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Collaborative Research: Molluscan Radiocarbon as a Proxy for Upwelling in Holocene Peru

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Title:
Collaborative Research: Molluscan Radiocarbon as a Proxy for Upwelling in Holocene Peru

Project Participants

Senior Personnel

Name: Sandweiss, Daniel
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Name: Rademaker, Kurt
Worked for more than 160 Hours: Yes
Contribution to Project:
Assisted in lab selecting, recording, and preparing samples for transfer to the other PIs in this collaborative grant. Took courses to advance training. Prepared for field work at start of year 2.

Undergraduate Student

Name: Reid, David
Worked for more than 160 Hours: Yes
Contribution to Project:
David Reid participated in our field work in Peru in the summer of 2006. The project covered some of his expenses but he was not paid stipend or salary. He assisted in the assessment of sites and the excavation and selection of samples from selected sites.

Technician, Programmer

Other Participant

Name: Chu, Alejandro
Worked for more than 160 Hours: No
Contribution to Project:
Peruvian archaeologist Alejandro Chu directs the Bandurria Archaeological Project (Proyecto Arqueol?gico Bandurria), which for several years has been excavating a 3rd millennium BC, Late Preceramic Period site on the south side of the Huacho Valley on the coast of Peru at 11˚11'12.3' S latitude. Mr. Chu opened his project to us so that we could participate in the field to understand site context; he let us select the best samples for our project from the results of multiple excavation seasons; and he obtained the necessary export permits from the Peruvian government. The investment in the Bandurria Project's excavations is multiple 10s of thousands of dollars. Mr. Chu received no direct compensation for his participation in the project, but he has received the radiocarbon dates on his samples at no cost to him or his project.

Name: Shady, Ruth
Worked for more than 160 Hours: No
Contribution to Project:
Peruvian archaeologist Ruth Shady directs the Caral-Supe/INC Special Archaeological Project (Proyecto Especial Arqueol?gico

Caral-Supe/INC), which has been excavating a 3rd millennium BC, Late Preceramic Period site on the left bank of the Supe Valley, 23 km inland from the coast of Peru at 10˚53'29.5' S latitude. Caral is the largest Late Preceramic site in Peru and has made headlines as the oldest city in the Americas. Dr. Shady has been excavating at Caral since 1994. Dr. Shady opened her project to us so that we could participate in the field to understand site context; she let us select the best samples for our project from the results of multiple excavation seasons; and she obtained the necessary export permits from the Peruvian government. The investment in the Caral Project's excavations is several million dollars. Dr. Shady received no direct compensation for her participation in the project, but she has received the radiocarbon dates on her samples at no cost to him or his project.

Name: Ghezzi, Ivan

Worked for more than 160 Hours: No

Contribution to Project:

Provided samples from prehistoric Chankillo site in Peru.

Name: Maquera, Erik

Worked for more than 160 Hours: No

Contribution to Project:

Proved samples from prehistoric Catalina Huanca site in Peru

Name: Quilter, Jeffrey

Worked for more than 160 Hours: No

Contribution to Project:

Provided samples from Colonial site at El Brujo, Peru.

Name: Uceda, Santiago

Worked for more than 160 Hours: No

Contribution to Project:

Provided samples from prehistoric Huaca de la Luna site, Peru.

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

I contacted several projects in Peru for collaboration which took place in Years 2 and 3.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Research:

Year 1 (2005)

During Year 1, I provided samples from my prior excavations: Ostra Base Camp (1991 excavations), Siches Site (1995 and 2001 excavations), and Quebrada Jaguay 280 (1996 excavations).

Siches (Sandweiss 2003, in press; Sandweiss et al. 1996) is located to the north of Talara, Peru, 4 km from the modern shorelines at 4˚30? S latitude. Most of the site dates to the Mid-Holocene (ca. 5200-8400 cal BP, but there is an Early Holocene component (ca. 10,800‐ 10,300 cal BP) deposit at the base. I provided samples from both components but they were not run as part of the project.

Ostra Base Camp (Sandweiss 1996, 2003, in press; Sandweiss et al. 1996) is a Mid-Holocene site. The site is located north of Chimbote Peru, 2.5 km from of the modern shoreline at 8˚55? S latitude. Prior to this project, dates on terrestrial samples ran between ca. 7150 and 6250 cal BP. Four terrestrial dates (see Table 1) were run during the project; calibrated, all fall within the previously established range, confirming the prior dating of the site.

Quebrada Jaguay 280 (Sandweiss 2003, 2008, in press; Sandweiss et al. 1998) is the oldest known fishing site in the New World. The site is located on the banks of en ephemeral stream about 2 km from the modern shoreline at 16˚30? S latitude. Forty radiocarbon dates on terrestrial samples were run during prior research and give a range of 13,000 to 8000 cal BP. For this project, I provided paired marine and terrestrial samples from a context immediately superposed on a series of thin use floors that had provided four consistent dates (two bulk dates on charcoal: 7690?100, 7620?100 14C BP, two AMS dates on the earliest gourd samples in South America: 7660?50, 7650?50 14C BP [Erickson et al. 2005]). This project produced two new AMS dates on wood charcoal that are consistent with the prior results (Table 1).

Years 2-3-4 (2006-2008)

Rademaker, Reid, and I travelled to Peru in summer 2006 and 2007 to acquire samples of paired terrestrial and marine materials appropriate to our project goals. We were joined for part of each season by Dr. Gregory Hodgins, his graduate student Mr. Kevin Jones, and Dr. Fred Andrus's graduate student Mr. Miguel Etayo. During summer 2008, I travelled to Peru to arrange for export of the final samples, and during fall 2008, Rademaker travelled to Peru to bring out the final samples (by Peruvian regulation, archaeological samples must be transported by an authorized individual, not sent by courier or mail).

As the archaeologist in charge of acquiring samples, I found that Peruvian colleagues were very willing to share samples from multiple years of excavations in appropriate sites in exchange for use of the resulting radiocarbon dates. Using my familiarity with Peruvian archaeology and archaeologists, I selected projects of high quality and strong potential to provide appropriate samples. This approach offered us the opportunity to access samples from extensive excavations carried out over multiple years with funding greatly in excess of our project budget (millions of dollars, in the case of one site that produced extraordinary samples). At the same time, we are able to support the advance of Peruvian archaeology, largely by Peruvian archaeologists, by providing radiocarbon dates at no cost to the projects. I therefore decided to follow this strategy instead of our original plan to excavate small test pits in selected sites.

In summer 2006, we visited a number of sites and selected three Late Preceramic, 3rd millennium BC sites from the north central coast of Peru, Bandurria, Caral, and Aspero. These sites represent a critical climate transition between the low interannual variability of the mid-Holocene (ca. 9000-5800 cal BP) and the enhanced variability of the Late Holocene (beginning in Peru around 3000 cal BP). We spent time with each of these projects, both in the excavations, gaining familiarity with site contexts, and in the lab, selecting the most appropriate samples from the various excavation seasons.

Bandurria (Chu 2008) is located immediately above the shoreline on the south side of the Huacho Valley, at 11˚11' S latitude. This Late Preceramic site consists of several medium sized mounds (pyramids) and sunken circular courts as well as a domestic area. The Bandurria project is directed by Alejandro Chu, a Peruvian graduate student at the University of Pittsburgh who recently defended his doctoral dissertation on Bandurria. Prior to Chu?s work, the domestic area of the site had been investigated in 1977 by Rosa Fung (1988), who obtained 8 radiocarbon dates ranging between 5300 and 4450 cal BP (with one outlier that dated anomalously young). Our project produced 8 AMS dates on terrestrial plant remains (Table 1), with calibrated ranges running from approximately 3700 to 4500 cal BP. These dates are slightly younger than those run by Fung, but according to Chu (2008:126) they

represent a later occupation at the site noted by not dated by Fung (1988).

Caral (Shady et al. 2001, 2007) is the largest Late Preceramic site in Peru. The site is located on the left (south) bank of the Supe Valley, 23 km from the modern shoreline at 10˚53' S latitude. The site has 6 major pyramids, several smaller structures, two sunken circular courts, and domestic areas that seem to represent different classes, given the differences in construction materials. Although the site has been known for over 50 years, its true age and cultural affiliation only became clear in 2001 when Shady and colleagues published the first radiocarbon dates from the site (ca. 3700-4800 cal BP) and its pottery-less cultural context. Our project provided dates on 11 terrestrial samples; in seven cases, the samples were split and two dates were run (Table 1). As in every case for this project, the samples we analyzed were selected to represent sealed contexts in direct association with mollusks. Perhaps for that reason, combined with the history of excavation at the site up to the time of our sample acquisition, almost all of our dates fall in a fairly narrow, 2σ band between ca. 4000 and 4500 cal BP. Among the samples we dated, the knotted cord that may be the earliest quipu (an Andean accounting system based on strings and knots) stands out as a particularly useful contribution to the Caral-Supe project. Prior to the discovery at Caral, quipus were known only as early as late first millennium AD. The bundle containing the quipu was discovered between two construction levels in one of the pyramids, wrapped in annual grasses and containing among other things fresh Choromytilus chorus (purple mussel) valves.

Shady also included a sample from the site of Miraya with the materials she exported for analysis. Miraya (10˚53? S latitude) is a smaller pyramid center contemporary with Caral and located near by on the left margin of the Supe Valley. We ran one date with a result of ca. 4000-4400 cal BP, in line with the Caral dates (Table 1) and confirming that the sites are contemporary.

We also spent time at the site of Aspero, another Late Preceramic site a few hundred meters from the shoreline on the north side of the Supe Valley at 10˚49? S latitude. This site was first identified by Gordon Willey in the 1940s, but until the early 1970s it was not recognized as preceramic (Moseley and Willey 1973). Robert Feldman (e.g., 1985) excavated in the 1970s; Ruth Shady renewed the operations at the site in 2005. In summer 2006 excavations had just begun (the first year was spent removing garbage from the town dump that had invaded the site), but we were able to get several usable samples. The project ran dates on three terrestrial samples, with a 2σ range of about 4250-4800 cal BP. These dates are in accord with those run by Feldman and support the suggestion that Aspero is contemporary with the earliest phases at Caral and may predate the latter site (see Sandweiss et al. 2001).

In summer 2007, we visited and/or reviewed collections from 14 sites. Of these, we acquired samples from five sites (Catalina Huanca, Chankillo, Huaca de la Luna, Magdalena de Cao [Colonial site], and Tucume). Samples were analyzed for all but Tucume. For the other sites, either there were no appropriate samples, or samples were promised but never delivered for permitting and export.

Catalina Huanca is located just inland of Lima, Peru, at 12˚3? S latitude, 116 km inland from the modern shoreline in lateral quebrada of the Rimac River. Based on the pottery and type of structures present, the site was estimated to date to the late Early Intermediate Period and the Middle Horizon (second half of the first millennium AD) (e.g., Isbell 2004). Site archaeologists Gloria Quispe and Erik Maquera provided access to the collections and assisted us in selecting paired shell and plant samples. We ran 10 dates on terrestrial remains (duplicate dates on 5 samples, see Table 1). The resulting dates confirm the chronological assignment and are the only dates yet available for the site.

Chankillo is a fortress-like, hilltop structure located above several contemporary buildings on either side of a small ridge with 13 towers used for astronomical observation (Ghezzi and Ruggles 2007). Located 15 km from the shoreline above the Sech?n branch of the Casma river at 9˚33.5? S latitude, the site dates to the second half of the first millennium BC, at the end

of the Early Horizon and the start of the Early Intermediate Period. Site director Ivan Ghezzi facilitated access to the collections from his excavations and began a side project with Co-PI Hodgins. As a result, 22 dates were run on plant remains; two runs failed, generating 20 new dates for the site (Table 1). The results are intriguing but require a full report from Ghezzi concerning context in order to interpret fully. Nine of the dates fall in the expected late first millennium BC span, consistent with the 16 dates run by Ghezzi prior to our collaboration (Ghezzi and Ruggles 2007: Fig. 1). Four dates pre-date 3600 cal BP, which generally marks the transition to pottery (end of Late Preceramic Period/start of Initial Period) on the Peruvian coast, though some of these dates have large errors and may be questionable. The remaining seven dates span the first millennium and early second millennium AD (Early Intermediate Period/Middle Horizon/Late Intermediate Period). In total, the dates produced by our project indicate that Chankillo was a locus of human activity for as much as five millennia.

Huaca de la Luna lies on the south side of the Moche Valley at 8˚08? S latitude in the Cerro Blanco or Moche site. This site dates to the Early Intermediate Period and beginning of the Middle Horizon, during the first millennium AD. Huaca de la Luna and its counterpart Huaca del Sol are the two largest adobe mounds in the New World (e.g., Moseley 2001; Richardson 1994). The site is the presumed center and possibly capital of the Moche culture and state. For over two decades, Huaca de la Luna has been the focus of a continuing Peruvian project directed by conservator Ricardo Morales and archaeologist Santiago Uceda (e.g., Uceda 2001). With Uceda?s help, we reviewed the collections for paired shell and terrestrial samples. We ran dates on 6 of the 8 terrestrial samples selected from Uceda?s collections. Three of our samples were from architectural compounds in the urban area between the two great pyramids, two were from tombs in the principal platform of the main mound of Huaca de la Luna, and one was from the great plaza to the north of the pyramid. All but the last dated to the middle of the first millennium AD, during the heyday of the site?s Moche culture occupation during Moche. The one outlier, from the plaza, may be a Chimu (Late Intermediate Period) offering; culturally diagnostic Chimu offerings have been found in the site previously (Uceda 1999).

Magdalena de Cao (El Brujo complex) is an early Colonial Period settlement in the Chicama Valley at 7˚54.5? S latitude. From historic data, we know that the site was first settled in AD 1578 as a consequence of the first major El Ni?o event after the Spanish Conquest; occupation continued until about AD 1780 (Huertas 2001; Quilter et al 2010). With the assistance of Magdalena de Cao project director Jeffrey Quilter, we excavated a sample of Donax obesulus (a small intertidal clam) from immediately above the sterile, waterlain deposits that underlay the Colonial midden. We did not extract botanical samples for radiocarbon dating, as the historic record offers more precise dating: the clams should date within a few years of the 1578 El Ni?o, which would have deposited the waterlain sediments and would have been covered quickly by garbage from the new Spanish settlement. Fred Andrus?s student Miguel Etayo is working on a manuscript using these shells, those from Huaca de la Luna, and associated absolute dates to identify a change in upwelling between the mid-first and mid-second millennia AD.

We collected one paired sample of shell and plant material from the Late Intermediate/Late Horizon (ca. AD 1100-1540) site of Tucume in the Lambayeque Valley at 6˚31? S latitude (Heyerdahl et al. 1995). These samples were not dated.

During the 2007 season, we also visited the following sites or collections but did not acquire samples from them:
-Huaca Malena, Mala Valley (12˚40? S latitude). Site Directors: Denise Pozzi-Escot, Rommel Angeles. Chronology: Middle Horizon (ca. cal AD 600-1000). No appropriate samples identified in collections.
-Cardal, Lurin Valley (12˚10? S latitude). Site Director: Richard Burger. Chronology: Initial Period (ca. 3500-2400 cal BP). We discussed criteria for sample selection with the site director, but no samples were sent to us.
-El Purgatorio, Casma Valley (9˚31.5? S latitude). Site Director: Melissa Vogel. Chronology:

Middle Horizon to Late Intermediate Period (ca. cal AD 600-1350). No appropriate samples identified in collections.
-Gramalote, north side of Moche Valley (8˚6.5? S latitude). Site Directors: Jes?s Brice?o and Brian Billman. Chronology: Initial Period (ca. 3600-3000 cal BP). Samples identified but never processed for permit by site directors.
-El Brujo, Chicama Valley (7˚54.5? S latitude). Site Director: R?gulo Franco Jord?n. Chronology: Early Intermediate Period (first half of first millennium AD). No appropriate samples identified in collections.
-Huaca Prieta, Chicama Valley (7˚55? S latitude). Site Director: Tom Dillehay. Chronology: Late Preceramic Period (ca. 5800-3600 cal BP). We discussed criteria for sample selection with the site director, but no samples were sent to us.
-San Jos? de Moro, Jequetepeque Valley (7˚11? S latitude). Site Director: Luis Jaime Castillo. Chronology: Early Intermediate Period to Late Intermediate Period (ca. cal AD 600-1350). No appropriate samples identified in collections.
-Bat?n Grande, Lambayeque Valley (6˚29? S latitude). Museum Director: Carlos Elera. We reviewed collections from sites of several ages but did not identify appropriate samples.
-Huaca Chotuna, Lambayeque Valley (6˚43? S latitude). Site Director: Carlos Wester. Chronology: Middle Horizon to Late Horizon (ca. cal AD 1000-1540). No appropriate samples identified in collections.

In 2008, I facilitated access to collections held at the Florida Museum of Natural History from my excavations at Lo Dem?s in the Chincha Valley (13˚27? S latitude, 1 km from the modern shoreline). Lo Dem?s is a Late Horizon site tightly constrained by historical record and artifacts to ca. cal AD 1470-1540 (Sandweiss 1992). Andrus?s student Etayo extracted samples of the clam Donax obesulus from unscreened column samples stored at FMNH and has dated some of them. No botanical samples were dated because they would not add to the precision of the absolute dating.

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Education:

I advised Kurt Rademaker on his M.S. thesis, which he completed successfully in 2006. He immediately transitioned into a doctoral program and I advise him in this program. I advised David Reid on his honors program and thesis, which he completed in 2008.

Findings:

My role in the project was to acquire appropriate samples from secure archaeological contexts. To achieve the project aims, these samples are analyzed for isotope and radiocarbon content at the University of Alabama and the University of Arizona. The results are reported by my colleagues Dr. Andrus and Dr. Hodgins, who have been carrying out the isotope and radiocarbon analyses.

Training and Development:

I have been training Rademaker in climatically oriented field archaeology and in South American archaeology. I have continued work with undergraduate Honors student David Reid, who participated in the field work at start of Year 2 and of Year 3 and has continued to work in the field both with me and with Rademaker after graduating from the University of Maine. I am also training two additional graduate students in climatically oriented field archaeology and in South American archaeology at this time (one is a Fulbright fellow from Peru), but neither was supported by this project.

Outreach Activities:

In have incorporated data and results from this project in lectures to diverse audiences in the US, Canada, and Peru, as a Sigma Xi Distinguished Lecturer (2005-2007) and as an invited lecturer. Principal venues include: University of New Mexico (2005), Memorial University (Canada) (2006), University of Puerto Rico-Mayaguez (2006), Mercer University (2006), U.S. Army Soldier Systems Center-Natick MA (2006), University of Missouri-Columbia (2006), the Columbia University Center for Archaeology (2007), Stanford University (2007), Universidad Nacional Mayor de San Marcos (Peru) (2007), Pontificia Universidad Cat?lica del Per? (2009), Yale University (2010), Universidad Nacional de Trujillo (Peru) (2010), Harvard University (2010), and University of Alberta (Canada) (2011). I have also used data from the project in conference presentations at: Society for American Archaeology Annual Meeting (2006, 2007, 2008), .Northeastern Section, Geological Society of America Annual Meeting (2009), and the NSF funded conference on Global Perspective on Long-Term Human Ecodynamics at the Humboldt Research Institute (2009).

Journal Publications

Andrus, C.F.T., G.W.L. Hodgins. D.H. Sandweiss, and D.E. Crowe, "Molluscan Radiocarbon as a Proxy for El Ni??o-related Upwelling Variations in Peru.", Geological Society of America Special Paper, p. 13, vol. 395, (2005). Published,

Sandweiss, D.H.; Shady S., R.; Moseley, M.E.; Keefer, D.K.; Ortloff, C.R., "Environmental change and economic development in coastal Peru between 5,800 and 3,600 years ago.", Proceedings of the National Academy of Sciences, p. 1359, vol. 106, (2009). Published,

Jones, K.B.; Hodgins, G.W.L.; Etayo-Cadavid, M.F. ; Andrus, C.F.T.; Sandweiss, D.H., "Centuries of marine radiocarbon reservoir age variation within archaeological Mesodesma donacium shells from southern Peru.", Radiocarbon, p. 1207, vol. 52, (2010). Published,

Books or Other One-time Publications

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

My role is to provide samples for analysis to my colleaguea and place the results of the analyses into culture context in terms of the development of societies in ancient Peru and possible implications for modern societies in the same region exposed to possibly similar environmental fluctuations. The activities report provides the cultural context of the terrestrial samples dated (those are the samples that contribute directly to understanding prehistoric chronology). Because most of the dated samples came from projects directed by Peruvian scholars who generally lack

access to radiocarbon dating, the results constitute a contribution to intra-hemispheric scientific relations. As my colleagues on this project continue to generate paleoclimatic data from the results of the paired sample studies, we will also be able to contribute to a better understanding of human-environment interaction through time in Peru.

Contributions to Other Disciplines:

Contributions to Human Resource Development:

In Years 2, 3 and 4, the project contributed to the training of a graduate student (Kurt Rademaker) and undergraduate David Reid (both at UMaine).

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Conference Proceedings

Categories for which nothing is reported:

Organizational Partners

Any Book

Any Web/Internet Site

Any Product

Contributions: To Any Other Disciplines

Contributions: To Any Resources for Research and Education

Contributions: To Any Beyond Science and Engineering

Any Conference

Table 1
Final Report for Award # 0502415

Location	Lab nr	14C age ± σ (14C yr BP)	2-σ calibrated age (cal kyr BP)	Material	Cal BC./AD dates
Huaca de la Luna, 8˚08'S	AA82351	1571 ± 40	1320 – 1519	Corn cob from Architectural Compound 21, Floor 1	cal AD 431 – 630
Huaca de la Luna, 8˚08'S	AA82352	1600 ± 39	1349 – 1527	Corn cob from Architectural Compound 35, Floor 5a	cal AD 423 – 601
Huaca de la Luna, 8˚08'S	AA82353	1642 ± 41	1376 – 1563	Cane from Architectural Compound 35, Floor 5	cal AD 387 – 574
Huaca de la Luna, 8˚08'S	AA82354	1627 ± 39	1369 – 1545	Cane from Platform 1, Tomb 34	cal AD 405 – 581
Huaca de la Luna, 8˚08'S	AA82355	1653 ± 45	1379 – 1604	Cane from Platform 1, Tomb 35	cal AD 346 – 571
Huaca de la Luna, 8˚08'S	AA82356	804 ± 38	578 – 745	Corn cobs from Plaza 1, Floor 1	cal AD 1168–1276
Ostra Base Camp, 8º55'S	AA75281	5720 ± 40	6316 - 6559	Charcoal	
Ostra Base Camp, 8º55'S	AA75282	5680 ± 40	6307 - 6491	Charcoal	
Ostra Base Camp, 8º55'S	AA75283	5740 ± 40	6323 - 6632	Charcoal	
Ostra Base Camp, 8º55'S	AA75284	5840 ± 40	6452 - 6716	Charcoal	
Chankillo, 9˚33.5'S	AA80510	6100 ± 310	6224 - 7563	Botanical samples	cal BC 5614 - 4275
Chankillo, 9˚33.5'S	AA80511	821 ± 40	660 - 763	Botanical samples	cal AD 1187-1290
Chankillo, 9˚33.5'S	AA80512	2176 ± 39	1954 - 2304	Botanical samples	cal BC 355 - 5
Chankillo, 9˚33.5'S	AA80513	2198 ± 42	1998 - 2307	Botanical samples	cal BC 358 - 49
Chankillo, 9˚33.5'S	AA80514	4110 ± 140	4099 - 4868	Botanical samples	cal BC 2919 - 2150
Chankillo, 9˚33.5'S	AA80516	2231 ± 42	2050 - 2328	Botanical samples	cal BC 379- 101
Chankillo, 9˚33.5'S	AA80518	3689 ± 41	3839 - 4085	Botanical samples	cal BC 2136 - 1890
Chankillo, 9˚33.5'S	AA80519	2229 ± 52	2009 - 2331	Botanical samples	cal BC 382 - 60
Chankillo, 9˚33.5'S	AA80520	2273 ± 38	2140 - 2337	Botanical samples	cal BC 388- 191
Chankillo, 9˚33.5'S	AA80521	2277 ± 72	2008 - 2352	Botanical samples	al BC 403 - 59
Chankillo, 9˚33.5'S	AA80522	1151 ± 40	927 - 1165	Botanical samples	cal AD 785 - 1023
Chankillo, 9˚33.5'S	AA80523	2177 ± 61	1949 - 2310	Botanical samples	cal BC 361 - cal AD 1
Chankillo, 9˚33.5'S	AA80524	1420 ± 82	1070 - 1412	Botanical samples	cal AD 538 - 880
Chankillo, 9˚33.5'S	AA80525	1473 ± 41	1279 - 1392	Botanical samples	cal AD 558 - 671

Table 1
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Location	Lab nr	14C age ± σ (14C yr BP)	2-σ calibrated age (cal kyr BP)	Material	Cal BC./AD dates
Chankillo, 9˚33.5'S	AA80526	1753 ± 80	1413 - 1813	Botanical samples	cal AD 137 - 537
Chankillo, 9˚33.5'S	AA80527	1798 ± 91	1418 - 1871	Botanical samples	cal AD 79 - 532
Chankillo, 9˚33.5'S	AA80528	2333 ± 39	2154 - 2353	Botanical samples	cal BC 404 - 205
Chankillo, 9˚33.5'S	AA80529	683 ± 40	554 - 662	Botanical samples	cal AD 1288 - 1396
Chankillo, 9˚33.5'S	AA80530	4280 ± 510	3447 - 5986	Botanical samples	cal BC 4037 - 4022
Chankillo, 9˚33.5'S	AA80531	2162 ± 43	1949 - 2301	Botanical samples	cal BC 352 - cal AD 1
Caral, 10º53'S	AA75271; AA75272	3939 ± 30; 3895 ± 35	4160 - 4419; 4100 - 4411	Offering box	
Caral, 10º53'S	AA75263; AA75264	3919 ± 36, 3904 ± 35	4155 - 4415; 4150 - 4413	Quipu fragments	Earliest quipu known
Caral, 10º53'S	AA75275; AA75276	3885 ± 37; 3943 ± 35	4094 - 4408; 4158 - 4422	Twined cord	
Caral, 10º53'S	AA75273; AA75274	4022 ± 30; 4035 ± 29	4294 - 4524; 4297 - 4528	Reed from child burial	
Caral, 10º53'S	AA75265; AA75266	3980 ± 35; 3979 ± 35	4238 - 4514; 4237 - 4514	Seeds form hearth	
Caral, 10º53'S	AA75267; AA75268	3995 ± 35; 3843 ± 35	4246 - 4516; 3991 - 4350	Seeds form hearth	
Caral, 10º53'S	AA75269; AA75270	3934 ± 35; 3947 ± 35	4157 - 4419; 4158 - 4423	Leaves and stems	
Caral, 10º53'S	AA80294	3960 ± 41	4158 - 4499	Reed from child burial	
Caral, 10º53'S	AA80295	4010 ± 41	4248 - 4523	Charcoal from burnt offering	
Caral, 10º53'S	AA80299	3759 ± 39	3903 - 4215	Burnt stems	
Caral, 10º53'S	AA80300	3906 ± 39	4103 - 4415	Burnt stems	
Miraya, 10º53'S	AA80301	3853 ± 39	3995 - 4406	Reed from mat around clay figurine	
Aspero, 10˚49'S	AA80296	4176 ± 42	4454 - 4824	Charcoal	
Aspero, 10˚49'S	AA80297	4084 ± 41	4411 - 4798	Small fragments of burnt stems	
Aspero, 10˚49'S	AA80298	4047 ± 51	4250 - 4784	Fragment of burnt stem	
Bandurria, 11º11'S	AA71433	3,764 ± 65	3853 - 4244	Stem	
Bandurria, 11º11'S	AA71434	3,909 ± 67	4007 - 4497	Stem	
Bandurria, 11º11'S	AA71437	3,769 ± 58	3886 - 4241	Reed	
Bandurria, 11º11'S	AA71438	3,750 ± 58	3862 - 4231	Reed	

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Location	Lab nr	14C age ± σ (14C yr BP)	2-σ calibrated age (cal kyr BP)	Material	Cal BC./AD dates
Bandurria, 11º11'S	AA71435	3,737 ± 38	3893 - 4148	Stem	
Bandurria, 11º11'S	AA71436	3,769 ± 59	3878 - 4241	Stem	
Bandurria, 11º11'S	AA71439	3,684 ± 58	3728 - 4146	Stem	
Bandurria, 11º11'S	AA71440	3,710 ± 59	3780 - 4213	Stem	
Catalina Huanca, 12˚3' S	AA85292; AA85293	1163 ± 68; 1138 ± 42	909 - 1234; 922 - 1075	Botanical samples	cal AD 716 - 1041; 875 - 1028
Catalina Huanca, 12˚3' S	AA85294; AA85295	1309 ± 36; 1160 ± 36	1079 - 1277; 931 - 1165	Botanical samples	cal AD 673 - 871; 785 - 1019
Catalina Huanca, 12˚3' S	AA85296; AA85297	1331 ± 67; 1343 ± 77	1016 - 1306; 1010 - 1339	Botanical samples	cal AD 644 - 934; 611 - 940
Catalina Huanca, 12˚3' S	AA85298; AA85299	1220 ± 36; 1186 ± 40	975 - 1175; 961-1170	Botanical samples	cal AD 775- 975; 780 - 989
Catalina Huanca, 12˚3' S	AA85300; AA85301	1516 ± 36; 1424 ± 35	1184 - 1348	Botanical samples	cal AD 541- 654; 602 - 766
Quebrada Jaguay (QJ-280), 16º30'S	AA75279	7600 ± 40	8208 - 8421	Charcoal	
Quebrada Jaguay (QJ-280), 16º30'S	AA75280	7670 ± 60	8225 - 8555	Charcoal	