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PERSPECTIVES

Tackling temporary names: interim solutions for the taxonomic impediment

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Abstract

Against a background of the climate and biodiversity crises, there is an urgent need for robust and citable biodiversity information for policy and management decisions. Species are fundamental units of biodiversity and underpin communication in biology. Delineating, describing, and naming species provide the foundation for tracking biodiversity. Taxonomists recognise over 2 million described species, the scientific names of which follow provisions of codes of nomenclature, providing stability for communication about biodiversity. However, described species represent only a fraction of global biodiversity. Current advances in the fields of molecular biology and the growing use of image-based identifications have resulted in an explosion of informal species names globally, herein referred to as temporary names, increasing the rate of discovery of undescribed species and cryptic species complexes. We define two categories of temporary names: Type 1 names that are delineated in a local context but not further assessed; and Type 2 names that have been taxonomically assessed and recognised as either new or part of an unresolved species complex. We explore the different types and uses of temporary names, indicate how they can be managed in a robust and standardised manner and demonstrate how biodiversity databases, such as WoRMS, can be expanded to allow the tracking of both formal and informal scientific names. We propose a solution for the expanding problem of temporary names by defining and recommending the addition of Type 2 temporary names to nomenclatural databases such as WoRMS. We provide practical recommendations on how such names should be selected for entry and then entered to databases in a standardised way. These recommendations are a small step forward, but their broad adoption would support the robust integration of informal and formal taxonomies.

Keywords Dark taxa · Open nomenclature · Species-level diversity · Taxonomy · Temporary names

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Introduction

With increasing human impacts on our environment, there is an urgent need for robust and citable biodiversity information for policy and management decisions. Large-scale surveys and sequencing have greatly expanded our knowledge of global biodiversity and are beginning to dwarf traditional taxonomic efforts in its documentation.

Formally established scientific names conforming to the provisions of codes of nomenclature (such as the International Code of Zoological Nomenclature (ICZN 1999)) underpin communication of biological knowledge about species and form the basis for biodiversity databases. Key databases here include the Catalogue of Life (COL; Bánki et al. 2023; https://www.catalogueoflife.org/), the Global Biodiversity Information Facility (GBIF 2024); https://www.gbif.org/), Ocean Biodiversity Information System (OBIS 2024; https://obis.org/) and the World Register of Marine Species (WoRMS Editorial Board 2024; https://www.marinespecies.org/). WoRMS captures most taxa described from marine environments, and currently contains > 247 000 accepted species (WoRMS Editorial Board 2024). However, the oceans are substantially more diverse than this, with estimates of marine biodiversity ranging from many hundreds of thousands to several million species (Mora et al. 2011; Appeltans et al. 2012; Bouchet et al. 2023).

Advances in the field of molecular biology are being applied to taxonomy, increasing the rate of discovery of undescribed species and cryptic species complexes (e.g., Brandão et al. 2010; Jażdżewska et al. 2021; Rocha et al. 2021; Maslakova et al. 2025). This has resulted in a mass proliferation of unnamed taxa, with data being uploaded to sequence databases (coined "Dark Taxa"; Page 2016). DNA barcoding and metabarcoding studies have drawn attention to understudied taxa where Molecular Operational Taxonomic Units (MOTUs; Glossary BOX 1) can surpass described species by an order of magnitude, necessitating that they be tracked by informal names until they can be formally described.

BOX 1 GLOSSARY: What are 'Temporary Names'?

Numerous types of temporary names are in current use in the fields of taxonomy and systematics, as well as in ecological studies where a complete identification is either not possible or was not attempted. The many types of temporary names currently in use cause problems as the definitions are often unclear, particularly so when used in a database where the user's intent or meaning for a particular temporary name is not provided and cannot be easily traced.

BOX 1 GLOSSARY: What are 'Temporary Names'?

Minelli (2019) offered some clarification of the different types of informal names in his 'Galaxy of non-Linnaean names' and this is further explored in relation to the use of open nomenclature in image-based identifications (Horton et al. 2021). Considering the increasing use of different types of temporary names in contemporary literature and the fact that these terms differ slightly conceptually, yet are often used interchangeably, here we provide definitions and examples to clarify the issues and provide a reference for future work. We do not aim to provide all possible definitions or uses of each term as we recognise that the terminology will differ depending on usage, or in different scientific fields. Here we define the terms with respect to temporary names in contemporary biodiversity literature and particularly in relation to biodiversity informatics.

Temporary Name: Temporary names are informal names given to taxa that have been provided with a temporary identification. These broadly include any name that is not a formal Linnaean name of binomial nomenclature. Temporary names can be applied at any taxonomic rank and for a wide variety of reasons and do not necessarily indicate a species-level identification. In this paper we are mostly concerned with temporary names applied to species-level taxa. These are here separated into two types: **Type 1** or **Type 2** temporary names.

Type 1 temporary names are given to delineated but incompletely identified taxa, often indicated by open nomenclature (for a comprehensive discussion see Sigovini et al. 2016). These can include species determined only to a higher taxonomic level, or species delineated within a genus that remain unidentified. For example, Ostracoda *stet.* (= *stetit*), meaning that the identification stayed/stopped here; Actiniaria *incertae sedis* and [unassigned] Bulimulidae, containing taxa of uncertain placement within Actiniaria or Bulimulidae, respectively, or *Nematocarcinus* sp. *indet.* (= *indeterminabilis*), meaning indeterminable, probably because the necessary characters for identification were missing or not visible from specimens or images at hand (see Sigovini et al. 2016). Type 1 temporary names are assigned in cases where there is a recognisable taxon, but it is not possible at that time to determine whether the taxon already has a formal scientific name (e.g., not enough expert taxonomists, group poorly known, etc.) and a label needs to be assigned to facilitate communication. Some Type 1 temporary names will eventually be mapped to existing names, while others may be determined to represent undescribed species (Type 2).

Type 2 temporary names are given to delineated taxa known to represent either an undescribed species or a species in an unresolved species complex. Type 2 temporary names arise from taxonomic studies that delineate taxa known to be new or for which identification is hindered or prevented by the current state of taxonomy in the group.

Informal Name: Another term for temporary name (see above).

Open Nomenclature: Open nomenclature (or ON) is a system of signs commonly used in taxonomic, ecological, and biodiversity studies to provide a means to explain the uncertainty of an identification and are extensively used in the designation of morphospecies and operational taxonomic units (OTUs) (Sigovini et al. 2016; Horton et al. 2021). Sigovini et al. (2016) provided a review of the history, a thorough discussion, and an updated list of recommended open nomenclature signs, as well as some preliminary suggestions for the standardisation of their use when a physical specimen is available. Horton et al. (2021) provided recommendations for the use of open nomenclature for taxon identification from images and suggestions for integration with Darwin Core.

BOX 1 GLOSSARY: What are ‘Temporary Names’?

Morphospecies: The morphological species concept is one of the oldest of the numerous different species concepts discussed in modern biology (e.g., see Mayr 1942; Krell 2004) and can be generally understood as a group of specimens that can be distinguished from others on the basis of morphological characteristics. In the current usage, and related to the concept of temporary names, the term morphospecies was introduced in the early 1990s in relation to the identification of taxa based on morphological grouping without considering taxonomic literature or taxonomic standards (Krell 2004) for use in making rapid biodiversity assessments (Derraik et al. 2002; Oliver and Beattie 1993; 1996). As a result of this practical usage for the identification of taxa from ecological/biodiversity surveys, the term is now **widely used** to refer to taxa that have been discriminated based on easily observable morphological characters without the aid of a taxonomic expert (Derraik et al. 2002). The term morphospecies is also unfortunately applied as an umbrella term for all categories of informal names, including for informal names that are based solely on morphological identification or those that may even exclude morphological methods. Morphospecies have also variously been termed ‘working species’, ‘putative species’, ‘morphotypes’, ‘Operational Taxonomic Units (OTUs)’ and ‘Recognisable Taxonomic Units (RTUs)’ (Trueman and Cranston 1997).

Putative species: Another term for morphospecies (see above).

Working Species: Another term for morphospecies (see above).

Morphotype: The term morphotype in contemporary literature generally refers specifically to taxa identified solely from imagery, such as megafauna identified from ROV or AUV footage (see e.g., Foell and Pawson 1986; Bluhm 2002; Amon et al. 2017; Simon-Lledó et al. 2020; Vinha et al. 2022). Species-level identification is, in many cases, not feasible from imagery because detailed and required morphological or genetic analysis of physical specimens is not possible. For instance, species-level identification typically requires visualisation of key ventral morphological features that are not visible in dorsal imagery (e.g., Christodoulou et al. 2020, 2022). As such, the taxonomic identification level associated with different morphotypes in image-based surveys is best described using open nomenclature (e.g., Simon-Lledó et al. 2023). Morphotype usually equates to a Type 1 temporary name.

Operational Taxonomic Unit (OTU) or **Molecular Operational Taxonomic Unit (MOTU):** These are both terms more often found in molecular studies in which the taxa have been discriminated by comparison of sequence data, often done computationally. The term Operational Taxonomic Unit (OTU) was originally introduced by Sokal and Sneath (1963) for numerical taxonomy, where it was the term used to define the group of organisms being studied. The term was originally introduced as a ‘molecular operational taxonomic unit’ or MOTU (Blaxter et al. 2005). In current usage, the terms OTU and MOTU are now most commonly used to refer to organisms grouped by DNA sequence similarity of a specific taxonomic marker. Unlike morphospecies, the usage of this term is generally consistent and mostly refers to identifications that are based on or include molecular data.

Cryptic species: Cryptic species are two or more distinct species that are classified (and hidden) under one species name, because they are phenotypically so similar that they cannot be differentiated by morphology (Bickford et al. 2007). However, there has been some criticism of this definition as being too reductive or simplistic, and other methods of recognising such species have been suggested, e.g., taxa that are recognised based on their low levels of phenotypic (i.e., morphological) differences relative to their degree of genetic differentiation and divergence times as compared with non-cryptic species (Struck et al. 2018). The concept is discussed (and challenged) by Korshunova et al. (2019).

The increasing need for rapid knowledge, coupled with a paucity of taxonomic experts and the growing use of image-based and/or sequence-based identifications has resulted in an explosion of informal species names (Mammola et al. 2023; Chapman et al. 2022; Engel et al. 2021; Page 2016). Parallel systems of nomenclature have emerged as a result: the formal, code-compliant names of traditional taxonomy, and the non-code-compliant, informal names heavily relied on in current, large-scale biodiversity efforts. The former are effectively tracked by biodiversity databases such as WoRMS, while the latter are currently not tracked on a global scale. This latter class of names are hereafter referred to as ‘temporary names’ (Glossary BOX 1).

The existence of these parallel nomenclatures limits our understanding and communication about biodiversity, and a global synthesis of the two is much needed. The ability to refer to these temporary named taxa in a coherent, standardised, and rapidly recognisable way is critical to our capacity to undertake robust analyses of biodiversity data. We need the ability to compare baseline biodiversity surveys, in a robust, accountable and biologically meaningful way, with post-impact assessments which vary across space and/or time (e.g. Ruhl 2007; Durden et al. 2015; Simon-Lledo et al. 2020) or in disturbance/monitoring studies (i.e. before/after impact, “BACI” approaches; e.g. Underwood 1992).

We approach this issue from the marine zoological perspective, with a focus on the deep sea, but this issue applies to all taxonomic groups (Page 2016; Caley et al. 2014; Mammola et al. 2023). The extent of the issue will vary, being particularly problematic in those taxa that are diverse (e.g., alpheid shrimp; Mathews and Anker 2009), have smaller body sizes (e.g., trichobranchid polychaetes; Nygren et al. 2018), have limited morphological characters (e.g., nemertean worms; Maslakova et al. 2025), are less well studied or have fewer taxonomic workers (e.g., terrestrial isopods; Sfenthourakis and Taiti 2015).

The goal of this paper is to explore how temporary names can be approached in a robust and standardised way and how biodiversity databases, such as WoRMS, could be expanded to capture both informal and formal taxonomies. We demonstrate how the WoRMS database can be developed to capture more of this diversity in the short term, and explore how databases could evolve to capture and combine the parallel worlds of formal and informal taxonomy in the future.

Temporary names in the current taxonomic field

A mountain of MOTUs

The influx of DNA sequence data has led to the delineation of many more species than previously recognised, and the recognition of cryptic species complexes within what were previously thought to be single species. Much of the revolution in cryptic species recognition has been driven by DNA barcoding, which can quickly highlight divergent clades (Brasier et al. 2016; Brandt et al. 2014). Molecular datasets are making species delineation more robust and promise to revolutionize our understanding of species diversity (Stanton et al. 2019; Janzen et al. 2017).

In many large-scale barcoding and metabarcoding studies, diversity is enumerated through amplicon sequence variants (ASVs), unique reads that differ at one or more loci, or through MOTUs that algorithmically cluster sequence diversity into units aimed to correspond to species. Different species delineation algorithms can cluster sequences into different MOTUs (e.g., Meier et al. 2022), with BOLD (Barcode of Life Data System; Ratnasingham and Hebert 2007; http://www.boldsystems.org/) BINs (Barcode Index Numbers; Ratnasingham and Hebert 2013) being the most widely used. While MOTUs can closely approximate species and have even been used to name species without additional evidence (e.g., Sharkey et al. 2021), most biodiversity scientists consider it best to treat them separately from species-based nomenclature (Meier et al. 2022). However, it is useful to link MOTUs to species because of their widespread use and generally strong correspondence to species-level taxa.

Automated species delineation algorithms can be utilised for organising and tracking such data. The databases BOLD and PR2 (Protist Ribosomal Reference database; https://app.pr2-primers.org/; Vaulot et al. 2021) have created curated, informal taxonomies based on these and offer a powerful way to track MOTUs. The 1.27 M BINs currently in BOLD (accessed 4 May 2025) are now a substantial fraction of the 2.1 M accepted species recognised in COL, even though this number is based on just 21.5 M barcoded specimens assembled in 20 years.

Molecular diversity efforts are rapidly growing; a Google Scholar search on “marine” and “metabarcoding” and “Since 2023” returned 10,900 results (search on 14 May 2025). In contrast, an average of only 2,332 new marine species are described per year (Bouchet et al. 2023) with extensive time lags between the collection or discovery of a species new to science and its formal description, with estimates from 13.5 (Bouchet et al. 2023) to 21 years (Fontaine et al. 2012). The Tara expedition, an early global effort using metabarcoding to assess the diversity of plankton in the photic zone, documented approximately 110,000 MOTUs among only 334 plankton samples, compared with only 11,200 total formally described planktonic species (de Vargas et al. 2015).

The need for solutions

In addition to the clear scientific need, the legally binding implementing agreement under the United Nations Convention on the Law of the Sea (UNCLOS) on the ‘conservation and sustainable use of marine Biological Diversity of Areas beyond National Jurisdiction’ (BBNJ) will formalise the requirements to report on biodiversity collected from Areas Beyond National Jurisdiction (ABNJ) (Gjerde et al. 2022; Rabone et al. 2019; 2025). Within national jurisdictions the relevant framework is the Nagoya Protocol under the Convention on Biological Diversity (CBD), already in force. Other relevant frameworks include the Sustainable Development Goals, and the United Nations Decade of Ocean Science for Sustainable Development, known as the Ocean Decade, 2021–2030 (Guan et al. 2023). To meet the aims of these biodiversity governance frameworks and directives, robust approaches to temporary names will be crucial.

At the start of the present decade, WoRMS aimed to provide a full taxonomic overview of all marine life through the project ‘ABC WoRMS’.[1] It was recognised that important taxonomic gaps in WoRMS remain to be addressed, and amongst the greatest challenges is the ever-growing number of temporary names used to document marine taxa. WoRMS aims to capture all published names, not only accepted but including unaccepted, unavailable and temporary names, among others (Horton et al. 2017). WoRMS already has the capacity to handle temporary names. The use of open nomenclature (Sigovini et al. 2016; Horton et al. 2021) is already in wide use in the field of taxonomy and bioinformatics. What is currently lacking, however, is a standardised means to tackle the input of temporary names to established biodiversity databases, and guidance on how to determine which names should be entered.

Categories of temporary names

Species delineation is independent of nomenclature, which is how the delineated species are referred to. Identified and described species are readily referred to by their currently accepted names, but there is no consistent, widely accepted method for referring to unidentified or undescribed species. However, delineated species that are not clearly matched to a named species can be given a temporary name for reference. Temporary names can be used to track species that are delineated but incompletely identified, i.e., work is still needed to determine if the taxon belongs to a known taxon or to a new one (here defined as Type 1 temporary names), as well as species that are delineated and **known** to represent either an undescribed species or a species in an unresolved

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[1] https://oceandecade.org/actions/above-and-beyond-completing-the-world-register-of-marine-species-abc-worms/

species complex (here defined as Type 2 temporary names) (See Glossary, BOX 1).

Type 1 temporary names are useful in the context within which they are delineated. For example, regional checklists commonly track species that are recognised in the biota, but that have not been identified in a **global** context. The use of temporary names allows for a thorough accounting of regional biotas before they are fully identified, and these names are routinely used in such efforts (e.g., SCAMIT 2023). Cross referencing regional checklists, especially when facilitated with the use of DNA barcodes, can connect these datasets with each other, as well as with expert-identified samples, leading to the eventual resolution of the species listed as either named taxa or new species to be described (Type 2).

Type 2 temporary names arise from revisionary taxonomic studies that delineate species that are either known to be new, or for which confirmation of identification is hindered or even prevented by the current state of taxonomy (e.g. part of a species complex where comparative material is not available/accessible/damaged). Type 2 temporary names refer to those taxa that, by whatever means (e.g., morphology, molecular or a combination of both), have been confirmed as new to science, but have not yet been formally described and provided with a Linnaean binomial name according to the relevant nomenclatural code. This category of temporary name is variously reported in both the published literature and in biodiversity databases, often given the open nomenclature sign 'sp. nov.' (*species nova*) or a variant thereof (see Sigovini et al. 2016), along with an alphanumeric coding to indicate the name status (e.g. *Genus* sp. nov. #5728) or along with the Open Nomenclature (or ON) sign 'aff.' (e.g., *Eurythenes* sp. nov. aff. *sigmiferus*).

Common sources of Type 2 temporary names are focused studies that combine existing taxonomic knowledge with new survey or genetic data and discover substantially more diversity than was previously recognized, especially cryptic lineages within named species (e.g., Maslakova et al. 2025). Type 2 temporary names are those we will be focussing on hereafter and will be the focus for the proposed entry of temporary names in WoRMS.

All temporary names are ephemeral by definition and should eventually be supplanted by formal names either through a completed identification or the description of new taxa. They can be tracked through synonymy the same way as formal names. They can also be registered in biodiversity databases, including WoRMS (see below), OBIS, GBIF and the Global Names Usage Bank (GNUB; the database behind ZooBank, the Official Registry of Zoological Nomenclature under the ICZN).

BOX 2: Temporary names in the Clarion Clipperton Zone

A recent study conducted a baseline assessment of benthic metazoan biodiversity for a region under intensive exploration for polymetallic nodules, the Clarion Clipperton Zone (CCZ), a vast region of the central Pacific Ocean, which stretches from Hawaii to Mexico (Rabone et al. 2023a, 2023b). The study provided the first species checklist of the region (Rabone et al. 2024; available at https://www.marinespecies.org/deepsea/CCZ/), housed on the World Register of Deep Sea Species, a thematic node of WoRMS (Glover et al. 2024). Such baselines and checklists are crucial first steps to iterative knowledge improvements and also for monitoring potential change. The study illustrates some of the complexities of temporary names in an abyssal region where most species are new to science. Of the 5,578 species documented, just 436 were formally named species, whereas 5,142 (92%) unnamed temporary species were reported. Overall, 14% of total names recorded were identified as temporary name synonyms (having slightly different name codings in different databases) and these were identified and removed from the final checklist. If these duplicates had not been identified, it would have resulted in a significant inflation of total names for the region. There are clear examples of these temporary name synonyms that can be tracked in published literature for the CCZ region (Bonifácio et al. 2020; Neal et al. 2022, Guggolz et al. 2020). Temporary name synonyms have also been detected in CCZ megafaunal catalogues where morphotype names are allocated to fauna seen in seabed imagery analyses (e.g. Durden et al. 2021; Amon et al. 2017), and which were later harmonised in a recent study that described broad biogeographic provinces in the CCZ (Simon-Lledo et al. 2023)

Proportions of temporary names by category in the CCZ analyses were as follows: 25% morphospecies (identified by morphology only—from specimens); 17% MOTUs (molecular data and/or referenced in literature as MOTUs); 12% morphotypes (morphology only – from imagery); 6% scientific names in open nomenclature, i.e., species names with cf., aff. etc.; 34% general (defined here as identified by morphology and molecular data but also including taxa with no identification information). Breakdown of temporary names into Type 1 and 2 was not feasible given the lack of available data to determine this (see Box 1)

Figure 1 outlines both the process and some of the common and regular uses for Type 2 temporary names, from the moment a tentative identification is reached for a specimen. This temporary name/code will be written on the specimen label and will then also likely be entered into a museum or institutional database. If subsamples are extracted for molecular (or other) studies, then these too will be tagged with this temporary name or code (or sometimes a slight variation thereof). It is then likely that the same temporary name/code will be used in the relevant database (e.g., International Nucleotide Sequence Database Collaboration (INSDC) group, GenBank or BOLD) when the sequence information is uploaded. A temporary name may also be included in peer-reviewed publications resulting from the study, and occurrence data may also be uploaded and made available on OBIS/GBIF where the name will be included in 'taxonConceptID'/'identificationQualifier' fields in Darwin Core (Horton et al. 2021; Bonifácio et al. 2021; Wiklund et al. 2023).

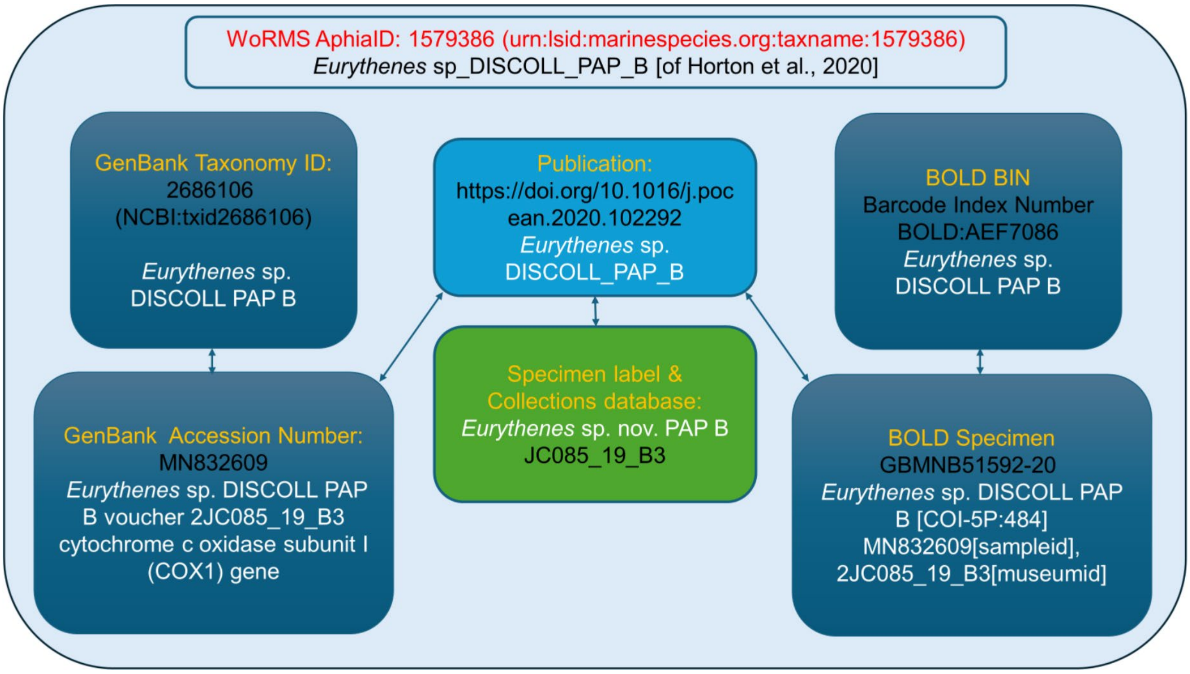


Fig. 1 Examples of temporary names and associated codes for the undescribed taxon *Eurythenes* DISCOLL PAP B commonly encountered in museums, publications and the biodiversity databases BOLD and GenBank

Potential confusions can arise in discriminating between a Type 1 and a Type 2 temporary name, as they are both often provided with an alphanumeric coding and a continuum exists between the categories. Unless there is a clear indication of whether a temporary name is of Type 1 or Type 2, this will be impossible to determine from an alphanumeric code alone (See Box 2 CCZ example). Therefore, it is critical that the reason for the temporary name is provided where possible, e.g., indicating those cases where morphological or molecular data have confirmed the taxon is new to science either in the text of the publication or in the identification remarks field in bioinformatics databases (as recommended by Horton et al. 2021). It may be necessary to clarify that the taxon is different from a currently accepted valid species, because the reason for not assigning a new name may be that the author suspects it could be a match for a previously synonymised taxon.

Proposed solutions

To ensure that we can accurately report, analyse, and communicate biodiversity, we recommend an alignment of the usages for Type 2 temporary names, and, at a minimum, the same 'temporary name' should be used when entering information into both institution level and global biodiversity databases, to facilitate linkages between the specimen, distributional occurrences, and associated genetic information extracted (Fig. 1).

Temporary names in WoRMS

There are five broad name status categories available in the WoRMS database: Accepted, Unaccepted, Uncertain, Alternative representation, and Temporary. Detailed guidance on the different name status types in current use is provided in Horton et al. 2017, and only the Temporary name status is covered here.

According to Horton et al. (2017), the temporary name status in WoRMS is intended to be used for two main objectives: 1) to create ad-hoc higher rank taxa of convenience to accommodate child taxa for which the classification is not yet finalised (i.e., *incertae sedis*); and 2) to record unnamed cryptic species. In the past, "temporary name" has sometimes been used incorrectly in WoRMS, and many of the temporary names are, in fact, validly described species and genera, indicating a historically erroneous usage of the concept. Current usage of different types of temporary names in WoRMS was assessed. Of the 438 names in WoRMS that were marked as "temporary" (as of 9 April 2023), 182 (42%) names were incorrectly labelled and were corrected, 17 (4%) were possibly correctly labelled, and 239 (55%) were correctly implemented. Those names correctly labelled as temporary included a mixture of higher-level (e.g., Copepoda *incertae sedis*) and species-level (*Echinometra* sp. E) names. It is important to clarify that while *incertae sedis* names are given the temporary name status in WoRMS, the child taxa of these placeholder names have accepted, not temporary, name status (e.g., https://www.marinespecies.org/aphia.php?p=taxdetails&id=22759).

Consideration for entry to WoRMS/Aphia

Despite the inherent difficulties with temporary names, management of Type 2 temporary names or codes can be improved by providing them with a unique global identifier, a Life-Science Identifier (LSID), such as those assigned to each entry in the Aphia database that underpins WoRMS (Vandepitte et al. 2015, 2018). By entering these temporary names in a standardised format, a stable interim solution for this ongoing and likely growing issue will be provided.

It is important to clarify that WoRMS does not propose to add all MOTUs published on GenBank/BOLD to WoRMS. Only robustly defined Type 2 temporary names will be considered. There will need to be a minimum quality of data and the 'name' will need to have been published in a peer-reviewed publication, clearly indicating the taxon as a new species (or part of an unresolved cryptic species complex). The taxon will need to be clearly differentiated from other taxa (with molecular and/or morphological evidence) and this evidence published before it can be entered as a temporary name in WoRMS. It will also be at the discretion of the taxonomic editor to add temporary names. Here we provide a framework and guidance on how to enter temporary names into WoRMS, and encourage and recommend taxonomic editors to make use of this capability.

We outline the requirements for consideration as a robustly defined new taxon that can be entered into WoRMS, and guidance for taxonomic editors entering these names, which we hope will also be useful and applicable to other nomenclatural databases. We highlight the need to ensure that these temporary names are (1) robust from a species delineation standpoint, and (2) sensible and persistent from a nomenclatural standpoint.

Requirements for entry of 'Type 2 Temporary Names' to WoRMS/Aphia

1. Published in at least one peer-reviewed publication that demonstrates that the taxon is distinct from formally named taxa currently considered valid, or represents a distinct, species-level lineage in a species complex where species names are not resolvable with the current state of taxonomy.
2. Clearly indicated as a new taxon or as a cryptic lineage within a species complex within the text of the paper, **not** just in a table, list, or illustration such as a phylogenetic tree, with evidence to show that the authors consider this as a species new to science (e.g., stating that '*Genus* sp. #5629 is new to science and will be formally described elsewhere') or as part of an unresolved complex.
3. Designation of a particular specimen as the "representative" of the taxon (this will be indicated as 'non-type specimen' material in WoRMS terms, see Fig. 3).
4. Evidence that the taxon is **clearly** defined by at least two independent lines of evidence or traits, for example, two independent molecular markers (a mitochondrial and an independent nuclear marker), or morphology and one molecular marker (e.g., COI).
5. Clearly differentiated from all other **described** taxa in the genus. It must be clear that this taxon is a new species to science and not just one of many taxa in the genus where not all species have been sequenced.

We encourage editors to also link additional papers referring to the same temporary species name in subsequent analyses (morphological and/or molecular). This is not a requirement by Aphia/WoRMS, but is highly recommended as it provides additional support for the temporary name. Formally described species known to represent complexes of cryptic species will **not** be given a temporary name status in WoRMS. The taxon name status will remain 'accepted'. If the taxon is known to be part of a complex of cryptic species, then this should be indicated by a taxonomic note on the accepted taxon page in WoRMS (e.g. https://www.marinespecies.org/aphia.php?p=taxdetails&id=333848). Sources supporting this information should be linked on the accepted taxon page. In publications, such taxa can be indicated by e.g., *Genus species* complex CODEABC123 with this information also included in the Darwin Core identificationQualifier or identificationRemarks fields. Type 2 temporary names that form part of a cryptic species complex can be added to the database as 'subspecies' of the accepted species page with 'temporary name' status.

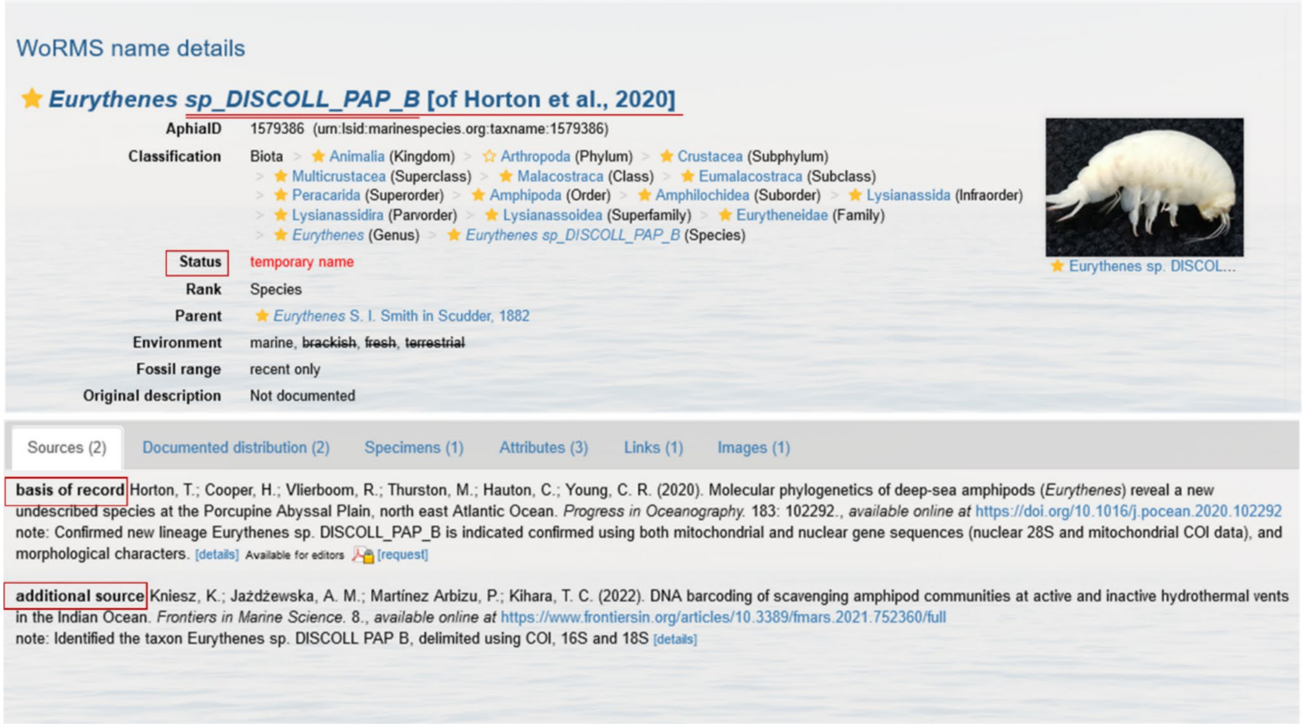
Format for adding Type 2 temporary names to Aphia/WoRMS

The approach needs to be sensible and persistent in terms of nomenclature. Provisional names will need to be anchored to a publication that provides a reasonably good diagnosis/description, and ***any*** sort of label (even if just "sp.", but addition of an alphanumeric code is highly recommended), allowing them to be entered into the database with their own permanent identifier and to be explicitly referenced by later publications and/or synonymised with other provisional or Linnaean names and/or placed in different genera/classifications by other authors. While it is correct that *any* label is sufficient because these unnamed taxa will be associated with a publication/published sequences and given an LSID, we still recommend moving away from "sp. 1… sp. 5, or sp. A… sp. E", to provide a more distinctive means of referring to these taxa. Therefore, we recommend that authors of Type 2 temporary names make use of a clear alphanumeric format concatenating not only the specimen number but also a text string identifying the collection and/or collecting event e.g. NHMUK_1234 or DISCOLL_PAP_1234. This is recommended for the creation of the Darwin Core term "OccurrenceID" in the OBIS manual (https://manual.obis.org/) and outlined in Horton et al. (2021).

An example has been entered into WoRMS to illustrate this concept based on a published Type 2 temporary name:

Eurythenes sp_DISCOLL_PAP_B https://www.marinespecies.org/amphipoda/aphia.php?p=taxdetails&id=1579386; In this case, the temporary name used a concatenation of the collection where the specimens are held (Discovery Collections, DISCOLL; the Global Registry of Scientific Collections; http://grscicoll.org/institution/national-oceanography-centre-southampton), the station/site info: PAP (Porcupine Abyssal Plain), and the letter B to indicate that it was different from species A at the same site (a type 1 temporary name which was resolved following molecular barcoding as the formally described species, *Eurythenes maldoror* d'Udekem d'Acoz and Havermans 2015). The same 'temporary name' is used in both the publication (Horton et al. 2020) and in GenBank (https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=2686106) and BOLD (http://boldsystems.org/index.php/Public_SearchTerms?query=BOLD:AEF7086). These links are included on the taxon page under the 'links' tab. It is highly recommended to include links to other databases where the name can be found.

Spaces cannot be included in species names entered into Aphia due to the structure of the database. The species epithet in the Aphia database is a separate field, and defined as a single-entry text field, where no spaces are allowed. To ensure consistency within the database, in the species epithet of a temporary name, these spaces need to be replaced by underscores (Fig. 2), a difference which also clearly distinguishes them from formally described species names. This will mean that, in some cases, name entries to the database may differ from the format of the published temporary name (e.g. *Eurythenes* sp. DISCOLL_PAP_B vs. *Eurythenes* sp_DISCOLL_PAP_B), but the source of the name will always be linked to the taxon page for clarification. Temporary names should also be provided with an authority and date. The authority should be added in square brackets with the addition 'of' followed by the authors and date of the publication supporting the entry to WoRMS, e.g., "[of Horton et al. 2020]" to clearly differentiate these from a formally established scientific name (Fig. 2).



WoRMS name details

Eurythenes sp_DISCOLL_PAP_B [of Horton et al., 2020]

AphiaID 1579386 (urn:lsid:marinespecies.org:taxname:1579386)

Classification Biota > Animalia (Kingdom) > Arthropoda (Phylum) > Crustacea (Subphylum) > Multicrustacea (Superclass) > Malacostraca (Class) > Eumalacostraca (Subclass) > Peracarida (Superorder) > Amphipoda (Order) > Amphilochidea (Suborder) > Lysianassida (Infraorder) > Lysianassidira (Parvorder) > Lysianassoidea (Superfamily) > Eurytheneidae (Family) > *Eurythenes* (Genus) > *Eurythenes sp_DISCOLL_PAP_B* (Species)

Status temporary name

Rank Species

Parent *Eurythenes* S. I. Smith in Scudder, 1882

Environment marine, ~~brackish~~, ~~fresh~~, ~~terrestrial~~

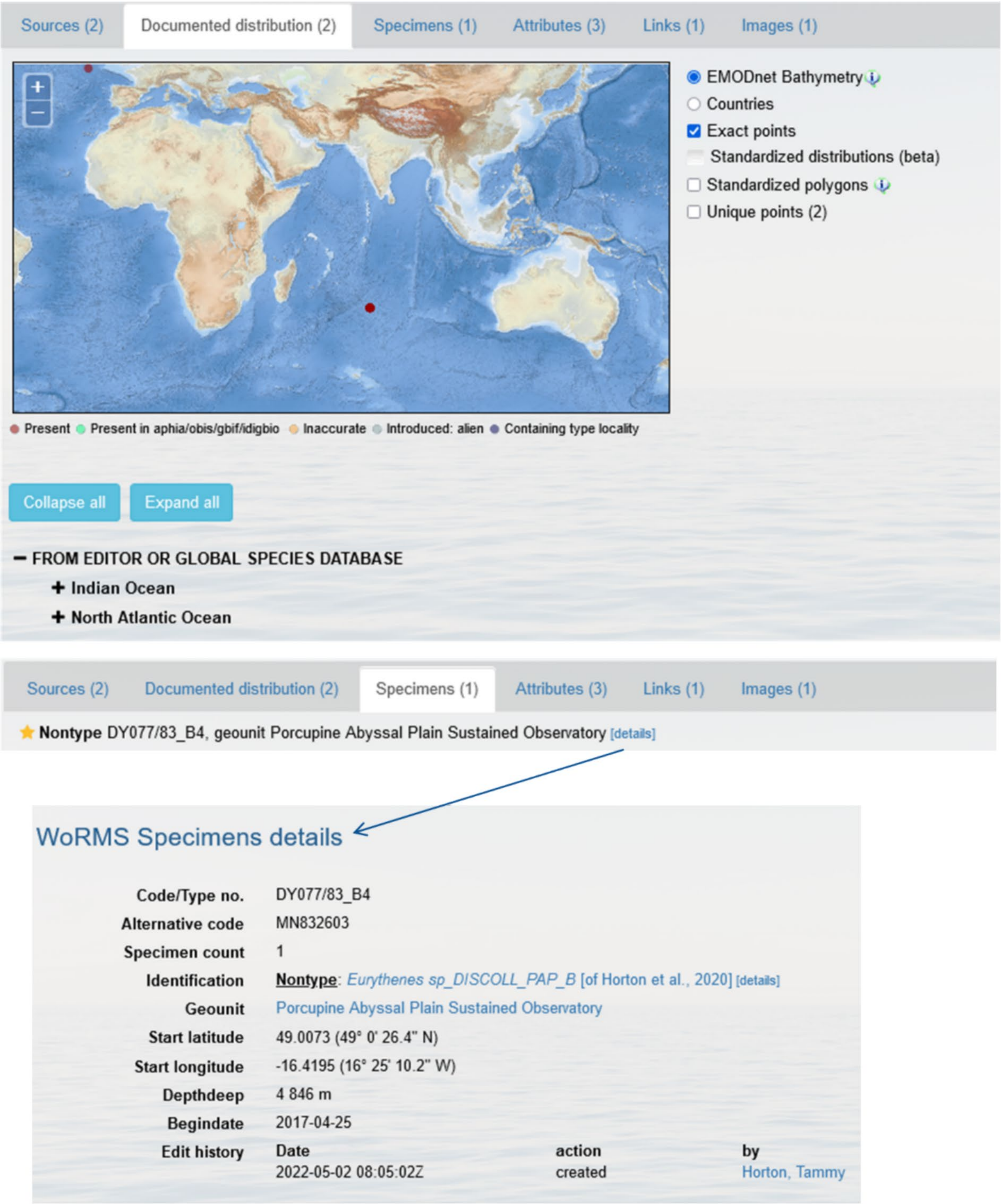
Fossil range recent only

Original description Not documented

basis of record Horton, T.; Cooper, H.; Vlierboom, R.; Thurston, M.; Hauton, C.; Young, C. R. (2020). Molecular phylogenetics of deep-sea amphipods (*Eurythenes*) reveal a new undescribed species at the Porcupine Abyssal Plain, north east Atlantic Ocean. *Progress in Oceanography.* 183: 102292., *available online at* https://doi.org/10.1016/j.pocean.2020.102292
note: Confirmed new lineage Eurythenes sp. DISCOLL_PAP_B is indicated confirmed using both mitochondrial and nuclear gene sequences (nuclear 28S and mitochondrial COI data), and morphological characters. [details] Available for editors [request]

additional source Kniesz, K.; Jażdżewska, A. M.; Martínez Arbizu, P.; Kihara, T. C. (2022). DNA barcoding of scavenging amphipod communities at active and inactive hydrothermal vents in the Indian Ocean. *Frontiers in Marine Science.* 8., *available online at* https://www.frontiersin.org/articles/10.3389/fmars.2021.752360/full
note: Identified the taxon Eurythenes sp. DISCOLL PAP B, delimited using COI, 16S and 18S [details]

Fig. 2 Example taxon page of a Type 2 temporary name in WoRMS. Spaces are replaced by underscores in the species epithet of a temporary name (double underline). The format of the authority placed in square brackets (single underline) clearly differentiates a temporary name from a formally established scientific name. The taxon is marked with the name status 'temporary name' and the original description publication is 'Not documented'. Published references supporting the name are linked on the taxon page as 'basis of record' and 'additional source'



● EMODnet Bathymetry
○ Countries
☑ Exact points
Standardized distributions (beta)
☐ Standardized polygons
☐ Unique points (2)

● Present ● Present in aphia/obis/gbif/idigbio ● Inaccurate ● Introduced: alien ● Containing type locality

− FROM EDITOR OR GLOBAL SPECIES DATABASE
 + Indian Ocean
 + North Atlantic Ocean

★ **Nontype** DY077/83_B4, geounit Porcupine Abyssal Plain Sustained Observatory [details]

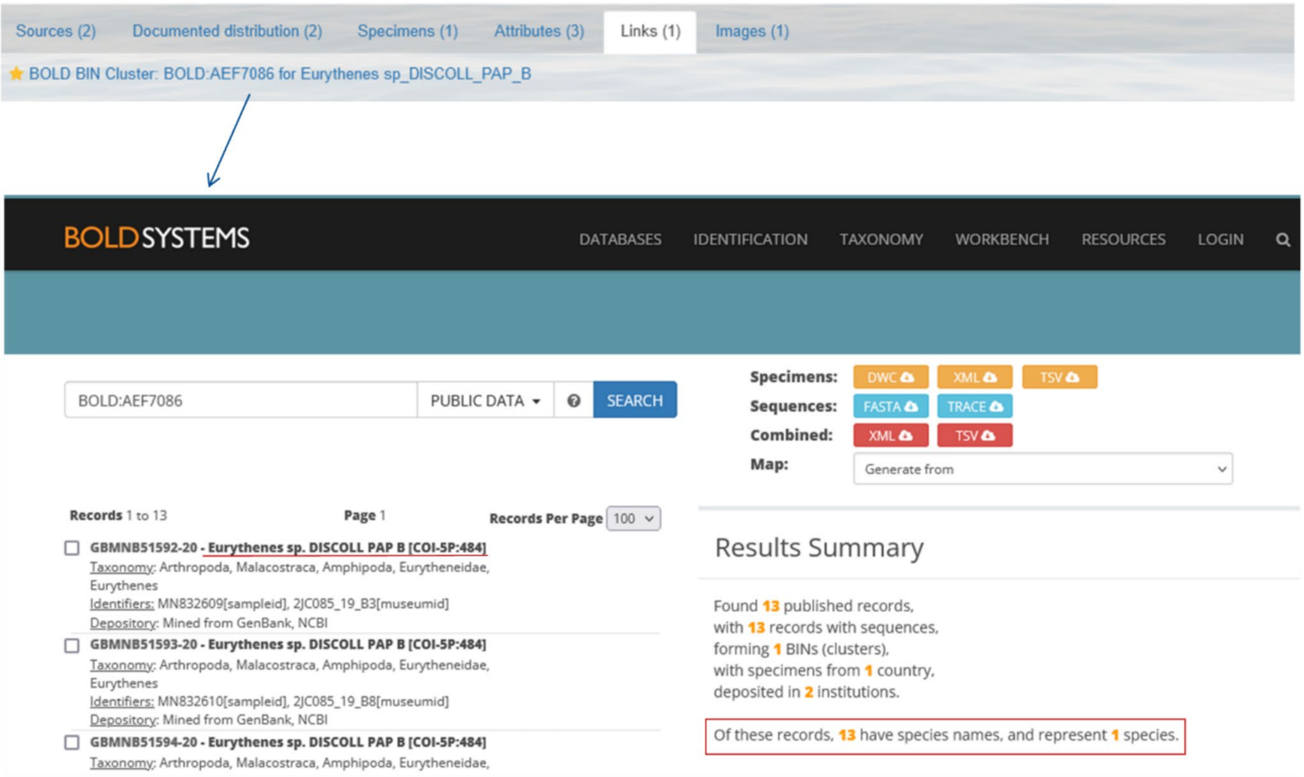
WoRMS Specimens details

Code/Type no.	DY077/83_B4		
Alternative code	MN832603		
Specimen count	1		
Identification	**Nontype**: *Eurythenes sp_DISCOLL_PAP_B* [of Horton et al., 2020] [details]		
Geounit	Porcupine Abyssal Plain Sustained Observatory		
Start latitude	49.0073 (49° 0' 26.4" N)		
Start longitude	-16.4195 (16° 25' 10.2" W)		
Depthdeep	4 846 m		
Begindate	2017-04-25		
Edit history	**Date**	**action**	**by**
	2022-05-02 08:05:02Z	created	Horton, Tammy

Fig. 3 Example taxon page of a Type 2 temporary name in WoRMS; Above: input of the distribution data and; below: specimen data added as non-type material in the relevant modules in WoRMS

The newly added taxon should be marked with the name status 'temporary name' (Fig. 2). This will clearly differentiate it from the valid accepted names in the database, and will facilitate searching, counting, and analyses of these types of names. On the genus page in WoRMS, temporary names appear in the list of taxa following the lists of accepted and unaccepted taxa and clearly separated from them. This avoids confusion and prevents mistaking them for a valid accepted name.

Because temporary names are not formally described, there is no original description publication, so the source



★ BOLD BIN Cluster: BOLD:AEF7086 for Eurythenes sp_DISCOLL_PAP_B

BOLD:AEF7086

Records 1 to 13 **Page** 1 **Records Per Page** 100

☐ **GBMNB51592-20 - Eurythenes sp. DISCOLL PAP B [COI-5P:484]**
Taxonomy: Arthropoda, Malacostraca, Amphipoda, Eurytheneidae, Eurythenes
Identifiers: MN832609[sampleid], 2JC085_19_B3[museumid]
Depository: Mined from GenBank, NCBI

☐ **GBMNB51593-20 - Eurythenes sp. DISCOLL PAP B [COI-5P:484]**
Taxonomy: Arthropoda, Malacostraca, Amphipoda, Eurytheneidae, Eurythenes
Identifiers: MN832610[sampleid], 2JC085_19_B8[museumid]
Depository: Mined from GenBank, NCBI

☐ **GBMNB51594-20 - Eurythenes sp. DISCOLL PAP B [COI-5P:484]**
Taxonomy: Arthropoda, Malacostraca, Amphipoda, Eurytheneidae,

Results Summary

Found **13** published records,
with **13** records with sequences,
forming **1** BINs (clusters),
with specimens from **1** country,
deposited in **2** institutions.

Of these records, **13** have species names, and represent **1** species.

Fig. 4 Example of links from a Type 2 temporary name in WoRMS; Above: link to the BOLD BIN cluster in the WoRMS link tab; below: The BOLD BIN cluster AEF7086 records in BOLD

type 'original description' in WoRMS must not be used when adding the 'name' to the database (Fig. 2). Equally, the name should **not** be marked as an 'original name' in the database. Rather than linking an 'original description' source type, published references where the name has been used (including the original usage of the temporary name) are linked on the taxon page as a 'basis of record' (Fig. 2). Additional sources that use the same temporary name can also be linked, as in this case where the species was recognised at a new locality but was determined to be the same taxon using molecular data (Kniesz et al. 2022) (Fig. 2). Distributions (Fig. 3) and specimens (indicated as non-type material; Fig. 3) should be added to the relevant modules in WoRMS.

Links between WoRMS and BOLD/GenBank can be strengthened by linking specimens to trusted barcode sequence data where this is available, ideally of the non-type specimen on which the name is based. A dedicated link can be made between the temporary name in WoRMS and the BOLD BIN for the taxon (Fig. 4). When the species is formally described, the temporary name will be treated in the database as a junior synonym, linked to the newly created formally described and nomenclaturally valid name. The temporary name is 'synonymised' and the sources (publications, sequence links, specimens, etc.) will remain linked to the temporary name, but will also now be associated with the valid formally described name. The page for the temporary name in WoRMS will thus act as a centralised hub with all links and references for this name in the literature and databases, as the 'master version' for the name (Fig. 1).

Conclusions and the way forward

The goals of this study were to explore the current concepts of temporary names in use throughout the fields of taxonomy and biodiversity informatics, as well as the importance of these names in communicating the changing state of the biodiversity of our planet. Our paper provides a solution for the expanding problem of temporary names by defining and recommending the addition of Type 2 temporary names to nomenclatural databases such as WoRMS. We have provided practical recommendations on how such names should be selected for entry and then entered to databases in a standardised way. The recommendations are a small step forward, but their broad adoption would support the robust integration of informal and formal taxonomies. Inclusion of temporary names in WoRMS would allow the tracking of undescribed species and unresolved species complexes, especially when linked to molecular data.

In terms of future work, inclusion of editor-vetted links to DNA barcodes and corresponding BINs to WoRMS species pages would be a significant improvement. Currently WoRMS links out to sequence data uncritically but edited links to vetted sequences would be useful. The ultimate goal would be for all species to include sequence data relevant for species delineation. Inclusion of vetted sequences/BINs in WoRMS would tie accepted nomenclaturally valid names to molecular databases (e.g., BOLD), facilitating species recognition and identification. This in turn will help in recognizing MOTUs that do not correspond to described species or may represent species complexes; and move towards fully connected biodiversity databases that are linked automatically from museum databases (specimen records) to uploads of sequences to formally described taxon names.

While these ideas are conceptually strong, implementation of what is proposed here is dependent on the taxonomic editor community behind WoRMS, and may be limited by the paucity of editors that are conversant in both taxonomies. Bouchet et al. (2023) noted that even today most marine species are described without the incorporation of sequence data. Furthermore, the potentially large numbers of these additional names will require dedicated time/funding for editors to make the necessary inputs. The recently established Ocean Census Program (Rogers et al. 2023) aims to document 100,000 informal species by 2030, utilising and building on well-established global biodiversity databases. Such initiatives will require careful consideration of the recommendations herein. We recognise that the recommendations provided herein represent an interim solution to the problem of dark taxa, in the sense that formal descriptions of all new species are ultimately needed. But we are also very aware that this solution is critically needed right now to document to improve the communication of a rapidly changing biodiversity. By ensuring the input of well-established Type 2 temporary names to biodiversity databases in a clearly defined and harmonised way, we will be better able to track and manage the current explosion of temporary names during the biodiversity crisis in the face of the taxonomic impediment.

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Declarations

Conflict of interest We have no competing interests.

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