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Review

Marine conservation: linking taxonomy, Red Listing, and public engagement

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The majority of marine invertebrate species are undescribed and absent from biodiversity frameworks, leaving them beyond the reach of conservation mechanisms. We show that three disciplines—taxonomy, International Union for Conservation of Nature Red List assessment, and public engagement—achieve disproportionately greater impact when operated as a coupled system rather than in isolation. Each pillar feeds the others: taxonomic knowledge underpins assessments; assessments attract public and policy attention; and public engagement, in turn, drives commitment to new discovery, evaluation, and actions to recover threatened species. New tools for DNA sequencing, specimen imaging, and data sharing have made this integration achievable at speed and scale. Public engagement amplifies the reach of taxonomy and conservation, generating funding, contributors, and the policy traction needed to protect the ocean's overlooked life.

Highlights

Most marine species remain undiscovered, and countless invertebrates—the silent architects of ocean ecosystems—are disappearing before science can name them.

Technological advances and open biodiversity data platforms are transforming taxonomy into a global, collaborative enterprise, accelerating species discovery at unprecedented scales.

Despite these advances, the International Union for Conservation of Nature Red List—the primary global tool for extinction risk assessments—remains heavily biased towards terrestrial vertebrates; entire clades of marine invertebrates remain unassessed, rendering them invisible to legislation, funding, and protection.

Integrating taxonomy, International Union for Conservation of Nature Red List assessment, and public engagement into a unified framework transforms marine invertebrate species from scientifically invisible to conservation relevant, offering a scalable model for protecting the most overlooked components of ocean biodiversity.

From unnamed marine biodiversity to conservation action

Marine organisms are critical to ecosystem functioning and biogeochemical cycles that regulate the planetary system. Biodiversity in the ocean far exceeds that in terrestrial ecosystems in terms of evolutionary diversity, as represented by the number of animal phyla and classes, as well as life history strategies [1]. Most animal phyla are strictly marine, and only a few clades have colonised terrestrial or freshwater realms. Estimates suggest that the majority (up to over 91%) of eukaryotic marine species (Figure 1) remain undiscovered [2–4]. This vast unknown represents a significant scientific opportunity: to describe and understand the full extent of marine biodiversity, its importance for ecosystem functioning, and ensure its integration into global conservation frameworks [5,6].

The UN Decade of Ocean Science for Sustainable Development[i] presents a pivotal impetus for aligning scientific discovery with conservation outcomes. We propose that integrating **taxonomy** (see Glossary), extinction risk assessment based on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (hereafter **Red Listing**), and **public engagement** can accelerate the discovery and protection of marine biodiversity. Advances in technology, collaboration networks, and public interest make this an opportune moment to accelerate effective conservation actions for marine species. However, mounting threats increase the risk of species extinction before discovery (see, e.g., Butler *et al.* [7] and Cowie *et al.* [8]). Many of these as-yet undiscovered species—and, indeed, most described marine species—are invertebrates, which dominate known and unknown marine diversity [9]. From microscopic meiofauna to deep-sea corals and surface primary consumers (i.e., animals eating phytoplankton) to deep-sea burrowers

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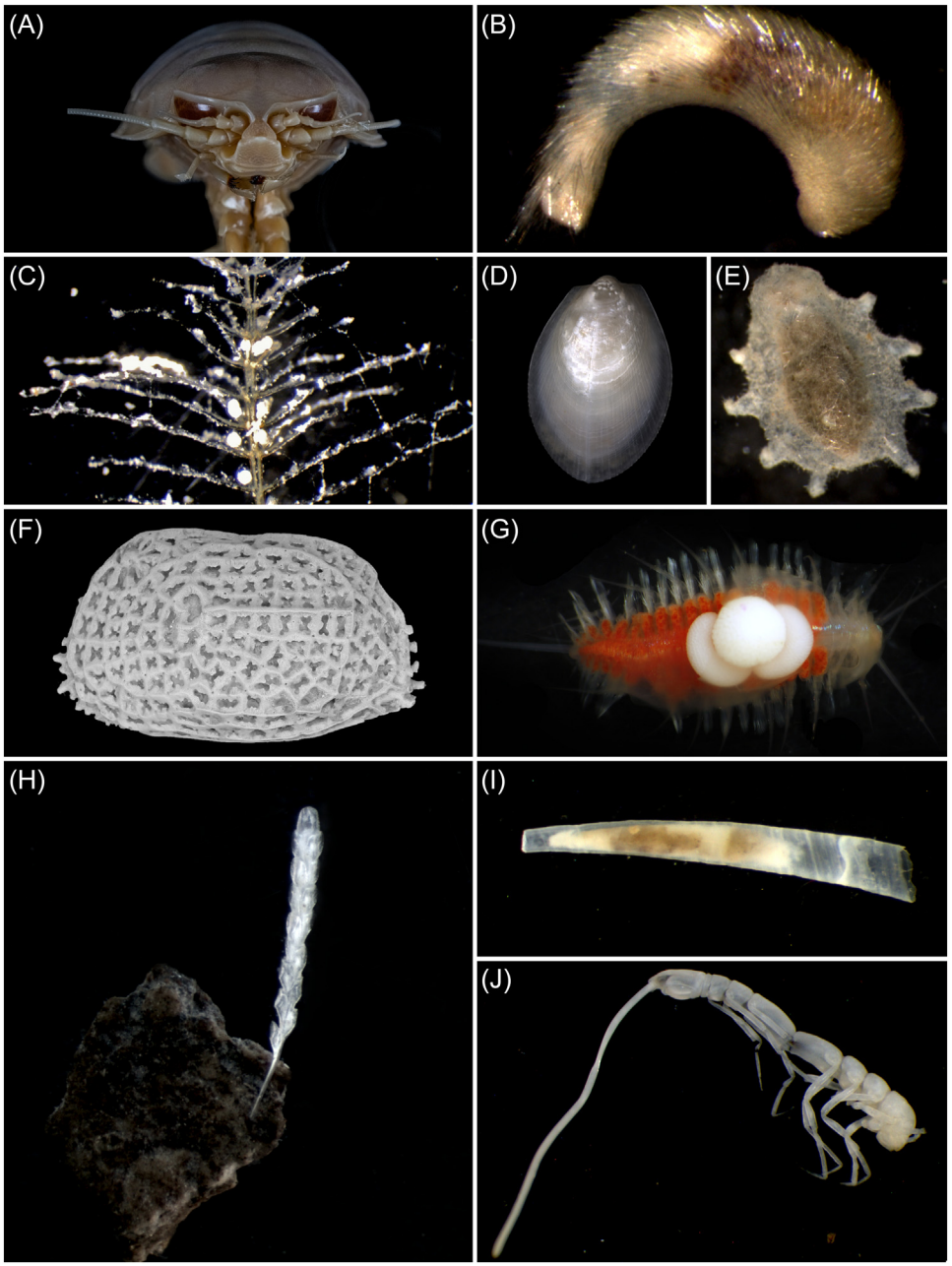

Figure 1. Marine invertebrates without a name or an IUCN Red List assessment—most undiscovered marine animal species are invertebrates; often, they inhabit remote habitats and are rather smaller in size. (A) Scavenging giant deep-sea isopod, *Bathynomus* sp. (Crustacea; Gulf of Aden, ca. 750 m depth; photo: Torben Riehl). (B) Shell-less mollusc (Solenogastres; Brazil Basin, SW Atlantic, ca. 5000 m; photo: Torben Riehl and Guillermo Diaz Agras). (C) Polyp colony (Hydrozoa; Argentine Basin, SW Atlantic, ca. 5000 m; photo: Torben Riehl and Guillermo Diaz Agras). (D) *Limatula* sp. (Bivalvia, 'file clam'; N Pacific, Aleutian Trench, 6199–6357 m depth; photo: Julia D Sigwart). (E) Sea cucumber (Holothuroidea, 'namako'; Argentine Basin, SW Atlantic, ca. 5000 m). (F) Seed shrimp *Lankacythere* sp. (Ostracoda; N Indian Ocean, Republic of Maldives, ca. 400 m depth; photo: Simone Nunes Brandão). (G) Bristle worm Macellicephalinae gen. sp. (Polychaeta; Costa Rica, Pacific, Seamount, 1807–2109 m depth; photo: Ekin Tilic) with parasitic

(Figure legend continued at the bottom of the next page.)

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affecting carbon sequestration, they form the foundation of marine ecosystems and play critical roles in food webs and biogeochemical cycles [10,11], yet marine invertebrates have been overlooked in conservation science and Red Listing, where this relationship is especially vital. Therefore, the present review focuses on invertebrates to demonstrate how an integrated approach can mobilise their study and protection.

Taxonomy has advanced substantially in recent decades. The increased rates of species description across certain taxa and regions [12] illustrate the enormous potential of integrating technological advances in DNA sequencing and databasing into taxonomy. Research on hyperdiverse terrestrial groups, such as insects, has demonstrated the potential of fast-track taxonomy [13–15]. The integration of high-throughput sequencing and automated image analysis will accelerate **species discovery** and naming [16–18]. Advances in technology, collaboration, and Findable, Accessible, Interoperable, and Reusable **(FAIR) data** sharing support this goal. Key platforms, including the Biodiversity Heritage Library[ii], World Register of Marine Species[iii], Global Biodiversity Information Facility[iv], and ZooBank[v] [19], have consolidated critical taxonomic information and enabled synthesis across regions and taxa. Natural history museums worldwide are also taking major steps towards digitising legacy specimen metadata and images from historical and ongoing collections that underpin biodiversity data [20,21]. Citizen science initiatives embedded in larger biodiversity projects have tremendous potential to be an integral component of global biodiversity assessment architectures and pinpoint areas of interest for species discovery. This is exemplified by the Atlas of Living Australia [22], which aggregates biodiversity information not only from museums, herbaria, universities, and field surveys, but also public contributions such as iNaturalist[vi], and volunteer-based specimen digitization, like DigiVol[vii] to support research, conservation, and environmental monitoring. Together, these developments point to a step change in solving the bottlenecks in what taxonomy can deliver—not only documenting life but also informing and supporting effective conservation and management (e.g., [6,23–25]).

Although taxonomy has traditionally been undervalued [26] in research and policy systems and is increasingly underrepresented in science and management [27], the present moment offers a unique opportunity to change this trend. The persistent framing of global changes, such as ocean acidification and biodiversity loss, as crises and losses can lead to disengagement and 'crisis fatigue', a condition in which urgent messaging becomes less effective in motivating public and political action [28,29]. This phenomenon is well studied in climate change communication and is equally relevant to biodiversity. Rather than continuing to present taxonomy as a discipline in perpetual decline, we argue that it is time to reposition it as a forward-looking and dynamic field (see [12,30]). Seizing opportunities created by new technologies and conservation frameworks requires a motivated, skilled, and visible practitioner community. Taxonomy, conservation, and public engagement are not isolated activities; they are mutually reinforcing. In this review, we first outline how taxonomy can accelerate the discovery and description of marine invertebrates. We then examine how linking taxonomic knowledge with IUCN Red List assessments can make marine invertebrate biodiversity more visible and actionable in conservation. Finally, we explore how public engagement can raise the profile of marine invertebrates and create feedback loops that support both taxonomy and Red Listing, together forming an integrated framework for marine biodiversity conservation.

'fish lice' (Copepoda). (H) Moss animal (Bryozoa; Argentine Basin, SW Atlantic, ca. 5000 m; photo: Torben Riehl and Guillermo Diaz Agras). (I) tusk shell (Scaphopoda; Argentine Basin, SW Atlantic, ca. 5000 m; photo: Torben Riehl and Guillermo Diaz Agras). (J) isopod crustacean (Isopoda) with parasitic roundworm (Nematoda, emerging from the isopod's posterior end; Argentine Basin, SW Atlantic, ca. 5000 m; photo: Torben Riehl and Guillermo Diaz Agras). Images not to scale. All photos: CCBY4.0.

Glossary

Endangered (EN): IUCN Red List category for species facing a very high risk of extinction in the near future.
FAIR data: guidelines ensuring that scientific data are Findable, Accessible, Interoperable, and Reusable (FAIR), maximising data utility and sharing.
Hydrothermal vent: a seafloor fissure emitting geothermally heated water, which, in deep-sea environments, creates unique ecosystems rich in specialised organisms.
IUCN Red List of Threatened Species: an authoritative global inventory of plant, fungi, and animal species' conservation status, evaluating extinction risk using standardised criteria.
Public engagement: two-way interactions between institutions, experts, or organizations and the broader public—encompassing outreach, communication, policy advocacy, and citizen science—grounded in principles of dialogue, mutual learning, and inclusive participation.
Red Listing: the process of assessing extinction risk according to the IUCN criteria and assigning species to the Red List categories.
Species discovery: recognising, documenting, and formally naming previously unknown organisms, encompassing their detection in nature and their formal taxonomic interpretation; the predescription phase involves collecting and recognising specimens as distinct—often through field exploration, morphology, or genetic data; the subsequent taxonomic phase transforms this into formal scientific knowledge by describing, diagnosing, and naming species; a species' official place in science and conservation is established through their unique, universally valid scientific names.
Taxonomy: a scientific discipline concerned with naming, describing, and classifying organisms into hierarchical groups based on shared characteristics in morphology and, increasingly, molecular data, forming a structured system of ranks such as species, genus, and family; hypotheses of evolutionary descent are (often implicitly) inherent, which help organise the vast diversity of life and facilitate communication about relationships and identities among organisms; a universal framework for identifying species, enabling accurate

Building momentum in marine taxonomy

Taxonomy is concerned with discovering, describing, classifying, and naming species; it provides fundamental knowledge for biodiversity assessment and conservation [25,31]. This research is essential for replicability and sustainability in the biological sciences, which depend on studying species or systems of species interactions, such as those found in ecology or physiology. Taxonomic investigations lead to the discovery of new species potentially at risk, understanding species distributions and ecological roles, and providing data for conservation assessments [24,32]. Taxonomic research identifies cryptic species—morphologically similar yet genetically distinct organisms [33–36]—that often require different conservation strategies [37–39]. Moreover, taxonomy can detect ecosystem threats from biological invasions [40,41] as biogeographic patterns are reshaped by anthropogenic activities [42].

In many groups of organisms, invertebrates in particular, new species are being described at an accelerating pace, with more researchers from a growing number of countries participating in this effort than ever before [43]. Although discovery rates have declined for some well-known animal groups, such as birds and mammals, this is not a general trend, and the community of taxonomists regularly names and describes between 15 000 and 20 000 new species every year [43], approximately 2000 of which are marine [9]. Recent developments in molecular science, digital imaging methods capable of processing large quantities of data, and increasing digitisation of historical documents and reference specimens have greatly increased the pace and ease at which biological classification research can be conducted [4]. When these advances are paired with the open sharing of information and worldwide cooperation among researchers, the field of taxonomy possesses a greater global reach than ever before [44,45], as demonstrated by the EU-funded Distributed System of Scientific Collections (DiSSCo) project[viii]. DiSSCo demonstrates this acceleration by integrating artificial intelligence-driven digital imaging, optical character recognition (OCR), and molecular data linkage on digitised specimens to automate trait extraction and taxonomic annotation at scale.

However, participation does not always equate to expertise, and new species discovery does not automatically mean that these species are available for science, conservation, and policy. On the one hand, while taxonomic authorship is increasing globally, this often reflects growing co-authorship across disciplines rather than a proportional increase in trained taxonomists [18,46]. The distribution of new species descriptions among taxonomists is highly uneven. Most new marine species are described by a core group of highly active taxonomists, where roughly 20% of taxonomists account for 80% of new species descriptions. In contrast, a significant proportion of taxonomists are 'occasional' contributors, with many authors participating in species descriptions infrequently [9]. There is also a clear shift in authorship trends, with a decline in regular taxonomic authors in Europe and Australia [27,47], and concurrently increasing contributions from Asia and Latin America [46]. Species newly discovered in the field, on the other hand, often take decades until they are 'rediscovered' in natural history museum collections and eventually described and named [48]. The priority now is to support and sustain the existing global community, ensuring that taxonomy continues to grow and that emerging contributors are empowered to deepen their expertise.

Consequences of these taxonomic gaps extend far beyond incomplete inventories and highlight the need for global collaborative initiatives such as the Ocean Census[ix], which help to accelerate the discovery and documentation of marine life in support of science and conservation. Without formal species descriptions, biodiversity cannot be fully incorporated into the frameworks that drive conservation action. Species descriptions are a fundamental prerequisite for extinction risk assessments via the **IUCN Red List of Threatened Species** (hereafter, 'IUCN Red

biodiversity assessments, and guiding targeted conservation and management.
Threatened (IUCN Red List): an umbrella term encompassing three IUCN Red List categories: Vulnerable (VU), Endangered (EN), and Critically Endangered (CR).
Type image: a photograph or digital representation of a specimen designated as the name-bearing type for a species.

List')[x]. Because undescribed species can only be assessed under strict and exceptional conditions [49], many still cannot be evaluated on the IUCN Red List, contributing to unnoticed extinctions [8,50]. This is not merely an abstract concern: the uneven geographic and taxonomic distribution of descriptive effort means that certain regions and lineages bear a disproportionate share of this invisibility—and, therefore, of extinction risk [51,52].

Red Listing as a framework for visibility and conservation action

Geographically, regions that are biodiversity hotspots [53], such as large parts of the tropics, are disproportionately affected by the potential extinction of undiscovered species. The Caribbean region, for instance, is recognised as a major global marine biodiversity hotspot, with high rates of endemism and more than 12 000 known marine species representing 31 animal phyla [54]. The Australian deep sea, comprising the largest habitat of the country, is another good example of a situation where a substantial lack of taxonomic knowledge [55] bears the risk of unnoticed species loss, for instance, as a consequence of future mining of polymetallic nodules or the effects of global change [55].

The IUCN Red List is the most widely used and authoritative global framework for assessing the extinction risk of species and is a critical indicator of progress towards the Kunming-Montreal Global Biodiversity Framework [56,57]. It offers a standardised, evidence-based system for evaluating the risk of extinction of species, grounded in quantitative criteria that include population size, rate of decline, geographic range, and population fragmentation [49,57]. Assessments within the IUCN Red List are regularly updated as new scientific information becomes available. These updates allow the IUCN Red List to track changes in species' status over time and thus offer a comprehensive and evidence-based foundation for conservation action. Its outputs are essential for directing resources, including stakeholders' attention and funding, towards the species and ecosystems facing the greatest threats, ultimately supporting more effective and informed conservation strategies.

Beyond individual assessments, the IUCN Red List underpins national and international biodiversity strategies. The Red List Index (RLI [58]), which quantifies trends in overall extinction risk for species, feeds directly into global policy frameworks to shape and track progress towards global targets, such as the Convention on Biological Diversity's Kunming-Montreal Global Biodiversity Framework and the UN Sustainable Development Goals [58,59]. Its influence stems from its credibility, transparency, and global applicability, making it a cornerstone of contemporary biodiversity monitoring and conservation decision-making. In Sicily, for example, a pilot study explicitly used IUCN Red List categories and the RLI of marine species to evaluate where **threatened** species assemblages were most concentrated and to inform the planning and justification of new or expanded marine protected areas in the region [60].

Although the IUCN Red List assesses animals, plants, and fungi worldwide, assessment efforts are heavily biased towards terrestrial vertebrates and other well-studied taxa [8,53,61]. The IUCN Species Survival Commission oversees IUCN Red List assessments through its network of Specialist Groups—volunteer-based expert communities responsible for taxon-specific evaluations [56,62]. However, few Specialist Groups exist for marine invertebrates (although recent years have seen the emergence of several new Specialist Groups), and currently, many organism groups at risk are not represented by any Specialist Group, such as deep-sea corals or giant isopods, leaving a significant gap in taxonomic coverage and applied expertise. Consequently, entire major clades remain unassessed, effectively excluding significant evolutionary heritage from legislative protection or funding allocations that may follow Red Listing [63].

Taxonomists often possess relevant information necessary for applying the criteria for IUCN Red List assessments. This includes data on endemicity, historical records, life history traits, obligate ecological associations, and locality-specific threats to focal taxa. Taxonomic publications, such as species descriptions, offer opportunities to incorporate this type of information, thereby making it openly available. Modern species descriptions often include subheadings for 'ecology', which could easily be modified or expanded to capture data items directly related to conservation, such as population size and potential threats. This presents a significant opportunity to utilise taxonomic expertise in assessing the extinction risk of marine invertebrates.

Structured assessments have been successfully applied to high-risk invertebrates, particularly those with restricted ranges and imminent threats, such as deep-sea species at **hydrothermal vents** threatened by mining [63,64] and those of economic importance [65,66]. Marine molluscs, as an example, represent nearly a quarter of all known marine species; certain mollusc groups are especially sensitive due to their specific biological and environmental characteristics or commercial interests, including being highly susceptible to habitat degradation and heavily impacted by climate change and ocean acidification [67]. Among 639 species of cone snails, 13.3% of species are assessed as Data Deficient (meaning that there is not enough information available to reliably assess a species' risk of extinction), but many show traits associated with high extinction risk; 6.6% were considered threatened with extinction, a further 4.7% being near threatened, and one species is declared extinct[xi] [68]. Marine invertebrates more broadly have been previously neglected in conservation science (e.g., [8,23]), with orders of magnitude fewer threat analyses and publications than vertebrate groups like marine turtles, and we are still lagging behind in filling these gaps. Many species have never been observed alive or are only known from a few specimens and/or single collecting events, making it challenging to assess their threats. However, this makes the case for inclusion even stronger: Red Listing—even where data are sparse—can highlight urgent conservation needs, stimulate research, and offer a pathway to visibility for overlooked marine taxa. IUCN Red List assessments are explicitly based on the best available evidence at the time of assessment and are subject to revision and updating. Even preliminary assessments can increase visibility and help identify areas and clades of concern.

When the IUCN Red List is actively linked to ongoing species research, it creates a powerful and immediate pathway for new scientific insights to directly shape conservation actions, such as habitat protection. Although such integration is not yet a standard practice, its demonstrated impact highlights the value of adopting this approach more broadly to accelerate effective conservation outcomes. Contemporary instances of this pathway are presented in Box 1.

Red Listing, in turn, can catalyse taxonomic research by prioritising poorly known taxa at risk. The link between taxonomy and the IUCN Red List has been particularly effective for amphibians, where coordinated IUCN Red List assessments have helped drive new taxonomic research, resulting in the description of hundreds of species and improved resolution in key clades[xiii] [75]. As a species-based tool, the IUCN Red List depends on clear taxonomic boundaries, but it also provides motivation to complete and revise the taxonomy of species where assessments are needed. This relationship is especially vital for marine invertebrates, where many taxa remain undescribed or are taxonomically unresolved. Red Listing can highlight research and conservation needs, attract attention to neglected groups, and incentivise taxonomic progress, ultimately making these species visible and actionable through global biodiversity policy. Beyond informing conservation needs and policy, the role of the IUCN Red List as a communication tool also serves to raise awareness of global species diversity in general [56,61,76].

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Box 1. Examples of an integrated framework linking taxonomy, Red Listing, and public engagement

Example 1 (taxonomy → assessment → public engagement → policy): The hydrothermal-vent snail *Chrysomallon squamiferum* was formally described in 2015 [69] and assessed as **Endangered** (EN) in 2019 [63]. Its striking iron sulfide scales made it a compelling flagship species; the IUCN Red List designation attracted broad media coverage (e.g., BBC, The Guardian), and organisations such as the Deep Sea Conservation Coalition[xii] used the listing to mobilise public opposition to seabed mining. The EN status has been cited in International Seabed Authority [70] deliberations over environmental management frameworks for hydrothermal-vent mining contracts, reinforcing calls for precautionary regulation of the deep-seabed mining sector before comprehensive ecological baselines are established.

Example 2: (taxonomy → public engagement → assessment → policy): Significant progress has been made in integrating taxonomic descriptions, Red Listing, and public engagement concerning Ecuador's herpetofauna. Newly described amphibian and reptile species are systematically accompanied by IUCN Red List assessments and receive substantial media coverage. For example, the Led Zeppelin's rain frog *Pristimantis ledzeppelin* [71] has been extensively publicised in leading international outlets, and its proposed threat status has been formalised in Ecuador's National Red List [72]. By formalising *P. ledzeppelin*'s EN status, the species gained legal standing and constitutional protection, mandating its consideration in environmental impact assessments, and strengthening mining opposition within its narrow range in the Cordillera del Cóndor. Beyond this single species, the listing added to a growing national dataset helping Ecuador make more accurate, policy-relevant conservation decisions for one of the world's most imperilled vertebrate faunas.

Example 3 (taxonomy → assessment → policy): The deep-sea coral *Deltocyathus zoemetallicus*, found in a proposed Pacific seabed mining area, is likely to be vulnerable to deep-sea mining impacts [73]. While its formal description has just been published, ongoing assessments of its extinction risk are already underway. Lessons learned from similar cases in terrestrial and shallow waters highlight that waiting for regulatory processes to run their course—while mining proceeds—is a demonstrably high-risk approach for species with small ranges and extreme habitat specialisation.

Example 4 (conservation → taxonomy): Conservation prioritisation surveys in two of East Africa's most threatened forest systems were the catalyst for a taxonomic synopsis of the white ironwood genus *Vepris* [74]. Specimens collected during those surveys could not be identified to species, blocking formal IUCN threat assessments and therefore hampering protection efforts. This gap drove a taxonomic investigation recognising three previously unknown *Vepris* species.

Public engagement and participation to expand interest, involve policymakers, and build community and partnerships

Names help make species 'real' by transforming abstract biodiversity into tangible and relatable entities. The desire to name and categorise is deeply human and underpins how people relate to nature [45]. Species names provide a semantic anchor for ecological and evolutionary understanding [77], but they also play a critical role in public discourse [78]. The process of species discovery and naming captures the imagination and offers a productive interface for broadening participation in biodiversity science. Public interest in 'new species' announcements illustrates this point: the act of naming provides a narrative hook that draws attention well beyond disciplinary boundaries (see, e.g., [79]). Similarly, species newly categorised on the IUCN Red List as threatened may attract widespread public attention [61,63]. In a contemporary world that often appears thoroughly explored and understood, recognising the vast extent of what remains undiscovered—and the significant implications of these unknowns—can serve as a compelling motivator for public interest in and support for biodiversity research, exploration, and conservation efforts [80].

The potential to inspire is particularly relevant for marine invertebrates, which are typically either absent from popular media and stakeholder debates or lumped into broad categories ('sea jellies' and 'crabs'). Taxonomic outputs—names, diagnoses, and **type images**—are ready-made assets for effective public engagement [81,82]. Successful programmes and organizations, such as the Schmidt Ocean Institute[xiv] and NOAA Ocean Exploration[xv], showcase how modern imaging, telepresence, and information-processing technology further assist this, rendering organisms linked to scientific names, even those barely visible to the naked eye, accessible to a worldwide audience. Thanks to efforts like these, ocean exploration is entering an era of real-time discovery, in which shore-based specialists can actively guide imaging systems at sea to focus on particular organisms and coordinate sampling.

In contrast to classical science communication, effective public engagement demands more than one-way dissemination. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)[xvi] emphasises stronger interfaces between research and decision-making, focusing on coproduced knowledge and participation [83]. Taxonomic and biodiversity data must be translated into policy-relevant formats. The translational ecology model emphasises coproduced research agendas and embedding technical knowledge into governance [84,85].

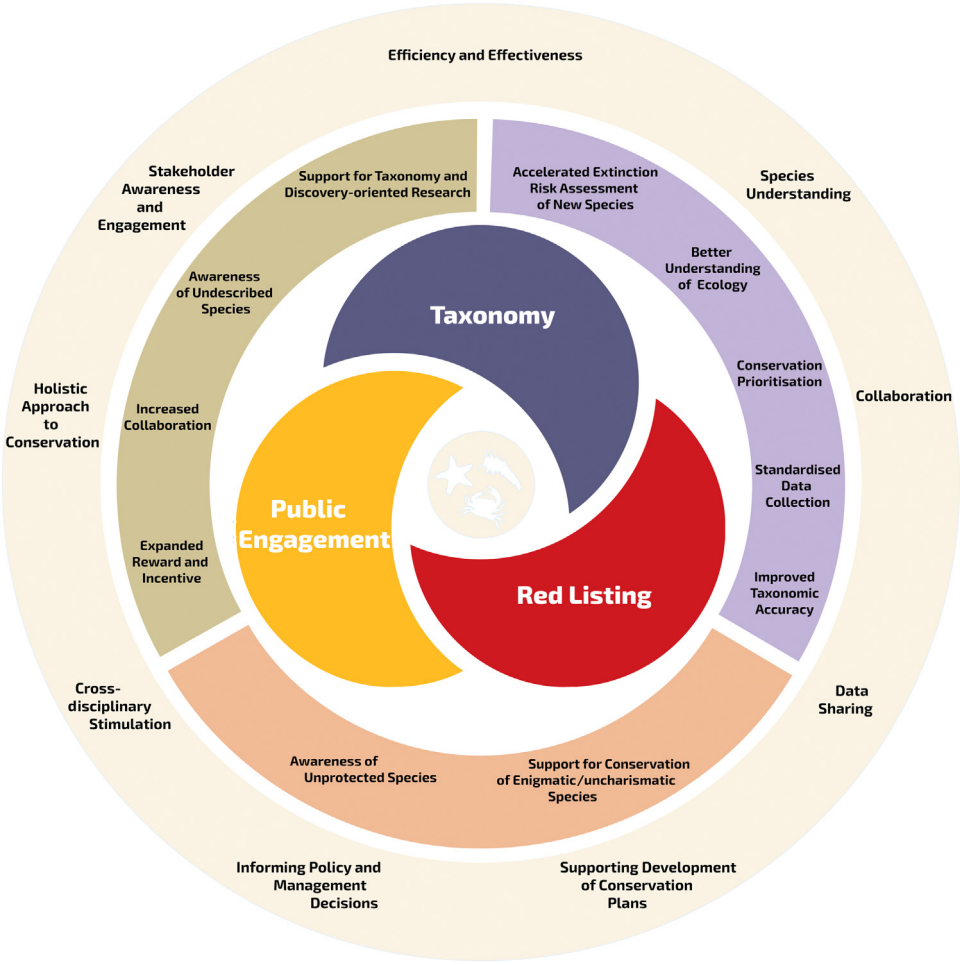

Figure 2. Synergistic interactions among the fields of taxonomy, IUCN Red List assessment, and public engagement maximise research and conservation output. Synergies may form between two or all three fields at all levels of interaction (inner and outer circles, respectively). Collaborations between taxonomy (species discovery and description) and Red Listing (assessment of extinction risk) promise a streamlined path from discovering to assessing and protecting threatened species where relevant, as well as increased efficiency and comprehensiveness of taxonomic research. The integration of taxonomic work with public engagement holds the potential for leveraging increased support as a result of greater awareness and collaboration. Furthermore, embedding taxonomic work in outreach campaigns represents an additional incentive for taxonomy in the first place. Red Listing can benefit from public engagement, for instance, by inspiring fascination for and valuing of species, especially those that are enigmatic or seemingly uncharismatic. Taxonomy and Red Listing cocreate compelling narratives with public engagement through iterative storytelling. Stakeholders collaboratively shape outreach campaigns by contributing perspectives that refine research priorities, while a holistic conservation approach—built via shared dialogue—heightens mutual awareness and mobilises sustained support for both fields.

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Public engagement, in this analytical sense, is a process of aligning taxonomic information with policy needs (refer examples in Box 1).

Species-level resolution is crucial for conservation and ecological management [86–89]. Marine ecosystems are often understood through broad categories, such as functional groups or ecosystem services, which can mask important differences among individual species. Considering individual taxa in policy enables more targeted protection of biodiversity and ecosystem functions that may be overlooked when focusing only on generalised roles or services (e.g., [90]). Species-focused conservation approaches are concerned with promoting the persistence of all biodiversity, including species or ecosystems that do not have identified value for humans, in contrast to ecosystem services approaches [91]. A lack of taxonomic clarity may reduce the effectiveness of policy decisions that depend on biodiversity indicators and restoration targets. Species-level data are, therefore, valuable for ecological interpretation and policy.

Expanding the work and influence of the taxonomic community requires active engagement with the broader public, policymakers, and resource managers involved directly in conservation

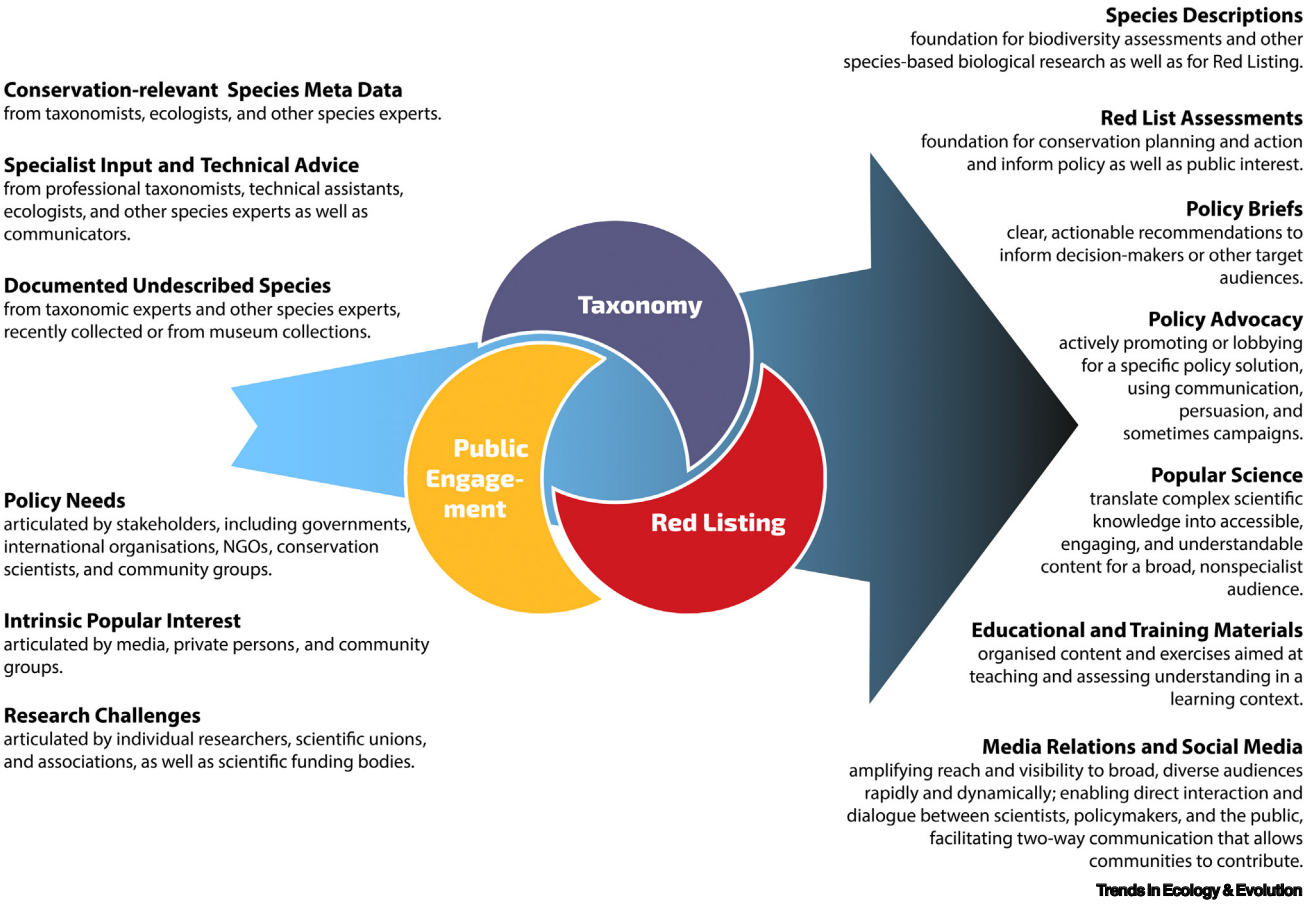

Figure 3. An integrated framework linking taxonomy, Red Listing, and public engagement towards conservation impact, where stakeholder needs and interests, conservation-relevant data, specialist knowledge, and undescribed species feed into interconnected processes of taxonomy, Red Listing, and public engagement. This emphasises that workflows may begin in any of these domains and can generate diverse conservation outcomes, ranging from taxonomic discovery catalysing conservation action to well-informed conservation priorities guiding taxonomic or engagement initiatives, as shown through four examples in Box 1.

decision-making. Public engagement and participation strategies that involve nonspecialists can directly contribute to the documentation and protection of marine biodiversity. Programmes involving citizen science, collaborative monitoring, and community fieldwork have expanded the scope and scale of data collection while also contributing to public awareness and stakeholder involvement [92–97]. Such initiatives also diversify funding streams: philanthropic and corporate donors tend to support projects that demonstrate clear public resonance, and species discovery reliably meets this criterion.

The intersection of taxonomy, IUCN Red List assessment, and structured public engagement forms a mutually reinforcing triad, with each element supplying the others with data, legitimacy, and audience. The task ahead is to institutionalise this synergy so that marine invertebrate biodiversity is not only documented but also represented in policy arenas where conservation priorities are set.

Synergy for ocean species

Synergy, where combined effects exceed individual contributions, requires structural integration beyond interdisciplinary collaboration. In marine biodiversity research, three pillars—taxonomy, IUCN Red List assessment, and public engagement—offer distinct value but have limited impact when considered in isolation. Taxonomists cannot effectively influence conservation policy alone; conservationists work better with described species, and stakeholders, including resource managers, need credible and relatable data for meaningful outcomes. An integrated approach combining taxonomic research, IUCN Red List assessments, and strategic public engagement (Figure 2) maximises the impact. When coordinated, these fields reinforce each other: taxonomy informs threat assessment, assessments drive effective decision-making, and engagement

Box 2. The Senckenberg Ocean Species Alliance (SOSA)—an integrative initiative for biodiversity discovery and conservation

SOSA exemplifies the integrative principles outlined in this article, applied to marine invertebrate biodiversity. It operates as a species knowledge hub and inclusive, growing network connecting experts across taxonomy, Red Listing, and public engagement—reflected in three pillars: Protect, Discover, and Inspire (Figure I). Hosted by the Senckenberg Society for Nature Research (Frankfurt, Germany), SOSA links individuals and organisations worldwide through three complementary units:

Discovery Unit: Drives global collaboration, centralises technical services [18], and incentivises taxonomic work [101] to accelerate species description, mobilising taxonomic innovation and efficiency.

Red List Unit: Coordinates extinction risk assessments through the Marine Invertebrate Red List Authority (MIRLA [102]) within the IUCN system, translating scientific discovery into conservation priority.

Public Engagement Unit: Mobilises support and awareness through outreach, science communication, and policy advocacy, inspiring and engaging broader audiences through partnerships and active participation (see, e.g., [79]).

By systematically connecting these components, SOSA ensures that taxonomic data move swiftly from discovery to risk assessment and societal impact. Through MIRLA, it provides an operational framework for assessing extinction risk across marine invertebrate phyla, bridging species discovery and practical conservation data, while addressing the chronic underrecognition of taxonomy.

Discovery services offered by SOSA accelerate species descriptions by taking time-consuming technical tasks—specimen dissection and imaging—off taxonomists' shoulders, freeing capacity for data interpretation and writing [18,101]. Its innovative publication strategy integrates individual species descriptions into collaborative, high-impact articles [79,101,103].

SOSA's public engagement work is equally multifaceted, spanning global science communication and participatory media campaigns (see, e.g., [79]) to community outreach and bidirectional partnerships with civil society, policymakers, and the public. Crucially, this work is deeply intertwined with the Discovery and Red List Units: new species descriptions fuel communication campaigns, public engagement generates societal support for extinction risk assessments, and IUCN Red List outcomes feed back into advocacy—creating reciprocal synergies across all three pillars.

By demonstrating that biodiversity science can be collaborative, scalable, and publicly resonant, SOSA reframes taxonomy as a modern, mission-driven discipline. It is intentionally designed as both a replicable model for similar initiatives elsewhere and an open alliance that welcomes institutions and individuals worldwide—mirroring transformative scientific collaborations such as the Census of Marine Life [104] and the Human Genome Project [105].

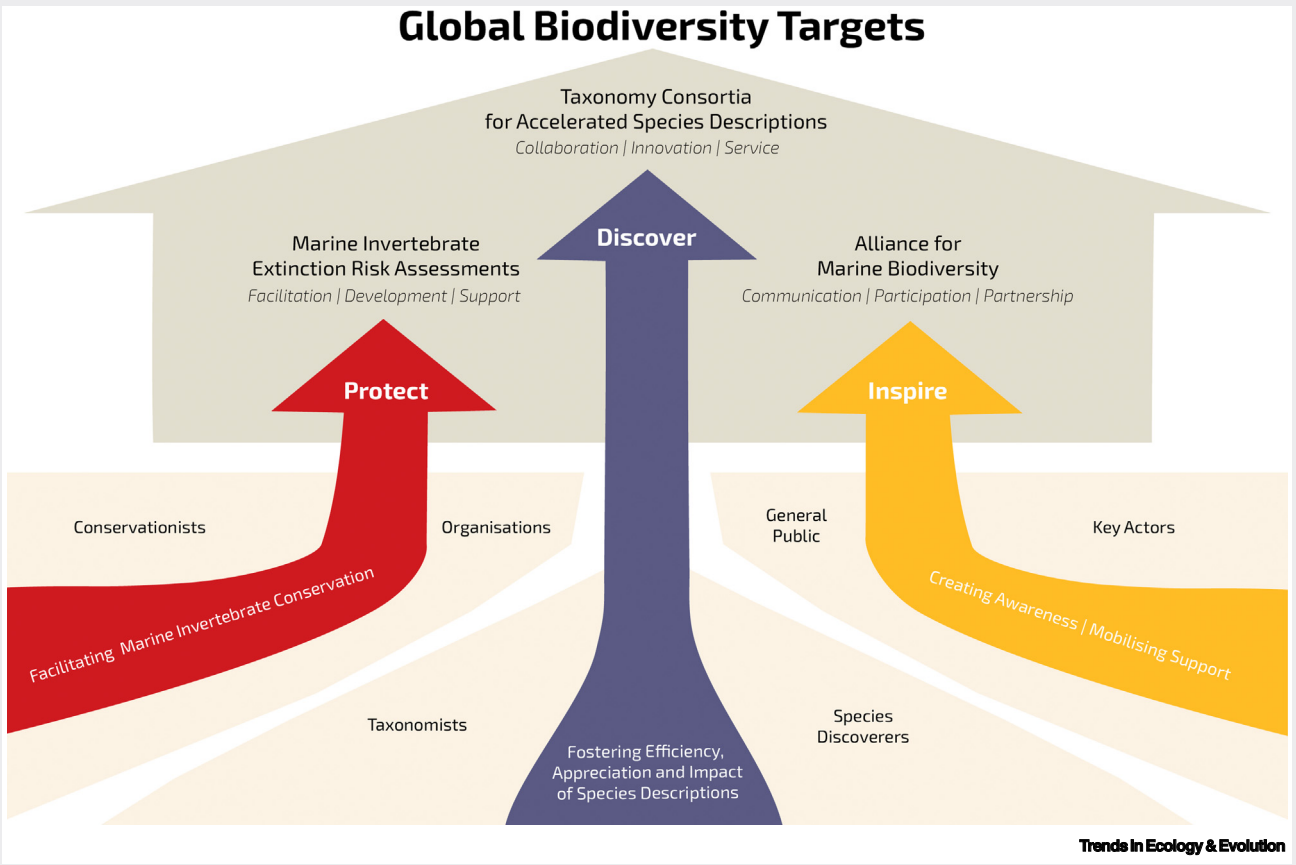

Figure I. Conceptual design of the SOSA's roles.

mobilises support for biodiversity protection. Finally, stakeholder involvement helps mobilise the additional resources and information that enable new discoveries and taxonomic advances. This integration unlocks the full potential of biodiversity science (Box 1).

Taxonomy and Red Listing are deeply interlinked, as both fields rely on species as their fundamental 'unit', creating a continuum from species discovery to effective conservation action. When new species are described and assessed simultaneously, conservation efforts can be implemented before losses become irreversible, especially in vulnerable marine ecosystems such as hydrothermal vents and cold seeps. This strategy has shown promise in terrestrial systems (e.g., [98–100]), where species descriptions include conservation-relevant information. IUCN Red List assessments require data on ecology and distribution, for example, which also inform taxonomy. Aligning these processes facilitates both activities, reduces duplication, and ensures that new species are visible in conservation decision-making. These benefits extend beyond science (Figure 3; Box 1).

Public engagement fertilises both taxonomy and Red Listing through two-way synergies. The IUCN Red List itself serves as a powerful communication tool, efficiently conveying extinction urgency to the public, stakeholders, and policymakers—prompting actions such as funding,

protection measures, or behavioural change that directly support taxonomic research and assessment efforts. Conversely, public participation opens the field of taxonomy to wider involvement, as exemplified by the chiton *Ferreiraella populi* Sigwart, 2026, named via a social media contest tied to a short, humorous documentary[xvii], which harnessed viral outreach to crowdsource name ideas [79]—increasing public understanding, valuing, and support for taxonomy and marine invertebrates. Moreover, public engagement catalyses taxonomic and Red Listing efforts via debates like deep-sea mining—widely covered in media and amplified by NGOs ensuring remote ecosystems stay visible. This spurs demands to document mining-zone biodiversity and impacts, driving initiatives like the Sustainable Seabed Knowledge Initiative[xviii] and Red List of Hydrothermal Vent Species[xix]. These accelerate discovery and risk assessments where threats meet knowledge gaps, fuelling triad synergies.

This integrated triad approach addresses the perception that taxonomy is too slow or disconnected to contribute meaningfully to conservation. Recent initiatives have demonstrated the dynamic nature of taxonomy by showing that species discovery aligns with conservation outcomes and policy-relevant workflows. Integration increases efficiency and restores the credibility of taxonomy as an active discipline, providing a framework to reposition it within biodiversity policy and communication.

Concluding remarks

The future of taxonomy is strengthened by underpinning biodiversity discovery and its foundational role in species conservation. As a central pillar of biological sciences, taxonomy provides foundational knowledge for understanding and sustainably managing the natural world. Its role ensures that science and society can address the most pressing conservation challenges. Interdisciplinary networks and policy frameworks now support this shift. An integrated approach connecting taxonomy with conservation mechanisms and tools for public engagement shows that taxonomic research can be fast, impactful, and socially engaged (see Outstanding questions). These advances establish taxonomy as a viable and appealing professional field that attracts investment and commands influence in the science and conservation landscapes. This approach offers a credible vision of marine biodiversity science that can meet current needs. The Senckenberg Ocean Species Alliance (SOSA) (Box 2) is an example of how researchers, conservationists, policymakers, and civil society can come together to achieve this goal, accelerate species discovery, and protect marine life for future generations.

Outstanding questions

How can collaborative research consortia in marine taxonomy, conservation, and public engagement be designed to maximise synergy and knowledge exchange across disciplines and countries?

What new models will ensure equitable and sustainable access to shared technical resources and expertise for marine species discovery research?

How do outsourcing and service-oriented approaches affect the quality and sustainability of taxonomic research?

How can integrative, network-based research approaches be translated into stronger cross-sector partnerships for marine species conservation?

How can cross-sectoral collaboration be strengthened to protect newly described ocean species from emerging threats?

Why is it important to invest time and resources in public engagement activities?

How can decision-makers and managers be encouraged to protect the functioning of marine ecosystems amid climate change, destructive fishing, and other escalating pressures?

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Declaration of interests

The authors declare no competing interests.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author used Claude Sonnet 4.6 (Anthropic) to improve the language, grammar, and spelling of the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Resources

[i]https://www.unesco.org/en/decades/ocean-decade

[ii]https://www.biodiversitylibrary.org/

[iii]https://www.marinespecies.org/

[iv]https://www.gbif.org/citation-guidelines

[v]https://zoobank.org/

[vi]www.inaturalist.org

[vii]https://volunteer.ala.org.au/

[viii]https://www.dissco.eu/

[ix]https://oceancensus.org/

[x]https://iucn.org/

[xi]https://www.iucnredlist.org/en

[xii]https://deep-sea-conservation.org

[xiii]amphibiaweb.org

[xiv]schmidtocean.org

[xv]oceanexplorer.noaa.gov

[xvi]https://www.ipbes.net/

[xvii]https://www.youtube.com/watch?v=G7HkBBJO7ZU

[xviii]https://isa.org.jm/sski/

[xix]https://sosa.senckenberg.de/en/press/hydrothermal-vent-species/

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