proulx, 2006). Since then, the increase in stratigraphic excavation and radiocarbon dating has suggested that the ceramic styles do not segregate as neatly in time as hoped. Carmichael (2013) argues that the Dawson seriation works for the Nasca Valley but not for other subregions. He also points out that the radiocarbon dates associated with ceramic phases overlap and that up to three style phases sometimes existed at any one time. Other chronological studies using optically stimulated luminescence (OSL) and obsidian hydration dating have similarly shown overlap in phases (Eerkens et al., 2008; Vaughn et al., 2014).

Changes in society and material culture are documented throughout the span of the Nasca culture (e.g., Orefici, 2011; Reindel, 2009; Schreiber and Lancho, 2003; Silverman and Proulx, 2002). The height of Cahuachi's power was associated with Early Nasca ceramics, while the cessation of construction at Cahuachi and the restructuring of society with new settlements in the region was associated with Middle Nasca ceramics, and a decrease in the number of settlements in certain areas and increase in frequency of conflict was associated with Late Nasca ceramics.

The appearance of Loro (local) and Wari (foreign) ceramics (markers of the Middle Horizon in the Rowe sequence) was associated with the waning of the Nasca culture and appearance of influence from the Wari civilization in the Ayacucho highlands. Wari colonies were established throughout the study area with a particular concentration of them–with distinctive imperial architecture consisting of orthogonal compounds and D-shaped structures –in the Nasca drainage (Conlee et al., 2021; Edwards and Schreiber, 2014; Isla and Reindel, 2014; Matsumoto et al., 2022). Nasca people had an early connection with Wari, and it may be through Nasca that Wari spread influence and people to other areas of the south and far south coast (Conlee et al., 2021; Jennings et al., 2022). Included in this study are two Wari colonies located in the Nasca subregion – Huaca del Loro (Conlee et al., 2021) and Pataraya (Edwards and Schreiber, 2014). Many other sites in this study have evidence of Wari influence in the form of new collective tomb types, the use of copper alloys especially arsenic bronze, and the presence of Wari pottery. The predominant pottery style is called Loro after the site of Huaca del Loro where it was defined by Strong (1957) although a detailed chronology of this style has not been developed. Loro pottery is the most common type at both local and Wari sites and although originally thought to be associated with the first half of the Middle Horizon (Menzel, 1964; Strong, 1957) it is documented at sites that previous studies have dated from 550–920 CE (Conlee, 2016; Edwards, 2010; Kerchusky, 2018; Sossna, 2014; Unkel et al., 2012).

The collapse of Wari brought disruption to many areas of the Central Andes, including the South Coast. Previous research documented that much of the Palpa and Nasca subregions were abandoned and not reoccupied for almost 200 years until the later part of the Late Intermediate Period, ca. 1250 CE (Conlee, 2016; Sossna, 2014; Unkel et al., 2012). In contrast, the upper elevations of Nasca (Nasca Alto) were occupied and marked by large defensive hilltop forts (McCool, 2017), while the lower Ica Valley shows little disruption and more continuity between Loro/Wari and the Late Intermediate Period (Cadwallader et al., 2018).

On the South Coast and in the adjacent highlands, the Late Intermediate Period is generally identified by three-color pottery (red, white, black) that is not as well made and does not contain the elaborate iconography of the previous time periods although it is much finer in some areas, such as Ica, than in others (Conlee, 2003; Menzel, 1976). Settlement patterns are also distinct: throughout the study area by the later part of the Late Intermediate Period, population grew, sites were larger, adobe mounds were constructed in some areas (Ica), and high levels of violence existed in others (Nasca Alto). The period ended when, at some point in the early to mid-15th century, the Inca conquered the valleys of the South Coast; in Rowe's period/horizon chronology the period of Inca rule is called the Late Horizon. In the study area local pottery and architecture did not change dramatically with the Inca presence, although at least one Inca center was established in each of the South Coast valleys (Menzel, 1959). No contexts from sites with definitive Inca material culture and associated radiocarbon dates were available to be included in this study. Although some radiocarbon dates are reported from Inca centers on the South Coast, such as Tambo Viejo in Acarí (Valdez and Bettcher, 2023), they are outside of the study area. Some of the sites in this study were occupied during the Inca period but were considered Late Intermediate Period since they had local material culture. Hopefully, radiocarbon dates associated with Inca architecture and artifacts will be obtained and published in the future. The contemporaneity of sites classified as Late Intermediate Period based on material culture and sites associated with Inca control of the South Coast typifies the challenges of periodization in the region. The goal here is to establish timespans associated with the material culture that has been used to assign chronological periods, and not to assume that if date falls within a certain range that it is associated with a certain culture.

### *2.2. Previous radiocarbon dating research in the study region*

The first published radiocarbon dates from the South Coast were in Arnold and Libby's (1951) paper introducing the radiocarbon method, which included dates on two wood artifacts collected by Alfred Kroeber from graves at the site of Cahuachi in Nasca and a textile from a Paracas Necropolis mummy (see also Bird, 1952). This was followed by William Duncan Strong's dates from eight samples obtained during 1952-53 excavations at the sites of Estaquería, Huaca del Loro, Cahuachi, and a post from a geoglyph on the San Jose Pampa (Broecker et al., 1956; Strong, 1957). Since then, especially beginning in the 1980s, radiocarbon dates have been integral to research in the region and several publications report radiocarbon dates and use them in analyses of cultural change. However, few studies focus primarily on the compilation and analysis of dates and their synthesis into a broader chronology. The most complete publication and interpretation of radiocarbon dates is by Unkel et al. (2012), who analyzed more than 150 samples from seventeen sites in the Palpa region. Building a Bayesian phase-and-boundary model in OxCal using those dates and the existing cultural sequence for Palpa, they produced age estimates for the start and end of each period, tying the cultural sequence more precisely to calendar ages than had previously been possible. This paper builds on the Unkel et al., (2012) study, including the radiocarbon dates that they published as well as other published dates and new unpublished dates from sites in Nasca, Ica, and the Paracas Peninsula. The goal is to provide an updated and comprehensive compilation of dates, evaluate assemblages of dates associated with suites of material culture diagnostic of regional periods, assess their implications, and reassess what is known about the timing of major cultural changes in the region.

## 3. Materials and methods

Previously published radiocarbon dates were compiled from various sources and filtered for duplicates using the laboratory identification codes, producing a compilation of 770 radiocarbon dates from >60 sites, compiled from >40 publications. Of these, 37 dates could not be clearly associated with diagnostic cultural material and were excluded from further analysis. An additional 88 dates were missing laboratory codes or from sites that could not be located. Where available, information about material dated, context, and associated material culture was also recorded. Dates were assigned to period/phase based on diagnostic material reported by the original researchers, which consisted primarily of ceramics, although architecture style and other diagnostic artifacts were used for some contexts. This posed some challenges due to variability in the level of detail reported by researchers and differing interpretations of ceramic phases. Site and period names were standardized, and latitude, longitude, and elevation were added for each site. The resulting compilation is available in the Supplementary Information.

New dates from Huaca del Loro were obtained from samples chosen during excavations in 2019 and 2022. The samples consist mostly of maize cobs and textile fragments except for a few samples that were wood, bone, and charcoal. The samples were prepared, and AMS dating was conducted, at the University of Arizona Accelerator Mass Spectrometry Lab. New dates from Wari Kayan were based on samples taken from human remains and associated textile fragments of vegetal or animal fiber from a series of tomb assemblages reanalyzed in 2011 and 2012; these had not undergone intensive conservation or exhibition but varied in their study and storage history. The samples were prepared, and AMS dating was undertaken at Beta Analytic, Inc.

All dates in this study were calibrated using SHCal20 (Hogg et al., 2020) in OxCal 4.4 (Bronk Ramsey, 2009a); data were managed in R (R Core Team, 2021). Radiocarbon evidence for each period/region is summarized with a Kernel Density Estimate (KDE) using OxCal's 'KDE_Model' function (Bronk Ramsey, 2017), also in OxCal 4.4. Based on published chronological assignments of associated contexts and/or associated material culture (generally ceramics), dates in the compilation were assigned to subsets, and each subset was modeled as a bounded phase. Because the question of temporal overlap between stylistically defined phases, especially across regions, is critical, no stipulations about sequencing of phases were included as model priors (see OxCal code in Supplemental Information). Dates that are obvious misfits–dramatically different than others in a subset–have been excluded from analysis but remain in the compilation. Dates that may be outliers – identified by their inconsistency with supposed contemporary samples – have been modeled as such in OxCal (Bronk Ramsey, 2009b).

## 4. Results

Summarizing the available radiocarbon evidence for the various cultural periods across the three subregions under consideration produces an overview of both pan-regional commonalities and inter-regional diversity. Because the summary of a given period within each region is a kernel density estimate (KDE) (color saturation corresponds to height of the KDE, so darker areas of each vertical bar are those of higher probability), these estimates compensate (Bronk Ramsey, 2017) for the tendency to overestimate phase lengths based on the combination of statistical scatter, uncertainty, and calibration effects (Bayliss et al., 2007) (Fig. 3). However, since no stratigraphic priors are incorporated and many of the dates are on charcoal and wood samples that may have inbuilt ages, these likely remain overestimates of the length of any given phase in each region. Associations between dated samples and classified material culture – sometimes difficult to assess for legacy dates – can also be a source of error. As noted above (and in contrast to Unkel

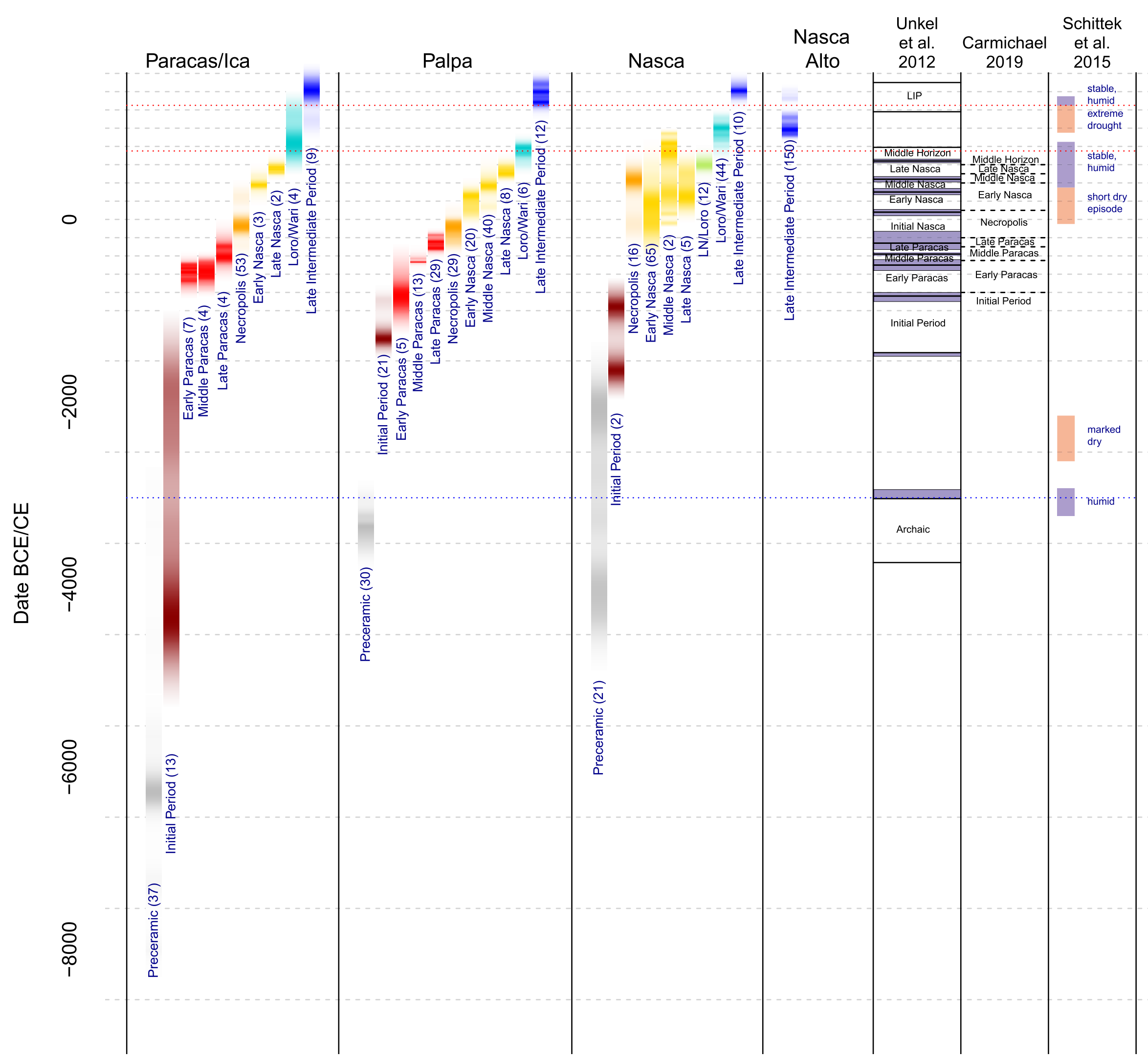


**Fig. 3.** Summaries of the radiocarbon evidence for each period in each region, color-coded by cultural period. Color saturation corresponds to probability density of the KDE for each phase. Number of dates on which each phase is based is indicated in parentheses.

et al., 2012), because the chronological relationships between phases are of key interest, no phase sequencing has been stipulated in the models. This regional overview should - we hope - stimulate additional research grounded in Bayesian models based on the stratigraphic relationships between samples from specific sites.

The results indicate that across all subregions there are chronological overlaps in the cultural phases. Which phases overlap temporally, and how, varies across regions, (e.g., most saliently, Early and Middle Paracas in Paracas/Ica, Late Paracas and Necropolis in Palpa, and Necropolis and Early Nasca in Nasca). Many of these overlaps are not simply of the tails of probability distributions but involve the bulk of probability of the date summaries, suggesting that the temporal overlaps are real and deserving of further investigation, rather than artifacts of methodology. Like any archaeological results, these are vulnerable to sampling bias: if for example Middle Paracas contexts in the Nasca region have been minimally excavated and/or dated, summarizing the radiocarbon evidence about them cannot produce an accurate chronological estimate. These chronological estimates are, however, accurate summaries of available evidence, and highlight where that evidence may be at odds with common interpretations, suggesting a need for revision of accepted models and/or additional research.

Contrasts across regions include.

- Much earlier dates for the Preceramic and Initial Period in the Paracas/Ica region than in Palpa and Nasca.
- Early Paracas material apparently appears earlier in Palpa than in Paracas/Ica. Middle and Late Paracas materials, in contrast, appear earlier in Paracas/Ica. Paracas material is absent or appears late in Nasca.
- The appearance of Necropolis in Nasca is late relative to Paracas/Ica and Palpa. The contemporaneity of the Necropolis and Early Nasca in Nasca - but not elsewhere - is also striking.
- Early, Middle, and Late Nasca materials all appear earlier in Nasca than they do in other regions.
- The absence of any pre-Late Intermediate Period occupation in Nasca Alto likely reflects some combination of research bias and sparse settlement.
- In Palpa and Nasca a hiatus of approximately two centuries occurred between the latest Loro/Wari material and the earliest Late Intermediate Period evidence. No such hiatus exists in Ica. In contrast, dates associated with Late Intermediate Period materials in Nasca Alto begin two centuries earlier and do overlap with the Loro/Wari contexts from Nasca.

## 5. Discussion

In the following discussion of the results, we discuss trends in material culture across the region in terms of space and time. Rather than conflate regional differences by suggesting ranges of time for each period, we provide 95% highest posterior density intervals (HPDI) for each period in each subregion. These ranges are summaries of the available radiocarbon evidence, which approximately capture the earliest and latest dates associated with production/use/discard of associated material culture, they are *not* proposals for divisions of time into periods, phases, or stages. An important caveat to the results presented here and discussed below is that they may reflect uneven dating (more attention to some periods and regions than others) or uncertainty resulting from few dates, and it has in many cases not been possible (based on the original publications of the dates included here) to critically evaluate the associations between dated sample and reported ceramics. HPDI have been rounded to the nearest decade. Where multiple ranges of time are indicated (resulting from discrete probability peaks) these have been maintained where hiatuses seem plausible (where of significant length, e.g. >500 years in the Ica Preceramic), and conflated where they are so brief as to not be behaviorally plausible (e.g., 30 years in the Early Nasca in Nasca, where such a brief hiatus more likely represents a calibration artifact than a period during which Early Nasca ceramics fell out of use). No attempt has been made to truncate ranges that seem implausibly long (e.g., dates associated with Middle Nasca in Nasca extend as late as 1020 CE); rather these stand as summarizing reported evidence, highlighting the difficulties of large-scale compilation of archaeological radiocarbon dates. Long 95% HPDI may also capture probability tails; in fact, consulting the graphic representation is more advisable (Figs. 3 and 5). Where no HPDI is indicated, no radiocarbon dates associated with those ceramics have been reported in that region.

### 5.1. Preceramic

**Paracas/Ica HPDI: 8190–7670/6680–6310/5430–4530/4320–3970 BCE**
**Palpa HPDI: 3700–3030 BCE**
**Nasca HPDI: 4630–1660 BCE**

A total of 88 dates were analyzed from nine sites (with the La Yerba sites counted as one) in all three subregions (Fig. 4). The dates in Paracas/Ica establish a high probability of Preceramic activity by at least 6000 BCE. Although some dates push occupation back earlier (see Fig. 3), this may be an artifact of large uncertainties – or problems of inbuilt age – in early radiocarbon dates. The dates in Paracas/Ica are almost a millennium earlier than those elsewhere. In Palpa the dates are centered around 3500 BCE and all come from the inland site of Pernil Alto. The dates in Nasca span a longer period but come from multiple settlements. The earliest sites in the study region were located on the coastline, where people focused on marine resources, suggesting that searches for very early settlements may be most productive along the coast.

### 5.2. Initial Period

**Paracas/Ica HPDI: 5090–1230 BCE**
**Palpa HPDI: 1450–1270/1190–800 BCE**
**Nasca HPDI: 2100–520 BCE**

A total of 36 dates associated with the Initial Period were obtained from five settlements from all subregions, the smallest number of dates from any major period (Fig. 5). The earliest dates are from settlements in Paracas/Ica. Twenty-one dates were from Pernil Alto in Palpa, a site that also had significant Preceramic occupation. These dates were included in Unkel et al.,'s (2012) publication, in which the authors noted a hiatus between the Late Preceramic and Initial Period. The new calibration and models do not change the existence of this gap in Palpa but show a long Initial Period occupation in Paracas/Ica that is contemporaneous with the Preceramic in the southern areas. However, Preceramic dates from these southern areas, like the very early Preceramic dates from Paracas/Ica, are legacies of mid-20th century research (Engel, 1991) and should be reevaluated.

### 5.3. Paracas

**Paracas/Ica HPDI:**
**Early Paracas: 790–440 BCE**
**Middle Paracas: 790–420 BCE**
**Late Paracas: 600–40 BCE**
**Palpa HPDI:**
**Early Paracas: 1150–350 BCE**
**Middle Paracas: 520–370 BCE**
**Late Paracas: 380–170 BCE**

A total of 73 dates were obtained from 12 Paracas sites. Previous research involving archaeological excavation and survey, ceramic analysis, radiocarbon dates, and DNA indicated a spread of the Paracas

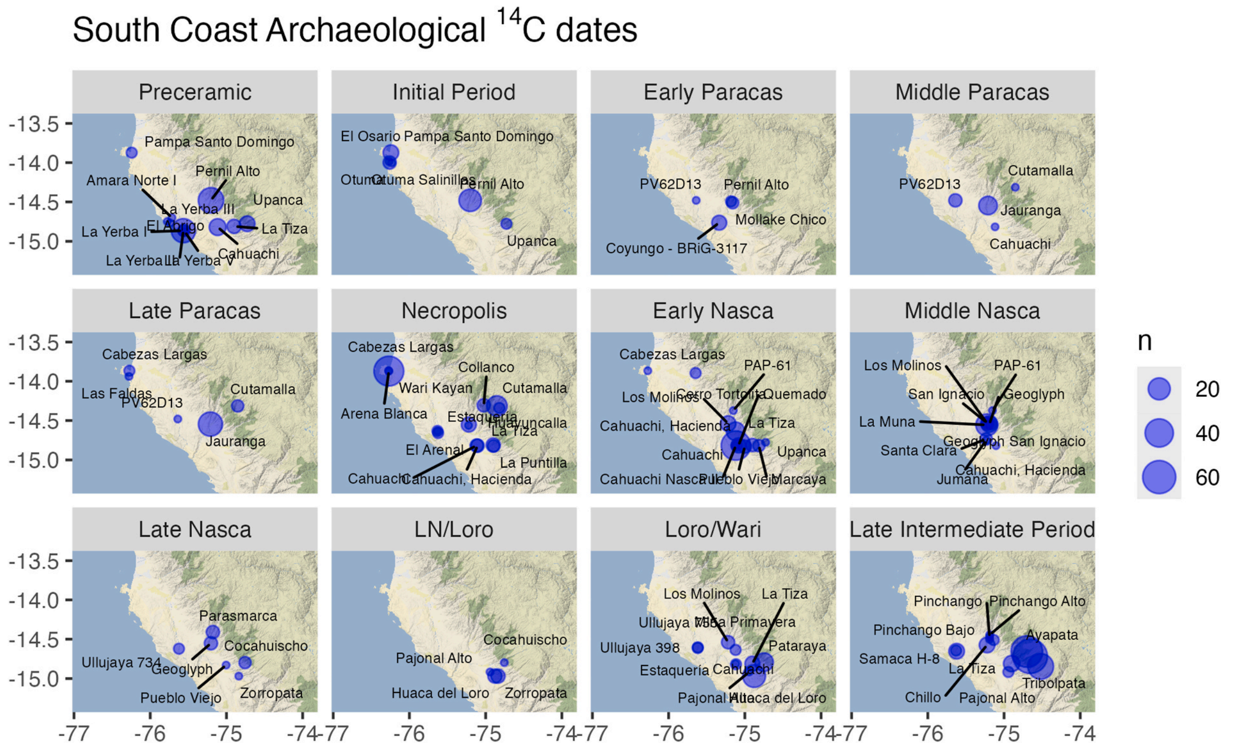


**Fig. 4.** Sites included in analysis for each cultural period. Points are scaled to the number of radiocarbon dates included in the analyses.

culture and people from north to south (e.g., Carmichael, 2019; Fehren-Schmitz et al., 2010; Van Gijseghem, 2006), and the results of our analysis generally support this conclusion. However, Early Paracas appears earliest in Palpa, while Middle Paracas appears earliest in Ica/-Paracas. Early and Middle Paracas settlements are unknown in Nasca. Late Paracas appears earliest in Ica/Paracas followed by Palpa; there are no recorded sites in Nasca that have contexts with only Late Paracas cultural material. Instead, the dated Nasca contexts with Late Paracas pottery (Ocucaje 8) also had Ocucaje 10 and Nasca 1 pottery and are considered part of Necropolis. When all Paracas dates from Paracas/Ica are combined and compared with all the dates from Palpa an earlier span for the Paracas/Ica subregion is evident (Fig. 6).

### 5.4. Necropolis

**Paracas/Ica HPDI: 360 BCE – 190 BCE/120 BCE – 300 CE**
**Palpa HPDI: 250 BCE – 110 CE**
**Nasca HPDI: 220 BCE – 230 CE/260–600 CE**

A total of 98 dates were obtained from 12 sites (with the Cahuachi and Samaca sites each considered as one) in all the subregions. On the Paracas Peninsula this period is associated with the burials from Wari Kayan (Peters, 2016); outside of the peninsula it is associated with settlements that have a variety of pottery styles, usually including Ocucaje 9, 10, and Nasca 1, though sometimes Ocucaje 8 and Nasca 2 pottery are also present (Bachir Bacha and Llanos Jacinto, 2006; Conlee, 2016; Van Gijseghem, 2006). In Nasca, dates associated with Necropolis begin later, and persist more than two centuries longer, suggesting a northern origin (Fig. 7). Necropolis overlaps completely with Early Nasca in Nasca, which supports the idea that this period is a mixing of cultures and artistic traditions and emphasizes that ceramic phases have subregional associations and are not temporal markers across the region.

### 5.5. Nasca

**Paracas/Ica HPDI:**
**Early Nasca: 200–560 CE**
**Late Nasca: 480–700 CE**
**Palpa HPDI:**
**Early Nasca: 10–370 CE**
**Middle Nasca: 210–650 CE**
**Late Nasca: 470–680 CE**
**Nasca HPDI:**
**Early Nasca: 220 BCE – 680 CE**
**Middle Nasca: 120 BCE – 1020 CE**
**Late Nasca: 70–690 CE**

A total of 191 dates were obtained from 24 sites, the largest number of dates and sites for any period in this study. Scholars studying Nasca have relied heavily on Dawson's detailed seven phase ceramic chronology. At the same time, it has been evident for at least two decades that the ceramic phases do not coincide well with radiocarbon dates and have sub-regional differences (Carmichael, 2019; Silverman and Proulx, 2002; Vaughn et al., 2014). The largest number of radiocarbon dates comes from the center of Cahuachi in the Nasca subregion, which is thought to date primarily to Early Nasca, a period associated with ceramics of the Nasca 2–4 phases. The center of the Early Nasca world was Cahuachi and the dates reflect a spread of cultural traditions from this center to the regions in the north, with Early Nasca first present in Nasca before Palpa and then later in Paracas/Ica (Fig. 8). This direction of influence reverses the direction of spread of Paracas material culture, though the small number of dates from Paracas/Ica (n = 5) makes this contrast tentative. Early Nasca also lasts the longest in the Nasca subregion.

Middle Nasca is associated with Nasca 5 pottery in the Nasca subregion, while in Palpa Nasca 4 and 5 pottery are found together and are considered to represent Middle Nasca. In Palpa, Middle Nasca is also defined by distinctive shaft tombs found at the site of La Muña (Isla and Reindel, 2006). Middle Nasca is well-dated (n = 40) in Palpa, but with only two radiocarbon dates from Nasca and none from Paracas/Ica productive comparison between the regions is not possible (the broad timespan associated with Middle Nasca in Nasca is a product of the

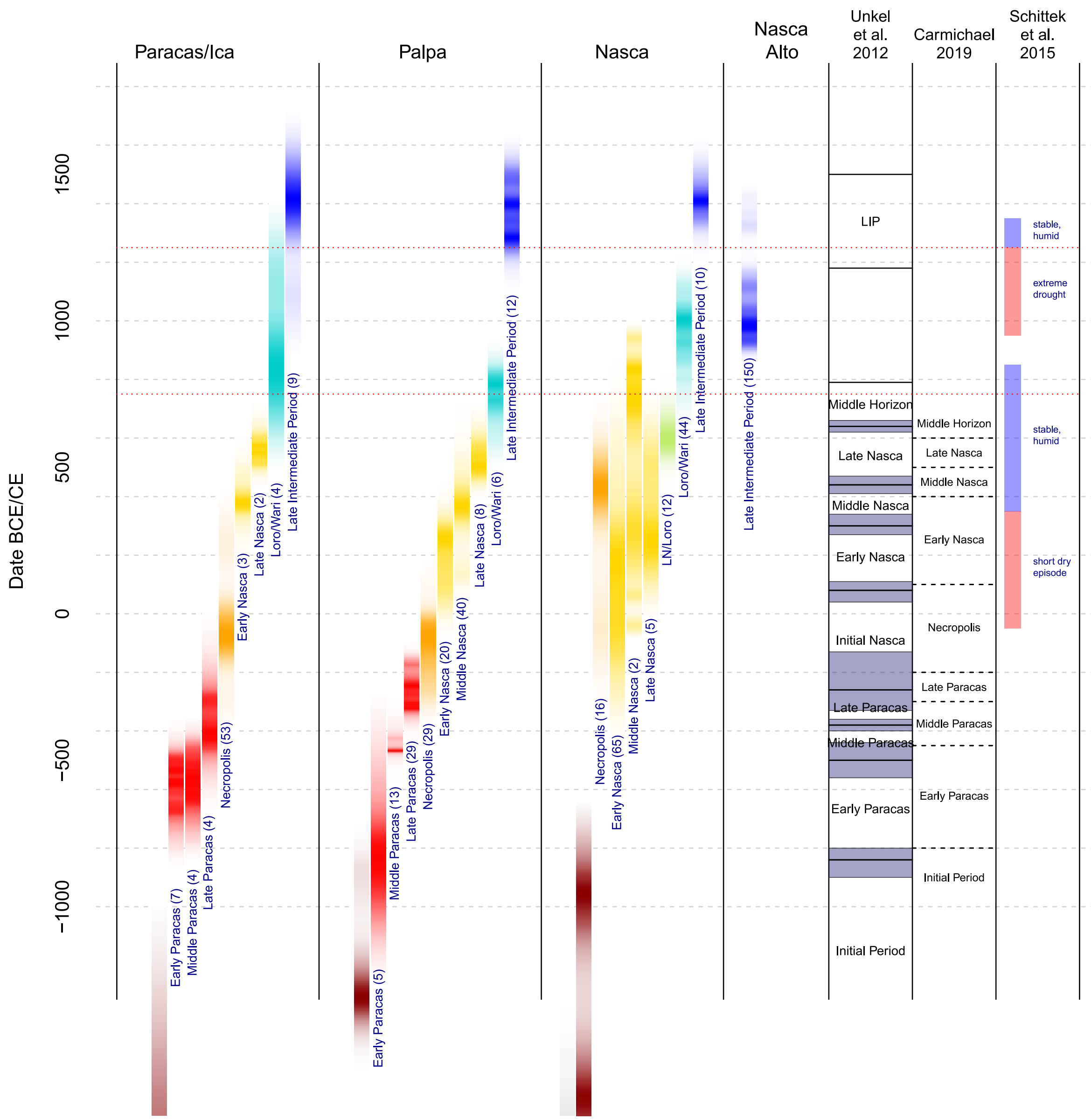


**Fig. 5.** Summaries of the radiocarbon evidence Initial Period – Late Intermediate Period.

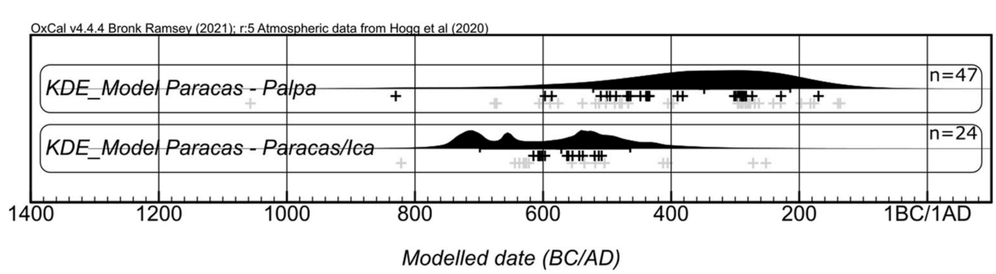


**Fig. 6.** KDE summaries of phase models that combine all dated samples with Paracas period associations, separated by Paracas/Ica and Palpa subregions.

broad uncertainties of the two dates). However, in Palpa Middle Nasca overlaps in time with Early Nasca and Late Nasca, and in Nasca the two Middle Nasca dates overlap in time with Late Nasca, indicating Middle Nasca phase pottery is not a good chronological marker.

Late Nasca is associated with shifts in settlement and ceramic styles along with the appearance of highland influence. It is associated with Nasca 6–7 ceramics, although in Palpa Nasca 6 is rarely found (Hecht, 2009) and work by Whalen (2014) in the Nasca subregion at Cocahuischo suggests that Nasca 6 pottery was rare at this Late Nasca residential site, indicating that the style had a limited distribution. The earliest dates associated with Late Nasca are in the Nasca subregion, suggesting once again that changes in pottery style, and presumably any cultural shifts associated with them, occurred first in the south and then moved north. Consistent with other chronological studies (e.g., Carmichael,

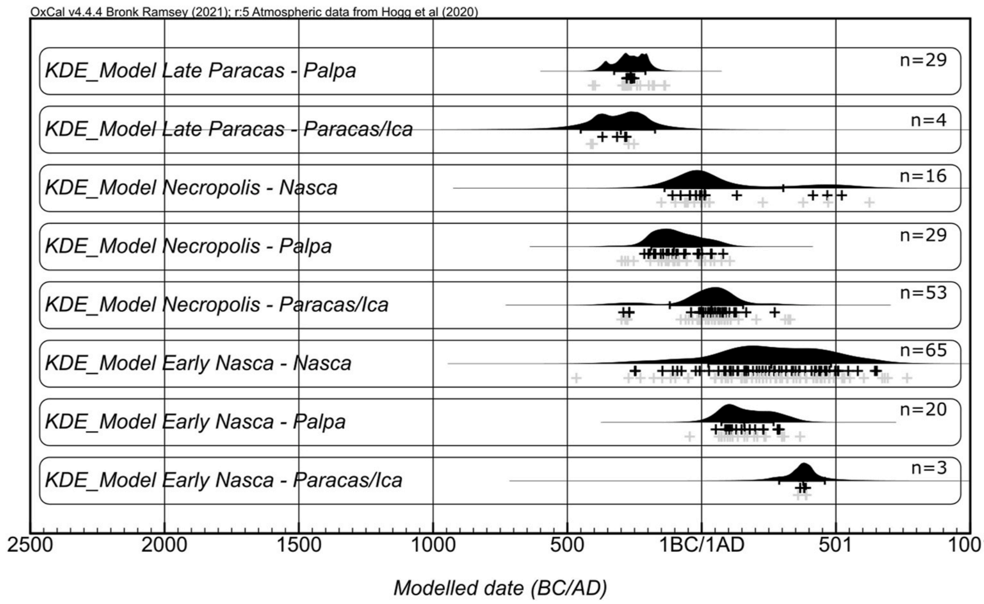


**Fig. 7.** KDE summaries of phase models that combine all dated samples with Late Paracas, Necropolis, and Early Nasca associations for each subregion.

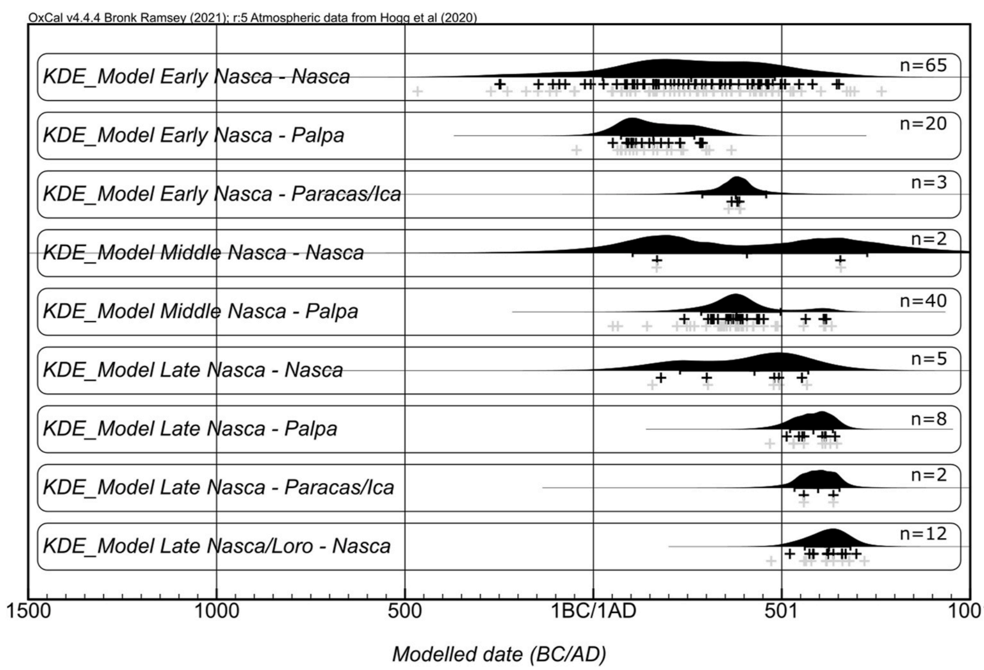


**Fig. 8.** KDE summaries of phase models that combine all dated samples with Early Nasca, Middle Nasca, Late Nasca, and Late Nasca/Loro associations for each subregion.

2019; Vaughn et al., 2014) the Late Nasca dates reported here overlap with Early and Middle Nasca dates, especially in the Nasca subregion, indicating that the pottery style is responsive to something other than time alone. When all Nasca dates from each subregion are plotted it shows an earlier beginning and longer span in the Nasca subregion, demonstrating this was where cultural developments were initiated and lasted longest (Fig. 9).

### *5.6. Late Nasca/Loro*

**Nasca HPDI: 500–740 CE**

A set of contexts termed Late Nasca/Loro include Nasca 7 pottery and Loro pottery, are found in the Nasca subregion (12 dates from four sites). These contexts do not include material from the highland Wari civilization. The associated dates overlap considerably with Late Nasca dates in all three subregions. Although Late Nasca and Loro pottery are found together in contexts in Palpa (Sossna, 2014:192), no dates from those contexts were available to be included in this study. It is possible that Loro pottery was in use earliest in the Nasca subregion, where it was used along with Nasca 7 pottery, and that the Loro pottery style then spread north. Radiocarbon dates from associated contexts outside of the Nasca subregion are needed to evaluate this possibility.

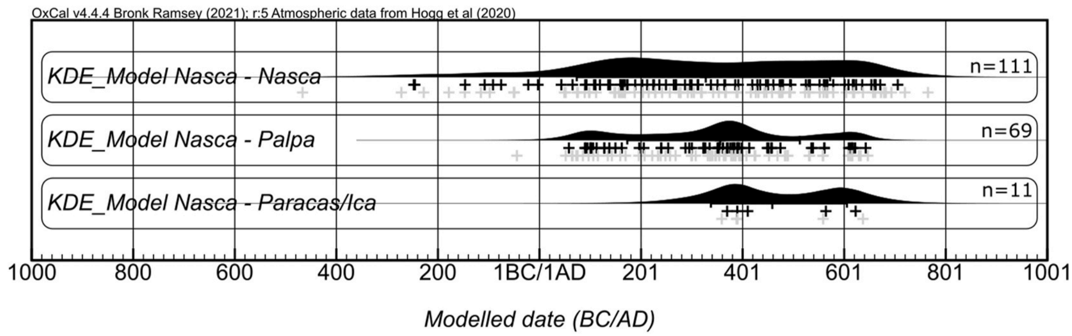


**Fig. 9.** KDE summaries of phase models that combine all dated samples with Nasca period associations, separated by subregion.

### 5.7. Loro/Wari

**Paracas/Ica HPDI: 580–1350 CE**
**Palpa HPDI: 550–860 CE**
**Nasca HPDI: 690–1080 CE**

A total of 54 dates associated with Loro/Wari contexts were obtained from ten sites. These settlements contained either local Loro pottery, imperial Wari pottery, or a mixture of both. Two of the sites included were Wari colonies (Huaca del Loro and Pataraya) both located in Nasca, while the others were local settlements with varying degrees of Wari influence. No Wari colonies in Palpa were dated and the local Loro sites in this area span the Late Nasca/Loro contexts and the first half of Loro/Wari in Nasca. In Paracas/Ica the dates span a much longer time period (Fig. 10). Dates from the Wari colonies in the Nasca subregion mostly span 700–1000 CE and the contexts dated contain both Wari and Loro pottery. The overall patterns show an early mixture of Late Nasca and Loro in the Nasca subregion, followed more broadly by the use of Loro pottery, and then the establishment of Wari colonies with the Loro pottery continuing to be used. The Nasca Alto fortified sites were established around 970 CE making them contemporary with the later dates of Loro/Wari in Nasca.

### 5.8. Late Intermediate Period

**Paracas/Ica HPDI: 960–1400/1420–1580 CE**
**Palpa HPDI: 1180–1530 CE**
**Nasca HPDI: 1270–1520 CE**
**Nasca Alto HPDI: 970–1020 CE/1140–1440 CE**

A total of 181 dates were obtained from 10 sites (with Samaca considered as one site) assigned to the Late Intermediate Period. Previous research (Conlee, 2016; Unkel et al., 2012) indicated a hiatus between the end of Loro/Wari settlements and the middle part of the Late Intermediate Period in the Palpa and Nasca subregions. The current study confirms this gap in the lower elevations of Palpa (ca. 860–1180 CE) and Nasca (ca.1080-1270 CE) but in the upper elevations of Nasca (Nasca Alto) fortified sites were occupied during this period, suggesting that people may have migrated up-valley from the lower elevations during a time of social, political, and environmental stress (Fig. 11). In the lower Ica valley at Samaca, occupation continued during the gap period, indicating little disruption and more favorable conditions. This might be explained in part by the lack of known Wari presence in the area, making this area less directly vulnerable to the Wari collapse.

The Late Intermediate Period was a time of population peak on the South Coast (Menzel, 1976; Reindel, 2009; Schreiber and Lancho, 2003). Large and numerous sites are found in all the subregions. The period begins and ends earliest in Nasca Alto. This is followed by occupation in Paracas/Ica while the lower elevations of Nasca and Palpa begin later and have similar trajectories to each other. This may reflect what is written in historical accounts that describe Palpa and Nasca as integrated and part of a regional polity at this time, and Ica as a more powerful independent polity (Conlee, 2016; Menzel, 1976). The upper elevations of Nasca were possibly incorporated by the Inca before the other regions (Conlee, 2021), which may have led to population resettlement and new types of material culture.

### 5.9. Climate and culture

Climate change has been suggested as a major factor in cultural change on the South Coast (e.g., Eitel et al., 2005; Mächtle and Eitel, 2013; Mächtle et al., 2017; Sossna, 2014; Schittek et al., 2015). The most localized climate information comes from peat cores near Cerro Llamoca in the upper elevations of the Palpa subregion, which span approximately the last 8600 years (Schittek et al., 2015). Schittek et al.'s age-depth model (2015:31) is based on 35 radiocarbon dates (50 samples were analyzed, but 15 dates were classified as resulting from redeposition and discarded). The dates were originally calibrated with IntCal09; in order to compare with our results, we have recalibrated the dates using SHCal20. The results are summarized in the right-hand

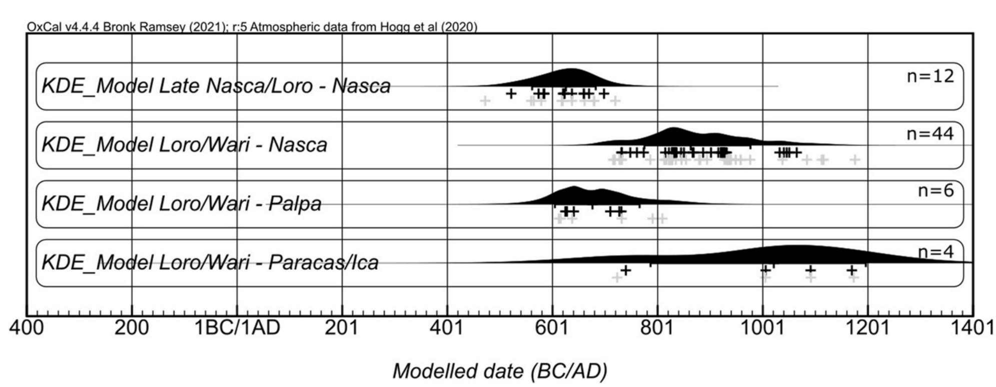


**Fig. 10.** KDE summaries of phase models that combine all dated samples with Loro/Wari and Late Nasca/Loro associations for each subregion.

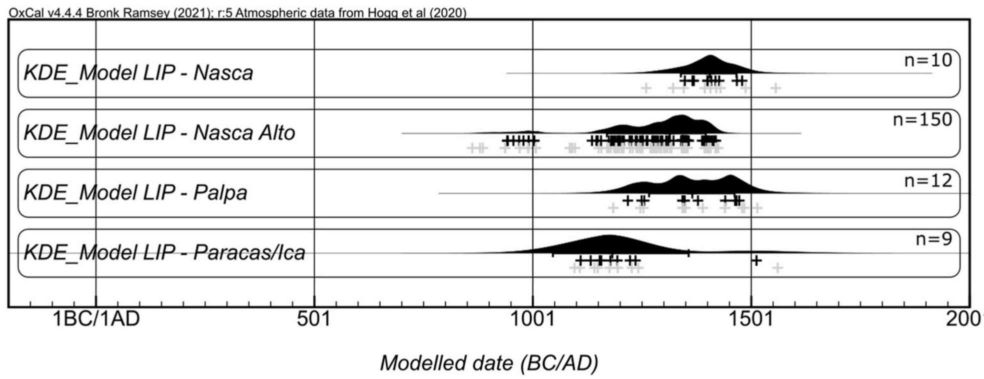


**Fig. 11.** KDE summaries of phase models that combine all dated samples with Late Intermediate Period associations for each subregion.

column of Figs. 3 and 5.

Schittek et al. (2015:39–40) found that the Mid-Holocene, the period of early occupation along the coast in Paracas/Ica but preceding documented settlements in Palpa and Nasca, had a highly variable hydroclimate. A subsequent humid period from 3250 to 2950 BCE, including a significant transition to wetter conditions around 3050 BCE, coincided with the occupation of inland sites in Palpa and Nasca and sparse occupation in Paracas/Ica. A marked dry period from 2650 to 2150 BCE is a time when no dated settlements are recorded in Palpa, a few dated Preceramic contexts are found in the upper elevations of Nasca, and some Initial Period occupation in Paracas/Ica. A short dry episode between 50 BCE-350 CE is not correlated with any particular material culture and spans Necropolis, Early Nasca, and Middle Nasca in Palpa, and Necropolis and Early, Middle and Late Nasca in Nasca. In Paracas/Ica this period coincides with Necropolis and Early Nasca. A stable humid period from 350 to 850 CE is coeval with Middle Nasca, Late Nasca, and Loro/Wari in Palpa, and with Necropolis through the first half of Loro/Wari in the Nasca region. This period in Paracas/Ica includes Early Nasca, Late Nasca, and the first half of the span of Loro/Wari. Schittek et al. also point to a return to dry conditions at 750 CE. An extreme drought from 950 to 1250 CE coincides with a gap in the archaeological radiocarbon record in Palpa, and in Nasca overlaps with the end of Loro/Wari and a gap in the archaeological record. However, Nasca Alto is occupied during this time and in Paracas/Ica it coincides with Loro/Wari contexts. Stable humid conditions returned from 1250 to 1350 CE, corresponding with the Late Intermediate Period and peak populations except in Nasca Alto, where few contexts are dated to this period.

The results suggest some connections between the climate fluctuations recorded at Cerro Llamoca and cultural changes in Palpa as Schittek et al. (2015) argued, such as a humid period coinciding with early settlements, and an extreme drought contemporary with the gap period, but it is more difficult to correlate climatic changes with cultural changes in other time periods and subregions of the study area. This highlights the difficulty of inferring causality in relating climate and cultural change, and the importance of applying regional climate data to regional cultural data instead of using information from remote regions and assuming uniform climatic changes across the Central Andes, something pointed out by Mächtle et al. (2017) previously. The comparisons of the climate and culture are further complicated by the regional differences in the cultural chronologies, as demonstrated with the South Coast data.

## 6. Conclusions

The results of this compilation and analysis of radiocarbon dates shed some new light on cultural dynamics in the region. The earliest sites are in the Paracas/Ica region, beginning at least 6000 BCE, are located on the coast. Inland sites were occupied more than a millennium later in Nasca and subsequently in Palpa coinciding with a humid period. The Initial Period dates have different spans in the three subregions, with the earliest in Paracas/Ica. This period has the lowest number of dates, and the dating is more uneven across the region, perhaps suggesting sparseness of occupation, and making interpretations of the dynamics of the period more difficult.

The development of the Paracas culture marks a dramatic change to more complex types of social, political, and economic organization. One of the most striking patterns to emerge from this research is the clear directional patterns between the northern and southern areas of the study region, beginning with the Paracas culture. Paracas occupations have an extensive history in the north, including the Chincha and Pisco watersheds (not included in this study; see review in Tantaleán, 2021) as well as on the Paracas Peninsula and in the Ica Valley. However, the earliest Paracas dates in this study were from Palpa, followed by Paracas/Ica. In contrast, the Nasca subregion lacks Early and Middle Paracas settlement and had a very late adoption of Late Paracas ceramics.

Necropolis appears to constitute a hybrid of several coeval cultural traditions, which overlap in time with Early Nasca in Nasca. This highlights two risks involved in using ceramic types as temporal markers: the potential for contemporary production/use/discard of multiple types, and the potentially time transgressive nature of both adoption and abandonment of particular ceramic types (e.g, the radiocarbon evidence suggests that Necropolis apparently remained in use in Nasca for ~250 years after it fell out of use in Paracas/Ica).

Such directionality was not fixed. Following Necropolis, the cultural influence changed direction, with innovation beginning in the south in Nasca and then spreading north. Despite Carmichael's (2013) suggestion that the ceramic seriation works best in the Nasca Valley (one of the three valleys of the Nasca subregion), overlap in the timespans associated with ceramic types (that have been divided into phases) is evident and particularly notable in Nasca, which was presumably the origin of the ceramic styles. Overall, the Nasca culture appears to be initiated in Nasca and lasts the longest in this subregion. The shift from relatively arid to relatively humid conditions at ca. 350 CE crosscuts the Nasca period in all three coastal regions. When the climate changed, Early Nasca ceramics were in use in Paracas/Ica, Middle Nasca ceramics were in use in Palpa, and Necropolis, Early Nasca, Middle Nasca, and Late Nasca ceramics were all in use in Nasca. The climate data do not indicate a drought period associated with Middle and Late Nasca as some previous investigators proposed (Schreiber and Lancho, 2003; Silverman and Proulx, 2002). Instead, much of the mid-late Nasca period and Loro/Wari coincide with a stable humid period although with drier conditions at 750 CE.

An early mixture of Late Nasca and Loro pottery is found in the Nasca subregion. Contexts in Nasca with Late Nasca and Loro pottery are contemporary with contexts containing Late Nasca ceramics in Palpa and Paracas/Ica, indicating that the Loro style was first used in the south and then became widespread. The Loro/Wari period witnessed the intrusion of the highland Wari state and the establishment of Wari colonies, although Wari influence was variable throughout the study region. Loro pottery continued to be used alongside Wari pottery in most places and was not exclusively an early Middle Horizon style as previous research suggested. The climate data indicate a period of extreme drought beginning around 950 CE that occurs a hundred years after the last Loro/Wari dates in Palpa and 100 years before the last dates in Nasca. It was a period of stress and movement of people in the south, and it was a period of continuity in Ica, signaling diverging trajectories in the subregions. These diverging trajectories are evident in the Late Intermediate Period, when the Nasca highlands (Nasca Alto), Nasca and Palpa (with similar patterns to one another), and Paracas/Ica have variable beginning and end dates.

The data and interpretations presented here provide a summary of current evidence regarding the dynamics of cultural change on the South Coast and emphasize that ceramic phases have subregional associations and are not temporal markers across the region. The synthesis of available radiocarbon evidence demonstrates that traditionally used chronological frameworks 1) obscure significant regional variability in the timing of production/use/discard of commonly recognized ceramic types, and 2) assume strict temporal sequencing of ceramic types when in fact substantial temporal overlap seems to be the norm. The constituent details of this synthesis can be built upon and modified in the future as more dates become available and additional archaeological contexts are investigated. Chronological precision can be improved through Bayesian models based on the stratigraphic relationships of samples from individual sites, and it is to be expected that improved chronologies may further change the interpretations of cultural (and climate-culture) dynamics. The synthesis we have provided here demonstrates how contingent such interpretations are on chronology, with significant interpretive ramifications. It is particularly notable how assumptions based on the summary chronological charts lead to the compression of time periods, sometimes by centuries. Instead of charts with discrete blocks of time, different approaches to chronology are needed to understand the regional variation and patterns of material culture that is critical to developing more accurate models of past sociopolitical and climate-culture dynamics on the South Coast and across the Andes.

## Data availability

All radiocarbon dates used in this paper are included in the Supplemental Information.

## Funding

Research for previously unpublished dates from Wari Kayan was supported by National Science Foundation Grant BCS-0852151. Research for previously unpublished dates from Huaca del Loro was supported by National Science Foundation Grant BCS-1758084.

## CRediT authorship contribution statement

**Christina A. Conlee:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Daniel A. Contreras:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ann H. Peters:** Writing – review & editing, Writing – original draft, Investigation, Funding acquisition, Data curation, Conceptualization. **Kevin J. Vaughn:** Writing – original draft, Investigation, Data curation, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgements

Thank you to Matthew Edwards, Sarah Kerchusky, and Weston McCool who shared radiocarbon dates and/or provided context information on dated samples. Thanks also to the organizers of the original SAA session and this special journal issue - Dan Contreras, Erik Marsh, and Kurt Rademaker.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.quaint.2024.06.014.

## References

Arnold, J.R., Libby, W.F., 1951. Radiocarbon dates. Science 113, 111–120.

Bayliss, Alex, Ramsey, Christopher Bronk, van der Plicht, Johannes, Whittle, Alasdair, 2007. Bradshaw and bayes: towards a timetable for the neolithic. Camb. Archaeol. J. 17, 1–28.

Bautista, Stefanie Lillian, 2018. The Household Thru Time: the Paracas to Nasca Transition at Uchuchuma, Aja Valley, Peru. Stanford University. Unpublished Ph.D dissertation.

Beresford-Jones, David, 2011. The Lost Woodlands of Ancient Nasca: A Case Study in Ecological and Cultural Collapse. Oxford University Press, Oxford.

Beresford-Jones, David G., Friesem, David E., Sturt, Fraser, Pullen, Alexander, George, Chauca, Moat, Justin, Gorriti, Manuel, et al., 2022. Insights into changing coastlines, environments and marine hunter-gatherer lifestyles on the pacific coast of SouthSouth America from the La Yerba II shell midden, río Ica estuary, Peru. Quat. Sci. Rev. 285, 107509.

Bird, Junius Bouton, 1952. South American radiocarbon dates. Memoirs of the Society for American Archaeology 8, 37–49.

Broecker, Kusp, W.S.J.L., Tucek, C.S., 1956. Lamont natural radiocarbon measurements III. Science 124 (3213), 154–165.

Bronk Ramsey, Christopher, 2009a. Bayesian analysis of radiocarbon dates. Radiocarbon 51, 337–360.

Bronk Ramsey, Christopher, 2009b. Dealing with outliers and offsets in radiocarbon dating. Radiocarbon 51, 1023–1045.

Bronk Ramsey, Christopher, 2017. Methods for summarizing radiocarbon datasets. Radiocarbon 59, 1809–1833.

Cadwallader, Lauren, Beresford-Jones, David G., Pullen, Fraser C. Sturt Alexander G., Torres, Susana Arce, 2018. Doubts about how the middle horizon collapsed (ca. AD 1000) and other insights from the looted cemeteries of the lower Ica Valley, South Coast of Peru. J. Field Archaeol. 43 (4), 316–331.

Carmichael, Patrick H., 2013. Regionalism in Nasca style history. Andean Past. 11, 215–231.

Carmichael, Patrick H., 2016. Nasca origins and Paracas progenitors. Ñawpa Pacha 36 (2), 53–94.

Carmichael, Patrick H., 2019. Stages, periods, epochs, and phases in Paracas and Nasca chronology: another look at John Rowe's Ica Valley master sequence. Ñawpa Pacha 39 (2), 145–179.

Conlee, Christina A., 2003. Local elites and the reformation of late Intermediate Period sociopolitical and economic organization in Nasca, Peru. Lat. Am. Antiq. 14 (1), 47–65.

Conlee, Christina A., 2016. Beyond the Nasca Lines: Ancient Life at La Tiza in the Peruvian Desert. University Press of Florida, Gainesville.

Conlee, Christina A., 2021. The importance of coastal-highland interactions and population movements on the development and collapse of complex societies in Nasca, Peru (AD 500-1470). Lat. Am. Antiq. 32 (2), 405–420.

Conlee, Christina A., Kellner, Corina, Walker, Chester, Noriega, Aldo, 2021. Early imperialism in the Andes, the Wari colonization of Nasca. Antiquity 95 (384), 1527–1546.

Cook, Anita, 1999. Asentamientos Paracas en el Valle Bajo de Ica, Perú. Gaceta *Arqueológica Andina*, 25, 61–90.

DeLeonardis, Lisa, 2005. Early Paracas cultural contexts: new evidence from callango. Andean Past. 7 (1), 27–55.

Dulanto, Jahl, 2013. Puerto Nuevo: Redes de intercambio a larga distancia durante la primera mitad del primer milenio antes de nuestra era. Boletín de Arqueología PUCP 17, 103–132.

Dulanto, Jahl, Accinelli, Aldo, 2013. Disco Verde: 50 años después de Frédéric Engel: la primera temporada de excavaciones del Proyecto de Investigaciones Arqueológicas Paracas en el sitio. Boletín de Arqueología PUCP 17, 133–150.

Dillehay, Tom D., Bonavia, Duccio, Goodbred, Steve L., Pino, Mario, Vásquez, Victor, Tham, Teresa Rosales, 2012. A late pleistocene human presence at Huaca prieta, Peru, and early pacific coastal adaptations. Quat. Res. 77 (3), 418–423.

Edwards, Matthew J., 2010. Archaeological Investigations at Pataraya: A Wari Outpost in the Nasca Valley of Southern Peru. University of California, Santa Barbara. Unpublished dissertation.

Edwards, Matthew J., Schreiber, Katharina J., 2014. Pataraya: the archaeology of a Wari outpost in Nasca. Lat. Am. Antiq. 25 (2), 215–233.
Eerkens, Jelmer W., Vaughn, Kevin J., Carpenter, Tim R., Conlee, Christina A., Grados, Moises Linares, Schreiber, Katharina J., 2008. Obsidian hydration dating on the South Coast of Peru. J. Archaeol. Sci. 35 (8), 2231–2239.
Eitel, Bernhard, Hecht, S., Mächtle, Bertil, Schukraf, G., Kadereit, A., Wagner, G.A., Kromer, B., Unkel, I., 2005. Geoarchaeological evidence from desert loess in the nazca–palpa region, southern Peru: paleoenvironmental changes and their impact on pre-columbian cultures. Archaeometry 47 (1), 137–158.
Engel, Frederic-Andre, 1981. Prehistoric andean ecology: man, settlement and environment in the Andes, the deep south. In: Papers of the Department of Anthropology, Hunter College of the City University of New York, 2. Humanities Press, New York.
Engel, Frederic-Andre, 1991. Un desierto en tiempos prehispánicos: Rio Pisco, Paracas, Rio Ica. La Universidad Nacional Agraria del Perú, Lima Perú.
Fehren-Schmitz, Lars, Reindel, Markus, Cagigao, Elsa Tomasto, Hummel, Susanne, Hermann, Bernd, 2010. Pre-columbian population dynamics in coastal southern Peru: a diachronic investigation of mtDNA patterns in the Palpa region by ancient DNA analysis. Am. J. Phys. Anthropol. 141, 208–221.
Gayton, Anna, Kroeber, Alfred, 1927. The Uhle pottery collections from nazca. University of California Publications in American Archaeology and Ethnology 24 (1), 1–46.
Gorbahn, Hermann, 2013. The middle archaic site of Pernil Alto, southern Peru: the beginnings of horticulture and sedentariness in mid-holocene conditions. Diálogo Andino 41, 61–82.
Hecht, Niels, 2009. Of layers and sherds: a context-based relative chronology of the Nasca style pottery from Palpa. In: Reindel, Markus, Günther, A., Wagner (Eds.), New Technologies for Archaeology: Multidisciplinary Investigations in Palpa and Nasca, Peru. Spinger-Verglag, Berlin, Heidelberg, pp. 207–230.
Hogg, Alan G., Heaton, Timothy J., Quan, Hua, Palmer, Jonathan G., Turney, Chris SM., Southon, John, Bayliss, Alex, et al., 2020. SHCal20 Southern Hemisphere calibration, 0–55,000 years cal BP. Radiocarbon 62 (4), 759–778.
Isla, Johny, 1990. La Esmeralda: una ocupación del períod arcaíco en Cahuachi, Nasca. Gaceta Arqueológica Andina 4 (20), 67–80.
Isla, Johny, Reindel, Markus, 2006. Burial patterns and sociopolitical organization in Nasca 5 society. Andean Archaeology III: North and South. Springer, Boston, pp. 374–400.
Isla, Johny, Reindel, Markus, 2014. La ocupación Wari en los valles de Palpa, costa sur del Perú. Arqueología y Sociedad 27, 193–226.
Jennings, Justin, Biwer, Mathew E., Conlee, Christina A., 2022. Assembling the early expansionary state: Wari and the southern Peruvian coast. Journal of Anthropological Archeology 65, 101395.
Kaulicke, Peter, Fehren-Schmitz, Lars, Kolp-Godoy, María, Landa, Patricia, Loyola, Óscar, Palma, Martha, Tomasto, Elsa, Vergel, Cindy, Vogt, Burkhard, 2009. Implicancias de un área funeraria del Periodo Formativo Tardío en el departamento de Ica. Boletín de Arqueología PUCP 13, 289–322.
Kroeber, Alfred L., Duncan Strong, William, 1924. The Uhle pottery collections from Ica. University of California Publications in American Archaeology and Ethnology 21 (3), 95–133.
Lumbreras, Luis G., 1974. The Peoples and Cultures of Ancient Peru. Smithsonian Institution Press, Washington D.C.
McCool, Weston C., 2017. Coping with conflict: defensive strategies and chronic warfare in the prehispanic nazca region. Lat. Am. Antiq. 28 (3), 373–393.
Mächtle, Bertil, Eitel, Bernhard, Schukraft, Gerd, Ross, Katharina, 2009. Built on sand: climatic oscillation and water harvesting during the late Intermediate Period. In: Reindel, Markus, Wagner, Günther A. (Eds.), New Technologies for Archaeology: Multidisciplinary Investigations in Palpa and Nasca, Peru. Spinger-Verglag, Berlin, Heidelberg, pp. 39–48.
Mächtle, Bertil, Eitel, Bernhard, 2013. Fragile landscapes, fragile civilizations — how climate determined societies in the pre-columbian South Peruvian Andes. Catena 103, 62–73.
Mächtle, Bertil, Schittek, Karsten, Reindel, Markus, Eitel, Bernhard, Eitel, Bernhard, 2017. Cambios paleoclimáticos y su Influencia sobre el desarrollo cultural en sur del área central andina. Rev. Arqueol. Am. 35, 33–50.
Mader, Christian, Reindel, Markus, Isla, Johny, 2023. Economic directness in the western Andes: a new model of socioeconomic organization for the Paracas culture in the first millennium BC. Lat. Am. Antiq. 34 (2), 385–403.
Massey, Sarah Ann, 1986. *Sociopolitical Change In the Upper Ica Valley: B.C. 400 to 400 A. D: Regional States On the South Coast Of Peru.* Unpublished Ph.D. Dissertation, Department of Anthropology. University of California, Los Angles.
Matsumoto, Yuichi, Olano, Jorge, Sakai, Masato, 2022. Tres Palos Revisited: Understanding the Middle Horizon in the Rio Grande de Nasca Drainage. Lat. Am. Antiq. 33 (2), 425–431.
Menzel, Dorothy, 1959. The Inca occupation of the South Coast of Peru. SW. J. Anthropol. 15 (2), 125–142.
Menzel, Dorothy, 1964. Style and time in the middle horizon. Ñawpa Pacha 2, 1–105.
Menzel, Dorothy, 1976. Pottery Style and Society in Ancient Peru: Art as a Mirror of History in the Ica Valley, 1350-1570. University of California Press, Berkeley.
Menzel, Dorothy, Dawson, Lawrence, Rowe, John, 1964. The Paracas Pottery of Ica: A Study in Style and Time. University of California Press, Berkeley.
ONERN (Oficina Nacional de Evaluación de Recursos Naturales), 1971. *Inventario, evaluación y uso racional de los recursos naturales de la costa Cuenca del Río Grande de Nazca*. 2 tomos. ONERN, Lima.
Orefici, Giuseppe, 1996. Nuevo enfoques sobre la transición Paracas-Nasaca en Cahuachi (Perú). Andes: Boletín de la Misión Arqueológica Andina (1), 173–198.
Orefici, Giuseppe, 2011. Cahuachi: capital teocrática Nasca. Universidad San Martín de Porres, Fondo Editorial. Lima, Peru.
Osborn, Jo, Hundman, Brittany, Weinberg, Camille, Huaman, Richard Espino, 2023. Reassessing the chronology of Topará emergence and Paracas decline on the Peruvian South Coast: a bayesian approach. Radiocarbon 1–23.
Peters, Ann H., 2013. Topará en Pisco: Patron de asentamiento y paisaje. BoletíndeArqueología PUCP17 77–101.
Peters, Ann H., 2016. The cemetery of Paracas Necropolis: mortuary practice and social network. In: Sinclaire, Carole, Berenguer, Andrea Torre y José (Eds.), Tres ensayos sobre Paracas Necrópolis. Historia de la investigación, tecnologías textiles y prácticas mortuorias. Arte Encuentro, 2. Museo Chileno de Arte Precolombino, Santiago, pp. 43–66.
Peters, Ann H., Tomasto-Cagigao, Elsa, 2018. De Paracas a Nasca: Por Qué la Necesidad de Estudiar una Época "Transicional". Boletín de Arqueología PUCP 25, 5–17.
Pozorski, Thomas George, Pozorski, Shelia, 2017. Early complex society on the north and central Peruvian coast: new archaeological discoveries and new insights. J. Archaeol. Res. 1–34.
Proulx, Donald, 2006. A Sourcebook of Nasca Ceramic Iconography: Reading a Culture through its Art. University of Iowa Press, Iowa City.
Ramón Joffré, G., 2005. Periodificación en arqueología peruana: genealogía y aporía. Bulletin de l'Institut français d'études andines. 34 (1), 5–33.
R Core Team, 2021. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. URL. https://www.R-project.org/.
Reindel, Markus, 2009. Life at the edge of the desert – archaeological reconstruction of the settlement history in the valleys of Palpa, Peru. In: Reindel, Markus, Wagner, Günther A. (Eds.), New Technologies for Archaeology: Multidisciplinary Investigations in Palpa and Nasca, Peru. Spinger-Verglag, Berlin, Heidelberg, pp. 439–461.
Reindel, Markus, Isla, Johny, 2018. De Paracas a Nasca: Nuevas evidencias desde la vertiente occidental de la sierra de Lucanas, Ayacucho. Boletín Arqueología PUCP 25, 229–254.
Riddell, Francis, Valdez, Lidio M., 1987. Hacha y la ocupación temprana del valle de Acarí, 1988 Gaceta Arqueológica Andina 16, 6–10.
Robinson, Roger W., 1994. Recent excavations at hacha in the Acarí valley, Peru. Andean Past. 4, 9–37.
Rowe, John H., 1962. Stages and periods in archaeological interpretation. SW. J. Anthropol. 18 (1), 40–54.
Rowe, John H., 1963. Urban settlements in ancient Peru. Ñawpa Pacha 1, 1–28.
Rowe, John H., 1967. An interpretation of radiocarbon measurements on archaeological samples from Peru. In: John, H. (Ed.), Peruvian Archaeology, Selected Readings. Rowe and Dorothy Menzel, Peek, Palo Alto, pp. 16–30.
Sandweiss, Daniel H., Heather, McInnis, Burger, Richard L., Cano, Asuncion, Ojeda, Bernardino, Paredes, Rolando, Sandweiss, Maria del Carmen, Glascock, Michael D., 1998. Quebrada jaguay: early South American maritime adaptations. Science 281 (5384), 1830–1832.
Schittek, K., Forbriger, M., Mächtle, Bertil, Schäbitz, F., Wennrich, V., Reindel, Markus, Eitel, Bernhard, 2015. Holocene environmental changes in the highlands of the southern Peruvian Andes (14°S) and their impact on pre-columbian cultures. Clim. Past 10, 1707–1746.
Schreiber, Katharina J., Rojas, Josué Lancho, 2003. Irrigation and Society in the Peruvian Desert: the Puquios of Nasca. Lexington Books, Lanham.
Silverman, Helaine, 1996. The formative Period on the South Coast of Peru: a critical review. J. World PreHistory 10 (2), 95–146.
Silverman, Helaine, 2002. Ancient Nasca Settlement and Society. University of Iowa Press, Iowa City.
Silverman, Helaine, Proulx, Donald, 2002. The Nasca. Blackwell Publishers, Malden, MA.
Sossna, Volker, 2014. Impacts of Climate Variability on Pre-Hispanic Settlement Behavior in South Peru: The Northern Rio Grande de Nasca Drainage between 1500 BCE and 1532 CE. PhD Dissertation, Faculty of Mathematics and Natural Sciences. Christian-Albrechts-Universität zu Kiel, Kiel, Germany.
Stanish, Charles, Tantaleán, Henry, Nigra, Benjamin T., Griffin, Laura, 2014. A 2,300-year-old architectural and astronomical complex in the Chincha valley, Peru. Proc. Natl. Acad. Sci. USA 20, 7218–7223.
Strong, William Duncan, 1957. Paracas, nazca and tiahuanacoid cultural relationships in south coastal Peru *Memoirs of the Society for American archaeology*, 13, 1–48.
Tantaleán, Henry, 2021. The Paracas society of prehispanic Peru. In: Oxford Research Encyclopedia of Latin American History. Retrieved 25 Feb. 2024, from. https://oxfordre.com/latinamericanhistory/view/10.1093/acrefore/9780199366439.001.0001/acrefore-9780199366439-e-981.
Tantaleán, Henry, Stanish, Charles, Rodríguez, Alexis, Pérez, Kelita, 2016. The Final days of Paracas in Cerro del Gentil, Chincha Valley, Peru. PLoS One 11 (5), e0153465.
Tello, Julio César, 1959. Paracas, primera parte. Empresa Grafica T. Lima.
Uhle, Max, 1914. The nazca pottery of ancient Peru. Davenport Academy of Sciences 18, 1–16.
Unkel, Ingmar, Reindel, Markus, Gorbahn, Hermann, Cuadrado, Johny Isla, Kromer, Bernd, Sossna, Volker, 2012. A comprehensive numerical chronology for the pre-columbian cultures of the Palpa valleys, South Coast of Peru. J. Archaeol. Sci. 39, 2294–2303.
Van Gijseghem, Hendrik, 2006. A frontier perspective on Paracas society and Nasca ethnogenesis. Lat. Am. Antiq. 17 (4), 419–444.
Vaughn, Kevin J., Eerkens, Jelmer W., Lipo, Carl, Sakai, Sachiko, Schreiber, Katharina, 2014. It's about time? Testing the Dawson ceramic seriation using luminescence dating, southern Nasca region, Peru. Lat. Am. Antiq. 25 (4), 449–461.

Vaughn, Kevin J., Grados, Moises Linares, 2006. Three thousand years of occupation in upper valley Nasca: excavations at upanca. Lat. Am. Antiq. 17, 595–612.

Wallace, Dwight T., 1986. The Topará tradition: an overview. In: Sandweiss, Daniel H., Peter Kvietock, D. (Eds.), Perspectives on Andean Prehistory and Protohistory. Cornell University Latin American Studies Program, Ithaca, pp. 35–48.

Whalen, Verity H., 2014. Re-Becoming Nasca: A Household-Based Analysis of the Transformation of Community and Tradition at a Late Nasca Village. Purdue University, Peru. Unpublished dissertation.