

Molecular and zooarchaeological identification of 5000 year old whale-bone harpoons in coastal Brazil

Corresponding Author: Professor André Carlo Colonese

This file contains all reviewer reports in order by version, followed by all author rebuttals in order by version.

Attachments originally included by the reviewers as part of their assessment can be found at the end of this file.

Version 1:

Reviewer comments:

Reviewer #1

(Remarks to the Author)

This is an interesting study that combines the analysis of artefacts associated with whaling, which are dispersed among local collections. It is an important addition to the growing knowledge about the complexity of prehistoric hunter-gatherer-fisher societies. At the same time, it expands our knowledge about whale ecology/habitats, which may be useful for future conservation efforts. This study is relevant for the understanding of the regional prehistory on the Brazilian coast as well as for the understanding of marine hunter-gatherers in a global context. While this study alone cannot explain the origin or decline of whaling in the study area, it removes a blind spot on our map of prehistoric whaling and will help to explore those questions worldwide - there might be parallels in climatic, environmental or cultural development that encouraged prehistoric coastal populations to develop whaling. The paper is well-written, the methods are explained in sufficient detail, and the figures are clear and informative.

This paper can be accepted for publication after a few minor additions/corrections/answers to the questions below.

Has the sea level changed during the study period? If yes, could the coastlines at different times be added to Figure 1?

In the results section, you mention the zooarchaeological analysis of 162 samples; however, in the supplementary dataset, there's only 160.

Please add one sentence in the results or discussion section about the differences in species identifications based on zooarchaeology and ZooMS - what are the strengths and weaknesses of those methods, or would you conclude that there will be no need for traditional zooarchaeology once ZooMS databases are expanded and the methodology has been even more refined?

If I understood it correctly, you used a mixed SHCal20/Marine20 calibration with 52+/-9% marine for all samples of human bone collagen. While this might be necessary for samples where the measurement of stable isotopes is impossible, this approach shouldn't be employed for samples where $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values actually are available. For example, there is one human bone with $\delta^{13}\text{C}=-11.74$ and one with $\delta^{13}\text{C}=-22.8$. Depending on the contribution of C3/C4 plants, these could have very different percentages of marine diet (you could check whether the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of the human bone collagen are correlated; this could help to distinguish whether the elevated $\delta^{13}\text{C}$ values of the humans are caused by C4-based diet or marine mammals). You could calibrate the human bones with individual reservoir corrections and see whether this will affect your general conclusions.

It is good that you use the local reservoir corrections depending on the feeding grounds of the different whale species. As most of the data in the Marine Reservoir Correction database was obtained on mollusk shells, do you expect any discrepancies - e.g. when correcting the bones of dolphins from Babitonga Bay? Would they/their prey have the same reservoir age as the gastropods, bivalves and barnacles of the region?

A plot of the reservoir-corrected calibrated radiocarbon ages would be a good help for the reader to understand the chronology of the study region.

In the discussion, please expand on the apparent paradox that whale hunting seemed to be restricted to a few individuals, but at the same time is connected to social gatherings. Of course, one whale would require a larger group of people to process the carcass and consume the products. But wouldn't you also need larger groups of people to hunt large whales? Would it at all be possible for a few individuals to successfully hunt and kill a large whale? Could the rarity of harpoon remains in sambaquis be caused by other factors? For example, could they have been used several times until they got broken or lost at sea, so they rarely got deposited in the sambaquis?

Reviewer #2

(Remarks to the Author)

This manuscript presents early evidence for active whaling by pre-colonial Indigenous populations in southern Brazil, dating back at least 5000 years. The study integrates zooarchaeological, biomolecular (ZooMS), and typological analyses of cetacean remains and whale bone artefacts recovered from shell mounds in the Babitonga Bay region. The authors argue that this constitutes the earliest known case of systematic whaling.

The archaeological material is undoubtedly of great significance, and the research design is thoughtful and promising. However, in its current form, we think the manuscript may not meet the editorial and scientific standards of Nature Communications. The main concern is that key interpretive elements are either underdeveloped or missing, which makes it difficult for readers to fully assess the strength of the conclusions. Additionally, the structure of the manuscript could be revised to improve clarity and impact—particularly by moving part of the lengthy method section to the Supplementary text to highlight the main findings more effectively for a general audience. For these reasons, we would respectfully recommend that the manuscript not be accepted for publication at this time.

Comments:

The central claim of the manuscript—that this is the earliest evidence of active whaling—is important and potentially groundbreaking. However, the main supporting evidence, the harpoon-related bone artefacts, deserves more focused treatment. The authors mention that similar artefacts have been documented ethnographically among Indigenous groups in South and North America, but no illustrations or detailed comparisons are provided. Without visual parallels or contextual explanation, it is difficult for readers to assess how the artefacts shown in Figures 3 and 4 would have functioned in whaling.

Additional context on subsistence strategies at the studied sites would greatly enrich the discussion. Are zooarchaeological data available for broader faunal assemblages at these sites? Were terrestrial or marine resources more dominant in the diet? What other food sources were exploited? This information could provide important background for evaluating the significance of whaling within these communities.

Lines 138–148: We recommend visualizing these data in a figure, even if placed in the Supplementary Information. It may be helpful to integrate marine mammal zooarchaeological data into Figure 2.

Figure 2: Please consider including absolute values alongside percentages in the pie charts for clarity.

Line 116: The authors mention 120 identifiable samples, 116 of which were cetaceans—but the remaining 4 are not described. In SI2, 123 samples are listed, including 6 marked as non-cetacean. Please verify and ensure consistency across the manuscript and Supplementary Information.

Line 178: The statement that “only a single peptide marker is used to distinguish right whale and fin whale” would benefit from clarification—please specify which marker is being referred to. It would be good if the authors could add a spectrum in the Supplementary Information.

Line 183: Based on the numbers, 60 out of 116 is 52%, not 50%. The percentages given for Delphinidae (32%) and humpback whales (11%) also appear to differ from those shown in Figure 2. Please check for consistency.

Line 195: It would be helpful to indicate that the specimen with chop marks is shown in Figure 5.

Lines 266–276: The tympanic bulla artefacts are not illustrated in the main text. At least one artefact's photo in the Supplementary Information would enhance reader's understanding. Are they particularly diagnostic within cetacean skeletons?

Additional information on why tympanic bullae were selected for artefact production (beyond their density) would also be valuable.

Lines 278–279: Images of the drop-shaped artefacts that resemble net weights (eg, Tiburtius 5281) could be presented in the main text or the Supplementary for clarification.

Line 308: Could the authors provide the proportion of cetacean bones that show cut marks?

Lines 400–402: The authors state that whales and dolphins may have played a greater dietary role than previously estimated. It would be helpful to briefly summarize what role faunal studies and isotopic analyses have indicated so far.

Lines 451–453: More information about the selection process for the 153 ZooMS samples would be appreciated. From how large an assemblage were they chosen? Are marine mammal bones easy to distinguish from other mammals in mixed contexts? What are the specific morphological or taphonomic features used?

Reviewer #3

(Remarks to the Author)

Dear authors, after a thorough review of your manuscript, I would like to provide some comments for your consideration. A detailed, point-by-point review can be found in the attached file.

I highlight the major strengths of the manuscript: 1) The study of historical archaeological collections preserved in museums is both interesting and valuable; 2) The identification of cetacean species used to craft tools and artifacts is a notable achievement. Also, the information provided about the cetacean species present along Brazilian coastal sites during pre-colonial times is important for this field of expertise, given the challenges involved in zooarchaeological identification of these bones; 3) The presentation of new radiocarbon dating results for the archaeological sites in the Babitonga Bay refines the chronology of occupation of this region.

However, I do not believe that your study provides strong evidence for systematic whale hunting by shellmound populations in Brazil. Could this be considered a hypothesis? Yes, but the assertion made in the manuscript is premature. The study, which focuses on a limited number of artifacts, does not offer sufficient robustness to support such a claim.

It is undeniable that the artifacts from the Tiburtius collection are highly interesting, and their identification and study are indeed important for advancing research on sambaquis. But large bone artifacts could have been used for fishing or hunting a variety of other animals. Furthermore, there is a lack of more comprehensive references to zooarchaeological studies, isotopic analyses, and bone artifact research from other regions, which would provide valuable context. It would be important to assess whether it is possible to quantify the significance of whales to the sambaqui populations in Brazil, particularly in comparison to the importance of fishing.

Version 2:

Reviewer comments:

Reviewer #1

(Remarks to the Author)

Thank you for addressing my concerns, especially about the calibration of human bones, and correcting the manuscript accordingly.

The other reviewers raised some important issues. It is indeed difficult to find the perfect proof for active or systematic whale hunting, and the evidence presented here can also be explained by other processes than active hunting (e.g. cut marks on bones could be the result of butchering stranded individuals). However, the presence of harpoons which would be well suited for whaling, but not for the other available animals, indicates that there is a good chance that whales were actively hunted. I will therefore still advise that this paper should be published, while the authors also should consider the issues raised by the other reviewers. This can for example be done by changing some formulations, such as:

Lines 91-93:

Our results reveal that the Sambaqui populations crafted large whale bone harpoons to hunt baleen whales and dolphins as early as 5000 years ago.

Replace with:

Our results reveal that the Sambaqui populations crafted large whale bone harpoons which may have been used to hunt baleen whales and dolphins as early as 5000 years ago.

Reviewer #2

(Remarks to the Author)

I would like to thank the authors for their thoughtful and extensive revisions. The manuscript has improved significantly. However, I still have the following suggestions and concerns that I believe should be addressed before publication:

Harpoon Assembly and Functionality:

In the first review round, I noted that "without visual parallels or contextual explanation, it is difficult for readers to assess how the artefacts shown in Figures 3 and 4 would have functioned in whaling." This comment was not fully addressed in the revised manuscript. To better understand the use of the harpoon components and sockets in whaling, a simple schematic or illustration showing how the harpoon head was mounted and used (either based on ethnographic analogs or inferred reconstruction) would be extremely helpful. This addition would significantly improve clarity for both specialist and general readers.

Spectral Assignment (SI6 Fig. 7C):

The authors state that the identification of the specimen remains ambiguous because peaks appear at both m/z 1652 and 1682, corresponding to two whale species, respectively. However, upon visual inspection of Supplementary Fig. 7C, the signal at m/z 1652 is very weak—its intensity is only slightly above nearby noise peaks and does not appear to represent a confident peak. I would recommend either reevaluating this spectrum with stricter peak criteria for peak detection to justify the assignment.

Clarification of ZooMS Sampling Criteria:

I appreciate the authors' explanation in the response regarding how the 155 ZooMS samples were selected (based on zooarchaeological identification, element type, preservation, and likelihood of success with minimally invasive methods). However, this information is currently not in the manuscript itself. I recommend that this criterion be added to the main text, to enhance transparency and reproducibility.

Reviewer #3

(Remarks to the Author)

I appreciate the authors' responses and the effort invested in addressing the reviewers' comments. This study presents valuable data and applies relevant analytical methods that contribute to the archaeology of sambaquis in southern Brazil, including zooarchaeological analysis of cetacean remains, molecular identification of bone tools, and new radiocarbon dates. These results have potential to advance knowledge of cetacean presence in Babitonga Bay and to demonstrate the usefulness of the applied methods for reducing the need for more invasive techniques.

However, I do not recommend publication of the manuscript in its current form. The narrative places excessive emphasis on a whaling hypothesis that is not sufficiently supported by the evidence presented. Regarding the authors' assertion while replying the comments (page 19, first paragraph) that the absence of organic tools in the archaeological record does not imply that whaling did not occur, I agree that absence of evidence is not evidence of absence. However, based on the analyses presented here and the existing literature, it is equally not possible to definitively affirm that whaling did take place. I respectfully disagree with the statement that there is no direct evidence for the exploitation of plant fibers, wood, or other vegetal resources (as used for comparison with whaling). Despite preservation challenges, macro- and especially micro-botanical remains have been rigorously documented and demonstrate the importance of these materials to shellmounds groups. Such evidence is recovered from sediments, artifacts, and human dental calculus, and is amenable to scientific study. Furthermore, evidence for fishing among these groups is well established through zooarchaeological analyses of thousands of faunal remains, technological artifacts such as lithics, bone tools, fishhooks, and net weights, as well as isotopic data indicating a predominantly fish-based diet in most of the studied shellmounds. Although terrestrial fauna remains are less common in southern Brazil, this pattern does not hold for sambaquis on the São Paulo coast, for example, where both isotopic and zooarchaeological data reveal a more diverse diet including terrestrial resources.

Critically, the presence of tools fashioned from cetacean bones does not in itself confirm their use in whaling. These implements could have been used in the capture of other large marine species such as sharks, seals, large aquatic birds, or large fish, which are well documented in the archaeological record. Moreover, there is significant literature, including by some of the co-authors of this study, showing that fish species during the pre-colonial period often reached sizes much larger than today's specimens, an important consideration when interpreting tool function.

I suggest that the manuscript be restructured to highlight the robustness of the methodological approach and the specific results obtained from the bone tool analyses, incorporating a more comprehensive discussion of the identified taxa, their ecology, and the potential insights from future studies. Such a reframing would, in my opinion, result in a stronger, more balanced, and evidence-based contribution.

Version 3:

Reviewer comments:

Reviewer #2

(Remarks to the Author)

I advise that this paper should be published.

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REVIEWER COMMENTS

Reviewer #1 (Remarks to the Author):

This is an interesting study that combines the analysis of artefacts associated with whaling, which are dispersed among local collections. It is an important addition to the growing knowledge about the complexity of prehistoric hunter-gatherer-fisher societies. At the same time, it expands our knowledge about whale ecology/habitats, which may be useful for future conservation efforts. This study is relevant for the understanding of the regional prehistory on the Brazilian coast as well as for the understanding of marine hunter-gatherers in a global context. While this study alone cannot explain the origin or decline of whaling in the study area, it removes a blind spot on our map of prehistoric whaling and will help to explore those questions worldwide - there might be parallels in climatic, environmental or cultural development that encouraged prehistoric coastal populations to develop whaling. The paper is well-written, the methods are explained in sufficient detail, and the figures are clear and informative.

This paper can be accepted for publication after a few minor additions/corrections/answers to the questions below.

Has the sea level changed during the study period? If yes, could the coastlines at different times be added to Figure 1?

R: Thank you to Reviewer 1 for the positive comments and constructive suggestions.

Yes, sea level has indeed changed over the last 6,000 years, and further details can be found in Toso et al. ¹, which is cited in our manuscript. In this region, sea level was approximately 2.5 meters above present levels around 5,000 years ago, gradually decreasing to modern levels thereafter. We have replaced the originally submitted Figure 1 with a revised version that reflects the maximum sea level at 5,000 years ago. A sentence was also added to the main text (introduction) to clarify the environmental context of sambaqui formation.

In the results section, you mention the zooarchaeological analysis of 162 samples; however, in the supplementary dataset, there's only 160.

R: Thank you for catching this oversight. Two samples were missing from the Supplementary Table (originally named SI2, now corrected to Supplementary Table 2), and they have now been included. All sample numbers throughout the main text and supplementary materials have been revised and corrected for consistency.

Please add one sentence in the results or discussion section about the differences in species identifications based on zooarchaeology and ZooMS - what are the strengths and weaknesses of those methods, or would you conclude that there will be no need for traditional zooarchaeology once ZooMS databases are expanded and the methodology has been even more refined?

R: A few sentences have been added to the discussion section regarding this, and the paragraph discussing the dolphin samples has been reworked. ZooMS should not be seen as a replacement for zooarchaeological analysis, rather the two techniques should be seen as complementary. Zooarchaeological analysis provides a great deal of information beyond taxonomic identification and is still a very important technique. Additionally, there are cases where, depending on the skeletal element and its state of preservation, zooarchaeological analysis can actually provide greater taxonomic resolution than ZooMS - for example, with many dolphins and porpoises.

The added statements and revised paragraph now reads (Page 7, lines 331 to 341):

“Moreover, as previously mentioned, ZooMS cannot effectively separate most dolphin and porpoise species, and conventional zooarchaeological analysis can often provide greater taxonomic resolution with good bone preservation. For example, a sternum from Porto do Rei (Col. Tiburtius 6847) identified as Delphinidae via ZooMS, was determined zooarchaeologically to be a Guiana dolphin. This species is associated with bays and estuaries along the coast where it forms resident populations, as is the case of Babitonga Bay, and may have constituted a resource available year round. Similarly, also from Porto do Rei, a caudal vertebra (Col. Tiburtius 6836) with a ZooMS identification of Delphinidae, was identified zooarchaeologically as a franciscana dolphin, another common coastal species with a resident population in Babitonga Bay and recorded in sambaqui sites, however in smaller numbers ². The combined zooarchaeological and ZooMS results highlight the complementary nature of these two techniques and the increased effectiveness when used together.”

If I understood it correctly, you used a mixed SHCal20/Marine20 calibration with 52+/-9% marine for all samples of human bone collagen. While this might be necessary for samples where the measurement of stable isotopes is impossible, this approach shouldn't be employed for samples where d13C and d15N values actually are available. For example, there is one human bone with d13C=-11.74 and one with d13C=-22.8. Depending on the contribution of C3/C4 plants, these could have very different percentages of marine diet (you could check whether the d13C and d15N values of the human bone collagen are correlated; this could help to distinguish whether the elevated d13C values of the humans are caused by C4-based diet or marine mammals). You could calibrate the human bones with individual reservoir corrections and see whether this will affect your general conclusions.

R: We agree with Reviewer 1, and we have now revised the radiocarbon calibration of human samples using individually reservoir-corrected, calibrated radiocarbon ages. In addition, a new Supplementary Information file has been provided (Supplementary Fig. 1), which includes the stable isotope distribution of human remains along with faunal data from the literature. This is intended to clarify the estimation of marine protein contribution to diet, which was used for the radiocarbon reservoir correction.

The revised section in Methods now reads (Page 12, lines 583 to 598):

"The radiocarbon dates of the human bone collagen were modelled using a mixed curve (SHCal20116 and Marine20) to take into account the variable intake of marine resources by these populations. As observed by others^{27,55,126,127}, the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of human bone collagen reflect three main dietary protein sources: marine resources, terrestrial C_3 animals, and terrestrial C_3 plants (see SI4). Based on the distribution of $\delta^{13}\text{C}$ values, and assuming that the highest (-11.22‰ and -11.74‰) and lowest (-22.80‰ and -22.60‰) values correspond to 100% and 0% marine protein intake respectively (here assumed to be the equivalent of the contribution of marine carbon to collagen), a linear equation was obtained to estimate the percentage contribution of marine protein to the diet of each individual analyzed in this study (Marine protein intake (%) = $8,9034\delta^{13}\text{C} + 202.14$). Although this represents a relatively simple model, it allows for individual-level estimations rather than relying on generalized dietary assumptions. To account for uncertainties in this estimation, we applied a deviation of $\pm 9\%$ as reported by Toso et al.²⁷. For one individual with no stable isotope data published by Colonese et al.¹⁰³, the contribution of marine carbon to collagen was assumed to be $52 \pm 9\%$ as proposed by Toso et al.²⁷. For samples analyzed by others, we used the published estimates of marine carbon contribution to collagen reported in their studies⁸². The modelled radiocarbon dates used the same local ΔR value of -126 ± 29 , as applied to the Delphinidae bone collagen."

And in lines 612 to 614:

"Calibrations were performed in OxCal 4.4 online^{124,125}, and radiocarbon dates were rounded to 10 years. Radiocarbon results are presented in Supplementary Table 1 and plots of reservoir-corrected calibrated radiocarbon ages for human and sea mammal bones are reported in Supplementary Fig 2."

It is good that you use the local reservoir corrections depending on the feeding grounds of the different whale species. As most of the data in the Marine Reservoir Correction database was obtained on mollusk shells, do you expect any discrepancies - e.g. when correcting the bones of dolphins from Babitonga Bay? Would they/their prey have the same reservoir age as the gastropods, bivalves and barnacles of the region?

R: Reservoir correction values are expected to propagate through the food web, so it is generally reasonable to assume a similar correction factor within the same ecological system. However, discrepancies can occur due to latitudinal movements and feeding

across different environments (e.g., pelagic vs. inshore systems, feeding in upwelling areas), which may influence the isotopic baselines. We have revised the text to account for these sources of uncertainty. It now reads (Page 12, lines 573 to 581):

"Because ΔR varies as a function of coastal environments and oceanographic dynamics through time ³, we assume that the local ΔR remained relatively stable throughout the period under consideration. This assumption is supported by the fact that the ΔR value applied in this study falls within the range of values recorded for Santa Catarina between approximately 4000 - 3500 years ago and the present day (-263 ± 46 , -244 ± 53 , -205 ± 80 , -114 ± 25) ^{4,5}. However, we acknowledge that the available ΔR values for the Brazilian coast were obtained through pairwise comparisons between marine shells and terrestrial plant materials, and uncertainties remain as to whether these corrections can be reliably applied to fish and marine mammals, which feed across distinct ecological niches."

A plot of the reservoir-corrected calibrated radiocarbon ages would be a good help for the reader to understand the chronology of the study region.

R: Plots have been provided in a new Supplementary Fig. 2, which includes radiocarbon calibration plots for humans and sea mammals (*Eubalaena australis*, *Megaptera novaeangliae*, Delphinidae).

In the discussion, please expand on the apparent paradox that whale hunting seemed to be restricted to a few individuals, but at the same time is connected to social gatherings.

R: We have expanded the text as requested (Page 7, lines 350 to 356):

"As documented among some whaling cultures of North America ⁶, the killing of a whale may have been restricted to a few individuals, passed through chiefly lineages that fostered social status, rights and privileges ⁶⁻⁸, while the processing could have involved the whole community ⁹. European travellers of the 16th and 17th centuries reported the killing of large whales by Indigenous groups in Chile and Florida, either for meat and oil ⁹, or specifically to recover tympanic bullae used in the funerary practices of deceased chiefs ¹⁰, with whales being targeted by both individuals and organized groups."

Of course, one whale would require a larger group of people to process the carcass and consume the products. But wouldn't you also need larger groups of people to hunt large whales?

R: Ethnographic and historical accounts of Indigenous groups in South and North America have documented the social dimensions of whaling, including the prestige and status associated with capturing whales ^{6,9}. In particular, among societies of the Northwest Coast of North America, individuals involved in pursuing and killing whales often occupied prominent social positions and enjoyed privileges over others. The act of killing whales may have been restricted to a few individuals, and the distribution of large

quantities of meat, oil, and other goods to the broader community is seen as a form of costly signaling that conferred elevated social status. However, the killing of whales may also have been a more collective activity, involving a larger number of participants.

Would it at all be possible for a few individuals to successfully hunt and kill a large whale?

R: Yes, accounts from European observers exist of single individuals paddling towards and killing large baleen whales ⁹.

Could the rarity of harpoon remains in sambaquis be caused by other factors? For example, could they have been used several times until they got broken or lost at sea, so they rarely got deposited in the sambaquis?

R: Yes and we have expanded the text to provide other possible explanations (Page 7, lines 345 to 348):

“The rarity of bone harpoons in sambaquis alludes to the importance of such artefacts that must have been maintained and curated and hence less frequently produced ¹¹; to their specific function, with harpoons likely often lost at sea or broken during the hunt; to the prestige of whaling; and to the social prominence of the individuals involved in these practices.”

Reviewer #2 (Remarks to the Author):

This manuscript presents early evidence for active whaling by pre-colonial Indigenous populations in southern Brazil, dating back at least 5000 years. The study integrates zooarchaeological, biomolecular (ZooMS), and typological analyses of cetacean remains and whale bone artefacts recovered from shell mounds in the Babitonga Bay region. The authors argue that this constitutes the earliest known case of systematic whaling.

The archaeological material is undoubtedly of great significance, and the research design is thoughtful and promising. However, in its current form, we think the manuscript may not meet the editorial and scientific standards of Nature Communications. The main concern is that key interpretive elements are either underdeveloped or missing, which makes it difficult for readers to fully assess the strength of the conclusions. Additionally, the structure of the manuscript could be revised to improve clarity and impact—particularly by moving part of the lengthy method section to the Supplementary text to highlight the main findings more effectively for a general audience. For these reasons, we would respectfully recommend that the manuscript not be accepted for publication at this time.

The central claim of the manuscript—that this is the earliest evidence of active whaling—is important and potentially groundbreaking. However, the main supporting evidence, the harpoon-related bone artefacts, deserves more focused treatment. The authors mention that similar artefacts have been documented ethnographically among Indigenous groups

in South and North America, but no illustrations or detailed comparisons are provided. Without visual parallels or contextual explanation, it is difficult for readers to assess how the artefacts shown in Figures 3 and 4 would have functioned in whaling.

R: We would like to thank Reviewer 2 for their constructive comments. We believe that references to Indigenous groups in South and North America have been adequately cited. These references already provide rich illustrations of several comparable artefacts, which we consider sufficient for supporting our arguments and therefore do not replicate in the paper. In addition, specific typological details, for example, Mason's Peruvian and Chilean harpoons, as well as Ballester's harpoon types B and D from coastal sites in Chile, both of which are illustrated in their original publications, were included in the submitted manuscript. Our decision not to reproduce figures reported by others is also guided by the copyright restrictions and space considerations. Should the editor consider their inclusion essential, we are willing to request the necessary permissions.

Additional context on subsistence strategies at the studied sites would greatly enrich the discussion. Are zooarchaeological data available for broader faunal assemblages at these sites? Were terrestrial or marine resources more dominant in the diet? What other food sources were exploited? This information could provide important background for evaluating the significance of whaling within these communities.

R: Zooarchaeological data have been produced in the region since the 1990s (see review in Fossile et al. ^{12–15}). When considering the southern coast of Brazil more broadly, the first zooarchaeological studies date back to the 1970s. Overall, marine-estuarine fish species were the most commonly exploited by archaeological groups in this region ¹⁵. Over 13 marine mammal species have been identified in 7.22% (n = 27) of archaeological sites with published zooarchaeological data, particularly in southern and northern Santa Catarina State (n = 17 sites; 5 in Babitonga Bay), totaling 3,380 analyzed remains. However, caution should be exercised when interpreting these data, as (1) tetrapods have received limited attention from researchers in the region ^{13,15,16}, even more so if we consider only marine mammals ^{17,18}; and (2) the identification of marine mammal remains is often more challenging due to the scarcity of reference collections and the generally poorer preservation of these materials compared to fish and terrestrial mammals. The prevalence of marine resources in the diet of Sambaqui people has been also demonstrated through stable isotope analysis ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) of bone collagen performed over hundreds of human individuals ^{1,19–21}. We have expanded the discussion to include additional information on faunal and stable isotope data, along with a new Figure 2, which now reads in lines 275 to 280 (Page 6):

“In particular, faunal ^{15,22} and stable isotope analyses ^{1,19,23} of hundreds of human individuals recovered from dozens of sites indicate dietary dependence on marine and brackish organisms, primarily fish, but also marine mammals ^{16,17}. Terrestrial mammals, by contrast, are relatively rare in sambaqui sites ¹³, and their dietary contribution is estimated to have been minor ¹. The large harpoons analyzed in this study were

therefore designed to target large marine prey, with baleen whales representing the largest of these targets.”

Lines 138–148: We recommend visualizing these data in a figure, even if placed in the Supplementary Information. It may be helpful to integrate marine mammal zooarchaeological data into Figure 2.

R: Figure 2 was modified to address the request of Reviewer 2. In addition, we have revised the Results section to provide a broader contextual background for evaluating the significance of whaling within these communities.

Figure 2: Please consider including absolute values alongside percentages in the pie charts for clarity.

R: Absolute values have been included in Figure 2 along with the percentages.

Line 116: The authors mention 120 identifiable samples, 116 of which were cetaceans—but the remaining 4 are not described. In SI2, 123 samples are listed, including 6 marked as non-cetacean. Please verify and ensure consistency across the manuscript and Supplementary Information.

R: Thank you for bringing the number issue to our attention. All of the sample numbers in the main text and in all of the supplemental material have been revised and corrected for consistency. The 4 samples identified as other than cetacean have not been discussed in the main text as the focus is on cetaceans and not other fauna; however, they are included in Supplementary Table 2 and 3. We believe Reviewer 1 was referring to SI3 (now submitted as Supplementary Table 3) in this comment rather than SI2 (current Supplementary Table 2), in which case the discrepancy in the numbers in the text and the total number in SI3 (Supplementary Table 3) is partially explained in the note below the table in Supplementary Table 3 (this note has now been revised to make this more clear). Two samples in Supplementary Table 3 (TRD_1741 and TRD_1742) were taken from opposite ends of a broken and restored harpoon. These two samples are considered as 1 object in the main text and in Supplementary Table 2. Supplementary Table 3 only contains the identified samples, however one sample (TRD_606) with no ID is included as it is believed to have been contaminated with animal (cow) glue. One other sample (TRD_577) is identified as both cattle and cetacean in SI3, however the final identification is only “Cetacea”.

Line 178: The statement that “only a single peptide marker is used to distinguish right whale and fin whale” would benefit from clarification—please specify which marker is being referred to. It would be good if the authors could add a spectrum in the Supplementary Information.

R: Agreed. The specific marker has been added to the text, and a Supplementary Information file (Supplementary Fig. 3) has been added with example spectra for each identified cetacean species and comparing a spectra from a right whale and a fin whale, and showing two from this study that are ambiguous in the specific marker location.

Line 183: Based on the numbers, 60 out of 116 is 52%, not 50%. The percentages given for Delphinidae (32%) and humpback whales (11%) also appear to differ from those shown in Figure 2. Please check for consistency.

R: Thank you for catching this discrepancy. All of the sample numbers in the main text and in all of the supplemental material have been revised and corrected for consistency, and have been corrected in Figure 2.

Line 195: It would be helpful to indicate that the specimen with chop marks is shown in Figure 5.

R: It can be found in the caption of Figure 5 (in the submitted version), "*Bone of southern right whale with cut marks from the sambaqui Areias Pequenas (I - Col. Tiburtius 3786).*"

Lines 266–276: The tympanic bulla artefacts are not illustrated in the main text. At least one artefact's photo in the Supplementary Information would enhance reader's understanding.

R: A number of the tympanic bulla artefacts are reported in Figure 5C-H (in the submitted version). We have added to Figure 5 other two artefacts manufactured on tympanic bulla.

Are they particularly diagnostic within cetacean skeletons? Additional information on why tympanic bullae were selected for artefact production (beyond their density) would also be valuable.

R: The bone itself is fairly diagnostic within the skeleton, having a rather unique shape, and there has been some work done looking at tympanic bullae for taxonomic identification²⁴. It is unclear why tympanic bullae were apparently selected for artefact production. Beyond their density, it is plausible that their selection was related to a combination of factors: their natural shape, which lends itself to the production of dense spheres and disks commonly found at some sambaquis, and their almost ivory-like appearance when polished. Some Indigenous groups occupying the coast of Florida in the 16th century apparently pursued whales specifically to recover tympanic bullae, which were then deposited as grave goods for deceased high-status individuals, such as chiefs¹⁰. Interestingly, several artefacts made from tympanic bullae have also been found in funerary contexts at sambaquis. We have incorporated this observation into the revised version of the manuscript (see comments above).

Lines 278–279: Images of the drop-shaped artefacts that resemble net weights (eg, Tiburtius 5281) could be presented in the main text or the Supplementary for clarification.

R: A photograph of one of the drop-shaped artefacts has now been added to Figure 5 (Fig. 5C).

Line 308: Could the authors provide the proportion of cetacean bones that show cut marks?

R: Information available in Supplementary Table 2, 46 bones out of 160 (28.75%). The following has been added to the Results section:

“Several bones had visible cut marks likely resulting from butchering (46 out of 162, 28.4%, Supplementary Table 2).”

Lines 400–402: The authors state that whales and dolphins may have played a greater dietary role than previously estimated. It would be helpful to briefly summarize what role faunal studies and isotopic analyses have indicated so far.

R: We have revised two sentences for clarity:

Page 6, lines 275 to 280:

“In particular, faunal ^{15,22} and stable isotope analyses ^{1,19,23} of hundreds of human individuals recovered from dozens of sites indicate dietary dependence on marine and brackish organisms, primarily fish, but also marine mammals ^{16,17}. Terrestrial mammals, by contrast, are relatively rare in sambaqui sites ¹³, and their dietary contribution is estimated to have been minor ¹.”

Page 8, lines 377 to 390:

“Whales and dolphins may have played a much higher role in the diet of Sambaqui people than estimated by studies of faunal remains ^{15–17} and stable isotope analyses of human individuals which have mostly focused on the contribution of fish in dietary models ^{1,19,23}. This has possibly been exacerbated by the fragmented and weathered condition of marine mammal bone remains, which often characterizes the bone assemblages at these sites ¹⁶.”

Lines 451–453: More information about the selection process for the 153 ZooMS samples would be appreciated. From how large an assemblage were they chosen? Are marine mammal bones easy to distinguish from other mammals in mixed contexts? What are the specific morphological or taphonomic features used?

R: The cetacean assemblage being studied probably had somewhere around 200 hundred bones/artefacts, however the entire assemblage is much larger. Marine

mammal bones do tend to be fairly distinct, particularly because of their porosity which makes them relatively easy to separate from other terrestrial mammals and large fish, however they can sometimes be confused with other large terrestrial mammals. The 153 (actually 155 as there was typo in the original version) ZooMS samples were selected based first on the zooarchaeological analysis, and secondly on the type of artefact or bone element and the likelihood of success with minimally-invasive methods. The majority of the samples identified zooarchaeologically as cetacean but not subjected to ZooMS were either disks or spheres made of tympanic bullae which were expected to have a low success rate and so it was decided to only sample a selection of them, or there were other factors that limited their likely success (ie. being burnt).

Reviewer #3 (Remarks to the Author):

Dear authors, after a thorough review of your manuscript, I would like to provide some comments for your consideration. A detailed, point-by-point review can be found in the attached file.

I highlight the major strengths of the manuscript: 1) The study of historical archaeological collections preserved in museums is both interesting and valuable; 2) The identification of cetacean species used to craft tools and artifacts is a notable achievement. Also, the information provided about the cetacean species present along Brazilian coastal sites during pre-colonial times is important for this field of expertise, given the challenges involved in zooarchaeological identification of these bones; 3) The presentation of new radiocarbon dating results for the archaeological sites in the Babitonga Bay refines the chronology of occupation of this region.

However, I do not believe that your study provides strong evidence for systematic whale hunting by shellmound populations in Brazil. Could this be considered a hypothesis? Yes, but the assertion made in the manuscript is premature. The study, which focuses on a limited number of artifacts, does not offer sufficient robustness to support such a claim. It is undeniable that the artifacts from the Tiburtius collection are highly interesting, and their identification and study are indeed important for advancing research on sambaquis. But large bone artifacts could have been used for fishing or hunting a variety of other animals. Furthermore, there is a lack of more comprehensive references to zooarchaeological studies, isotopic analyses, and bone artifact research from other regions, which would provide valuable context. It would be important to assess whether it is possible to quantify the significance of whales to the sambaqui populations in Brazil, particularly in comparison to the importance of fishing.

R: We are very grateful to Reviewer 3 for the constructive and highly relevant comments on our manuscript. The suggestions have helped us improve the clarity of the text. We have replaced the term “systematic whaling” with “active whaling”. Nevertheless, we respectfully disagree with the suggestion that our interpretation of active whaling among Sambaqui populations is premature. Identifying active whaling has long been one of the

most complex and debated issues in prehistoric archaeology^{9,11,25}. It is striking that when bone or lithic artefacts are found in association with terrestrial mammal remains, archaeologists readily interpret them as evidence of hunting. However, similar associations with whale remains have often been viewed with skepticism, especially when proposing that people actively pursued these large animals rather than exploiting them opportunistically¹¹. But here, our evidence goes beyond faunal remains: we demonstrate that tools suitable for hunting large prey were indeed manufactured, and that other materials derived from whales were widely used by these populations, often in direct association with whale remains, in much the same way as documented among ethnographic groups across the Americas. We have been working in this region for years, and zooarchaeological studies led by our team and others have shown that very few animals are likely candidates for the use of large harpoon heads, some measuring up to 50 cm in length, with whales being the most probable.

We believe we have adequately addressed the relevant zooarchaeological literature but we have now expanded the references in the main text to include additional sources. Isotopic and faunal analyses from other contexts do not provide significant insights in this case. The question of whale quantification in diet remains unresolved, just as it does in Northern Europe and North America, due to methodological challenges that have been acknowledged by others and by ourselves on isotope equifinality involving whales and a range of marine fish consumed by these groups¹. Moreover, we do not argue that whales were consumed on a regular basis, but rather that they were possibly seasonal prey, pursued for a variety of reasons (see Discussion). Unfortunately, there remains ambiguity, and a degree of arbitrariness, when relying solely on the number of artefacts or bone remains. What constitutes a statistically significant number of artefacts? How many bones must be counted for an interpretation to be accepted? These questions lack definitive answers.

While further studies are certainly needed to better quantify fragmented bones, what is most crucial is the growing recognition that whales played a meaningful role in Sambaqui society. This is becoming increasingly evident through the reinterpretation of bone artefacts that have been housed in museum collections for decades. As we noted, *"We suspect that there are many more such objects sitting in archive boxes in museums, unseen and untouched for decades, just waiting for their stories to be rediscovered."* Reconsidering Sambaqui societies as whalers challenges and reshapes long-held narratives that portrayed them as incapable of accessing the full range of available coastal resources. Our paper is thus (also) a call to archaeologists to pay closer attention to both artefacts and often-overlooked faunal remains (most of these remains are not even counted because they do not fall under the category of NISP, as they cannot be taxonomically identified, and we suspect that this is precisely where the majority of the "invisible whales" are hidden). We hope this will inspire a shift in recovery methodologies, identification strategies, and theoretical interpretations concerning these materials.

Abstract

55-56: The term "shell mound" should be corrected to "shellmound". Please ensure consistency by reviewing and correcting this throughout the entire manuscript.

R: Done

56: The term "sambaqui" appears sometimes written in lowercase and other times capitalized as "Sambaqui." Please choose one form and ensure it is applied across the Manuscript.

R: Text amended where needed. Just for clarity, the term "sambaqui/s" refer to the site typology (shellmound); "Sambaqui" is used as a Proper noun, referring to the people who produced them (e.g. Sambaqui people, Sambaqui society, Sambaqui population) or the sites (Sambaqui Morro do Ouro, Sambaqui Edgard Tiburtius-Praia Grande) and the discipline (Sambaqui archaeology).

57-58: It would be appropriate to include the Latin names of the species mentioned here.

R: Scientific names added

Introduction

84-90: The references cited in this section are focused on the southern region of Brazil. Given that Brazil is a continental-sized country with a long and diverse coastline, it would be good to consider the broader geographic context. Pre-colonial coastal sites are widespread along the Brazilian coast, and it would be relevant to address whether cetacean presence has also been documented in other regions.

R: Thank you for pointing out this lack of clarity. We have revised the text to ensure that it refers exclusively to sites in southern and southeastern Brazil.

Are cetaceans more abundant in certain coastal areas?

R: Due to research bias, where some areas, such as Santa Catarina state, have been more extensively studied than others, like Paraná and São Paulo, it is difficult to determine whether cetaceans were more abundant in certain regions. However, southern sites, particularly those in Santa Catarina and Paraná, appear to yield more cetacean remains. This may reflect both the intensity of research and a possible historical concentration of whales in that region.

Also, are the tools/artifacts found in Babitonga Bay unique to that region, or have similar cetacean-related artifacts been identified elsewhere?

Whale bones have been found at archaeological sites along the south and southeast coasts of Brazil. However, artefacts previously reported as bastões (sticks or rods), such as those from the sambaquis of Cubatãozinho, Conquista, and Morro do Ouro, and interpreted here as 'harpoon foreshafts' (Figure 4 in the submitted manuscript), have, to our knowledge, only been identified in the Babitonga Bay region. A potentially similar artefact featuring a bird-shaped extremity (like the one shown in Figure 5) was also found at Sambaqui Matinhos, a few kilometers north in the state of Paraná ^{26–31}.

The text has been revised for clarity, and the following has been added (Page 5, lines 237 to 240):

“Artefacts crafted on tympanic bullae were also found in sites to the north, from the coasts of São Paulo (e.g. Piaçaguera ³²) and Paraná (e.g. Gomes, Matinhos, Guaraguaçu, Ramal, Araujo II ^{27,28,31,33–36}), and south to Santa Catarina Island (e.g. Pantano do Sul, ^{28,37}), spanning approximately 700 kilometers of coastline.”

96-100: Can it be stated with confidence that this type of bone artifact is exclusive to this region? Have similar cetacean-derived artifacts not been identified in other shellmounds? It would be important to clarify whether such artifacts have been reported elsewhere along the Brazilian coast or in other coastal sites of South America.

R: To the best of our knowledge, and that of Brazilian scholars working with our team over the past decades, there is no record of similar harpoon foreshafts manufactured from whale bone found or documented outside Babitonga Bay region. One artefact made from a long bone, similar to Figure 5A, has been documented in the Sambaqui Matinhos in Guaratuba Bay ³¹. Artefacts crafted from cetacean bones and tympanic bullae have been found at sites along the southern coast of Brazil, but not the specific types of harpoon foreshafts reported here. Harpoon heads have been documented by colleagues further south, in La Plata basin ³⁸ and reported for sambaquis ³⁹; however, these are typologically very distinct and those in La Plata Basin were not used for marine prey, let alone large baleen whales, and were manufactured from terrestrial mammal bones and antler. They also date to a much more recent period. Harpoon foreshafts typologically similar to those described in this study (although not made of whale bone) have been found in the Atacama Desert, as cited in the manuscript.

114: DeBlasis, not Blasis

R: Amended, thanks

120-121: I wonder how can this be confirmed by the methods of the study

R: By association. To acknowledge that our conclusion is supported but not definitively proven, we have revised the tone and replaced “revealed” with “indicate”.

Results

138-148: From all the 18 shellmounds studied, only 162 remains (regular bones/teeth and artifacts) were found? Or are those the only one studied? If yes, why? What the number of cetacean bone/teeth fragments were not possible to be identified rather than Cetacea? Non identifiable remains should always be mentioned in zooarchaeological studies. Considering the number of sites studied and the amount of zooarchaeological material found in sambaquis, it seems a low number of samples analyzed.

R: While we agree that all faunal remains, including non-identifiable fragments, should be considered in zooarchaeological studies, the specimens analyzed here were mostly handpicked by Guilherme Tiburtius. Sambaqui archaeology during the 1940s to 1960s prioritised visible elements such as large bones, stone and bone artefacts, and human remains, and did not follow protocols for recovering and analyzing biological materials at high resolution as we do nowadays. As a result, the collections lack the comprehensiveness (e.g. including small, fragmented and non-identifiable remains) expected in modern archaeological practice.

Moreover, our study focus only on cetacean samples from collections housed at the *Museu Arqueológico do Sambaqui de Joinville* (lines 96-103, original submission): *"Many of these sites no longer exist, with the only remaining tangible evidence being the artefacts, and human and faunal remains that have survived in Tiburtius' collection ^{26-28,39}, the majority of which is currently housed at the Museu Arqueológico do Sambaqui de Joinville (MASJ, Santa Catarina, Brazil)."* In lines 371-373 (original submission): *"It is worth noting, however, that the collection studied was specifically searched for cetacean remains, as such the remains of other marine mammals may have been overlooked and thus underrepresented."* Lines 443-447, *"The archaeological material was largely collected by Guilherme Tiburtius between 1940 and 1960, through a combination of controlled excavations and rescue interventions carried out when sites were being dismantled for the lime industry."*

The Material and Methods section has been revised to reflect this context more clearly, and now reads:

"For most of these sites, the faunal remains were handpicked during excavations that did not follow modern standards (such as sediment sieving using different mesh sizes, recovery of all remains, etc.), with a focus on visible specimens (large bones, bone and stone artefacts, human materials). As a result, some of the collections lack the comprehensiveness (including small, fragmented and non-identifiable remains) expected in modern archaeological practice. The cetacean bones analyzed herein likely represent only a very small fraction of the total amount of whale bone originally present within the sambaquis."

154-181: I consider the application of this technique and the results obtained to be the

highlight of the study. It is remarkable that such data can be generated through a nondestructive method. Furthermore, the information provided regarding the cetacean species present along the Brazilian coast during that period is particularly valuable and significantly contributes to our understanding of past marine biodiversity and to shellmounds archaeology.

R: We agree, and we hope to see this approach applied to other bone materials, including highly fragmented remains that are often discarded due to the absence of diagnostic taxonomic traits.

201-213: The ethnographic references cited here are limited, with a predominant focus on the North American context. Are there no studies that specifically address South American populations?

R: The cited references in the original submission covered harpoon typologies from both South and North America: *"The first class, manufactured from cetacean rib bone, comprises four objects (three of which were broken at one extremity) showing striking similarities with harpoon socket pieces documented among ethnographic coastal Indigenous populations in South and North America* ⁴⁰⁻⁴²."

These works primarily address artefact typologies rather than the practice of whaling itself. Concerning the latter, we have expanded the reference in the Discussion to include ethnographic examples, based mainly on early European observations, of whaling by Indigenous populations in South and North America ^{6,9,10} (Page 7, lines 353 to 356):

"European travellers of the 16th and 17th centuries reported the killing of large whales by Indigenous groups in Chile and Florida, either for meat and oil ⁹, or specifically to recover tympanic bullae used in the funerary practices of deceased chiefs ¹⁰, with whales being targeted by both individuals and organized groups."

The text overlooks the extensive historical use of whales in Brazil, particularly in the state of Santa Catarina, where whales were hunted and utilized for various purposes. This should be acknowledged in the manuscript. Furthermore, it would be important to explore what tools were used for whale hunting during that period, as this information could offer valuable insights into the technological and cultural practices of the time.

R: There are several references to colonial-era whaling in the Discussion section of the submitted version, specifically when discussing the hunting of southern right whales and also fin whales. We chose not to go into great detail about colonial-era whaling because it falls outside the scope of our study. Colonial commercial-mercantile whaling operated under a very different social and political framework, shaped by monopolies, colonization, and market-driven forces. Our objective was not to compare pre-colonial and colonial whaling, but rather to demonstrate that whaling was practiced by pre-

colonial Indigenous groups in Brazil thousands of years before the emergence of commercial whaling activities.

232: The whale names should also be standardized, review throughout the manuscript

R: We are unsure what Reviewer 3 intended by the term 'standardization' in this context. In our manuscript, we follow the common practice in biology, ecology, and archaeology of introducing the scientific name upon first mention, followed by the use of vernacular names thereafter. We revised this throughout for consistency.

235: For the artifacts that were direct dated, where they destroyed for that purpose?

R: We dated only two whalebone artefacts, both of which had broken distal extremities. Small samples were taken specifically from the damaged portions to minimize any further alteration to the objects, and only after permission were granted.

283: Some references are missing here. What are the studies saying that those artifacts are present? Where in Brazil?

R: Text revised and references now provided (Page 5, lines 237 to 240):

"Artefacts crafted on tympanic bullae were also found in sites to the north, from the coasts of São Paulo (e.g. Piaçaguera ³²) and Paraná (e.g. Gomes, Matinhos, Guaraguaçu, Ramal, Araujo II ^{27,28,31,33-36}), and south to Santa Catarina Island (e.g. Pantano do Sul, ^{28,37}), spanning approximately 700 kilometers of coastline."

286-290: The information that those artifacts are found in funerary contexts can be crucial for this study, and the interpretations. Are cetacean artifacts found in other sambaquis from Brazil? Where? What the authors say about it?

R: We agree. The text has now been revised in both the Introduction, Results and Discussion to address the recovery of whale artefacts in funerary contexts.

Discussion

304-318: I do not see how your study shows evidence of systematic whale hunting. The outcomes of your analysis include new radiocarbon dates for archaeological sites in Babitonga Bay (although the detailed results, including plots displaying the new dates, are not presented), the identification of cetacean bone artifacts, and the taxonomic classification of both worked and unworked bones. However, I do not see a clear connection between these findings and the assertion of significant whale hunting activities.

R: The archaeology of prehistoric whaling has, for decades, debated which lines of evidence, when considered together, can more confidently indicate that prehistoric groups actively hunted whales rather than merely exploiting stranded individuals. The paragraphs in the Discussion section brings these elements together to support our claim that the Sambaqui populations of southern Brazil engaged in deliberate whale hunting. The first two paragraphs of the Discussion have been revised for clarity, and now read (Pages 5 and 6, lines 251 to 280):

“The antiquity of subsistence whaling has been the subject of vibrant debate for decades, particularly due to the difficulty of using often fragmentary and ephemeral archaeological evidence to determine whether whales were exploited opportunistically as stranded animals or drifted carcasses, or actively hunted^{11,43}. Today, multiple lines of evidence are generally invoked as likely indicators of active whaling among prehistoric groups. These include, for example, the abundance of whale bones, the presence of specialised hunting technology, bones with butchering and harpoon strike marks, bones with embedded points, the repeated occurrence of inshore and slow moving species across multiple sites, a high quantity of artefacts crafted from whale bone, such as figurines representing whales, and whale-derived objects used as grave goods, the depiction of hunting scenes, among others^{6,25,44,45}. With the exception of bones bearing harpoon strikes, embedded points and depictions of whaling, all other key indicators are present in sambaqui sites in southern Brazil. Significantly, our study shows that Sambaqui populations in Babitonga Bay also produced large whale bone harpoons for the pursuit of large marine prey, such as baleen whales, as early as 5000 years ago. These lines of evidence would push back the earliest known record of active whaling, previously documented among whaling cultures in cold temperate and arctic regions between approximately 3500 and 2500 years ago⁴³. Early harpoon heads have been recovered from coastal sites in the Atacama Desert and Tierra del Fuego, dated to around 7000–6000 years ago^{46,47}, but their association with the hunting of large whales remains uncertain.

Although large harpoon heads have been documented at only three sites in Babitonga Bay, and the distinctive features of a few localized sites cannot be taken to represent all Sambaqui populations, the broader archaeological record exhibits socio-ecological traits characteristic of prehistoric whaling societies²⁵. These include reliance on predictable fish resources, community-based exploitation strategies that enable cooperative hunting¹, reduced residential mobility, and locally high population densities⁴⁸. In particular, faunal^{15,22} and stable isotope analyses^{1,19,23} of hundreds of human individuals recovered from dozens of sites indicate dietary dependence on marine and brackish organisms, primarily fish, but also marine mammals^{16,17}. Terrestrial mammals, by contrast, are relatively rare in sambaqui sites¹³, and their dietary contribution is estimated to have been minor¹. The large harpoons analyzed in this study were therefore designed to target large marine prey, with baleen whales representing the largest of these targets.”

In addition, below we explain those criteria and reasoning in more detail for Reviewer 3.

Perhaps the most acknowledged challenge is the fact that it has generally been assumed that the abundance of whale bone remains in archaeological sites correlates with the type of exploitation: relatively few remains have often been interpreted as evidence of opportunistic use of stranded animals, whereas larger quantities are seen as possible indicators of organized hunting, also referred to as active or systematic whaling^{11,25}. This assumption has been problematic because of the overall underrepresentation of whale materials in the archaeological record. Whales are large animals, and studies have shown that their carcasses are often processed at butchering sites along the shore, with only selected parts transported back to consumption sites (which often make up the majority of the archaeological record). With the exception of whale use for architectural purposes⁴⁹, this would mean that the vast majority of whale materials used by prehistoric groups, having relatively limited technology for transporting large bones, would leave limited, if any, traces in the archaeological record^{6,50–52}. For example, ethnographic studies based on modern Inuit groups exploiting beluga whales (*Delphinapterus leucas*) reveal that some portions of meat and blubber can be obtained from vertebrae, without needing to remove large bones⁵³. Additional criteria are therefore employed to differentiate between varying levels of subsistence whaling in the archaeological record. Systematic whaling, for instance, is typically inferred from a combination of indicators, including: i) the prevalence in whale bone remains of inshore and slow-moving species with high buoyancy (*Eubalena australis*, but also *Megaptera novaeangliae*), with their increased accessibility suggesting deliberate targeting and thus supporting the case for organized hunting rather than opportunistic scavenging; ii) the presence of bones with cut marks and harpoon strikes; iii) a relatively high quantity of artefacts made from whale bones (e.g., figurines representing whales); iv) specialized hunting technology, such as harpoon foreshafts and boats; and v) depictions of whaling and ethnographic evidence for historical continuity in whale hunting as documented among some arctic and subarctic cultures^{6,11,25,43–45}.

375-387: What ethnographic records? You did not bring significant or national ethnographic study to compare the use of those artifacts with whale hunting.

R: The relevant ethnographic records are cited throughout the paragraph, for example^{6–9,50,52}. However, there is no ethnographic documentation of the specific foreshafts found in sambaquis among historical Indigenous groups in Brazil. While other types of harpoons have been documented⁴⁰, artefacts similar to those recorded at sites in Babitonga Bay have not been described elsewhere. This suggests the presence of ancestral knowledge and practices that no longer exist in the country.

389-391: As stated in this section of the text, there is no evidence to support the existence of technology associated with the systematic maritime exploitation of large mammals within the context of the Brazilian shellmound culture. Therefore, drawing conclusions regarding systematic whale hunting appears to be premature and unsupported by the current data.

R: What we argue is that whaling, like other subsistence activities, required a set of technologies, many of which were made from perishable materials. Due to their organic nature, these technologies are rarely preserved in the archaeological record, and even less so in tropical and subtropical environments. However, the absence of these artefacts does not imply that whaling did not occur. The same applies to tools that may have been used for hunting terrestrial animals, harvesting plants, or fishing, many of which were likely made from plant fibres, wood, or other organic materials. Despite their poor preservation and complete absence in most sites, activities such as hunting, fishing, and plant consumption are widely accepted for Sambaqui populations and for numerous other groups across the Neotropics.

391-392: As mentioned in this section of the text, a single whale could provide a substantial quantity of raw material, which complicates the quantification of cetacean remains in shellmounds. The Brazilian sambaqui populations inhabited the Babitonga region for millennia, so the presence of whale bones could have resulted from occasional occurrences. The number of bones recovered, however, is not substantial enough to support the conclusion of large-scale whale hunting activities.

R: Unfortunately, we simply do not know how much whale bone exists in sambaquis due to long-standing deficiencies in recovery and documentation techniques. Whale bones are known to present significant preservation challenges due to their porosity and structural composition. Moreover, archaeologists working in this region have historically recorded only identifiable specimens (NISP), often excluding small or highly fragmented remains that cannot be taxonomically assigned. Our study aims precisely to challenge and change this practice by demonstrating that valuable information can be recovered from these overlooked fragments through molecular methods. In addition, the remains studied herein were those collected directly from the sambaquis and not necessarily in a systematic manner, and it is very likely that they represent only a very small fraction of the total amount of whale bone actually contained within the sambaquis. Moreover, the whale bones in the sambaquis also likely only represented a small portion of the total whale bone used by Sambaqui societies. As discussed in a previous response, whales are large and so are their bones, thus transporting them in their entirety is complicated. It is very likely that the whales would have been processed where they were brought to shore, and not actually at the sambaqui sites, meaning a large amount of their carcass (especially bone) remained where it was processed or were taken elsewhere (ie. residential sites). This topic has been widely discussed within the archaeological community, as referenced in the manuscript.

411-412: The statement made in this sentence is problematic in several ways. It is not appropriate to compare the well-established trajectory of sambaqui archaeology—which, after initially characterizing these groups as mollusk gatherers, has come to emphasize fishing as their primary social and economic activity—with the claim that they may also have been whale hunters. The interpretation of sambaqui builders as primarily fishers is supported by a robust body of evidence resulting from decades of research, involving

multiple institutions, diverse geographic regions, and a range of methodological approaches. If the intention is to enter this debate and suggest that these populations were also whale hunters, a more substantial and methodologically grounded discussion is necessary. There is currently no definitive evidence to rule out the possibility that whale bones found in sambaquis were the result of opportunistic use of stranded animals or isolated hunting events. However, these would be exceptional occurrences in comparison to fishing activities. This interpretation is supported both by previous zooarchaeological studies and by isotopic data—which, notably, are not considered in the current manuscript.

R: We respectfully disagree with this position. From an epistemological standpoint, it is important to consider the historical trajectories of the field. At no point in our statement do we dismiss the characterization of Sambaqui groups as fishers. Rather, our argument is that they should also be considered as whalers, based on the new lines of evidence presented. This perspective does not negate existing interpretations but expands them by incorporating underexplored dimensions of their subsistence strategies.

Material and Methods

Important: The Brazilian government permissions for transporting and analyzing samples (including destructive analysis) abroad are missing in the materials session. Different laboratories were used for this study (Spain, France, Austria, USA, Italy), did you have the permission to transport the samples to different countries? Were the samples repatriated after the analysis?

R: Yes, permissions were all granted before analysis, as stated in the Acknowledgments section of the original manuscript:

"Prior to analysis, permits for proteomic analysis and radiocarbon dating were obtained from the Instituto do Patrimônio Histórico e Artístico Nacional (IPHAN, Processes 01450.006223/2024-657 21, 01510.000059/2021-43, 01510.000039/2022-53)."

We have moved the sentence above to the Methods section (Page 9, lines 436 to 439).

451-452: The methods used for zooarchaeological analysis are missing. What collections were used to compare with the archaeological remains? What bibliography were consulted?

R: We have now added the reference collection used in the analysis and a reference list of the works consulted (Supplementary References). The revised version of the manuscript now reads (Page 9, lines 443 to 445):

"Archaeological specimens were identified through side-by-side comparison with modern specimens of Iperoba Biological Collection (ABI) at the University of the Joinville Region"

(UNIVILLE), in São Francisco do Sul, along with specialised literature (Supplementary References).”

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REVIEWER COMMENTS

Reviewer #1 (Remarks to the Author):

Thank you for addressing my concerns, especially about the calibration of human bones, and correcting the manuscript accordingly. The other reviewers raised some important issues. It is indeed difficult to find the perfect proof for active or systematic whale hunting, and the evidence presented here can also be explained by other processes than active hunting (e.g. cut marks on bones could be the result of butchering stranded individuals). However, the presence of harpoons which would be well suited for whaling, but not for the other available animals, indicates that there is a good chance that whales were actively hunted. I will therefore still advise that this paper should be published, while the authors also should consider the issues raised by the other reviewers. This can for example be done by changing some formulations, such as:

Lines 91-93:

Our results reveal that the Sambaqui populations crafted large whale bone harpoons to hunt baleen whales and dolphins as early as 5000 years ago.

Replace with:

Our results reveal that the Sambaqui populations crafted large whale bone harpoons which may have been used to hunt baleen whales and dolphins as early as 5000 years ago.

R: The sentence has been replaced. It now reads (Page 2, lines 94-96):

"Their association with whale bone remains and artefacts reveal that Sambaqui populations possessed the technology for hunting large baleen whales and dolphins as early as 5000 years ago".

Reviewer #2 (Remarks to the Author):

I would like to thank the authors for their thoughtful and extensive revisions. The manuscript has improved significantly. However, I still have the following suggestions and concerns that I believe should be addressed before publication:

Harpoon Assembly and Functionality:

In the first review round, I noted that "without visual parallels or contextual explanation, it is difficult for readers to assess how the artefacts shown in Figures 3 and 4 would have functioned in whaling." This comment was not fully addressed in the revised manuscript. To better understand the use of the harpoon components and sockets in whaling, a simple

schematic or illustration showing how the harpoon head was mounted and used (either based on ethnographic analogs or inferred reconstruction) would be extremely helpful. This addition would significantly improve clarity for both specialist and general readers.

R: We have now provided a schematic illustration of the Sambaqui harpoons (foreshafts and socket-pieces) and a redrawing of selected ethnographic analogues from Chile. These illustrations are now in a new Figure 5. The text has been modified to accommodate the new figure 5, and now reads (Pages 4-5, lines 206 to 211):

“As observed with Chilean harpoons, both types were probably mounted at the distal end of a main shaft and may have included lines for retrieval of the prey by the hunter. The main shaft was likely made of wood, while the lines would have been plant fibre or sinew, all of which rarely survive in subtropical burial environments except under exceptional circumstances (Figure 5A-F).”

Spectral Assignment (SI6 Fig. 7C):

The authors state that the identification of the specimen remains ambiguous because peaks appear at both m/z 1652 and 1682, corresponding to two whale species, respectively. However, upon visual inspection of Supplementary Fig. 7C, the signal at m/z 1652 is very weak—its intensity is only slightly above nearby noise peaks and does not appear to represent a confident peak. I would recommend either reevaluating this spectrum with stricter peak criteria for peak detection to justify the assignment.

R: We agree that m/z 1652 is very weak and just above the surrounding background noise for sample TRD_600, however the same argument could be made for m/z 1682, which has only a slightly greater intensity (a.i. 27 for m/z 1682 vs 21 for m/z 1652, using the normalized intensity scale as depicted in SI6 Fig 7C). The majority of these ambiguous assignments, including TRD_600, are from minimally-invasive samples which tend to produce poorer quality spectra with significantly more background noise, making confident peak identification for markers which generally show a lower intensity, such as m/z 1652 and m/z 1682, more difficult. While we do believe that this bone (and the other samples with this problem) is likely from a right whale, we have chosen to err on the side of caution and take a relatively conservative approach to the identifications for such samples. As these ambiguous IDs account for less than 1% of the total cetacean samples (9 out of 118 identified as cetaceans), we do not believe better resolution for these few samples changes the overall argument, and prefer to maintain the conservative assignment.

Clarification of ZooMS Sampling Criteria:

I appreciate the authors' explanation in the response regarding how the 155 ZooMS samples were selected (based on zooarchaeological identification, element type, preservation, and likelihood of success with minimally invasive methods). However, this

information is currently not in the manuscript itself. I recommend that this criterion be added to the main text, to enhance transparency and reproducibility.

R: We have added more detail on the sample selection in the methods section (page 9, lines 456 to 465). The information specifically regarding ZooMS sample selection was already in the manuscript, so the additional information included is in reference to the initial zooarchaeological sample selection/identification which we expanded upon for Reviewer 2 in the previous rebuttal. The section now reads:

“The Collection Tiburtius at MASJ consists of more than 9,000 specimens, while Tiburtius’ notebooks (which unfortunately are not complete and do not include all of his collected items) list over 200 whale bone specimens from pre-colonial sites in Babitonga Bay; however in some cases the sites and/or specific contexts are not clear. Initial zooarchaeological analysis was performed to first identify potential cetacean remains, generally avoiding those from unknown archaeological contexts. Marine mammal bones tend to be fairly distinct when compared to those of terrestrial mammals and large fish because of their high porosity. Nevertheless, when dealing with highly fragmented bone assemblages, they can be confused with those of certain large terrestrial mammals; however, such mammals tend to make up a small proportion of the fauna found in sambaquiss ^{22,91}. Once separated, the potential cetacean remains were classified based on artefact types ⁹², and further taxonomic identifications were assigned when possible through side-by-side comparison with modern specimens of the Iperoba Biological Collection (ABI) at the Universidade da Região de Joinville (UNIVILLE) in São Francisco do Sul, along with specialised literature (Supplementary References).”

Reviewer #3 (Remarks to the Author):

I appreciate the authors’ responses and the effort invested in addressing the reviewers’ comments. This study presents valuable data and applies relevant analytical methods that contribute to the archaeology of sambaquis in southern Brazil, including zooarchaeological analysis of cetacean remains, molecular identification of bone tools, and new radiocarbon dates. These results have potential to advance knowledge of cetacean presence in Babitonga Bay and to demonstrate the usefulness of the applied methods for reducing the need for more invasive techniques.

However, I do not recommend publication of the manuscript in its current form. The narrative places excessive emphasis on a whaling hypothesis that is not sufficiently supported by the evidence presented. Regarding the authors’ assertion while replying the comments (page 19, first paragraph) that the absence of organic tools in the archaeological record does not imply that whaling did not occur, I agree that absence of evidence is not evidence of absence. However, based on the analyses presented here and the existing literature, it is equally not possible to definitively affirm that whaling did take place. I respectfully disagree with the statement that there is no direct evidence for the exploitation of plant fibers, wood, or other vegetal resources (as used for comparison with

whaling). Despite preservation challenges, macro- and especially micro-botanical remains have been rigorously documented and demonstrate the importance of these materials to shellmounds groups. Such evidence is recovered from sediments, artifacts, and human dental calculus, and is amenable to scientific study. Furthermore, evidence for fishing among these groups is well established through zooarchaeological analyses of thousands of faunal remains, technological artifacts such as lithics, bone tools, fishhooks, and net weights, as well as isotopic data indicating a predominantly fish-based diet in most of the studied shellmounds. Although terrestrial fauna remains are less common in southern Brazil, this pattern does not hold for sambaquis on the São Paulo coast, for example, where both isotopic and zooarchaeological data reveal a more diverse diet including terrestrial resources.

Critically, the presence of tools fashioned from cetacean bones does not in itself confirm their use in whaling. These implements could have been used in the capture of other large marine species such as sharks, seals, large aquatic birds, or large fish, which are well documented in the archaeological record. Moreover, there is significant literature, including by some of the co-authors of this study, showing that fish species during the pre-colonial period often reached sizes much larger than today's specimens, an important consideration when interpreting tool function.

I suggest that the manuscript be restructured to highlight the robustness of the methodological approach and the specific results obtained from the bone tool analyses, incorporating a more comprehensive discussion of the identified taxa, their ecology, and the potential insights from future studies. Such a reframing would, in my opinion, result in a stronger, more balanced, and evidence-based contribution.

R: We thank Reviewer 3 for their comments, which have considerably improved the manuscript. Along with the recommendations from Reviewers 1 and 2, they have strengthened the methodological and conceptual aspects of our work. We have addressed most of Reviewer 3's concerns by considering the use of harpoons for hunting other marine animals, including large fish (e.g., sharks, rays) and marine mammals (pinnipeds), which are well represented in sambaqui archaeological records (Page 6, lines 292 to 296), which now reads:

"Pinniped remains were absent in Tiburtius' collection, but their occurrence in sites in southern Brazil^{17,22,25,62} suggest these animals may also have been targeted by Sambaqui groups in Babitonga Bay through harpooning. The use of harpoons likely extended to other marine animals as well, such as sharks, rays, and other large fish which are well represented in the archaeological record²⁷."

We have in several parts of the paper highlighted the robustness of the methodological approach and the specific results obtained from the bone tool analyses, specifically:

Page 1, lines 91 to 96 - "Significantly, comparison with archaeological and ethnographic literature shows that some enigmatic artefacts recovered from the sambaquis in the second half of the last century are in fact harpoon foreshafts made of whale bone, among the largest documented from archaeological sites in South America. Their association with whale bone remains and artefacts reveal that Sambaqui populations possessed the technology for hunting large baleen whales and dolphins as early as 5000 years ago. "

Page 4, lines 200 to 201 - "In the case of Conquista, the foreshafts were recovered from deposits containing marine mammal remains, along with other artefacts manufactured from marine mammal bones ⁶."

Page 4, lines 205 to 207 - "Bevelled points are widely documented in sambaqui sites, where they formed part of the hunting and fishing arsenal ^{8,9}. Their use as composite side barbs on projectile points is also well attested among Indigenous groups in tropical South America ¹⁰⁻¹². "

We also acknowledge that Reviewer 3 remains unconvinced by our interpretation, and we regard this as a positive outcome, as it fosters debate - an element that has characterized discussions on prehistoric whaling since their earliest formulations, but one that has been largely absent from Sambaqui archaeology for nearly two decades. Our whale-hunting hypothesis is firmly grounded in the literature, as highlighted in the opening paragraph of the discussion, and is based on the same inferential processes archaeologists routinely apply when linking faunal-plant remains with associated tools for hunting, fishing, and harvesting. In response to the statement, "*Critically, the presence of tools fashioned from cetacean bones does not in itself confirm their use in whaling,*" we agree but also contend that our interpretation extends well beyond the simple identification of the existence of whale-bone artefacts. We present evidence for a broader whale-related cultural sphere, including whale skeletal remains and reports from excavators who personally described large quantities of visible whale bones that unfortunately went unrecovered. Taken together with the near-coast species identified, these multiple lines of evidence would, in North Pacific and North Atlantic contexts, be convincingly associated with whaling ¹³⁻¹⁷.

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Review of the paper: Archaeological and molecular evidence for whale hunting in coastal Brazil 5000 years ago

Comments for the authors:

Dear authors, after a thorough review of your manuscript, I would like to provide some comments for your consideration. A detailed, point-by-point review can be found in the attached file.

I highlight the major strengths of the manuscript: 1) The study of historical archaeological collections preserved in museums is both interesting and valuable; 2) The identification of cetacean species used to craft tools and artifacts is a notable achievement. Also, the information provided about the cetacean species present along Brazilian coastal sites during pre-colonial times is important for this field of expertise, given the challenges involved in zooarchaeological identification of these bones; 3) The presentation of new radiocarbon dating results for the archaeological sites in the Babitonga Bay refines the chronology of occupation of this region.

However, I do not believe that your study provides strong evidence for systematic whale hunting by shellmound populations in Brazil. Could this be considered a hypothesis? Yes, but the assertion made in the manuscript is premature. The study, which focuses on a limited number of artifacts, does not offer sufficient robustness to support such a claim.

It is undeniable that the artifacts from the Tiburtius collection are highly interesting, and their identification and study are indeed important for advancing research on sambaquis. But large bone artifacts could have been used for fishing or hunting a variety of other animals. Furthermore, there is a lack of more comprehensive references to zooarchaeological studies, isotopic analyses, and bone artifact research from other regions, which would provide valuable context. It would be important to assess whether it is possible to quantify the significance of whales to the sambaqui populations in Brazil, particularly in comparison to the importance of fishing.

Point per point review

Abstract

55-56: The term "shell mound" should be corrected to "shellmound". Please ensure consistency by reviewing and correcting this throughout the entire manuscript.

56: The term "sambaqui" appears sometimes written in lowercase and other times capitalized as "Sambaqui." Please choose one form and ensure it is applied across the manuscript.

57-58: It would be appropriate to include the Latin names of the species mentioned here.

Introduction

84-90: The references cited in this section are focused on the southern region of Brazil. Given that Brazil is a continental-sized country with a long and diverse coastline, it would be good to consider the broader geographic context. Pre-colonial coastal sites are widespread along the Brazilian coast, and it would be relevant to address whether cetacean presence has also been documented in other regions. Are cetaceans more abundant in certain coastal areas? Also, are the tools/artifacts found in Babitonga Bay unique to that region, or have similar cetacean-related artifacts been identified elsewhere?

96-100: Can it be stated with confidence that this type of bone artifact is exclusive to this region? Have similar cetacean-derived artifacts not been identified in other shellmounds? It would be important to clarify whether such artifacts have been reported elsewhere along the Brazilian coast or in other coastal sites of South America.

114: DeBlasis, not Blasis

120-121: I wonder how can this be confirmed by the methods of the study

Results

138-148: From all the 18 shellmounds studied, only 162 remains (regular bones/teeth and artifacts) were found? Or are those the only one studied? If yes, why?

What the number of cetacean bone/teeth fragments were not possible to be identified rather than Cetacea? Non identifiable remains should always be mentioned in zooarchaeological studies.

Considering the number of sites studied and the amount of zooarchaeological materials found in sambaquis, it seems a low number of samples analyzed.

154-181: I consider the application of this technique and the results obtained to be the highlight of the study. It is remarkable that such data can be generated through a non-destructive method. Furthermore, the information provided regarding the cetacean species present along the Brazilian coast during that period is particularly valuable and significantly contributes to our understanding of past marine biodiversity and to shellmounds archaeology.

201-213: The ethnographic references cited here are limited, with a predominant focus on the North American context. Are there no studies that specifically address South American populations?

The text overlooks the extensive historical use of whales in Brazil, particularly in the state of Santa Catarina, where whales were hunted and utilized for various purposes. This should be acknowledged in the manuscript. Furthermore, it would be important to explore what tools were used for whale hunting during that period, as this information could offer valuable insights into the technological and cultural practices of the time.

232: The whale names should also be standardized, review throughout the manuscript

235: For the artifacts that were direct dated, where they destroyed for that purpose?

283: Some references are missing here. What are the studies saying that those artifacts are present? Where in Brazil?

286-290: The information that those artifacts are found in funerary contexts can be crucial for this study, and the interpretations. Are cetacean artifacts found in other sambaquis from Brazil? Where? What the authors say about it?

Discussion

304-318: I do not see how your study shows evidence of systematic whale hunting. The outcomes of your analysis include new radiocarbon dates for archaeological sites in Babitonga Bay (although the detailed results, including plots displaying the new dates, are not presented), the identification of cetacean bone artifacts, and the taxonomic classification of both worked and unworked bones. However, I do not see a clear connection between these findings and the assertion of significant whale hunting activities.

375-387: What ethnographic records? You did not bring significant or national ethnographic study to compare the use of those artifacts with whale hunting.

389-391: As stated in this section of the text, there is no evidence to support the existence of technology associated with the systematic maritime exploitation of large mammals within the context of the Brazilian shellmound culture. Therefore, drawing conclusions regarding systematic whale hunting appears to be premature and unsupported by the current data.

391-392: As mentioned in this section of the text, a single whale could provide a substantial quantity of raw material, which complicates the quantification of cetacean remains in shellmounds. The Brazilian sambaqui populations inhabited the Babitonga region for millennia, so the presence of whale bones could have resulted from occasional occurrences. The number of bones recovered, however, is not substantial enough to support the conclusion of large-scale whale hunting activities.

411-412: The statement made in this sentence is problematic in several ways. It is not appropriate to compare the well-established trajectory of sambaqui archaeology—which, after initially characterizing these groups as mollusk gatherers, has come to emphasize fishing as their primary social and economic activity—with the claim that they may also have been whale hunters. The interpretation of sambaqui builders as primarily fishers is supported by a robust body of evidence resulting from decades of research, involving multiple institutions, diverse geographic regions, and a range of methodological approaches. If the intention is to enter this debate and suggest that these populations were also whale hunters, a more substantial and methodologically grounded discussion is necessary. There is currently no definitive evidence to rule out the possibility that whale bones found in sambaquis were the result of opportunistic use of stranded animals or isolated hunting events. However, these would be exceptional occurrences in comparison to fishing activities. This interpretation is supported both by previous zooarchaeological studies and by isotopic data—which, notably, are not considered in the current manuscript.

Material and Methods

Important: The Brazilian government permissions for transporting and analyzing samples (including destructive analysis) abroad are missing in the materials session. Different laboratories were used for this study (Spain, France, Austria, USA, Italy), did you have the permission to transport the samples to different countries? Were the samples repatriated after the analysis?

451-452: The methods used for zooarchaeological analysis are missing. What collections were used to compare with the archaeological remains? What bibliography were consulted?