nature portfolio

Peer Review File

A 5.3-million-year-old deep-sea whale necropolis in the Diamantina Zone

Corresponding Author: Xiaotong Peng

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

Version 0:

Reviewer comments:

Referee #1

(Remarks to the Author)
A. Summary of the key results. The ms gives an account of a really exceptional accumulation of whale skeletons, in an poorly explored area of the deep sea floor. These skeletons are mostly of beaked whales, a poorly known group, and include both extant and extinct species. The oldest skeletons are dated as 5.3 million years old. Some skeletons are 'active' in that they support chemosynthetic communities and other bone specialists (e.g. Osedax); some are 'inactive' in the 'reef stage', acting as hard substrates on the muddy seafloor.
B. Originality and significance: if not novel, please include reference. The results are novel and significant for quite a few reasons: the location, the density on whale carcasses, the taxonomic elements (dominance by beaked whales), and the number of novel invertebrate whale-fall species supported by the 'active' whale carcasses.
C. Data & methodology: validity of approach, quality of data, quality of presentation. All seems good to me, although I have one question about the calculated skeleton accumulation rate in one part of the ms (see detailed comments below).
D. Appropriate use of statistics and treatment of uncertainties. All appropriate.
E. Conclusions: robustness, validity, reliability. All appropriate.
F. Suggested improvements: experiments, data for possible revision. None.
G. References: appropriate credit to previous work? Yes.
H. Clarity and context: lucidity of abstract/summary, appropriateness of abstract, introduction and conclusions. The ms reads well. I have a few more detailed comments and questions (see below).
Minor comments:
Main text
Line 12. Adding 'in this area' before 'comprises' would clarify this sentence.
Line 30. Either 'a different set of taxa', or 'different sets of taxa'.
Line 41. Is the Labuan Basin relevant, or could this sentence equally just end at 'faulting'?
Line 45. Which zone? Clarify by saying 'The Diamantina Zone' (if this is correct).
Line 81. See comment about chemosymbiosis below. Also, Thyasiridae should not be in italics.
Line 98-99. 'led to the identification of..', or 'led us to identify…'
Line 145. I don't quite understand the phrase 'have been recorded' in this sentence. Is it necessary?
Lines 149-151 and 185-186. Does this calculation include all the whale skeletons? If so the estimation of 10.93 million carcasses would be over 5.3 million years, to include the oldest dated material. This would give an average accumulation rate of 2.06 carcasses per year over the whole Diamantina Zone, which actually sounds quite low, and is counter to later calculations on the number of 'active' carcasses (112, 500; line 215). Perhaps the authors could clarify.
Line 488. Typo. Abyssogena not Abyssinia.
Extended data
In Figure 1 Adipicola is identified. Is this the same as the mytilid in Figure 2b? In which case the latter could be identified as such (as it seems to be in species 30 in the Extended Data Table 1, and also in the main text, line 81). Also, in Figure 2 text chemosymbiotic should be one word. Finally, has chemosymbiosis actually been proven in the mytilid and thyasirid? Highly likely for the mytilid, but some thyasisids do not have symbionts. Perhaps 'putative chemosymbiotic bivalve species' would be better at this point.

Referee #2

(Remarks to the Author)
This is such an amazing and exciting publication. The sheer scale of this discovery is super-impressive and mind-boggling! I only had a couple of trivial editorial comments. My biggest question is: Why did any bone survive on this deep ocean floor for that long? It was my impression that bacterial colonization and their resulting metabolizing/dissolution of bone would pretty much guarantee that bone would eventually completely disappear. I know that ziphiid bone is often osteosclerotic, but are the bones that survive permineralized/fossilized without becoming entombed in sediment? Presumably permineralization would help prevent or slow dissolution? I know of Bianucci et al's description of ziphiids from off the coast of South Africa...but would it be possible to include a paragraph in this publication explaining how/why bone can remain exposed and seemingly mostly intact on the ocean floor for millions of years?

Summary of the key results: Yes, explicit.
Originality and significance: Yes, should have very broad interest given the scale/scope of this discovery.
Data & methodology: validity of approach, quality of data, quality of presentation: Appears to be of a very high caliber, and their presentation is clear and concise.
Conclusions: robustness, validity, reliability: That there are an estimated 10.93 million carcasses on that seafloor is hard to take in, the number is so high. Future work will validate or not. There were so many areas sampled that their conclusions seem justified! Astounding really.
References: appropriate credit to previous work? References appear fine!
Clarity and context: lucidity of abstract/summary, appropriateness of abstract, introduction and conclusions: Yes, excellent presentation and very well written ms.
The Extended Data is very good!

Line 15, change "ecosystem" to "ecosystems"
Line 65, this sentence seems to me to need a bit more context. Of all the whale falls that you observed/samples there were only 5 in the sulfophilic stage?
A truly remarkable discovery!
Stephen J. Godfrey

Referee #3

(Remarks to the Author)
General comments:

This paper documents the important discovery of 9 modern whale falls (5 in the sulphophilic stage and 4 in the reef stage) and hundreds of cetacean fossils at hadal depths over a large length (1200 km) of the Diamantina Fracture Zone in the Indian Ocean. I congratulate the authors on collecting this extraordinary data set.

The modern sulphophilic whale-fall communities are the first reported from hadal depths, and in this region of the SE Indian Ocean. The communities contain microbial mats and numerous apparently new species, including chemosymbiotic bivalves, Osedax bone-eating worms, many other polychaetes, gastropods and crustaceans, as well as novel higher level taxa for whale falls, specifically brittle stars and Xyloplax. These novel whale-fall sulphophilic species in a new region at hadal depths provides new insights of major significance to whale-fall, and reducing habitat, ecology, connectivity, evolution and biogeography. The figures, tables and video are well presented.
However, these modern results could be better placed in the current relevant literature, with more detailed presentation of relationships to other whale falls and reducing habitats in the broader region, specifically in Extended Data Table 1. Also, there must be an error in this table since the genus Silax is indicated to have been observed only by video (no collection indicated), but GenBank accession numbers are indicated. Was this genus actually collected?

Relevant whale-fall papers not cited include:

Georgieva, M. N., Wiklund, H., Ramos, D. A., Neal, L., Glasby, C. J., & Gunton, L. M. (2023). The Annelid Community of a Natural Deep-sea Whale Fall off Eastern Australia. Records of the Australian Museum, 75(3), 167-213. https://doi.org/10.3853/j.2201-4349.75.2023.1800

Taviani, M., Montagna, P., Hosie, A.M., Castellan, G., Kemper, C., Foglini, F., McCulloch, M. and Trotter, J., 2024. Whale fall chemosymbiotic communities in a southwest Australian submarine canyon fill a distributional gap. Heliyon, 10(8).

The documentation of four whale falls in the reef stage is also important because it demonstrates the broad occurrence of this stage at hadal depths after the demise of Osedax and other bone eaters, and the presumed depletion of bone organic material in the skeleton. While this reef stage has been observed in other regions (e.g., the abyssal Pacific), its existence has remained controversial.
The discovery of >400 fossil cetaceans in the hadal zone of dating back 5.3 million years also is remarkable and seems very significant to understanding cetacean, especially beaked whale, ecology and evolution. However, the importance of these finds and their interpretations and implications, including the new species description of a beaked whale, must be evaluated by other reviewers with expertise in paleontology, cetacean ecology/physiology, taxonomy and evolution.

The postulated mechanisms leading to the concentrations of modern and fossil whale falls (aside from enhanced mortality) seem plausible, and it is good to see predictions of other oceanic regions which may show high concentrations of such fossils, if these mechanisms are correct.
The extrapolations of data from 0.64 km2 to predict >100,000 modern whale falls and >10 million fossil cetaceans in the 14,000 km2 of the DFZ region are over ambitious. What are the assumptions behind these predictions (random distributions across the 14,000 km2 region)? Were the HOV dive locations randomized or stratified across the region to allow regional generalizations, or did they target particular geological features? There is no mention of any statistical sampling design (random, stratified) to support general statements across the 14,000 km2 area. Nor is there mention of confidence limits. These extrapolations are worth mentioning, along with any assumptions, but are very, very rough with huge confidence limits (especially when extrapolating from n=5 to >100,000 whale-fall communities). Confidence limits could be calculated from statistical distributions of random rare events, if assumptions are met.

Overall, the paper is well written but is quite telegraphic (brief) due to its very large scope (whale-fall ecology and biodiversity; cetacean ecology/physiology, paleontology and evolution). The broad and exciting nature of the material would make it of very broad interest in oceanography, whale-fall ecology, the biogeography of reducing habitats, cetacean evolution and paleontology, and other areas. The authors also do a nice job of highlighting the potentially important implications of these findings in the “Implications” section.

Ultimately, the modern whale-fall communities will merit more detailed treatment in more specialized publications to present detailed identifications, as well as descriptions of new species and phylogenetic relationships, and comparisons of community resemblance to whale falls from other regions and depths (e.g., detailed biogeographic analyses), but the short format of Nature precludes full treatment here, especially if combined with paleo results. Publishing these initial findings in Nature seems warranted due to the novel and exciting nature of the results.

Methods:

The methods for the modern whale-fall studies generally may be reasonable, but they are far too briefly explained. How were macrofauna and megafauna distinguished and sampled? The methods for the extrapolations need better explanation and the results require more conservative presentation. How was the total area survey (0.64 km2) estimated? How was the absence of whale-fall species in the background sediments determined? Were collected specimens examined by taxonomic experts or only barcoded? What specific papers were used for IDs of different taxa? Also, see specific comments below

Specific comments:

Lines 7-11. Change sentence beginning with “This area…” to: “This area represents the deepest and most extensive accumulation of natural whale-fall communities and fossils reported in the scientific literature to date, with 5 modern communities and 476 fossil cetaceans recorded.” The estimate of 10 million is very poorly constrained and too sensational for the abstract.

Line 13: insert “in this region” after “whale falls”

Line 15: insert “some” before “deep”

Lin 29: add ref. 6 to refs. 8,9.

Line 59: image documentation of the ~480 fossil sites is warranted. Can these be made available online as an image library?

Lines 76-79: Mention size difference between macrofauna and megafauna, and mention how they were separated. Also, while many of the taxa mentioned in this paragraph occur on multiple whales, the vesicomyd and the two species of brittle stars each occur on only a single whale fall (See Extended Data Table 1). This should be pointed out since these are not recurrent species in a common whale-fall assemblage across this area. They may be site specific. Also, it would be good to see (minimum) abundance counts on each whale fall for each species in Extended Data Table 1, rather than simple presence indicated.

Line 80: I would suggest: “The majority of recovered taxa may be new to science.” Note that barcoding alone cannot necessarily indicate if a species is new, since all deep-sea species described by morphotaxonomy have not yet been barcoded. Granted, there may be a lot of cryptic speciation in the deep sea, but we are not at the point of discarding morphotaxonomic descriptions. Ultimately, both barcoding and morphological comparisons are needed.

Line 81: say: “only the vesicomyid bivalve Abyssogena southwardae”

Line 185-187: If we accept the estimate of 10,000,000 whale falls over 5.3 million years to this 14,000 km2 area, this does not necessarily imply a high mortality rate (only an average of two whale falls per year across a huge area). Also, most of the ocean exceeds the diving depths of beaked whales so is there any reason to think that in the Diamatina FZ, beaked whales are more likely to dive beyond their safe limits and sustain increased mortality? What may be remarkable here is not the cetacean mortality rate, but rather the large area surveyed, the downslope accumulation of whale carcasses, and the high fossil exposure rate, as discussed in lines 188-192.

Line 92: How was the absence of whale-fall species in the background sediments determined?

Line 205: add the word “apparently” as follows: “Isolation, imposed by extreme depth, apparently has facilitated the development…”

Supplementary Table 1: Indicate whale falls in reef stage.

Recommendation: Based on modern whale fall components – requires significant revision (see comments above). Overall acceptance will depend on review of the paleontological components. This paper is exciting and could be published in Nature in its entirety, following revision, if the paleo results pass review, because of the complementary nature of the modern and paleo results. However, I do think this paper may be better broken into two papers (modern and paleo components), allowing expansion of the modern whale-fall analyses.

Version 1:

Reviewer comments:

Referee #1

(Remarks to the Author)
The authors have done a good job responding to the reviewers' comments. I have no further concerns.

Minor comment:

Lines 107 and 174. Andrews' beaked whale, not Andrews's (at least what I can glean from the internet).

Referee #2

(Remarks to the Author)
Perhaps because this represents my second time through the manuscript, wow, this version seemed so much easier to read with no outstanding or lingering questions left in my mind upon completion! It was so satisfying. I my first review, I was concerned about the extrapolated numbers of potential specimens (which may prove to have been realistic) and as I recall the method of preservation of the specimens, some for millions of years. Both of these have been amply addressed. For me, it was an honor to have been asked to review this manuscript. I think this is a super-exciting discovery and I applaud the authors for pursuing these beaked whales into this other worldly environment.

I only found one typo...line 47, I think "zone" ought to be capitalized.
I look forward to seeing this manuscript published.
Best,
Stephen J. Godfrey

Referee #3

(Remarks to the Author)
The authors have done a very nice job addressing all the comments in my initial review. It seems that they have also addressed the comments of the other two reviewers as well. I recommend publication of this revised version as is. This will make a very important and exciting contribution to the modern and fossil whale-fall scientific literature.

Signed,

Craig Smith

Author's responses re review

Nature manuscript (2026-01-02729)

We are most grateful to the editor and three reviewers for their careful and constructive comments. We have fully addressed the concerns raised by all reviewers, and substantially revised the manuscript for all comments. See our point-to-point revision details below.

Editor:

Your manuscript, "A 5.3-million-year-old deep-sea whale necropolis in the Diamantina Zone", has now been seen by three referees. You will see from their comments below that while they find your work of great interest, some important points are raised. We are very interested in the possibility of publishing your study in Nature, but would like to consider your response to these concerns in the form of a revised manuscript before we make a final decision on publication.

You will also need to make some editorial changes to your paper so that it is as brief as possible and complies with our Guide to Authors. We also strongly suggest that your revised manuscript has tracked changes, which is increasingly requested by referees to aid in their re-review.

Response: The revised manuscript has tracked changes.

We would appreciate your careful attention to the following:

STATISTICS: When revising your manuscript, you should ensure that any statistical analysis used is sound and that it conforms to Nature's guidelines). A collection of articles explaining the basics of statistical analysis and advice on how to best present it can be found here.

Response: N/A.

REPRODUCIBILITY: All of the checklists provided with the current submission (Reporting summary, and Code and software checklist (if applicable)) should be updated to reflect the revisions made and submitted with the revised manuscript.

Response: All checklists updated and resubmitted.

TITLE: Titles cannot exceed 75 characters (including spaces); they must not contain punctuation.

Response: Conformed (71 characters; no punctuation).

SUMMARY PARAGRAPH: All Nature papers begin with a fully referenced paragraph, typically no longer than 200 words, aimed at readers in other disciplines. This paragraph starts with a 2- to 3-sentence, basic introduction to the field; continues with a 1-sentence statement of the main findings starting 'Here we show' or an equivalent phrase; and finally, concludes with 2 to 3 sentences putting the main findings into general context so it is clear how the results described in the paper have moved the field forward. A downloadable, annotated example is available here. In some cases it may be necessary to exceed this limit modestly in order to explain complex material for readers in other fields. The extra length, however, is for introduction and context, and not for additional technical information.

Response: Conformed (157 words; structure follows the guidelines).

MAIN TEXT: If further introductory material is necessary, the main text can begin with up to 500 words of introduction expanding on the background to the work (some overlap with the summary is acceptable), before proceeding to a concise, focused account of the findings, and ending with 1 or 2 short paragraphs of discussion. Sections are separated with subheadings (up to 40 characters including spaces) to aid navigation.
Response: Conformed.

REFERENCES: As a guideline, most papers should include no more than 50 main text references; additional references can be cited in (and listed after) the Methods section, as detailed below.
Response: Conformed (50 main text references, 27 additional references).

FIGURE LEGENDS: These should be listed sequentially after the main text references and not in the figure files; they should not exceed 300 words each. Each legend should begin with a brief title for the whole figure and continue with a short description of each panel and the symbols used. Each figure legend should contain, for each panel where relevant, the following information:
* the exact sample size (n) for each experimental group/condition, given as a number, not a range;
* a description of the sample collection allowing the reader to understand whether the samples represent technical or biological replicates (including how many animals, litters, cultures, etc);
* a statement of how many times the experiment shown was replicated;
* definitions of statistical methods and measures:
* very common tests (e.g., t-test, simple Chi-square tests, Wilcoxon and Mann-Whitney tests) can be identified by name only, but more complex techniques should be described in the Methods;
* whether tests are one-sided or two-sided;
* whether there are adjustments for multiple comparisons;
* the statistical test results (e.g., P values);
* the definition of 'center values' as median or average;
* the definition of error bars as s.d. or s.e.m.
Any descriptions too long for the figure legend should be included in the Methods section; see here for further explanation.
Response: All conformed.

METHODS: After the main text figure legends there should be a section entitled "Methods", which provides the full, step-by-step instructions that would allow other researchers to replicate the results. The Methods section will not appear in print but will appear online in the full-text HTML and PDF versions. The Methods section should be written as concisely as possible but should contain all elements necessary to allow interpretation and reproduction of the results. If there are additional references in the Methods section, their numbering should continue from the last reference in the main text, and they should be listed following the Methods section. Specialized methods that require chemical structures, figures or tables, or methods requiring equations, cannot be accommodated in the Methods section of the main text file. If such information is part of the Methods, the entire Methods section must instead be

included within a Supplementary Information text file.
Response: Conformed.

MAIN TEXT STATEMENTS: Several statements (which will not appear in print but will appear online in the full-text HTML and PDF) are required after the Methods, and before the Extended Data legends. First, there should be an Acknowledgements section, listing grant/financial support. Next, we require a detailed Author Contribution statement; the specific contributions of each author, particularly in terms of which authors performed which specific experiments, must be listed. This is followed by a Competing Interest statement. Financial or non-financial interests should be noted here, as well as any patents; patent information should include at a minimum what is covered by the patent and who submitted the patent application. Finally, an Additional Information statement should include information regarding reprints and permissions and name the author(s) to whom correspondence and requests for materials should be addressed. For details of "end note" style and an example see here.
Response: All conformed.

DATA AND CODE AVAILABILITY STATEMENTS: All original research manuscripts published in Nature Portfolio journals must include a Data availability statement (DAS). This statement must make the conditions of access to the “minimum dataset” that is necessary to interpret, verify and extend the research in the article, transparent to readers. This minimum dataset may be provided through deposition in public community/discipline-specific repositories, custom proprietary repositories for certain types of datasets, or general repositories like Figshare, Zenodo and Dryad. Providing large datasets in supplementary information is strongly discouraged and the preferred approach is to make data available in repositories. More information on Nature Portfolio’s reporting standards and preparing your Data availability statement can be found here.

For all studies using custom code or mathematical algorithms that are deemed central to the conclusions, a Code availability statement (CAS) must be included, indicating whether and how the code or algorithm can be accessed, including any restrictions to access. the CAS should be provided as a separate section after the DAS but before the references. Code should be deposited in a DOI-minting repository such as Zenodo, Gigantum or Code Ocean and cited in the reference list. We encourage you to manage subsequent code versions and to use a license approved by the open source initiative. Additional details can be found here.

Wherever possible the data used in the paper should be placed into a public data repository or presented as Supplementary Information. If data can only be shared on request, please explain why in the DAS and in the cover letter. The DAS must list which data are included (e.g. by figure panels and data types) and mention any restrictions on availability. If a dataset generated or analysed during the study is publicly available and has a unique DOI, please include it in the reference list and cite the dataset in the Methods. Accession numbers for any newly determined sequences, structures, microarray or zoobank data; project IDs for MG-RAST data; accession numbers for X-ray crystallographic coordinates and structure factor files; or comparable NMR or cryoEM data, should be included only in the DAS.
Response: In this revision, we have deposited new original data to a public data

repository, and now all related original data are fully transparent to readers. The newly deposited data (1.8G) include in situ images of whale fossils and whale falls, and microbial MAGs of the dominant bivalve symbionts, available in Science Data Bank (https://doi.org/10.57760/sciencedb.28830) (Main text, Clean version, Line 518). For peer review, the new dataset can be accessed here: https://www.scidb.cn/en/anonymous/ekFGN3p1.

DISPLAY ITEMS: We ask that you take stock of all the data that have been generated throughout the review process and ensure that only the data most central to the conclusions are presented in the main text figures. Although figures can be presented within the text file during the review process, they must be removed from the final text file and uploaded as separate individual files. Figures should be comprehensible to readers in other or related disciplines and assist their understanding of the paper. Figures should be as small and simple as is compatible with clarity. Main text figures (but not Extended Data) must be provided in an editable format. Acceptable formats include .ai, .cmx, .cdr, .doc, .eps, .pdf, .ppt, .ps, .psd, .svg and .xls; unacceptable formats include .cvs, .gif, .jpg, .png and .tif. All panels of a figure should be logically connected; each panel of a multipart figure should be sized so that the whole figure can be reduced by the same amount and reproduced on the printed page at the smallest size at which essential details are visible. For guidance, Nature's standard figure sizes are 9, 12, or 18 cm wide; the maximum permitted height of a figure is 17 cm. All panels of figures must be on a single page and assembled into a rectangular shape for publication; any essential alignments (parts horizontal, vertical, spacings of stereo pairs, etc) should be indicated. Nature requests that authors of accepted manuscripts contribute towards the total cost of reproduction of colour figures in print. You will be charged a fee for the print reproduction of colour figures (see here for cost information). Tables should be prepared using the Table menu in Microsoft Word.
Response: All conformed.

FIGURE FORMATTING: Lettering in all figures (e.g., labelling of axes) should be in uniform, sans-serif font, in lower-case type, and large enough to permit substantial reduction for publication (the minimum font size permitted is 5 pt). Separate parts of a figure are labelled a, b, etc. Units have a single space between the number and the unit, and follow SI nomenclature or the nomenclature common to a particular field. Thousands are separated by commas (1,000). Unusual units or abbreviations are defined in the legend.
Response: Revised.

IMAGE PRESENTATION: Data figures are integrated into the main paper online. An overview of the key features of this presentation may be found here. We strongly encourage you to consult the guidelines. A discussion of our standards regarding how images should be prepared and presented can be found here.
Response: Revised.

EXTENDED DATA: Extended Data do not appear in print but are included online within the full-text HTML and integrated in the downloadable PDF. Extended Data are an integral part of the paper, and only data that directly contribute to the main message should be included. All Extended Data must be referred to in the main text, and their legends should be listed sequentially at the end of the main text, not in the

Extended Data files. The Extended Data should be assembled into a maximum of 10 A4 size, multi-panelled display items, submitted as individual files in .jpg, .tif or .eps format only. They should be of the same quality as print figures, but there are important differences in their formatting. More specific instructions can be found here. We encourage authors who are describing complex processes to include a schematic of the main finding as part of the Extended Data to aid readers unfamiliar with the immediate discipline.

Response: All conformed.

SUPPLEMENTARY INFORMATION: Supplementary Information (SI) is online-only, peer-reviewed material that is essential background to the study (e.g., large data sets, more complex methods, and calculations), but which is too large or impractical, or of interest only to a few specialists, to justify inclusion in the print version of the paper (see here for further details). While SI should not typically contain data figures (any figures additional to those appearing in the main text should be formatted as Extended Data), we require that the raw, uncropped data for gels be presented as an SI figure (see below). Tables may be included in SI, but only if they are unsuitable for formatting as Extended Data (e.g., tables containing large data sets or raw data tables that are best suited to Excel files). If a manuscript has SI, each discrete item of the SI (e.g., videos, tables) must be referred to at an appropriate point in the main manuscript. We ask that you provide a word file entitled "SI Guide", containing a cover page with manuscript title and author information; a table of contents (preferably with page numbers); and then any SI text, notes, figures, and titles and legends for any separate SI files. Additional information can be found here.

Please pay careful attention to the formatting of the SI because it is not subedited. After the paper has been accepted, SI files can only be amended for critical changes to the scientific content, not for style.

Response: All conformed.

SOURCE DATA (GRAPHS): To increase transparency, we strongly encourage you to provide, in spreadsheet form, the data underlying the graphical representations used in the figures. In the case of all experiments presenting data from animal models, this is a requirement and is not optional. This is in addition to our well-established data-deposition policy for specific types of experiments and large datasets. Online readers of the manuscript will be able to access the graphical source data directly from the figure legend. Spreadsheets can only be submitted in .xls, .xlsx or .csv formats. One file per figure is permitted. If there is a multi-panelled figure, the source data for each panel should be clearly labeled in the file; alternatively the source data for a figure can be included in multiple, clearly labeled sheets within an Excel file. File sizes of up to 30 MB are permitted, but it is expected that the vast majority of graphical source data files will be considerably smaller than this. When submitting these files with your manuscript, you should select the "Source Data" file type and use the title field in the file description tab to indicate the figure(s) to which the source data pertain.

Response: N/A.

RAW DATA (GELS): You must provide the original source images for all data obtained by electrophoretic separation (e.g., EMSA, northern/Southern/western blots, etc). The raw images must be assembled into a single .pdf or .tif file (multiple gels on a single page is encouraged). The file should be uploaded as Supplementary Figure 1.

The full scanned images must be in uncropped form and contain size/molecular weight markers and loading controls. There should be an accurate indication of how the gels were cropped for the final figure. Please clarify in the figure legends and raw data files whether controls (such as beta-actin) were run on the same gel as loading controls, or on separate gels as sample processing controls (see here). While the data can be displayed in a relatively informal style, there must be a correspondence between each source data image and a specific main text or Extended Data figure. The main text or Extended Data figure legends should refer to the uncropped scans explicitly (e.g., "For gel source data, see Supplementary Figure 1."). For examples, see here or here.

Response: N/A.

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Response: We have removed the five previous reference images in Extended Data Figs. 4 and 5 that come from third-party sources. As these images were not essential, their removal has no impact on the results. Now no third-party content is included.

ORCID: As part of our efforts in improving transparency in authorship, we now request that all authors identified as 'corresponding author' create and link their Open Researcher and Contributor Identifier (ORCID) with their account on Nature's manuscript tracking system prior to acceptance. ORCID helps the scientific community achieve unambiguous attribution of all scholarly contributions. More information and instructions on how to associate your ORCID and MTS accounts can be found here. If you have any issues attaching an ORCID identifier to your MTS account, please contact the Platform Support Helpdesk.

Response: Done.

When revising your paper:

* Include a point-by-point response to our referees and to any editorial suggestions;

Response: See this letter.

* Complete the Reporting summary;

Response: Completed.

* Complete the Code and software checklist (if applicable);

Response: N/A

* Ensure it complies with our format requirements.

Response: Complied.

We hope to receive your revised paper within four weeks. If you cannot send it within this time, we will still be happy to reconsider your paper at a later date as long as nothing similar has been accepted for publication at Nature or published elsewhere in the meantime.

We look forward to hearing from you soon.

Yours sincerely

Dr Henry Gee
Senior Editor Biological Sciences
nature@nature.com
http://www.nature.com/nature
See Nature's new guide to authors at www.nature.com/nature/submit

Referees' comments:

Referee #1 (Remarks to the Author):

Comment 1:
A. Summary of the key results. The ms gives an account of a really exceptional accumulation of whale skeletons, in an poorly explored area of the deep sea floor. These skeletons are mostly of beaked whales, a poorly known group, and include both extant and extinct species. The oldest skeletons are dated as 5.3 million years old. Some skeletons are 'active' in that they support chemosynthetic communities and other bone specialists (e.g. *Osedax*); some are 'inactive' in the 'reef stage', acting as hard substrates on the muddy seafloor.
B. Originality and significance: if not novel, please include reference. The results are novel and significant for quite a few reasons: the location, the density on whale carcasses, the taxonomic elements (dominance by beaked whales), and the number of novel invertebrate whale-fall species supported by the 'active' whale carcasses.
C. Data & methodology: validity of approach, quality of data, quality of presentation. All seems good to me, although I have one question about the calculated skeleton accumulation rate in one part of the ms (see detailed comments below).
D. Appropriate use of statistics and treatment of uncertainties. All appropriate.
E. Conclusions: robustness, validity, reliability. All appropriate.
F. Suggested improvements: experiments, data for possible revision. None.
G. References: appropriate credit to previous work? Yes.
H. Clarity and context: lucidity of abstract/summary, appropriateness of abstract, introduction and conclusions. The ms reads well. I have a few more detailed comments and questions (see below).
Response: Highly appreciated. See our detailed responses below.

Minor comments:
Main text
Comment 2: Line 12. Adding 'in this area' before 'comprises' would clarify this sentence.
Response: Added.

Comment 3: Line 30. Either 'a different set of taxa', or 'different sets of taxa'.

Response: Revised as ‘different sets of taxa’.

Comment 4: Line 41. Is the Labuan Basin relevant, or could this sentence equally just end at ‘faulting’?
Response: Deleted as requested.

Comment 5: Line 45. Which zone? Clarify by saying ‘The Diamantina Zone’ (if this is correct).
Response: Clarified as suggested.

Comment 6: Line 81. See comment about chemosymbiosis below. Also, Thyasiridae should not be in italics.
Response: Revised.

Comment 7: Line 98-99. ‘led to the identification of..’, or ‘led us to identify…’
Response: Revised as ‘led to the identification of…’.

Comment 8: Line 145. I don’t quite understand the phrase ‘have been recorded’ in this sentence. Is it necessary?
Response: The phrase has been deleted.

Comment 9: Lines 149-151 and 185-186. Does this calculation include all the whale skeletons? If so the estimation of 10.93 million carcasses would be over 5.3 million years, to include the oldest dated material. This would give an average accumulation rate of 2.06 carcasses per year over the whole Diamantina Zone, which actually sounds quite low, and is counter to later calculations on the number of ‘active’ carcasses (112, 500; line 215). Perhaps the authors could clarify.
Response: We highly appreciate the reviewer for this comment. To maintain accuracy and avoid potential bias from extrapolating our study-area data to the entire Diamantina Zone, we retained only the whale-remains density based on our observed seabed area using the manned submersible. We have removed the broader estimations of accumulated fossil and active whale carcasses for the whole Diamantina Zone, specifically deleting:
‘with an estimated total of 10.93 million carcasses accumulated on 14,400 km^2 Diamantina Zone seafloor’ and ‘leading to an estimate of roughly 112,500 active carcasses throughout the broader 14,400 km^2 Diamantina Zone seafloor’. (Clean version, Lines 156, 227)

Comment 10: Line 488. Typo. *Abyssogena* not *Abyssinia*.
Response: Revised.

Comment 11: Extended data
In Figure 1 *Adipicola* is identified. Is this the same as the mytilid in Figure 2b? In which case the latter could be identified as such (as it seems to be in species 30 in the Extended Data Table 1, and also in the main text, line 81). Also, in Figure 2 text chemosymbiotic should be one word. Finally, has chemosymbiosis actually been proven in the mytilid and thyasirid? Highly likely for the mytilid, but some thyasisids do not have symbionts. Perhaps ‘putative chemosymbiotic bivalve species’ would be better at this point.
Response: Yes, Extended Data Figs 1 and 2b show the images of the same mytilid

species *in situ* and in the laboratory, respectively. To maintain consistency, we have revised 'Mytilidae sp.' to *Adipicola* sp. in Extended Data Fig. 2. This species was identified based on integrated morphological and molecular data. The term 'chemo symbiotic' has been corrected to 'chemosymbiotic'.

In this revision, we have added new data (Extended Data Fig. 2d) demonstrating that all three bivalve species host symbionts. The new data shows the dominant microbial symbionts in the gill tissues of these three bivalve species via metagenomic analysis. Each species hosts a single sulphur-oxidising microbial symbiont, with relative sequence-read abundance ranging from 71% to 81% (Extended Data Fig. 2d).

In the main text, the original sentence has been revised to 'Three chemosymbiotic bivalves (*Adipicola* sp., *Abyssogena southwardae* and Thyasiridae sp.) hosting different sulphur-oxidising microbial symbionts (Extended Data Fig. 2) and …' (Clean version, Lines 84–86).

Referee #2 (Remarks to the Author):

Comment 1: This is such an amazing and exciting publication. The sheer scale of this discovery is super-impressive and mind-boggling! I only had a couple of trivial editorial comments.

Response: Highly appreciated.

Comment 2: My biggest question is: Why did any bone survive on this deep ocean floor for that long? It was my impression that bacterial colonization and their resulting metabolizing/dissolution of bone would pretty much guarantee that bone would eventually completely disappear. I know that ziphiid bone is often osteosclerotic, but are the bones that survive permineralized/fossilized without becoming entombed in sediment? Presumably permineralization would help prevent or slow dissolution? I know of Bianucci et al's description of ziphiids from off the coast of South Africa...but would it be possible to include a paragraph in this publication explaining how/why bone can remain exposed and seemingly mostly intact on the ocean floor for millions of years?

Response: Thank you for this thought-provoking question. Based on analysis of our dive footage, we observe that the majority of identified fossils are partially buried within the sediment. However, a subset is found completely exposed on hard substrates, where they are often heavily encrusted with ferromanganese (Fe-Mn) crusts. A key distinction between partly buried and exposed specimens is that the partly buried fossilized bones appear denser and exhibit less Fe-Mn encrustation. While a reducing, buried environment is typically considered more conducive to long-term fossilization, several factors suggest that both buried and unburied bones are routinely preserved in this deep-sea setting.

Firstly, the fossilized bones we observed are almost exclusively rostra, which constitute the densest part of a beaked whale's skeleton. In certain species, particularly the Blainville's beaked whale (*Mesoplodon densirostris*), the rostral bone density is the highest known in the animal kingdom[40]. This near-complete compactness is instrumental in resisting rapid degradation.

Additionally, the precipitation of ferromanganese oxides, which we have observed forming an obvious envelope within and around many fossils, likely has a role in promoting the long-term persistence of skeletal elements on the seafloor by isolating the bones from the surrounding environment while further enhancing their robustness.

Further, for buried bones, the localized chemical environment in pore water during degradation of whales may also drive authigenic carbonate mineral precipitation and facilitate the fossilization.

We have added a paragraph to explaining why bone can remain exposed on the ocean floor for millions of years as follows:

‘The fossilized remains we observed are almost exclusively beaked whale rostra, some of which have the highest bone density and mineral content among extant vertebrates[40]. This high compactness likely inhibits rapid degradation, with long-term preservation on the seafloor being further enhanced by the progressive accumulation of ferromanganese oxides both within the bone matrix and on the outer bone surface. The latter process isolates the skeletal elements from the surrounding environment while increasing their robustness. For buried bones, additionally, authigenic carbonate precipitation during the organic degradation may also facilitate fossil preservation’ (Clean version, Lines 197–204)

Comment 3: Summary of the key results: Yes, explicit.

Originality and significance: Yes, should have very broad interest given the scale/scope of this discovery.

Data & methodology: validity of approach, quality of data, quality of presentation: Appears to be of a very high caliber, and their presentation is clear and concise.

Response: Highly appreciated.

Comment 4: Conclusions: robustness, validity, reliability: That there are an estimated 10.93 million carcasses on that seafloor is hard to take in, the number is so high. Future work will validate or not. There were so many areas sampled that their conclusions seem justified! Astounding really.

Response: We highly appreciate the reviewer for this comment. To maintain accuracy and avoid potential bias from extrapolating our study-area data to the entire Diamantina Zone, we retained only the whale-remains density based on our observed seabed area using the manned submersible. We have removed the broader estimations of accumulated fossil and active whale carcasses for the whole Diamantina Zone, specifically deleting (Clean version, Lines 156, 227):

‘with an estimated total of 10.93 million carcasses accumulated on 14,400 km^2 Diamantina Zone seafloor’ and ‘leading to an estimate of roughly 112,500 active carcasses throughout the broader 14,400 km^2 Diamantina Zone seafloor’.

Comment 5: References: appropriate credit to previous work? References appear fine!

Clarity and context: lucidity of abstract/summary, appropriateness of abstract, introduction and conclusions: Yes, excellent presentation and very well written ms.

The Extended Data is very good!

Response: Many thanks.

Comment 6: Line 15, change "ecosystem" to "ecosystems"

Response: Revised.

Comment 7: Line 65, this sentence seems to me to need a bit more context. Of all the whale falls that you observed/samples there were only 5 in the sulfophilic stage?

Response: We have extended the sentence (Lines 66–68):

'At 6,789 m water depth, the Dordrecht Deep beaked whale carcass WF1, consisting of three elongated vertebrae, hosts the deepest active whale fall community hitherto recorded.'
Yes, only five whale falls we observed were in the sulfophilic stage.

Comment 8: A truly remarkable discovery!
Stephen J. Godfrey
Response: Highly appreciated.

Referee #3 (Remarks to the Author):

General comments:

Comment 1: This paper documents the important discovery of 9 modern whale falls (5 in the sulphophilic stage and 4 in the reef stage) and hundreds of cetacean fossils at hadal depths over a large length (1200 km) of the Diamantina Fracture Zone in the Indian Ocean. I congratulate the authors on collecting this extraordinary data set.
The modern sulphophilic whale-fall communities are the first reported from hadal depths, and in this region of the SE Indian Ocean. The communities contain microbial mats and numerous apparently new species, including chemosymbiotic bivalves, *Osedax* bone-eating worms, many other polychaetes, gastropods and crustaceans, as well as novel higher level taxa for whale falls, specifically brittle stars and *Xyloplax*. These novel whale-fall sulphophilic species in a new region at hadal depths provides new insights of major significance to whale-fall, and reducing habitat, ecology, connectivity, evolution and biogeography. The figures, tables and video are well presented.
Response: Highly appreciated.

Comment 2: However, these modern results could be better placed in the current relevant literature, with more detailed presentation of relationships to other whale falls and reducing habitats in the broader region, specifically in Extended Data Table 1. Also, there must be an error in this table since the genus *Silax* is indicated to have been observed only by video (no collection indicated), but GenBank accession numbers are indicated. Was this genus actually collected?
Response: We thank the reviewer for this valuable comment. We have added brief taxonomic remarks (~650 words) below the Extended Data Table 1, to connect the investigated whale falls to other whale falls and other reducing habitats (e.g., hydrothermal vents and cold seeps) worldwide.
Regarding *Silax*, specimens of this genus were indeed collected from Whale fall 5 (WF5). We have corrected the typo and carefully checked the entire table.

Comment 3: Relevant whale-fall papers not cited include:
Georgieva, M. N., Wiklund, H., Ramos, D. A., Neal, L., Glasby, C. J., & Gunton, L. M. (2023). The Annelid Community of a Natural Deep-sea Whale Fall off Eastern Australia. Records of the Australian Museum, 75(3), 167-213. https://doi.org/10.3853/j.2201-4349.75.2023.1800
Taviani, M., Montagna, P., Hosie, A.M., Castellan, G., Kemper, C., Foglini, F., McCulloch, M. and Trotter, J., 2024. Whale fall chemosymbiotic communities in a southwest Australian submarine canyon fill a distributional gap. Heliyon, 10(8).

Response: Cited (reference 65, 66).

Comment 4: The documentation of four whale falls in the reef stage is also important because it demonstrates the broad occurrence of this stage at hadal depths after the demise of *Osedax* and other bone eaters, and the presumed depletion of bone organic material in the skeleton. While this reef stage has been observed in other regions (e.g., the abyssal Pacific), its existence has remained controversial.

The discovery of >400 fossil cetaceans in the hadal zone of dating back 5.3 million years also is remarkable and seems very significant to understanding cetacean, especially beaked whale, ecology and evolution. However, the importance of these finds and their interpretations and implications, including the new species description of a beaked whale, must be evaluated by other reviewers with expertise in paleontology, cetacean ecology/physiology, taxonomy and evolution.

Response: Highly appreciated. We notice that Reviewer #2, who signed his review report, is a senior expert in cetacean palaeontology, ecology, taxonomy and evolution, and has provided a thorough evaluation of these aspects.

Comment 5: The postulated mechanisms leading to the concentrations of modern and fossil whale falls (aside from enhanced mortality) seem plausible, and it is good to see predictions of other oceanic regions which may show high concentrations of such fossils, if these mechanisms are correct.

The extrapolations of data from 0.64 km2 to predict >100,000 modern whale falls and >10 million fossil cetaceans in the 14,000 km2 of the DFZ region are over ambitious. What are the assumptions behind these predictions (random distributions across the 14,000 km2 region)?

Were the HOV dive locations randomized or stratified across the region to allow regional generalizations, or did they target particular geological features? There is no mention of any statistical sampling design (random, stratified) to support general statements across the 14,000 km2 area. Nor is there mention of confidence limits. These extrapolations are worth mentioning, along with any assumptions, but are very, very rough with huge confidence limits (especially when extrapolating from n=5 to >100,000 whale-fall communities). Confidence limits could be calculated from statistical distributions of random rare events, if assumptions are met.

Response: We highly appreciate the reviewer for raising this comment. To maintain accuracy and avoid potential bias from extrapolating our study-area data to the entire Diamantina Zone, we retained only the whale-remains density based on our observed seabed area using the manned submersible. We have removed the broader estimations of accumulated fossil and active whale carcasses for the whole Diamantina Zone.

Concerning the seabed observation by the HOV, we added the following contents in the Method (Clean version, Lines 435–443):

'Thirty-two HOV surveys were conducted on the seafloor along the trench axis, spanning over 1,200 km and distributing relatively evenly from the western to the central and south-eastern regions. The estimated trench floor area is approximately 14,400 km^2, calculated in Global Mapper by delineating the areal extent of the trench bottom. The HOV video survey had a field of view of approximately 5 m in width, calibrated using 10 cm laser scale points. The surveyed area was estimated from the view width and the seafloor transect length recorded by the *in situ* footage. Each transect was 2.4–5.5 km long (4.3 km on average), with a cumulative length of 127.72 km for all 32 dives, yielding a total surveyed area of approximately 0.64 km^2.'

Comment 6: Overall, the paper is well written but is quite telegraphic (brief) due to its very large scope (whale-fall ecology and biodiversity; cetacean ecology/physiology, paleontology and evolution). The broad and exciting nature of the material would make it of very broad interest in oceanography, whale-fall ecology, the biogeography of reducing habitats, cetacean evolution and paleontology, and other areas. The authors also do a nice job of highlighting the potentially important implications of these findings in the "Implications" section.

Response: Highly appreciated.

Comment 7: Ultimately, the modern whale-fall communities will merit more detailed treatment in more specialized publications to present detailed identifications, as well as descriptions of new species and phylogenetic relationships, and comparisons of community resemblance to whale falls from other regions and depths (e.g., detailed biogeographic analyses), but the short format of Nature precludes full treatment here, especially if combined with paleo results. Publishing these initial findings in Nature seems warranted due to the novel and exciting nature of the results.

Response: Highly appreciated.

Methods:

Comment 8: The methods for the modern whale-fall studies generally may be reasonable, but they are far too briefly explained. How were macrofauna and megafauna distinguished and sampled? The methods for the extrapolations need better explanation and the results require more conservative presentation.

Response: When working on board, we treated all animal specimens as fauna samples. We did not distinguish the macrofauna and megafauna specimens. Concerning the sampling method, we add the following details in the Method (Lines 447–452):

'The whale-fall bones in the sulfophilic stage were collected using the arms and kept in the biobox. Some associated free-living whale-fall fauna species like gastropods, squat lobsters and brittle stars, were collected using the slurp sampler mounted on the submersible. Upon retrieval of the submersible, the whale bones and associated specimens were immediately sorted, fixed and registered in the ship's laboratory.'

We have deleted the extrapolation of whale fossil densities of the whole Diamantina Zone (Clean version, Lines 156, 227).

Comment 9: How was the total area survey (0.64 km2) estimated?

Response: Please see our response to Comment 5.

Comment 10: How was the absence of whale-fall species in the background sediments determined?

Response: Except for whale-fall species, we conducted routine collections of sediment-dwelling fauna during each dive. The absence of whale-fall species, which appear to be endemic to the sulphophilic whale falls in the Diamantina Zone, is therefore evident. For example, brittle star species from the whale falls and the surrounding sediments are distinctly different (Lines 90–95).

Comment 11: Were collected specimens examined by taxonomic experts or only barcoded? What specific papers were used for IDs of different taxa? Also, see specific comments below

Response: The collected specimens were examined by taxonomic experts, including several co-authors and consulted specialists from different biological groups. In the resubmission, we have listed the names of eight consulted experts in the Acknowledgements.
We adopted an integrative approach combining morphological and molecular data, which is widely used for specimen identification. During the initial submission, in addition to depositing DNA barcodes in GenBank, we also archived the morphological data for all 35 species of the whale-fall communities in MorphoBank (https://morphobank.org/permalink/?P6064). Now these morphological data can be accessed for peer review at: https://www.morphobank.org/users/login
Email address or Project ID: 6064
Password: hadal

The main specific papers we used for identification of different taxa are listed in the Appendix.

Specific comments:

Comment 12: Lines 7-11. Change sentence beginning with "This area…" to: "This area represents the deepest and most extensive accumulation of natural whale-fall communities and fossils reported in the scientific literature to date, with 5 modern communities and 476 fossil cetaceans recorded." The estimate of 10 million is very poorly constrained and too sensational for the abstract.
Response: We agree with the reviewer and have revised as suggested (Line 7).

Comment 13: Line 13: insert "in this region" after "whale falls"
Response: Inserted.

Comment 14: Line 15: insert "some" before "deep"
Response: Inserted.

Comment 15: Lin 29: add ref. 6 to refs. 8,9.
Response: Added.

Comment 16: Line 59: image documentation of the ~480 fossil sites is warranted. Can these be made available online as an image library?
Response: We have deposited the image documentation of the ~480 fossil sites as well as the five whale fall sties to a public data repository. It is available in Science Data Bank (https://doi.org/10.57760/sciencedb.28830). (Line 518)
It is temporarily confidential before the publication. For peer review, it can be accessed here: https://www.scidb.cn/en/anonymous/ekFGN3p1.

Comment 17: Lines 76-79: Mention size difference between macrofauna and megafauna, and mention how they were separated. Also, while many of the taxa mentioned in this paragraph occur on multiple whales, the vesicomyd and the two species of brittle stars each occur on only a single whale fall (See Extended Data Table 1). This should be pointed out since these are not recurrent species in a common whale-fall assemblage across this area. They may be site specific. Also, it would be good to see (minimum) abundance counts on each whale fall for each species in Extended Data Table 1, rather than simple presence indicated.

Response: We have mentioned the size different for macrofauna (over 0.5 mm in size) and megafauna (over several centimetres in size) when firstly used in the main text (Lines 73, 78).

In the main text, we have added one sentence: 'The different faunal composition of the studied whale falls may be attributable to their sites, successional stages or carcass sizes' (Lines 100, 101).

We have added the abundance counts for each species of each whale fall according to *in situ* imagery in a new table (Supplementary Table 2). We updated the counting method in the Method section (Lines 476–487).

Comment 18: Line 80: I would suggest: "The majority of recovered taxa may be new to science." Note that barcoding alone cannot necessarily indicate if a species is new, since all deep-sea species described by morphotaxonomy have not yet been barcoded. Granted, there may be a lot of cryptic speciation in the deep sea, but we are not at the point of discarding morphotaxonomic descriptions. Ultimately, both barcoding and morphological comparisons are needed.

Response: Revised as suggested, and we also added 'integrating morphological data' at the end of this sentence (Lines 83, 84).

Comment 19: Line 81: say: "only the vesicomyid bivalve *Abyssogena southwardae*"

Response: Revised as suggested.

Comment 20: Line 185-187: If we accept the estimate of 10,000,000 whale falls over 5.3 million years to this 14,000 km^2 area, this does not necessarily imply a high mortality rate (only an average of two whale falls per year across a huge area). Also, most of the ocean exceeds the diving depths of beaked whales so is there any reason to think that in the Diamatina FZ, beaked whales are more likely to dive beyond their safe limits and sustain increased mortality? What may be remarkable here is not the cetacean mortality rate, but rather the large area surveyed, the downslope accumulation of whale carcasses, and the high fossil exposure rate, as discussed in lines 188-192.

Response:

We highly appreciate this thoughtful comment and agree that the estimated number should not be interpreted as evidence of high mortality. The text has been revised to remove this 'high mortality rate' inference. In light of previous research indicating that deep foraging may predispose whales to fatal exhaustion or decompression sickness, we discuss this as a potential contributing factor for beaked whale's death. The revised paragraph is provided below (Lines 181–191):

'Natural mortality, combined with the inherent risks of deep diving, likely contributes to the accumulation of beaked whale remains in the seafloor of this zone. These beaked whales possess extraordinary physiological adaptations for deep diving, routinely reaching depths over 1,000 meters and holding their breath for more than a hour[33–35]. The maximum dive depth for beaked whales is estimated between 3,000–4,000 meters based on lung collapse and oxygen storage[34–38]. Thus, foraging at depths exceeding 4,000 m would be too physiologically taxing for beaked whales and may heighten the risk of fatal exhaustion[38,39] or decompression sickness[37]. Ultimately, the V-shaped topography of the Diamantina Zone may further contribute to this accumulation by funnelling and concentrating the sinking carcasses caused by natural and accidental mortality onto the seafloor.'

Comment 21: Line 92: How was the absence of whale-fall species in the background sediments determined?
Response: Except for whale-fall species, we conducted routine collections of sediment-dwelling fauna during each dive. The absence of whale-fall species, which appear to be endemic to the sulphophilic whale falls in the Diamantina Zone, is therefore evident. For example, brittle stars from the whale falls and the surrounding sediments are distinctly different (Lines 90–95).

Comment 22: Line 205: add the word "apparently" as follows: "Isolation, imposed by extreme depth, apparently has facilitated the development…"
Response: Added.

Comment 23: Supplementary Table 1: Indicate whale falls in reef stage.
Response: We have added a column in Supplementary Table 1 to show all whale fall stages including the reef stage.

Comment 24: Recommendation: Based on modern whale fall components – requires significant revision (see comments above). Overall acceptance will depend on review of the paleontological components. This paper is exciting and could be published in Nature in its entirety, following revision, if the paleo results pass review, because of the complementary nature of the modern and paleo results. However, I do think this paper may be better broken into two papers (modern and paleo components), allowing expansion of the modern whale-fall analyses.
Response: We sincerely thank you for your recommendation. We prefer to publish these findings in one paper.

Appendix: References used for identification whale-fall fauna (Referee #3 Comment 11)

Jellyfish

Lindsay, D. J. & Hunt, J. C. Biodiversity in midwater cnidarians and ctenophores: submersible-based results from deep-water bays in the Japan Sea and north-western Pacific. *J. Mar. Biol. Assoc. U. K.* **85**, 503–517 (2005).

Ford, M., Bezio, N. & Collins, A. *Duobrachium sparksae* (incertae sedis Ctenophora Tentaculata Cydippida): A new genus and species of benthopelagic ctenophore seen at 3,910 m depth off the coast of Puerto Rico. *Plankton Benthos Res.* **15**, 296–305 (2020).

Sea anemone

Daly, M. & Gusmão, L. The first sea anemone (Cnidaria, Anthozoa, Actiniaria) from a whale fall. *J. Nat. Hist.* **41**, 1–11 (2007).

Daly, M., Chaudhuri, A., Gusmão, L. & Rodríguez, E. Phylogenetic relationships among sea anemones (Cnidaria: Anthozoa: Actiniaria). *Mol. Phylogenet. Evol.* **48**, 292–301 (2008).

Goffredi, S. K. et al. Mixotrophic chemosynthesis in a deep-sea anemone from hydrothermal vents in the Pescadero Basin, Gulf of California. *BMC Biol.* **19**, 8 (2021).

Rodríguez, E. et al. Hidden among sea anemones: the first comprehensive phylogenetic reconstruction of the order Actiniaria (Cnidaria, Anthozoa, Hexacorallia) reveals a novel group of hexacorals. *PlOS ONE*, **9**, e96998 (2014).

Polychaeta

Bergamo, G. et al. Revealing a new eyeless *Nereis* (Nereididae: Annelida) clade from deep-sea organic falls. *Zool. J. Linn. Soc.* **201**, 1–31 (2024).

Eilertsen, M. H. et al. Genetic connectivity from the Arctic to the Antarctic: *Sclerolinum contortum* and *Nicomache lokii* (Annelida) are both widespread in reducing environments. *Sci. Rep.* **8**, 4810 (2018).

Georgieva, M. N. et al. A chemosynthetic weed: the tubeworm *Sclerolinum contortum* is a bipolar, cosmopolitan species. *BMC Evol. Biol.* **15**, 280 (2015).

Georgieva, M. N. et al. The annelid community of a natural deep-sea whale fall off eastern Australia. *Rec. Aust. Mus.* 75, 167–213 (2023).

Kobayashi, G., Goto, R., Takano, T. & Kojima, S. Molecular phylogeny of Maldanidae (Annelida): multiple losses of tube-capping plates and evolutionary shifts in habitat depth. *Mol. Phylogenet. Evol.* **127**, 332–344 (2018).

Kongsrud, J. A., & Rapp, H. T. . *Nicomache* (*Loxochona*) *lokii* sp. nov. (Annelida: Polychaeta: Maldanidae) from the Loki's Castle vent field: an important structure builder in an Arctic vent system. *Polar Biol.* **35**, 161–170(2012).

Miura, T. *Nicomache otai*, new species (Polychaeta: Maldanidae) collected from the Hatsushima cold-seep in Sagami Bay. *Proc. Biol. Soc. Wash.* **104**, 159–165 (1991).

Morineaux, M., Nishi, E., Ormos, A. & Mouchel, O. A new species of *Phyllochaetopterus* (Annelida: Chaetopteridae) from deep-sea hydrothermal Ashadze-1 vent field, Mid-Atlantic Ridge: taxonomical description and partial COI DNA sequence. *Cah. Biol. Mar.* **51**, 239–248 (2010).

Nishi, E. & Rouse, G. W. First whale fall chaetopterid; a gigantic new species of *Phyllochaetopterus* (Chaetopteridae: Annelida) from the deep sea off California. *Proc. Biol. Soc. Wash.* **126**, 287–298 (2014).

Rangani, E. Systematics of deep-sea Nereididae (Annelida) from vents, seeps & whalefalls. *MSc thesis, Univ. California San Diego* (2023).

Rouse, G. W., Goffredi, S. K. & Vrijenhoek, R. C. *Osedax*: bone-eating marine worms with dwarf males. *Science*, **305**, 668–671 (2004).

Rouse, G. W., Wilson, N. G., Worsaae, K. & Vrijenhoek, R. C. A dwarf male reversal in bone-eating worms. *Curr. Biol.* **25**, 236–241 (2015).

Rouse, G. W. & Goffredi, S. K. *Osedax* (Siboglinidae: Annelida) utilizes shark teeth for nutrition. *J. Mar. Biol. Assoc. U. K.* **103**, e35 (2023).

Villalobos-Guerrero, T. F. et al. A remarkable new deep-sea nereidid (Annelida: Nereididae) with gills. *PLOS ONE* **19**, e0297961 (2024).

Wang, Y., Zhou, Y., Zhang, D. & Wang, C. Are maldanids from deep-sea reduced habitats closely related? Implications of a new wood-fall species of *Nicomache* from the South China Sea. *Front. Mar. Sci.* **11**, 1401688 (2024).

Echiura

Biseswar, R. Report on deep-sea bonelliids (Echiura) from the East Equatorial Atlantic Ocean. *Zoosystema* **32**, 139–154 (2010).

Maiorova, A. S. & Adrianov, A. V. Deep-sea spoon worms (Echiura) from the Sea of Okhotsk and the adjacent slope of the Kuril-Kamchatka Trench. *Deep Sea Res. II* **154**, 177–186 (2018).

Brittle star

Boschen, R. E., Tyler, P. A. & Copley, J. T. Distribution, population structure, reproduction and diet of *Ophiolimna antarctica* (Lyman, 1879) from Kemp Caldera in the Southern Ocean. *Deep Sea Res. II* **92**, 27–35 (2013).

Fell, H. B. A revision of the major genera of amphiurid Ophiuroidea. *Trans. R. Soc. N. Z. Zool.* **2**, 1–26 (1962).

Lyman, T. Ophiuridae and Astrophytidae of the “Challenger” expedition. *II. Bull. Mus. Comp. Zool, Cambridge, Mass.* **6**, 17–83 (1879).

Okanishi, M., Kato, M., Watanabe, H. K., Chen, C. & Fujita, T. Large populations of two new species of *Ophiambix* (Echinodermata, Ophiuroidea) discovered on Japanese hot vents and cold seeps. Raffles Bulletin of Zoology, 68, 196–213 (2020).

Xyloplax

Baker, A. N., Rowe, F. W., & Clark, H. E. A new class of Echinodermata from New Zealand. *Nature* **321**, 862–864 (1986).

Janies, D. & Mooi, R. *Xyloplax* is an asteroid. *In Echinoderm research*, 311–316 (1998).

Payne, C. Y. et al. *Xyloplax princealberti* (Asteroidea, Echinodermata): a new species that is not always associated with wood falls. *Diversity*, 15, 1212 (2023).

Mah, C. L. A new species of *Xyloplax* (Echinodermata: Asteroidea: Concentricycloidea) from the northeast Pacific: comparative morphology and a reassessment of phylogeny. *Invertebr. Biol.* 125, 136–153 (2006).

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Author’s responses to review
Nature manuscript (2026-01-02729)

Referees' comments:

Referee #1 (Remarks to the Author):
The authors have done a good job responding to the reviewers' comments. I have no further concerns.
Response: Highly appreciated.
Minor comment:
Lines 107 and 174. Andrews' beaked whale, not Andrews's (at least what I can glean from the internet).
Response: We have revised the typo.

Referee #2 (Remarks to the Author):
Perhaps because this represents my second time through the manuscript, wow, this version seemed so much easier to read with no outstanding or lingering questions left in my mind upon completion! It was so satisfying. I my first review, I was concerned about the extrapolated numbers of potential specimens (which may prove to have been realistic) and as I recall the method of preservation of the specimens, some for millions of years. Both of these have been amply addressed. For me, it was an honor to have been asked to review this manuscript. I think this is a super-exciting discovery and I applaud the authors for pursuing these beaked whales into this other worldly environment.
Response: Highly appreciated.

I only found one typo...line 47, I think "zone" ought to be capitalized.
Response: We have revised the typo. Thank you.

I look forward to seeing this manuscript published.
Best,
Stephen J. Godfrey
Response: Thank you.

Referee #3 (Remarks to the Author):
The authors have done a very nice job addressing all the comments in my initial review. It seems that they have also addressed the comments of the other two reviewers as well. I recommend publication of this revised version as is. This will make a very important and exciting contribution to the modern and fossil whale-fall scientific literature.
Signed,
Craig Smith
Response: Thank you.