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OPINION PAPER

The World Register of Marine Species (WoRMS) through the looking glass: insights from the data management team in light of the crystal anniversary of WoRMS

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Abstract The World Register of Marine Species (WoRMS) started in 2007 with the question "how many species live in our oceans?". Now, a little over 15 years later, WoRMS is able to answer several questions related to marine species discovery rates and provides a dynamic number of existing marine species, based on the information provided by hundreds of taxonomic experts worldwide, who have proven to be diverse and dynamic. We present basic statistics on marine species discovery rates based on the currently available content of WoRMS, as well as insights in the day-to-day activities and dynamics of our editorial board and the progress made so far on the content priorities as defined by the WoRMS Steering Committee. As for all dynamic systems, WoRMS is not complete and faces challenges. As an endorsed project of the UN Ocean Decade, WoRMS aims to tackle a number of these challenges and knowledge-gaps by 2030, including detailed documentation of authorships and original descriptions, and will provide continuous support to all marine initiatives, programs and projects that rely on WoRMS as an authoritative classification and catalogue of marine names.

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Introduction

In 2022, the World Register of Marine Species (WoRMS) celebrated its fifteenth anniversary. WoRMS started from a single question: how many species live in our oceans? From its inception in 2007, the vision and aim of WoRMS has been to provide an authoritative and comprehensive list of all published names of marine organisms (Costello et al., 2013; Horton et al., 2017; Vandepitte et al., 2018 and references therein). Although the first priority has always been to assemble a list of accepted names for marine species, an equal effort has been directed towards including synonyms and other published scientific names used in the past. By adding all these names to WoRMS, as well as ensuring the correct linkages between different names, the World Register can truly serve as a guide to interpret the long history of taxonomic discovery, while doing its utmost to keep up with the very dynamic field of taxonomy and the changes in names over time. A recent survey among taxonomists and users of taxonomic information (Lien et al., 2023) has identified a strong need for global species lists, both within the community involved in description and revision of species, as well as in other fields of science that use species names, such as ecology and conservation, to name just two examples. Currently, the number of historical marine species names and synonyms in WoRMS is about 51.5% of the total number of species names.

Significant progress has been made over the last fifteen years, but WoRMS cannot yet be considered complete. A large pool of experts voluntarily supports WoRMS to keep its content up to date with the latest literature on species descriptions, and by adding a treasure trove of extra information including type locality data, geographic distributions, ecological information (traits and attributes), images, vernacular names, and notes on any aspect of the species relevant to users. On average, 422 edits on WoRMS are made daily, which roughly translates to an addition or improvement to the content of WoRMS every three minutes.

In honour of the fifteenth anniversary of WoRMS, a series of fifteen stories related to the World Register of Marine Species was released that explored different aspects from a data management perspective (https://lifewatch.be/news/celebrating-15th-anniversary-world-register-marine-species). This paper brings these stories together and presents them with additional data and statistical analyses.

Organisation, governance and content management of WoRMS have evolved since its inception. Details of its recent status are outlined by Vandepitte et al. (2015, 2018) and Horton et al. (2017) and not repeated here. For more details on Aphia, the data infrastructure and IT platform behind several global, regional and thematic registers, including WoRMS, we refer to Vandepitte et al. (2015). In this paper we highlight: (1) major changes, additions and updates in the last five years; (2) previously unpublished basic findings on marine biodiversity; and (3) challenges identified for WoRMS based on the analysis of its content and the many user requests received by the WoRMS Data Management Team (DMT) over the years.

WoRMS editorial board

The continuous growth of WoRMS in providing all the marine taxon names ever published is made possible by the voluntary efforts of the many taxonomic and thematic editors. Their numbers have fluctuated in a general growth pattern over the years, numbering 314 as of 1 December 2023 (https://marinespecies.org/aphia.php?p=editors). The WoRMS editors are based in 45 countries and reside at 226 institutions. Quite logically, many of these countries have a coastline, although there are some exceptions to that situation, which mostly concern editors working at a natural history museum, university or institute where they are usually involved in collection curation and research (Fig. 1). Editor activity can still be described as a 24/7 activity (cfr. Vandepitte et al., 2018), due to the global coverage of the network.

During Autumn 2022, a questionnaire (Supplementary Information 1) was sent to all Aphia editors, a pool of nearly 600 that includes the WoRMS editors. The overall goal of the questionnaire was to get to know our editors better and to be able to provide detailed statistics on the composition of

Fig. 1 Editor distribution map

Table 1 Number of respondents to the questionnaire, in comparison with the number of active editors at the time of sending out the questionnaire

	# Respondents	# Editors (Oct 2022)	Relative response rate (%)
Aphia editors	109	598	18
WoRMS editors	88	317	28

The pool of Aphia editors (all environments) includes the pool of WoRMS editors (marine environment)

the Editorial Board, a widely distributed network of volunteers, all working towards the same goal of making WoRMS and a series of related species registers more complete and of the highest possible quality standard. The presented results focus on the WoRMS editors only, excluding editors that only contribute to the non-marine parts within the Aphia database. 28% of all WoRMS editors completed the survey (Table 1). Based on the results of the questionnaire, in combination with additional available information on the professions and professional residences of the WoRMS editors, some remarkable insights were revealed.

From the respondents, 30% are 44 years or younger, 50% are 52 years or younger and the overall age-range lies between 23 and 85 years. The majority of our respondents work in a science-related environment, either as a (full-time) scientist, professor or scholar. Only 15% of them indicated they are retired, which roughly corresponds to an age of about 69 years and older. The survey, as well as the personal conversations of the Data Management Team with editors, tells us that this small group of retired professionals see their retirement as beneficial for WoRMS, as it allows them to invest more time into completing and quality-controlling the content of WoRMS, and to further explore its possibilities and functionalities in depth. Although the WoRMS editor pool does not fully represent the global marine taxonomist community, personal insights of editors suggest that our editor pool does roughly reflect this community. Within the current WoRMS editor pool, 25% of our editors are women, strongly related to the number of women active in marine biology (Giakoumi et al., 2021).

Although this does not yet reflect gender parity for women, there has been a slow but steady increase in the number of female taxonomists and experts joining the editorial board over the last five years. When comparing age—expressed as a decadal birth year—to gender, on average 28% are female editors (Fig. 2). Our eldest editor, born in the 1930s, was excluded from the graph as she is the only (female) editor from that decade. These findings are in contrast with the perceived ideas that active taxonomists are largely middle-aged or retired men, or that taxonomists are a "dying breed".

As editor contributions to WoRMS are on a voluntary basis, the questionnaire also inquired how much time each editor contributes during an editing session, and how often editing sessions take place. The preferred place for editing is at home (47%) or at the office (27%), depending on how editing can be combined with daily work and/or access to literature and information for the editing task at hand. Editors active from home refer to the availability of a home office and a place where they can cancel out distractions. Whether editing happens from home, the office or any place with a good internet connection, editing activity mostly happens when there is a desire and enthusiasm to do so, which is reflected in the response to the question "How often do you edit online?". Half of the responding editors indicate they edit on an ad hoc basis: whenever they find something new (24.7%) or whenever they feel like it (23.8%). Roughly 30% edit on a regular basis, varying from every day (7.3%), to once or twice per week (17.4%) or once a month (6.4%). As variable as the frequency of editing is, so is the time that is spent online during a single session, as seen in answer to the question "On average, how long do you usually edit in one session?". In general, the time spent on an online Aphia-WoRMS-related portal varies from five minutes to over two hours, the latter being referred to as "binge-editing" by some of our editors in their replies, in parallel with "binge-watching" defined as watching several episodes of a television series or programme, one after the other by the Cambridge Dictionary. In Aphia-WoRMS perspective, "binge-editing" is defined as editing several taxa one after the other, for more than two hours. Over 40% (43.1%) of our editors indicate that each session varies greatly in invested time, all depending on the taxa or the problem they are dealing with. About 13.8% define themselves as a regular binge-editor.

The dark cloud of the taxonomic impediment

Despite regular references to the "taxonomic impediment" and the shortage and loss of taxonomic expertise (e.g. Buyck 1999; Wägele et al., 2011; Löbl et al., 2023 and references therein), we have never seen

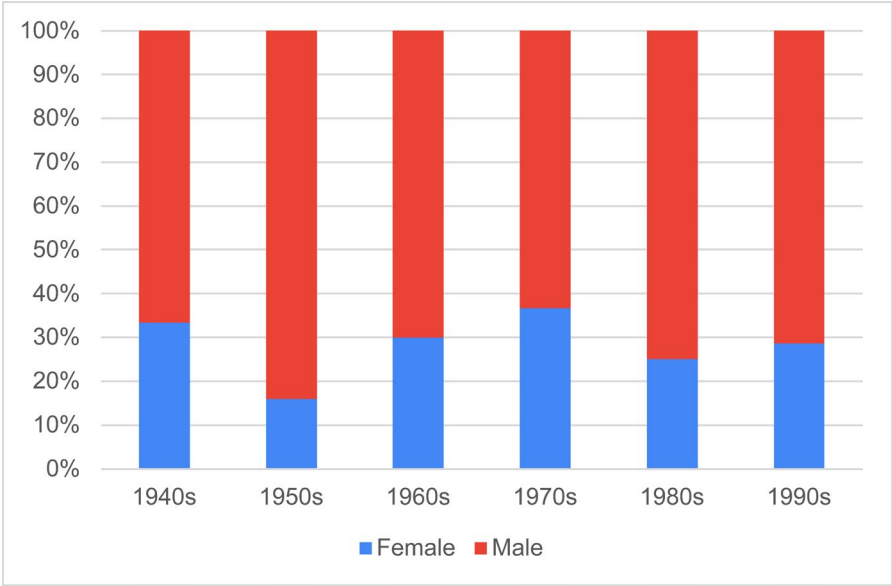

Fig. 2 Relative gender ratio of the current WoRMS editors (Y-axis) expressed per decadal birth year (X-axis)

more marine species descriptions in taxonomic history per year than in the last two decades, since the introduction of the binominal system by Linnaeus (Fig. 3). We do not question the fundamental arguments provided by many authors who point out the general undervaluation of the field of taxonomy (e.g. De Carvalho et al., 2013; Engel et al., 2021; Löbl et al., 2023), as well as the shortage of funded (permanent) taxonomic positions (e.g. Löbl et al., 2023), but the data in WoRMS show that the marine taxonomic community has at this time apparently found ways to deal with these constraints, thereby ensuring that a steady stream of new species descriptions is not hampered; this was already noted more generally by Drew (2011) as well as Tancoigne & Dubois (2013) and in the marine environment by Appeltans et al. (2012). Nuances with these numbers need to be taken into account: this observation is based solely on the number of available species descriptions documented in WoRMS; it does not reflect an in-depth analysis of the taxonomist community responsible for these species descriptions. It also does not mean that marine taxonomists are able to keep up with the rate of newly discovered species, or that species that are known to be new, but have not yet received enough attention to be formally described are easily managed. Many yet-undescribed species are known to exist within the collections of museums, institutes and universities (e.g. Appeltans et al., 2012; Löbl et al., 2023). One hypothesis is that the current, apparent boost in species descriptions is made possible due to retired taxonomists, employed during the "Sputnik era" (De Grave et al., 2023), who have more time available to describe species during their retirement compared to during their working years. Due to a current lack of additional data within WoRMS, this is a hypothesis that cannot yet be tested to its fullest extent.

In 2023, the Sustainable Seabed Knowledge Initiative (SSKI) project of the International Seabed Authority (ISA) launched the "One Thousand Reasons" campaign, in collaboration with WoRMS and co-funded by the European Commission. The deep-sea environment (depths greater than 500 m) still harbours a multitude of marine species new to science, as recently documented in one of the most studied deep-sea regions in the central Pacific Ocean, the Clarion-Clipperton Zone (Rabone et al., 2023). For a number of these, the specimens have already been identified and are available within scientific institutes or museums but are currently undescribed. The goal of the "One Thousand Reasons" campaign is to facilitate the full description and publication of at least a fraction of these deep-sea species in 2024 and make sure their names are properly documented in WoRMS. Financial support for species descriptions is both a major driving force and a strong obstacle in accelerating species descriptions. It is hoped that similar funding streams can be established during the UN Ocean

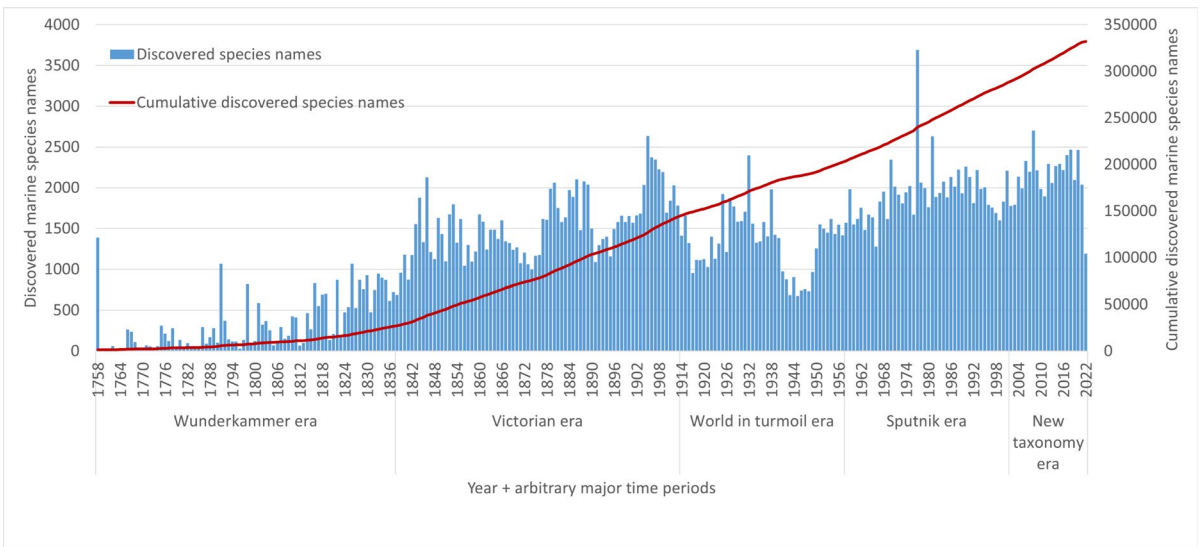

Fig. 3 Absolute (left Y-axis, blue) and cumulative (right Y-axis, red) marine species discovery rate per year, since 1758

Decade, to reach the SSKI-targeted goal of species to be described by 2030 in deep international waters.

Number of marine species and their discovery rates according to WoRMS

The publication of the 10th edition of Systema Naturae by Carolus Linnaeus (Linnaeus, 1758) marked the starting point of zoological nomenclature by the introduction of binominal nomenclature. Just a few years earlier, the first edition of Species Plantarum (Linnaeus, 1753) was accepted internationally as the start of binominal nomenclature for ferns and flowering plants. Since 1758, the average overall discovery rate based on data in WoRMS is 1254 marine species per year. The overall discovery rate statistics in WoRMS reflect the number of marine species originally described per year, regardless of their current status. WoRMS data demonstrates that the overall, cumulative marine species discovery rate has not yet reached an asymptote (Fig. 3). When considering only the last 15 years (2007–2021), the yearly average discovery rate has risen to 2239 marine species.

The overall rate of marine species discovery is thus still high, considering that binominal taxonomy began in 1753 (Plantae s.l.) and 1758 (other kingdoms). Although there is an overall constant average number of marine species descriptions per year, Fig. 3 confirms earlier general observations that the so-called World in Turmoil era (circa. 1914–1955) strongly and negatively impacted taxonomic activity, not at least through world-affecting events such as the First and Second World War (1914–1918 & 1940–1945) (e.g. Costello et al., 2012), as well as the "Roaring Twenties" (1920–1929) and the following Great Depression (1930–1939) (e.g. De Grave et al., 2023). The indicated eras in Fig. 3 originate from De Grave et al. (2023), where a detailed decapod species discovery analysis through time revealed these five major eras, roughly corresponding to major socio-economic time periods. Although the start and end years of these era-trends might be slightly arbitrary and display some differences between taxonomic groups, the overall era-indications are believed to be present throughout the taxonomic tree, as also demonstrated by comparing the Decapoda analysis (De Grave et al., 2023) with our current analysis.

Other extremes also become clear (Fig. 3). For example, there were an absolute maximum number of marine species descriptions in 1977, when 3,695 new marine species were introduced to science. A single publication was responsible for this peak, when Dr. Irene McCulloch formally described 1727 species of Foraminifera as new to science (McCulloch, 1977). With her effort, she surpassed Linnaeus himself and is, to date, the person responsible for describing the most marine species within a single publication. For Linnaeus, there are currently 1239 marine animal species documented in WoRMS from his Systema Naturae edition of 1758. Single publications describing as many new marine species as this are extremely rare. Within WoRMS, these are, at the time of writing, the only two references containing more than 1,000 new marine species descriptions. Seven references are currently known to contain between 500 and 1000 newly described species, six of which pre-date 1940 (Gmelin, 1791; Röding, 1798; Goldfuss, 1833–1841; Turton, 1932; Canu & Bassler, 1920; Thiele, 1925). Curiously enough, the seventh publication in this list is also by Dr. Irene McCulloch (1981), where she introduced an additional 518 marine foraminiferan species new to science.

An often-asked question is whether WoRMS can give insights in the trends of marine species descriptions, as well as state or predict trends in marine species discovery. When analysing all accepted marine species within WoRMS for which the publication date has been documented, it becomes clear that for the Kingdoms Animalia, Chromista and Plantae, a very small number of marine species names that pre-date Linnaeus (1758) have survived the test of time (Table 2). Of those 17 species, 16 date back to 1753 (12 Plantae & 4 Chromista species), in correspondence with Species Plantarum (1753), and a single species dates from 1757, the spider *Pardosa pullata* (Clerck, 1757) known to occur in both tidal debris and non-littoral habitat (WoRMS, 2023). For other kingdoms, the first marine species were not described until 1783 (Fungi), 1830 (Protozoa), 1836 (Bacteria) and 1880 (Archaea), based on currently available information in WoRMS (January 2024). The number of accepted marine species described in a given year varies greatly over time, with 2008 being the first year where more than 2,000 marine Animalia species were described, a milestone at least partly connected to the overall outcomes of the Census of Marine Life

Table 2 Accepted marine species names within WoRMS that pre-date Linnaeus, 1758 (status January 2024)

Scientific Name	Authority	Kingdom	Phylum	Class
Fucus ceranoides	Linnaeus (1753)	Chromista	Ochrophyta	Phaeophyceae
Fucus serratus	Linnaeus (1753)	Chromista	Ochrophyta	Phaeophyceae
Fucus spiralis	Linnaeus (1753)	Chromista	Ochrophyta	Phaeophyceae
Fucus vesiculosus	Linnaeus (1753)	Chromista	Ochrophyta	Phaeophyceae
Chara hispida	Linnaeus (1753)	Plantae	Charophyta	Charophyceae
Chara tomentosa	Linnaeus (1753)	Plantae	Charophyta	Charophyceae
Conferva reticulosa	Linnaeus (1753)	Plantae	Chlorophyta	Ulvophyceae
Ulva compressa	Linnaeus (1753)	Plantae	Chlorophyta	Ulvophyceae
Ulva intestinalis	Linnaeus (1753)	Plantae	Chlorophyta	Ulvophyceae
Ulva lactuca	Linnaeus (1753)	Plantae	Chlorophyta	Ulvophyceae
Ulva linza	Linnaeus (1753)	Plantae	Chlorophyta	Ulvophyceae
Hibiscus moscheutos	Linnaeus (1753)	Plantae	Tracheophyta	Magnoliopsida
Eryngium aquaticum	Linnaeus (1753)	Plantae	Tracheophyta	Magnoliopsida
Ruppia maritima	Linnaeus (1753)	Plantae	Tracheophyta	Magnoliopsida
Salsola kali	Linnaeus (1753)	Plantae	Tracheophyta	Magnoliopsida
Zostera (Zostera) marina	Linnaeus (1753)	Plantae	Tracheophyta	Magnoliopsida
Pardosa pullata	(Clerck 1757)	Animalia	Arthropoda	Arachnida

(Ausubel et al., 2010). The other kingdoms are much smaller in size, with Archaea only reaching a maximum of 8 marine species descriptions in the years 1998 and 2007, and Bacteria only having more than 130 marine species described in the years 2005, 2006 and 2007.

Animalia is by far the best studied taxon within the marine realm (Figs. 4, 5), so further in-depth analyses focus on this Kingdom. Analyses of the data for all Animalia in WoRMS (from 1758 to 2022) indicate that 24% of newly described extant marine species are crustaceans, with molluscs a close second at 21%. This does not really come as a surprise, given that these two groups are considered to be the most speciose in the marine environment (Appeltans et al., 2012). When considering more recent trends over the last 5 years (2018–2022), WoRMS content demonstrates that gastropod molluscs represent, on average, 28% of all new species descriptions in any given year in that time period, closely followed by newly described crustacean species (21%). When examining the number of accepted marine species for these two groups in more detail and over the whole time range since Linnaeus, a clear fluctuation can be observed, where crustaceans and molluscs are the alternating dominantly described species groups within the marine realm (Fig. 6). Throughout marine taxonomic history, crustaceans and molluscs combined, on average, represent 44% of all accepted marine species descriptions within any given 5-year time range, with a historical high of 65.2% in 1788–1792 and a historical low of 29.7% in 1773–1777. For a detailed analysis and insights on the decapod crustacean species description rates and their evolution throughout taxonomic history, we refer to De Grave et al. (2023).

When considering all names ever published for marine species and the ratio at which certain names become unaccepted, it is clear this is also changing over time. Of all marine species described in 1758, only about half (47.3%) are currently still accepted species names. A relative historical low is visible in 1762. In that year, 61 species were described, of which only 6 names (9.9%) are still considered valid species today. Over time, the number of newly described marine species that are considered synonymous shows a decreasing trend; note that a species name moved from one genus to another is not considered a synonym in WoRMS, but a new combination. Since 1996, the number of species names placed into synonymy falls below 20% of all described names per year. From 2015 onwards, the synonymy ratio drops below 10% (Fig. 7). Although this may reflect a positive trend in the lasting validity of described marine species, some care is needed, as more recently described species (e.g. in the last 20 years) are yet to face the test of time. Bouchet et al. (2023) provided

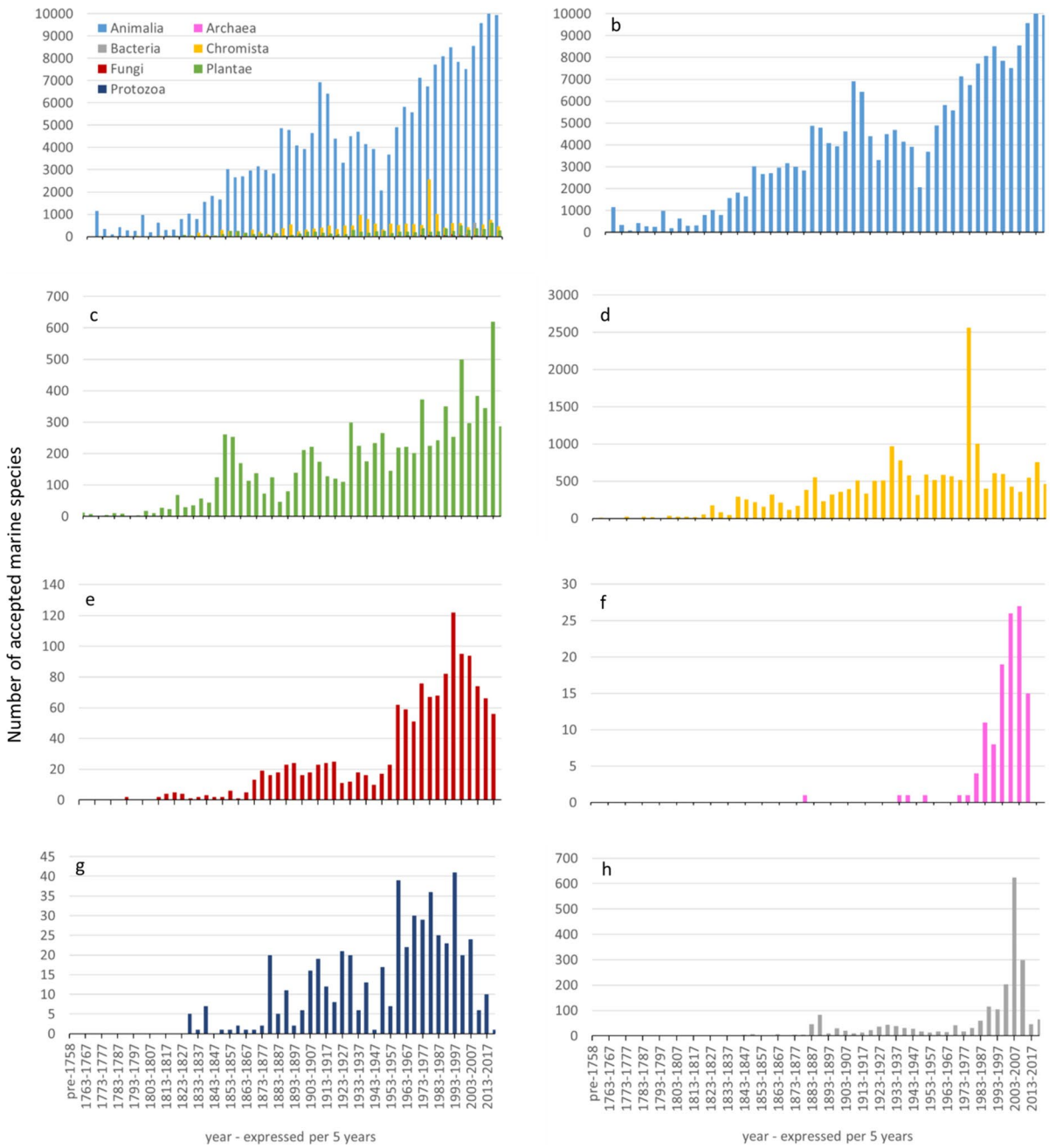

Fig. 4 Number of accepted marine species (Y-axis) per 5-year time ranges (1758–2022; X-axis), per kingdom. **a** All marine species, **b** Animalia, **c** Plantae, **d** Chromista, **e** Fungi, **f** Archaea, **g** Protozoa, **h** Bacteria

a similar analysis on all marine species, based on WoRMS data from 1910 to 2020. Here, we provide the complete time range for all marine taxa since 1758 (Fig. 7). The presented numbers slightly deviate from Bouchet et al. (2023) owing to the recent taxonomic status updates, although the overall general trend remains the same.

Over the last five years, technical improvements to the Aphia infrastructure, based on Horton et al.

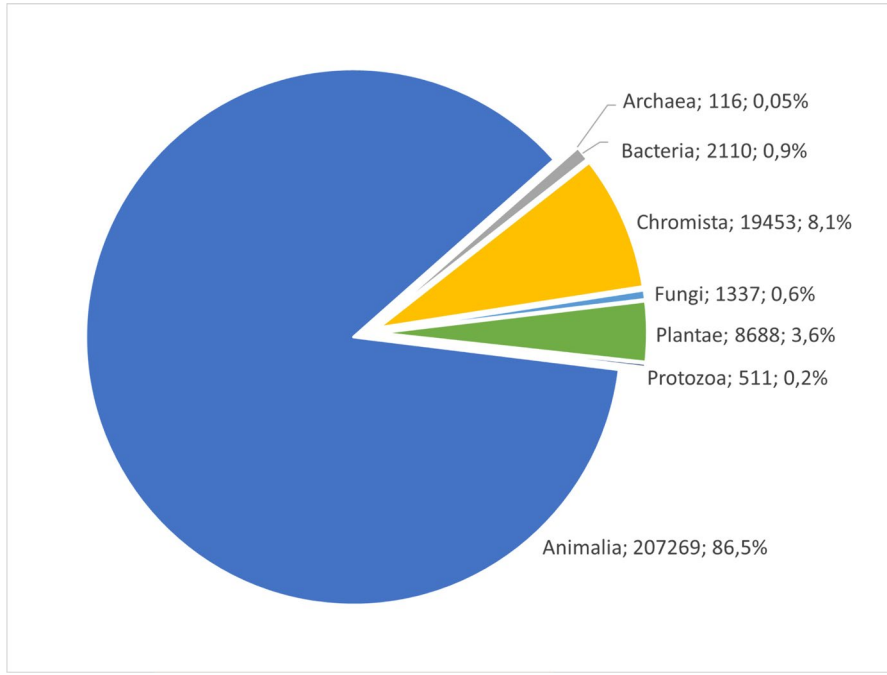

Fig. 5 Total number of accepted marine species per kingdom, based on marine species descriptions from 1758 until 2022. Totals per kingdom expressed as absolute numbers, followed by relative numbers compared to the total number of accepted marine species, expressed as percentage

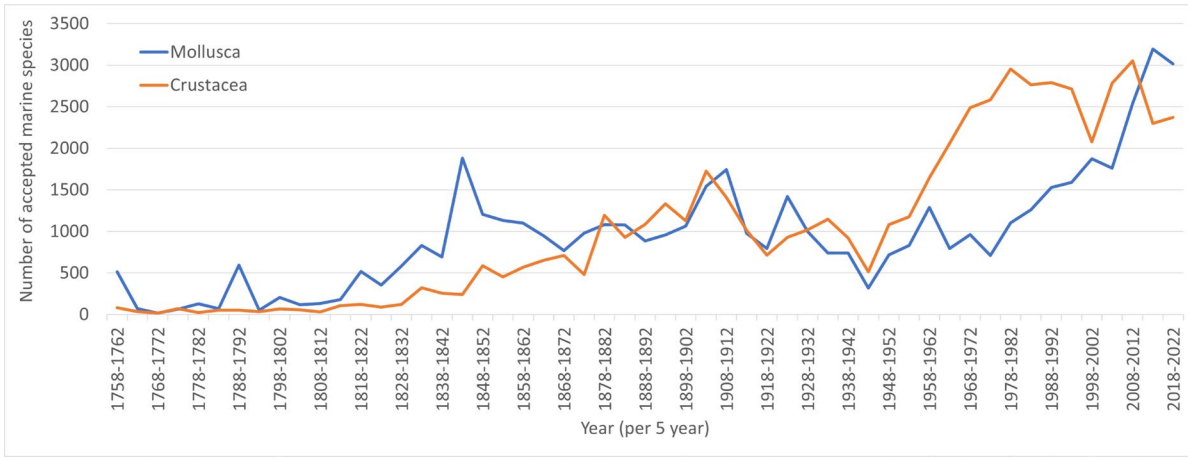

Fig. 6 Total number of accepted marine crustacean and mollusc species, represented in 5-year time ranges (1758–2022)

(2017), allow editors to be more structured, detailed and consistent in documenting the name status of a taxon. The original status picklist was expanded from 9 basic non-hierarchical options to 23 options with a basic hierarchy (Table 3), still offering a free text field to expand on the "unaccept reason" if the chosen option needs clarification.

WoRMS priorities and opportunities

In 2015, the WoRMS Steering Committee (SC) compiled a list of priorities, to help editors focus on particular types of information with high potential to help answer outstanding questions related to marine taxonomy and biodiversity. The original list of 2015 contained nine priorities. In 2018, four extra

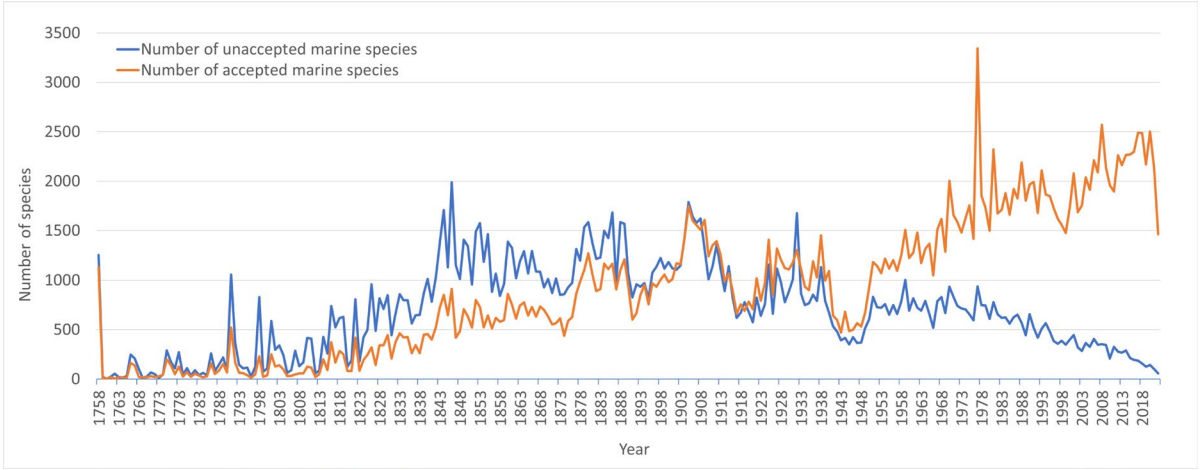

Fig. 7 Number of accepted marine species (orange) versus the number of currently unaccepted marine species (blue) per given year

Table 3 Statistics (13 December 2023) on the name status for all marine, non-fossil species within the World Register of Marine Species

Column 1 (Status) represents the status as it was in use from the start of WoRMS (2007); Column 2 (Status—since January 2022) represents the updated status representation in WoRMS, since January 2022. Column 3 (statistics) displays the number of marine, non-fossil species within each category, based on December 2023 content of WoRMS. Non-bold numbers are included in the bold numbers. Bold numbers can be higher than the sum of the underlying statuses, as these were just recently introduced and still incomplete. Terminology is based on Horton et al. (2017), the basis for implementation of these status categories in WoRMS

Status (original)	Status (since January 2022)	Statistics (Dec 2023)
Accepted	**Accepted name**	**243,788**
	Unreplaced junior homonym	92
Unaccepted	**Unaccepted name**	**192,064**
	Incorrect original spelling	190
	Superseded combination	21,520
	Superseded rank	23
	Junior homonym	512
	Junior subjective synonym	11,221
	Junior objective synonym	181
Nomen nudum	*Nomen nudum*	1705
	Nomen oblitum	22
	Misspelling	1479
	Unjustified emendation	61
	Incorrect grammatical agreement of specific epithet	311
	Misapplication	147
	Unavailable name	417
Interim unpublished	*Interim unpublished*	62
Uncertain	**Uncertain name**	**2638**
Nomen dubium	*Nomen dubium*	3450
Taxon inquirendum	*Taxon inquirendum*	6750
	Unassessed	7500
Temporary name	**Temporary name**	**22**
Alternate representation	**Alternate representation**	**8698**

priorities were added, in keeping with progress in the completeness of WoRMS and the evolving field of marine biodiversity science. The most obvious priority, to "document all marine taxa ever published", was not included in the list, as this is the main goal of WoRMS, and need not be listed separately. In addition, this priority cannot be accurately measured, as the estimates on the known and unknown number of marine species vary greatly.

The DMT regularly reports on the status of these priorities to the WoRMS Steering Committee. The status is reflected as percentage completeness compared to the number of marine species available in WoRMS at the time of reporting (Table 4). As WoRMS is constantly growing and has a dynamic editor pool that does not always cover all taxa, there will always be certain constraints to reaching 100% completeness on all these priorities at any given point in time. Taking this into consideration, the SC assumes priorities with over 95% completeness as effectively complete, with the exception of authorships (see Challenges and Problem Solving within WoRMS).

Since the tenth anniversary of WoRMS (2017) (Vandepitte et al., 2018), major progress has been made on priority 5, documenting the original description of each species. Through targeted communication to the editors on the importance of this priority, and additional efforts by the DMT to fill this gap, an almost 50% increase was accomplished. The level of completeness reflects the reference of the original description being documented in the system, not the availability of a PDF (see also Challenges and Problem Solving within WoRMS).

The documentation of the type locality is an ongoing effort. As the type locality is considered highly relevant, the Aphia infrastructure allows its detailed documentation, either very structured or more general, depending on the level of detail of the available information (see also Horton et al., 2017). Of the 24% accepted marine species that have their type locality documented (Table 4), only 10% have the actual latitude–longitude data available, allowing precise, unambiguous geographical visualisation (Fig. 8). The majority of the currently documented type localities in WoRMS seems to be situated along coastlines.

Ultimately, WoRMS aims to provide latitude–longitude data for the type locality of each species. The level of detail of the type locality can, however, vary widely within original descriptions, ranging from exact coordinates to a vague, verbatim description of the location where the specimen was collected, such as "Bay between Taboga and Taboguilla, Taboga Island, Panama, Pacific Ocean" or even "Atlantic Ocean". When no coordinates are provided in the original description, several approaches are possible. Where maps or very detailed descriptions of the discovery location are provided, coordinates can be estimated and documented as such, with the annotation that these are derived values. When this is not

Table 4 Management and content priorities for the World Register of Marine Species, as defined by the WoRMS Steering Committee in 2015 (1–9) and 2018 (10–13)

		June 2017 (%)	December 2022 (%)
1	Have at least 1 active editor per taxonomic group	***	***
2	Mark (accepted) taxa as "checked by editor"	93	97
3	Document basionym (original name)	89	92
4	Complete missing authorships*	99.3	99.5
5	Document original description of each species	36	83
6	Complete environment flags	98%	99.9
7	Document higher classification	***	***
8	Document type localities	20%	24
9	Document type species	37	53
10	Document all published name combinations	–	***
11	Make available at least 1 image per species	–	16
12	Document (general) distribution for each species	–	***
13	Document relevant species traits	–	***

A numerical estimate of priorities 1-7-10-12-13 (***) is not possible. The numbers reflect the percentage of accepted marine species with this information available. Priority 4 (*) percentages are based on at least an author name being present, though not necessarily a year

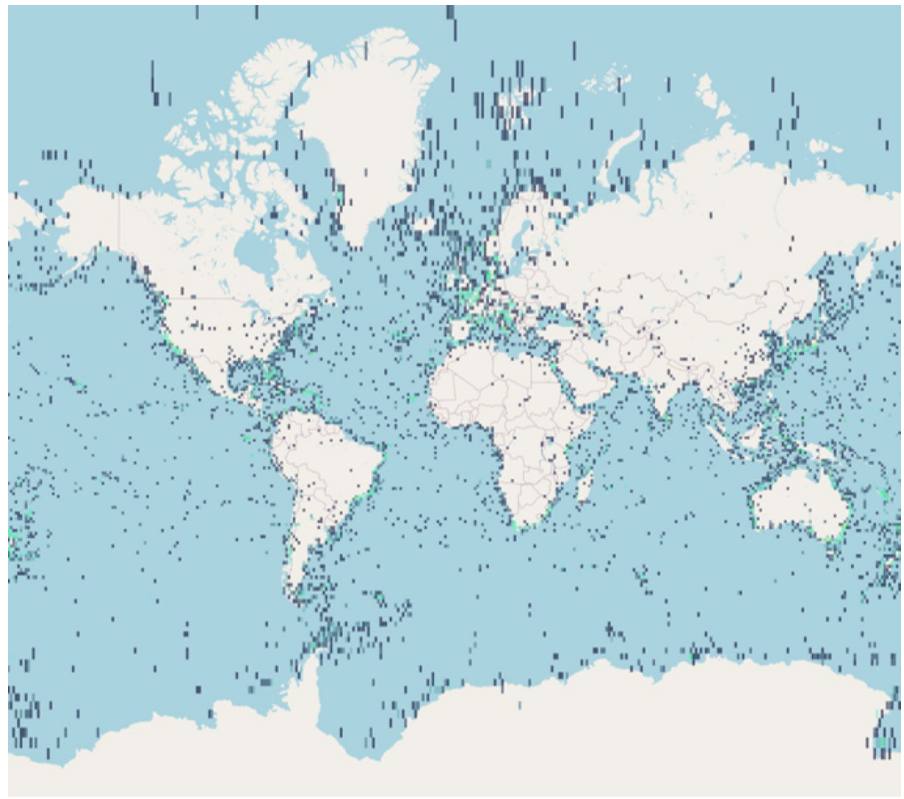

Fig. 8 WoRMS type locality data documented with latitude and longitude values (June 2024)

possible, the information is displayed as "type locality contained in [place name X]". Linking these place names to the Marine Regions geographical information system hosted at the Flanders Marine Institute (VLIZ) (Claus et al., 2014; www.marineregions.org), makes the assignment of approximate coordinates and/or shape files possible, still allowing a geographical visualisation.

Although still a long way from completion, the documentation of all type localities can give insights into potential biodiversity hotspots or undersampled regions on the map. Within the framework of the UN Ocean Decade and the Ocean Census Alliance (www.oceancensus.org, Rogers et al., 2023), the WoRMS Steering Committee and the Data Management Team will explore targeted approaches to tackle underexplored areas, one taxonomic group at a time.

A second type-related priority is a little over half complete: documenting the type species. Within the field of taxonomy, types are considered crucial anchor points for species names. For each taxon, each of its nested ranks is attached to a type, which represents its defining features (ICZN)—type specimens at species level, and type taxa at higher ranks. In WoRMS, the priority is on documenting the type at the level of species. In addition, the Aphia infrastructure also allows the documentation of the repository where type specimens are located, although this is not prioritised.

Each of the four priorities added in 2018 have seen progress, although this progress is not always easily quantified. The documentation of all published name combinations (priority 10) is being tackled by processing a number of targeted species registers and lists, such as InvertEBase (https://invertebase.org/portal/index.php) and SCAMIT (Southern California Association of Marine Invertebrate Taxonomists, 2018). Mismatches between these registers and WoRMS are shared with the DMT and sent to the relevant taxonomic editors for assessment. In most cases, the mismatches can be narrowed down to missing genus-species combinations in WoRMS, if, for instance, the currently accepted name is contained within a subgenus. This exercise, uncovering a systematic gap in WoRMS, has led to a new editing recommendation, to include the genus-species combination for species with subgenera and to treat these

genus-species names as "alternative combinations". By including these, the taxon matching process will be greatly improved for many names, in parallel leading to improved linking across data infrastructures.

The priority to make available at least one high-quality image per species (priority 11) comes from the underlying wish of WoRMS to visualise all marine life for a wider audience. To reach this goal, the DMT is capturing existing images from several museum and personal collections globally (e.g. Museum National d'Histoire Naturelle, MalacoPics, ReefLife App,etc.), as well as aiming to collaborate with ongoing initiatives that already have verified images available, e.g. iNaturalist (https://www.inaturalist.org/), FathomNet (https://fathomnet.org/fathomnet/#/) and Mollusca types in Great Britain (Ablett et al., 2019).

Over the past five years, several actions have been undertaken to better document the general literature-based distribution of marine species within WoRMS. Although the possibility to document a distribution was already available through the Aphia infrastructure before 2017, major actions were undertaken to improve the quality of the available literature-based distribution information, as well as to seek ways to connect with other infrastructures that contain distribution information, including OBIS, iDigBio and GBIF. A long-standing complaint about the distribution content was that, very often, distribution information was added at a political (i.e. country), instead of a biogeographically meaningful level (i.e. marine region). Wherever possible, the translation from land to sea, specifically the Exclusive Economic Zone, has been made. This has led to the improvement of more than 56,000 distribution records for marine, recent-only species.

The new priority with the most progress made over the last five years is the documentation of relevant species traits and attributes, all referred to as "attributes" within WoRMS. The possibility to document them has been available since before 2017, although only in the last five years has more focus and efforts been directed towards documenting this type of information. The attribute and trait documentation currently goes far beyond the onset of what was described as the "top 10 proposed priority traits" listed in Costello et al. (2015). Reasons for this are threefold: (1) having certain attributes available was high on the wish list of WoRMS users, specifically from the ecological domain. Great effort has been made in documenting the "functional group" (whether an organism belongs to the plankton, benthos, nekton, etc.), which is currently (December 2023) available for 80% of the marine, extant, accepted species in WoRMS. Also, body size (both quantitative in absolute numbers and qualitative as categories from micro to mega) is increasingly being collected since 2017, mainly for ecological modelling. (2) Some taxonomic editors are investing in documenting specific species traits and attributes, as the taxonomic information within their group is nearing completion, and they see the benefits of having this additional ecologically oriented information available. (3) Over the last five years, more thematic registers have become available, where species are being grouped specifically based on a trait or attribute, for example, whether a species belongs to the deep sea or not, is an alien species, is considered as a harmful algal bloom species or is an inhabitant of caves. These traits correspond to specific thematic portals: the World Register of Deep-Sea Species (WoRDSS, Glover et al., 2023), the World Register of Introduced Species (WRiMS, Rius et al., 2023), and the World Register of Cave Species (WoRCS, Gerovasileiou et al., 2023). An overview of all traits and attributes currently available in WoRMS can be found at https://marinespecies.org/traits/aphia.php?p=attrdefinitions.

Challenges and problem solving within WoRMS

Based on the WoRMS priorities and their progress (Table 4), it is clear that filling gaps is one of the major challenges for the WoRMS Editorial Board, the Steering Committee and the Data Management Team. Next to filling gaps, controlling the quality and format of the entered information is equally important. It is the combination of available content, its format and its level of quality that allow us to answer specific questions related to the field of (marine) taxonomy throughout history. Filling gaps does not always mean that information was not yet available within the database. It also refers to fine tuning of already available information, to allow easy and correct extraction of the required information, as well as to eliminate confusion.

WoRMS taxon authorities

Completing the taxon authority field in WoRMS is one of the top priorities. At first sight, its high level of completeness (over 95%) could bring WoRMS in reach of answering the question "How many people have actually described marine species?" Linking this answer to specific time spans would then allow a better understanding of how many people are active in the field of marine taxonomy over time and could unambiguously demonstrate an increasing or decreasing trend in their numbers, thus either confirming or rejecting the commonly heard hypothesis that taxonomists are a dying breed. Even with this high level of completeness of the authority field, the answer to this question is still not within the immediate reach of WoRMS, for the simple reason that authority information also has many levels of ambiguity which need to be cleared up. The calculation of the percentage of completeness does not take into account these ambiguities, but only reflects whether some content is available within the authority field, regardless of its format or exact content. There are for example still 2,371 accepted marine species where the publication year is missing.

The level of detail in the authority depends on the applied International Codes of Nomenclature. Within Botany, the International Plant Names Index (IPNI) provides a standardised list of authors and their abbreviations, with a strong recommendation to follow this. The Zoological Code does not offer such a recommendation. Unless a link is made within WoRMS to this IPNI authority list, and the editors are recommended to also document the year of publication in the authority field, unambiguously distinguishing authors of marine plants will remain a challenge in WoRMS (see also Horton et al., 2017).

The spelling of the author name itself is not always straightforward because the orthography sometimes changes over time or between publications. Examples of these are De Gregorio, de Man and Bory de Saint-Vincent. Several spelling variations of these author names appear in the literature. Likewise, some taxonomists have used different spelling variations for their own name, such as Charles Desmoulins, who described species both under "Desmoulins" and "Des Moulins". Within certain taxonomic groups, e.g. Mollusca, the editors are currently standardising these spelling variations to the "original" spelling of the author name, often as retrieved from the birth certificate or other official documents. Although this is not the original guideline set forward by Horton et al. (2017), it does give the editors the opportunity to unambiguously group species per author, as WoRMS currently cannot offer an alternative solution for this problem.

Some author names are very common throughout history and are currently not fully distinguishable within the WoRMS taxon authority field (although this is possible from the original description reference). Different editor groups have already taken on the challenge to document the authority in more detail, specifically by adding initials to surnames. Within WoRMS, initials can be captured within the authorship information, and the general rule is to add initial(s) to a name if there can be confusion. In case authors also have the same initials, as many letters of the first name(s) as needed are to be used to discriminate them. An example of this is Ev. Marcus versus Er. Marcus (Eveline & Ernst Marcus, husband & wife) (see also Horton et al., 2017). By including initials, distinguishing father and son or other family connections is possible. This is the case for Ant. Bivona versus And. Bivona. (Antonino and Andrea, father and son). However, family ties often go further than two people or two generations, as is the case with "de la Torre". Within molluscan taxonomy, three related nephews and cousins with the last name de la Torre have been active. Simply adding their initials, A., R. and C., makes it possible to clearly distinguish them, avoid incorrect assumptions on how many species each of them described, and leads to a more correct estimate of the number of active people in the field of taxonomy. An additional level of complexity is sometimes added when a father names his son after himself, as is the case for George Brettingham (G.B.) Sowerby in the late 1700s. Both father and son worked together in the field of taxonomy, so the need arises to not only add the initials, but also indicate the generation by I and II. The Sowerby family was very active in marine species descriptions and their knowledge and skills were passed down to the third generation, as the grandson George Brettingham Sowerby also described marine species, requiring the need to document his name as G.B. Sowerby III. For a complete overview of the taxonomic endeavours of three generations of Sowerby, we refer to Petit (2009), a source of tremendous importance to the

MolluscaBase editors, in their actions to clear out the confusion surrounding the surname Sowerby. Documenting initials also distinguishes completely unrelated namesakes, e.g. in the case of authors named Grant. Within Mollusca, four completely unrelated people named Grant have described taxa. The addition of initials in these cases allows to distinguish these four people and assign the correct number of described taxa to each one of them, thus making sure they are correctly recognized as four individual taxonomists instead of just one.

An extra level of complexity is added on the authority level when scientists have described taxa under their maiden name, married name, divorced name and/or re-married name. At this point, WoRMS does not offer a possibility to link these different names to each other, thereby indicating they are all the same taxonomist. These cases are most common with, but not limited to, women. Two examples are Mary Jane Longstaff and Michèle de Saint Laurent. Mary Jane Longstaff was a British malacologist, specialising in fossil Gastropoda. She was born with the surname Donald which she used to publish species descriptions until 1906. After her marriage, she published under Longstaff (Poppe & Poppe, 1994–2023). Michèle de Saint Laurent was a Decapoda taxonomist, publishing species descriptions under her maiden name (Dechancé), her married name (de Saint Laurent-Dechancé) and her divorced name (de Saint Laurent). Men have also gone through name changes, examples being Paul H. Scott, who published species descriptions as P.H. Scott, P. Valentich Scott and P. Valentich-Scott, and Fujio Hiro, who changed his name to Huzio Utinomi upon marriage, as did Taku Fukuda, who changed his name to Taku Komai.

The above-listed examples are not at all exhaustive. These are just a few familiar or often stated examples to illustrate the complexity of authorships. Additional problems can e.g. appear with the transcription of Russian or Asian author names. From these listed challenges, it is clear that WoRMS is today not yet in the position to be able to unambiguously answer the question “How many marine taxonomists are there now, how many have there been throughout history and how have species authorships evolved over time?”. However, the completion and fine-tuning of authorities is steadily moving forward, which makes the Steering Committee and Data Management Team hopeful that we will be able to answer this question by 2030, as part of the WoRMS commitments to the UN Ocean Decade. Within the same endeavour, it is aimed to also document the gender of taxonomists, to evaluate the gender balance among taxonomists and to thus also unambiguously answer questions such as “how many marine taxonomists are women?”, extended with a more detailed look of the geographical distribution of taxonomists.

WoRMS literature

One of the golden editor rules of WoRMS is that all information entered into the database needs to be supported by a source, preferably published literature, but also allowing for a database reference or even an expert opinion (see also Horton et al., 2017). The main goal of this is transparency regarding data provenance. Added benefits include that (1) editors themselves can easily keep track of information sources and (2) users can retrace where information comes from, and they can consult these references in search of extra information that was not captured in WoRMS. Whenever possible, editors are strongly encouraged to also upload the PDF of the reference into the database.

As of 29 July 2024, WoRMS contained 448.034 references. The priority reference within WoRMS is that of the original description, accounting for 173.202 (=39%) of all available references. This corresponds to 197.874 marine-accepted species having the reference to their original description available. The perceived mismatch between the numbers makes sense, as a single publication can contain multiple new species descriptions. By the end of the UN Ocean Decade (2030), the WoRMS Steering Committee (SC) will not only strive towards 95% completion for this priority to document the original description reference of each species but will expand this priority to also make available the PDF of each of these references, either directly through WoRMS, or by providing deep links to the Biodiversity Heritage Library (BHL). As of August 2023, a user can retrieve and consult the original description publication for roughly 40% of all marine-accepted species names. This can either be done directly for all Open Access publications, or through a "source request” for publications that are available within the database but are not (yet) in the public domain.

The "source request" service for WoRMS was launched on August 26th, 2018. Through this service, users can request a digital copy of a publication, under the condition they can provide a valid scientific reason for their request. Since its launch, a total of 27,564 PDF requests have been made (as of 11 May 2023), that is an average of approximately 14 publication requests per day. The 27,564 PDF requests can be narrowed down to 11,680 unique PDFs, which represents 23% of all PDFs available within WoRMS. Of these 11,680 unique PDFs, 97% are for PDFs that have only been requested once (58%) or twice (39%). The most requested publication (480 unique requests) is a marine checklist of the China Seas (Liu, 2008), followed by Linnaeus' Systema Naturae (1758), requested 279 times, although this work is also available for consultation and download through the Biodiversity Heritage Library (BHL, https://www.biodiversitylibrary.org/). There are 75 publications in WoRMS that have been requested 20 times or more. For each request, contact information and a reason for download needs to be provided. When no reason is provided, the request is not approved. This avoids bulk download actions on all the available PDFs within WoRMS, for which we cannot control the download reason. The offered service is first and foremost intended to assist WoRMS users and editors to more easily access taxonomy-related literature, facilitating their work. Reasons for a PDF request are diverse, although a number of recurring keywords can be identified, such as research, taxonomic revision, new species description, species comparison, reviewer revision, museum collection revision and identification. Some sources, however, pose a challenge in obtaining their PDF. They can be hard to find online, even in the current digital era, with the existence of the Biodiversity Heritage Library (BHL) and extensive support from the Library team at VLIZ, the host institute of WoRMS. Many rare papers have been obtained and added to WoRMS by the efforts of editors, either from their own sources or reaching out to their colleagues, but many more remain to be located and added.

Within the WoRMS-context, editors often refer to "dark literature" or "grey literature", thereby indicating literature that is extremely hard to find, mostly because it is not yet digitally available, or literature that is in circulation but has never been formally published. The problem with the latter is that taxon names within unpublished works can still be cited in published works and, this way, the names can become common in use. Although this brings the names themselves in vernacular usage, they are not necessarily formally recognized as available names in the sense of the nomenclatural codes (e.g. ICZN). Two "publications", actually unpublished but circulated manuscripts by Renier (Renier, 1804a, 1804b), are such cases, containing more than fifty new species names, but which were ruled as unavailable publications according to ICZN Opinion 316 (ICZN, 1954). Some of the names from these Renier papers were, however, at later stages validated by other ICZN rulings and all have been cited in other published works. Ideally, all these names should become documented in WoRMS with reference to their corresponding ICZN Opinion or any subsequent Opinion overruling the original Opinion. Such cases of dark literature, with names in common use, are rather rare, but nonetheless should be documented in WoRMS, in order to be able to provide a full historical overview of all names ever published or cited, with clear references to their historical and current status. The option to link a source with the flag "Original description (unavailable nomenclaturally)" allows to clearly distinguish between sources where a name has first been used and the source that made it available as an accepted name for a biological species.

WoRMS taxonomy is…

In 2003, five years before the start of WoRMS, Bill Bryson wrote "A Short History of Nearly Everything", which included a section on taxonomy (Bryson, 2003). He casually, but very adequately described the field of taxonomy as follows: "*Taxonomy is described sometimes as a science and sometimes as an art, but really it's a battleground*". His observations on waltzing through the tree of life, pinpointing the existing disorder and disagreement, made him reach the conclusion that there are, in essence, too few taxonomists to describe all the still undescribed species. Gradually, this quote has become a mantra for the WoRMS Data Management Team, as these three fields of art, science and battleground are reflected within WoRMS, each in their own way.

There is no doubt that all species descriptions are, in fact, science. It requires knowledge, expertise and

skills to be able to successfully describe a species, a combination of traits found both in professional and amateur taxonomists. Although in the past, taxonomy seemed to be a man's profession, women have gradually become better represented in the field. The first women involved in taxonomy were not necessarily taxonomists themselves, but women with exquisite artistic skills, providing illustrations for the species descriptions written by male taxonomists. Women have been involved in taxonomy for a very long time and were in some cases crucial for taxonomic progress, although they were largely in the background in the past. Examples are Anna and Susanna Lister, well-known for their copper plate engraved illustrations of shells and anatomical images of marine molluscs from the 1600s (Roos, 2011, 2019). In the early 1900s, the taxonomist Thomas Alan Stephenson gave clear acknowledgements to his wife Anne for providing illustrations for his publications, as well as assisting in the sample preparations (e.g. Stephenson, 1929). To our knowledge, women have officially described marine species only since the late 1800s and early 1900s. A non-exhaustive list of female taxonomists from that time period includes Mary Rathbun (1860–1943, crustaceans), Katharine J. Bush (1855–1937, molluscs), Harriet Richardson (1874–1958, isopods) and Elsie Sexton (1868–1959, amphipods). Looking back in history, contributions by women who provided exquisitely detailed illustrations to accompany species description text would certainly meet today's standards for co-authorship of species. How times are changing….

Many species names can be categorised under science and/or art, as the choice of a species name is at the discretion of the scientist describing it. Species names can from a scientific perspective refer to colour, morphological or ecological characteristics, geographic discovery locations or the names of their collectors or colleagues that have significantly contributed to the field, whereas species names from an artistic perspective can reflect the wide interests of the taxonomists, in many cases reaching far beyond the scientific field. The name of a newly discovered species is the result of the perception of the taxonomist, who is knowingly or unknowingly influenced by his or her location in history. The given scientific genus and species combination reflects the best possible hypothesis of relationships, based on the facts and evidence available to the taxonomist at a given time. But these hypotheses may be subject to change, within or after the lifetime of the taxonomist. Based on the accumulation of additional evidence, the genus species combinations may well change, although the species epithet itself remains the same, with the exception of altered endings conforming to Latin gender agreement with a new genus combination. Although etymology is not seen as a priority within WoRMS, the system does allow for its documentation, and some editors have made a habit of entering this information. The etymology of marine species provides interesting and fascinating background information, and it is a wish of the Data Management Team to someday be able to provide statistics on the inspiration sources for scientific names, and how the naming of marine species might have evolved over time.

The "battleground" of Bryson's quote should be looked at metaphorically. Next to correct taxon identifications, the correct spelling of the name in the field of marine biodiversity is equally important to avoid confusion when bringing together taxon lists from different resources. For non-taxonomists, correctly spelling scientific names can sometimes also be seen as a battle, as some taxon names are not always straightforward to spell. At the time of this writing (December 2023), the longest documented scientific name within WoRMS is a marine ostracod: *Paradoxostoma promunturiumphysicicotum* Hartmann, 1979 (Brandao et al., 2023), certainly posing a spelling challenge. Within WoRMS, the Aphia Taxon Match tool (https://www.marinespecies.org/aphia.php?p=match) allows easy verification of both the spelling and validity of a taxon name, next to the possibility to retrieve the full classification and environment details of each taxon. The Taxon Match tool has been available since the start of WoRMS in 2007, and a steady increase in the number of files that is run through the tool has been observed, reaching over 16,000 file uploads in 2022.

WoRMS under the UN Ocean Decade

WoRMS was officially endorsed as a UN Ocean Decade Project in October 2021, entitled "Above and Beyond—Completing the World Register of Marine Species (ABC WoRMS)". Six main objectives were put forward, generally in correspondence with the list

of management and content priorities for WoRMS agreed upon by the WoRMS Steering Committee in 2015 and have since then been a guideline for the editorial board to help organise their voluntary contributions to WoRMS. The WoRMS objectives under the Decade not only focus on expanding and improving the taxonomic and trait content of WoRMS, but also focus on consolidating and expanding existing and exploring new collaboration opportunities with other global databases, infrastructures and initiatives (e.g. LifeWatch, OBIS, GBIF, COL, GOOS, BoLD and GenBank). In doing so, WoRMS can widen its user group, not only targeting scientists, but also policy makers, industry and the public at large. The underlying infrastructure of Aphia has always been offered as a data rescue platform for taxonomically focused databases at the brink of disappearing, thereby safeguarding expert knowledge and making it widely and publicly available. The first rescue action dates back to 2013, when the Check-List of European Marine Mollusca (CLEMAM) was fully integrated into Aphia, and its content became part of WoRMS and MolluscaBase (MolluscaBase eds, 2024). Since then, 13 similar rescue activities have been undertaken for various groups, covering diatoms, nematodes, bryozoans and hexacorallians from the marine realm. Under the UN Ocean Decade, WoRMS is strongly connected to the MarineLife 2030 endorsed Program: A Global Integrated Marine Biodiversity Information Management and Forecasting System for Sustainable Development and Conservation (https://marinelife2030.org/). Connections with other UN Ocean Decade initiatives are being made as the UN Ocean Decade progresses. Some of these support and lean on already long-lasting collaborations, e.g. the usage of WoRMS as the taxonomic backbone for the Ocean Biodiversity Information System (OBIS, 2023), while others are completely new, e.g. FathomNet and the Sustainable Seabed Knowledge Initiative (SSKI). The common denominator among these is that WoRMS forms a solid basis for marine taxonomic information, supported by a wide network of editors representing the collective memory of the marine taxonomic world.

In conclusion—authors contemplations

The World Register of Marine Species is definitely living up to its initial goal of being an authoritative classification and catalogue of marine names, demonstrated by our wide and diverse user community. Crucial for the future of WoRMS are the continuous voluntary efforts and contributions by hundreds of experts worldwide, with the support of a rather small Data Management Team.

Despite its high level of completeness and the fact that WoRMS is seen as an authoritative reference for marine taxonomy, each day behind the scenes teaches the Data Management Team that there are still gaps in the available information, which could largely be addressed by continuously targeting the identified priorities. It is hoped that initiatives such as the UN Ocean Decade and Ocean Census can boost financial support for marine taxonomists as well as data managers to fill these gaps, so that by 2030 we will be able to accurately answer some of the long-standing questions we have touched upon in this paper.

With the celebration of its fifteenth or crystal anniversary, WoRMS is nearing adulthood, with a clear goal of tackling at least some of the current knowledge gaps. All highlighted examples in this paper are either well-known to the Data Management Team through close interactions with the related editor-groups or through discussions within the Steering Committee. It is by no means the intention to favour any taxonomic group or species over another, either generally by the DMT or within this paper. The names of all species are equally important to be documented within WoRMS.

We do believe that many more stories are to be found within WoRMS, if only one has a strong enough interest, motivation and, above all, time to take a deep dive into all its content. The DMT will not cease to try to uncover such stories, along with its ongoing efforts to support the WoRMS editor community in achieving its long-term goals for the content of WoRMS.

For those of you looking for another angle on the WoRMS crystal anniversary, we refer to a series of 15 short stories, published at https://lifewatch.be/news/celebrating-15th-anniversary-world-register-marine-species. The content from a number of these stories has formed the basis for this paper, together with feedback provided by editors and users of these stories.

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content and technical work on the Aphia infrastructure is possible through support of the LifeWatch Species Information Backbone. This backbone aims at bringing together taxonomic and species-related data and at filling the gaps in our knowledge. It gives support to taxonomic experts by providing them logistic and financial support for meetings and workshops related to expanding the content and enhancing the quality of taxonomic databases. In addition, it looks for active and long-lasting collaborations with related initiatives and databases, avoiding duplication of efforts. This paper would not have been possible without the feedback and invaluable input of the full WoRMS Steering Committee, as they represent our editor network and have first-hand knowledge on many of the examples that are given throughout this paper: Nicolas Bailly, James Bernot, Rüdiger Bieler, Simone Brandão, Meg Daly, Sammy De Grave, Serge Gofas, Lauren Hughes, Thomas Neubauer & Gustav Paulay. The Data Management Team (DMT) is grateful to all current and past WoRMS editors for their never-ending enthusiasm, support, feedback and patience towards the DMT. A word of thank you to all former DMT members, interns and students that have contributed to the activities and initiatives of the DMT over the past five years. They have made it possible for the DMT to tackle some open-ended editor and user requests in rather short timeframes of one to a few months, where the DMT has in many cases challenged their knowledge and abilities in the field of databasing, data management and insights in the field of taxonomy.

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Data availability All taxonomy-related data presented in this paper are available online through the World Register of Marine Species (WoRMS): WoRMS Editorial Board (2024). World Register of Marine Species. Available from https://www.marinespecies.org at VLIZ. DOI: https://doi.org/10.14284/170. The results of the editor questionnaire are not freely available, to protect personal and confidential information and feedback received through the questionnaire. The questionnaire was carried out in Autumn 2022, and sent out to all Aphia-WoRMS editors, with an open invitation to complete this. Questionnaire participants were informed as follows: "The results of this questionnaire will be used for several purposes, and for general analytical use only. Responses will not be connected to your name in any way in outside communication, and your individual responses will not be given to any third party." An anonymised, generalised version of the data can be made available upon reasonable request. The data are stored in the Marine Data Archive (MDA) at the Flanders Marine Institute (VLIZ).

Declarations

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