The Magnitude of Global Marine Species Diversity

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Highlights

- We find that ~227,000 marine species have been described, and an additional 170,000 are no longer valid.
- The sum of our individual estimates suggest 0.7 to 1.0 million marine species may exist, and the statistical model 0.5 ± 0.2 million.
- 70,000 species may already be in specimen collections and waiting to be described
- Taxonomic revisions and molecular methods will discover more synonyms and cryptic species, and will further refine these estimates.

Abstract

Background
The question of how many marine species exist is important because it provides a metric for how much we do and do not know about life in the oceans. We have compiled the first register of marine species of the world and use this baseline to estimate how many more species, partitioned among all major eukaryotic groups, may be discovered.

Results
There were ~227,000 eukaryotic marine species described. An additional 170,000 species names were no longer valid because they had been found to be synonyms. An unprecedented number of over 20,000 marine species had been described in the past decade. The number of people describing new species has been increasing more than the number of new species in the past six decades.

We estimated that 0.7 to 1 million marine species may exist, and a statistical model that used past rates of species description predicted 0.5 ± 0.2 million. About 70,000 species may already exist in specimen collections waiting to be described. 'Cryptic' species (only distinguishable by molecular as distinct from morphological methods) may add 40,000 to the number of currently known species, rescue names from synonymy, and synonymise some names. A review of the proportions of undescribed species in samples from 113 studies found an average of 37% (median 31%) of species may be new to science.

Conclusion
More species than ever before are being described annually by more people. Thus most species will be discovered this century. Considering also the proportions of undescribed species in samples, previous estimates of there being well over 1 million marine species are highly unlikely.

Introduction

The most widely used metric of biodiversity is species richness, and much has been written about how many species may exist on land and in the sea [1-3]. Recent estimates of the number of extant described marine species have varied from 150,000 to 274,000 and of those that may exist from 0.3 million to 10 million (see overview in Table S1 – in online supporting material). Most of these estimates have been made without the benefit of a global inventory of known marine species. Here, we report on the near completion of just such an inventory. The World Register of Marine Species (WoRMS) is an open-access, online database created by an editorial board of 240 taxonomists from 176 institutions in 33 countries [4]. The first goal of WoRMS has been the compilation of a list of all taxonomically accepted marine species, commonly used synonyms and key literature sources. Beyond complete taxonomic coverage, the longer-term aim is to provide or link to data on species distributions, biology, ecology, images and guides to their identification. An important side-benefit is that it facilitates communication within and beyond the taxonomic community which can lead to increased rates of discovery of species and synonyms, and decreased creation of synonyms.

This collaborative database enables the following set of metrics of marine biodiversity to be compiled for the first time: (1) the number of nominal species, *i.e.* species named, including those now recognized as synonyms due to multiple descriptions of the same species; and (2) the number of taxonomically accepted species, i.e. recognized species, excluding names that have been relegated to synonymy. In addition, we estimated (3) the number of species that have been collected but not yet described and the number of species that are (4) undiscovered (unsampled) and (5) morphologically cryptic, *i.e.* only distinguishable by molecular analyses. We also apply a statistical model that predicts how many more species may be discovered from the history of species descriptions, and compare it with values from the above estimates. We omitted the Bacteria and Archaea from our analysis because a comparable species concept cannot be applied to these taxa as can to eukaryotes.

Our estimates of valid and nominal species are based on the WoRMS database on 17 February 2012 and/or the literature for taxa for which WoRMS was not yet complete. The data on species collected but not yet described, undiscovered, and cryptic are based on personal experience, considering information on numbers of undescribed species we have observed in samples and our knowledge of particular habitats and geographic areas that remain little explored. The rationales for these estimates are provided in Supplementary Material (Table S3). We each limited our estimates to groups for which we have close working knowledge. The expert-opinion approach to estimating the magnitude of unknown biodiversity has been endorsed, for example, by Gaston [5], and used by many others (e.g. [6-7]). It complements macro-ecological approaches involving extrapolation from surrogate taxa, habitats and/or geographic areas [reviewed in 2]. As expertise declines away from a taxonomists focal group, our collective estimates are less likely to be biased than previous estimates made by fewer experts. The 240 editors in WoRMS represent ~5% of the active marine taxonomists today (based on ca. 4,900 publishing marine taxonomists in the last decade), but are responsible for nearly one third of new species descriptions in the past decade [4]. To indicate areas of uncertainty, we applied minimum and maximum estimates.

There is a large literature on statistical prediction of the number of species remaining to be described [8-9], where it is known more generally as the 'number of kinds' problem. Most methods of estimation require data in the form of a sample of individuals of known size, where each individual in the sample has been identified so that the proportional abundance of individuals among species in the sample is known.

Such samples are available for only a small portion of the biosphere, making their use difficult. However, the global rate of species description is known, allowing curve fitting and extrapolation to be used for prediction [10-14]. We compared the expert-based estimates on the total number of marine species to predictions generated by a non-homogeneous renewal process model based on extrapolation of the discovery curve as a logistic function[P1]. The logistic function has the form

$$\text{Number discovered by year } t = \frac{N}{1+\exp\left(-\beta(t-\alpha)\right)},$$

and takes on an 'S' shape, going from 0 at t = –∞ to N at t = +∞. The logistic function is a popular choice as a model for the trend in species discovery in a taxon, as it has the property of an initial slow rate of discovery, rising to a peak before discoveries tail off when most of the species in the taxon are described. The three parameters of the function are: N, the total number of species to be discovered; α, the year of maximum rate of discovery; and β which describes the overall rate of discovery, with a larger β implying a faster rate. This has the advantage over other models in producing confidence limits based on the variation in the rate of description between years [15]. This model is stochastic and describes the time between discovery of species as a renewal process [16] where the mean number discovered as a function of time follows a logistic function. Bayesian statistical inference methods are used to fit the discovery curve to this model, giving an estimate of the 3 parameters of the logistic function and in particular an estimate of N, the total number of species. This is then used to gives an estimate of the number of species in the taxon remaining to be described.

Unfortunately, predictions based on extrapolating a logistic curve are very sensitive to the fitted value of α, the date of maximum rate of discovery [P2] . That date is very difficult to estimate from the data in cases where there is no sign that it has been reached (e.g. groups where the majority of species remain to be described), making the application of this model challenging. In these cases it is only assumed that the date of maximum rate of discovery occurs between 2010 and 2450. In our analysis we focused on lower and upper bounds for the predicted numbers of species.

Results

Description rate

Altogether, the description rate of marine species has increased since the 1750s, with a very high rate of discovery around 1900, declines during the two World Wars, and recovering from 1950 to present (Fig. 1a). The curve dipped in the 1990s, but sharply increased again since 2000 with over 20,000 marine species (8% of those currently known) described in the last decade. The number of marine species described per year reached all-time highs in the past decade, with over 2,000 species described in four different years (Fig. 1a). Even in taxa of large body size and high-economic value, many new species have been discovered and described in recent years (1999-2008): including 780 new crabs, 29 lobsters and 286 shrimps (in total 1,401 decapods), 1,565 marine fish, 6 sea snakes, and 3 new species and 7 subspecies of cetaceans [4]. We consider that there were 223-231,000 accepted marine species described. We are unable to give a more precise number due to the uncertainty in the total number of gastropod species.

Synonyms

Of ~400,000 species names established, ~170,000 (~40%) are currently not accepted, *i.e.* are synonyms (Table 1). This means that on average, for every five species described as new to science, at least two have already been described. The level of synonymy was greatest among the most studied organisms, like cetaceans where 1,271 names existed for only 87 valid species. Taxa where over 70% of names were now known to be synonyms are: Cetacea, Reptilia, Sirenia, Sipuncula, Siphonophora, Zoanthidea, and Bacillariophyceae. Taxa with over 50% synonymy rates include Pisces, Mollusca, Myriapoda, Scleractinia, Asteroida, Pennatulacea, Chaetognatha and Larvacea. The proportion of recognized synonyms has been steadily decreasing since the early 20th century (Fig. 1b). Of species described in the first decade of the century, 30% were now synonyms, from 1950's 20%, and 1980's 10%. If this was only due to the time it takes to discover synonyms, then a further 13,600 species remained to be synonymised since 1900.

Taxonomic effort

Our data in WoRMS show that 4,900 authors described marine species in the past decade and the number of authors describing new species each year has been increasing (Fig. 2). However, the number of authors has been increasing faster than the number of new species. The number of valid species described per author decreased from 6 to 3 species per year before 1900 to <2 since 1990s.

Estimated global species richness

Our collective estimates suggest that global marine species richness was between 705,000 and 973,000, so that only one third to one fourth of marine species has been discovered. However, this proportion varied greatly between taxa. In contrast, the prediction of the total number of marine species based on our statistical model was 540,000, with a 95% probability interval of 320,000 to 760,000 (Fig. 3).

Based on our personal estimates, no new species are expected in some groups with already few species: namely marine mammals such as Sirenia (4 spp.) and Carnivora (44 spp.); horseshoe crabs (Merostomata, 4 spp.); crustaceans such as Mictacea (1 spp.), Amphionidacea (1 spp.), Lomisoidea (1 spp.), water fleas (Branchiopoda, 90 spp.) and krill (Euphausiacea, 86 spp.); and horseshoe worms (Phoronida, 18 spp.). Only a few species may still be discovered in Cetacea (+2-8 spp.), Reptilia (+10 spp.), Hemichordata (+10 spp.), Aspidogastrea (+6 spp.), Thaliacea (+13 spp.) and Nematomorpha (+10-15 spp.). Other well-known taxonomic groups that are > 90% known, but with hundreds of species, were seabirds, and with over 2,000 species, were marine Hexapoda (e.g. Insecta, Collembola). The marine vascular plants (mangrove species and seagrasses) were >80% known, but seaweeds and microalgae remained poorly known (Table 1).

The least known taxonomic groups (based on our individual estimates), for which fewer than an estimated 20% of the species have been described, include some taxa with few known species (*i.e.* Cycliophora, Loricifera, Placozoa, Tantulocarida, Leptostraca, Caudofoveata). However, most have hundreds (Myxozoa, Acoela, Kinorhyncha, Oligochaeta, Gastrotricha, Mesozoa, Entoprocta) to thousands (Ciliophora, Rhabditophora, Cumacea, Bacillariophyceae, Tanaidacea, Isopoda) of species. The largest numbers of undiscovered species may be in Isopoda (+63,150-123,600 spp.), Gastropoda (+85,000-105,000 spp.), Bacillariophyceae (+50,000 spp.), Nematoda (+50,000 spp.), Copepoda (+30,125-50,125 spp.), Rhabditophora (+5,400-42,900 spp.), Ostracoda (+2,625-34,000 spp.), Tanaidacea (+21,900-24,900 spp.), Amphipoda (+20,000 spp.), Monogenea (+10,700-20,300 spp.), Porifera (+17,300-18,000 spp.), Ciliophora (+4,231-19,368 spp.), Oligochaeta (+5,900-16,900 spp.) and marine Fungi (+15,000 spp.) (Table 1).

The estimates of undiscovered species by the statistical model were comparable to or less than expert estimates. For several taxonomic groups the rate of discovery was still rising and the model could not make a meaningful estimate of total species numbers. This was the case for: Acanthocephala, Polychaeta, Hirudinea, Oligochaeta, Cumacea, Isopoda, Tanaidacea, Copepoda, Ostracoda, Bryozoa, Cephalorhyncha, Chaetognatha, Hexacorallia, Octocorallia, Hydrozoa, Gastrotricha, Gnathostomulida, Bivalvia, Gastropoda, Cestoda, Digenea and Porifera (Table 1).

Undescribed species in samples collected

Another approach to estimating how many species are undiscovered is empirical data on the numbers of undescribed species in samples. Field studies on over 31,000 marine species in over 100 studies found an average of 37% (median 31%) of species were undescribed (Fig. 4), primarily invertebrates from tropical and offshore environments (Table S2 – in online supporting material). The largest sample for which we had an estimate of unknown species was for the marine biota of New Zealand, estimated at 17,135 species of which 25% were unknown. Overall the studies, Pisces and Echinodermata were below the median, but so also were Scleractinia, Pycnogonida, Porifera and free-living Nematoda. Taxa with a higher percent of species unknown than the average included Oligochaeta, Polychaeta, Mollusca, Turbellaria, and Peracarida (especially Isopoda). The proportion of unknown species was higher than average for studies from Australia (52%), but lower than the median for New Zealand and the Southern Ocean (25% each). Averages for studies from Europe, deep-sea and tropics were close to the overall average (37%, 39% and 33%

respectively). These proportions can help balance estimates of total species richness. For example, the estimate of free-living nematode diversity reported here as 50,000 species suggests that 86% of the presently known species remain to be discovered. Yet, field surveys have found only 6 to 56% undescribed species.

We estimated that between 58,000 and 72,000 species, or 25-30% of the known marine diversity, are already represented in specimen collections waiting to be described (Table 1).

Cryptic species

The number of estimated cryptic species was 9,000-40,000 (Table 1). However, this was for 49 taxa with a total of 80,000 described accepted species, and thus is 11-50 % of their known species. Cryptic species would not occur in 12 taxa and for 32 of the 97 remaining taxa the experts did not have a basis on which to make this estimate. Within taxa, the occurrence of cryptic species can vary greatly between genera such that calculating up in this way may be exaggerating diversity. Such species mainly occurred in taxa with few externally visible diagnostic characters, such as Plazozoa, Oligochaeta, and some Turbellaria. There was no evidence that other taxa, such as Sirenia, Staurozoa and some Crustacea, have any cryptic species.

Discussion

Rate of discovery

We found that the rate of description of marine species has been steadily increasing since 1955. Costello *et al.* [17] found a similar trend for marine and terrestrial (including freshwater) species, but that the relative rate of description of marine species was higher than for terrestrial. However, they used an earlier version of WoRMS which did not show that the rate of discovery reached the all-time high in the past decade as is reported here for the first time, and predicted 0.3 million species may exist. This higher rate of discovery in recent years increased the model predictions to the 0.5 ± 0.2 million reported here. Evidently, we are in the most productive age of marine taxonomy. This may be due to more taxonomic effort, new technologies, exploration of new habitats and localities, use of molecular methods, or a combination of these factors.

Temporal trends were for a decreasing rate of species description (6 to 2 species/year) per author, and an increased number of authors engaged in species descriptions. This increase in the number of taxonomists is likely to contribute to the continued high rates of species description. Other studies have similarly reported an increasing number of authors describing fossil North American mammals [18], marine fish [19], terrestrial vertebrates and plants in Brazil [20], flowering plants of the world [21,22], cone snails, spiders, amphibians, birds and mammals [22], as well as marine and terrestrial species globally [17]. The increased number of taxonomists reflects the increase in the number of scientists worldwide [23]. The number of taxonomic publications has increased over eight-fold from 1969 to 1996 [24]. Haas and Häuser [25] estimated there to be 5,000 professional and 35,000 amateur taxonomists worldwide and concluded that taxonomists were not in danger of extinction. Our data suggests this may be an underestimate. We found 4,900 people described marine species alone in the past decade, which were about 8% of all species described. Not all people who could be considered taxonomists will have recently described species, especially those in well-studied geographic regions and taxa.

The advent of scuba-diving [26], deep-water tangle nets [27], submersibles and Remotely Operated Vehicles (ROVs) and other technologies [19] has allowed sampling of previously unexplored habitats such as cold seeps, mud volcanoes, submarine canyons and caves [28] and of very fragile organisms previously unavailable to scientists [29]. For example, the number of remipedes (crustaceans that live exclusively in coastal anchialine caves) has doubled since 2002 from 11 to 24. The use of submersibles and deep-diving resulted in the discovery of 30 new fish species around even such a highly studied area as the Galapagos Islands [19]. Thus, combined with the greater number of taxonomists, the sampling of more remote geographic areas, and the use of a greater variety of sampling methods must also be contributing to the high rate of species description.

Molecular methods and cryptic species

The diversity of cryptic species, *i.e.* species that remain unrecognized because of limitations of practiced morpho-taxonomic methods, is challenging to estimate, because molecular surveys that most readily reveal them have been applied to but a fraction of marine diversity. For example, only 6,199 species have been genetically 'barcoded' by MarBOL (checked 20 February 2012: http://www.marinebarcoding.org). Furthermore, in all taxa except Placozoa (with only one species at present), these discoveries of 'cryptic' species only apply to some of the presently known species, sometimes only within genera. Thus multiplying up from the discovery of cryptic species within a genus or family to order of phylum level may exaggerate potential cryptic species.

For about one third (in terms of described richness) of the marine biota experts were not willing to provide or indicated there was no good basis for any estimate for the diversity of cryptic species, reflecting our poor understanding of this problem. For the remaining two thirds, estimates ranged widely, partly reflecting clear differences in the incidence of cryptic species among taxa. Some of this variation further reflects our lack of knowledge, but actual differences in the utility of morphological relative to molecular characters in species differentiation across taxa are also evident in groups that have received modest genetic scrutiny. Thus in Pisces, a morphologically complex and visually-communicating group of animals, the likely incidence of cryptic diversity is low, estimated here as 1-3% of total diversity [30]. Conversely in Sipuncula, which have limited morphological complexity as well as eyes, cryptic species are estimated to comprise between 10-55% of total diversity [31]. Our knowledge is most incomplete in the smallest and potentially most diverse organisms, especially unicellular eukaryotes. Environmental sequencing is indicating that some of these groups may be orders of magnitude more diverse than currently recognized based on morphological taxonomy [32].

Furthermore, molecular analyses complement morphological approaches, and where the latter are equivocal, have supported the raising of subspecies to species status [19]. For example, the killer whale and the common bottlenose dolphin have each been split into two or more species [33-34]. The World Register of Marine Species currently contains 7,600 recognized infra-species (*i.e.* 3%). Molecular methods will also resurrect some names from synonymy. Let us assume that pre-1900 names assigned to synonymy are truly synonyms. Then about 28,000 names of species described since 1900 were synonymised and another 13,800 may yet be synonised due to the time delay in recognizing synonyms. It is highly unlikely that all 41,800 would be resurrected from synonymy by molecular methods. If all recognized subspecies, and say ¼ of synonyms were restablished as accepted species, then the number of known species could be increased by about 18,000 species.

Clearly there is considerable uncertainty in these estimates, but they help to illustrate the degree to which molecular methods will increase our knowledge of marine biodiversity. Considering the numbers of subspecies that may be raised to species, synonyms that may be resurrected to accepted species, and cryptic species, molecular methods may add tens of, rather than hundreds of, thousands of species to the currently accepted ~227,000 species. Molecular methods are also proving invaluable in reclassifying species relationships and assigning species to synonymy, which can reduce the number of species.

Synonyms

Our data shows that the proportion of described species that are later recognized to be synonyms of others is decreasing over time. This could be the result of less synonyms being created and/or reflect the time it takes to discover synonyms. Taxa that are more popular tend to have more synonyms (*e.g.* fish, molluscs), but are also more likely to have had their taxonomy revised and thus such synonyms discovered. Even the same taxonomist can describe a species several times; for example, nine of the sperm whale's 19 synonyms were coined by three authors, each naming the species three times [35]. With better access to publications, type specimens, improved communication among taxonomists, and the greater availability of systematic revisions, the rate of introduction of synonyms should decline.

The occurrence of as yet unrecognized synonyms is the most significant problem in estimating the true number of described species. Taxonomic revision may find more synonyms, but in some cases, often assisted with the discovery of cryptic species, previously 'sunken' species may found to be real. While the significance of synonymy in biasing estimates of taxon and global species richness merits more in-depth study, action to reduce the re-occurrence of synonyms can be undertaken. This must include taxonomic revisions, rapid publication, open-access to descriptions, online species identification guides, knowledge of where type specimens and genetic profiles are located, accessibility of taxonomic expertise, and continued inventorying of species at global to local levels.

Global species richness

Both the sum of our individual estimates and the statistical model predict that there are less than 1 million marine species on Earth. Recent estimates of the richness of insects and terrestrial species have also been more modest, in the order of 6 million, compared to the 30-100 million species proposed by some authors [reviewed by 1 & 17]. The same model we used here predicted only 0.3 million marine species may exist on Earth using an earlier version of WoRMS [17]. This model is sensitive to the period of highest species description. Because the data now show the highest rates of description of marine species occurred in the past decade, the present model predicts 0.5 million species. Both estimates will be inflated by undiscovered synonyms. Future modeling may be improved by distinguishing the taxa and geographic regions which are well known, and by quantifying the effects of taxonomic effort.

Some of our higher estimates of undiscovered species may be questioned. Findings of high local species diversity do not necessarily imply high global species diversity [36]. Species with life-stages that are easily dispersed (*e.g*. due to small-body size as in microbes and meiofauna) and can survive conditions sub-optimal for growth tend to be cosmopolitan and thus have low spatial turnover (β-diversity) in species [discussed in 17 & 36]. This may be the case for the high predictions of undiscovered species for Nematoda. Indeed, one analysis suggests there are 10,000-20,000 free-living marine nematodes rather than the 50,000 listed in this paper [37]. However, comparable life-stages are not common in macroinvertebrate taxa such as Crustacea (especially Copepoda, Isopoda, Tanaidacea, Amphipoda, Cumacea, Leptostraca) and Mollusca where thousands of undiscovered species are also predicted. Moreover, more cosmopolitan species also tend to be discovered first and perhaps the remaining species of such taxa will be geographically rare. Thus, a particular problem in estimating global species richness is understanding geographic patterns. It is well-known that most species are geographically rare (*i.e*. endemic to small areas), but whether all taxa show similar β-diversity is not clear. For example, is there an equal proportion of parasitic and non-parasitic copepods that are cosmopolitan, and does the spatial occurrence of parasitic and symbiotic species scale similarly with their hosts? If taxa do scale similarly, then this will aid prediction of both global species richness and sensitivity to extinction [36]. However, the present evidence suggests that taxa have contrasting geographies, with pelagic mega-fauna (mammals, birds, reptiles) and meiofauna being more cosmopolitan than benthic macroinvertebrates [reviewed by 17]. Thus taxonomic research into this spectrum of rare and endemic species is critical for scientific discovery and conservation priorities.

Field studies found that most samples have less than 37% undescribed species (median 31%), suggesting that our estimate of two-thirds to three quarters of species being undiscovered may be too high rather than too low. Furthermore, these averages may be over-estimates because (a) authors do not report when all species in samples have been described, (b) some of these putative species may occur in samples collected by different people, and (c) upon closer analysis some may prove not to be new to science (but perhaps new to the observer). Europe has probably the best studied sea area in the world, but a third of its biodiversity may yet be undescribed [2]. Thus the proportion of undiscovered species is likely between one and two-thirds of all described marine species. However, this is a global figure, and some taxa provide exciting opportunities for discovering many new species, notably Mollusca, Turbellaria, Oligochaeta, Tanaidacea and Isopoda.

If we further consider that the number of authors describing species has been increasing at a faster rate than the number of new species, then it seems that it has become harder to find new species [17]. If the description curves for taxa have not reached an asymptote because of the increasing taxonomic effort then the model will over-predict marine species richness, as well as bias our personal estimates. Consideration of the increasing effort suggests that we should be conservative in our estimates of the number of undiscovered species.

Rates of marine species description have never been higher, and are driven by the increasing number of taxonomists and their ability to sample geographic areas and habitats previously under-sampled. If the rate of 2,000 new species per year can be maintained by continued taxonomic effort and focus on the least known places, habitats and taxa, then another 100,000 species will be described in the next 50 years, and the number of described species will be within the 95% Confidence Limits of our predictions.

As more species are described, the skills to diagnose them will be increasingly in demand. This applies to both the large easily identified species that may be important for food, conservation, and ecosystem function, but also the less conspicuous small body-sized taxa because they will include parasites and pathogens of other species, may become pests, and may have as yet unrealized roles in ecosystem function.

The online open-access World Register of Marine Species (WoRMS) has set the stage for our estimates of marine diversity. Collaborative international initiatives such as WoRMS help increase our knowledge, promote standardization in taxonomy, and bring the community together in a more coordinated and, because of the shared responsibility of maintaining the database, a more sustainable way. This paper provides a baseline of the diversity of marine species and higher taxa which the editors of WoRMS should revisit in five to ten years time in the light of future discoveries.

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Table 1. Estimates of known and unknown marine species diversity.

The number of currently described and taxonomically **accepted** species; percent of all nominal species names considered subjective synonyms (**% synonyms**); **undescribed** species in specimen collections; unsampled and **undiscovered** morphospecies; undiscovered molecular **cryptic** species; **total** species **unknown** (undescribed + undiscovered based on expert opinions); **total** species **unknown** based on the statiscal **model**; **total estimated** number of species (expert-based); estimated percent of all existing species that are currently described (**% known**); number of **new species** published in the last decade (1999-2008, data from WoRMS). ? = not estimated, NB = no basis for judgment, **rate of discovery still rising so no meaningful estimate of total species numbers can be made using the statistical model.

	Total known spp.	Described (**accepted** spp.)	**% synonyms**	**Undescribed** (collected)	**Undiscovered** (morpho-spp.)	Undiscovered (molecular **cryptic** spp.)	**Total unknown** spp. (experts)	**Total unknown** spp. **(model)**	**Total est.imated** spp.	**% Known**	**New spp.** (1999-2008-)
Plantae	**7593**							**2500-3600**	**22798-22803**	**33**	**632**
Chlorophyta		1300	19	?	1200		1200			52	
Rhodophyta		6150	49	?	14000		14000			31	
Mangroves		75	29	?	0-5		0-5			94-100	
Seagrasses		68	6	0	5		5			93	
Chromista	**19444**							**3500-4200**	**77880-92923**	**21-25**	**790**
Bigyra		76	?	**?**	75		75			50	
Cercozoa		173	?	**?**	160		160			52	
Ciliophora		2615	39	0	1058-4648	3173-14526	4231-19174			12-38	
Cryptophyta		86	?	?	150		150			36	
Foraminifera		6000	40	1000	500		1500			80	
Haptophyta		241	?	?	100-150		100-150			62-71	
Heliozoa		10	?	?	20		20			33	
Myzozoa		2686	?	?	575		575			82	
Ochrophyta			?								
Phaeophyceae		1800	49	50	150-200		200-250			88-90	

Bacillariophyceae		5000	75	?	50000		50000			9	
Chrysophyceae		51	-	?	1000		1000			5	
Other Ochrophyta		263	?	?	160		160			62	
Oomycota		43	?		225		225			16	
Radiozoa		400	30	0	40	50-1000	40			28-82	
Protozoa	**542**							**150-400**	**2207**	**25**	**23**
Amoebozoa		117	?	?	450		450			21	
Apusozoa		3	?	?	15		15			17	
Choanozoa		150	?	?	750		750			17	
Euglenozoa		243	?	?	370		370			40	
Excavata		29	?	?	80		80				
Fungi								**1100-1500**			
marine fungi	**1035**	1035	10	200	14800		15000		**16035**	**0**	**125**
Animalia											
Acanthocephala	**450**	450	25	20	150	50-150	220-320	**	**670-770**	**58-67**	**30**
Annelida	**13721**								**26021-37111**	**37-53**	**841**
Polychaeta		12632	35	3160	3160	NB	6320	**		67	
Hirudinea		179	28	25-50	50-100	5-20	80-170	**		51-69	
Oligochaeta		910	30	300	5000-15000	600-1600	5900-16900	**		5-13	
Arthropoda											
Chelicerata	**2685**							**2700-3000**	**5334-7065**	**38-50**	**340**
Merostomata		4	-	0	0	NB	0			100	
Pycnogonida		1307	3	150-500	979-1650	50-100	1179-2250			37-53	
Acarina		1218	-	100	1220-1830	150-200	1470-2130			36-45	
Araneae		125	-	?	?		-			-	
Pseudoscorpionida		31	-	?	?		-			-	
Crustacea											
Decapoda	**13319**							**4500-5100**	**22474-25507**	**52-59**	**1611**
Dendrobranchiata		551	31	50	100	NB	150			79	
Achelata		142	38	10	30-70	10-30	50-110			56-74	
Chirostyloidea		206	2	250	580	45-55	875-885			19	
Galatheoidea		715	8	250	830	135-150	1215-1230			37	
Hippoidea		81	19	3	10	NB	13			86	
Lithodoidea		129	20	10	40		50			72	
Lomisoidea		1	0	0	0		0			100	
Paguroidea		1106	17	150-200	400	NB	550-600			65-67	
Enoplometopoidea		12	20	0	2-7	1-3	3-10			55-80	
Glypheoidea		2	0	0	1-2		1-2			50-67	

Nephropoidea		54	24	1	10-28	5-12	16-41			57-77	
Brachyura		6978	22	310	3000	550-3400	3860-6710			51-64	
Procarididea		6	0	0	2	NB	2			75	
Caridea		2572	25	400	1500	NB	1900			58	
Polychelida		38	27	0	7-15	3-10	10-25			60-79	
Stenopodidea		68	16	10	50	NB	60			53	
Gebiidea		203	10	50	100		150			58	
Axiidea		455	10	50	200		250			65	
Peracarida	**17115**							**	**132357-228741**	**7-13**	**2275**
Amphipoda		6947	-	?	20000		20000	4000-4300		26	
Bochusacea		5	0	0	10	NB	10			33	
Cumacea		1444	2	45	6000		6045	**		19	
Isopoda		6345	2	3400	60000-120000	50-500	63450-123900	**		5-9	
Lophogastrida		56	24	10	120	1-5	131-135			29-30	
Mictacea		1	0	0	0	0	0			100	
Mysida		1180	32	80-100	2000-4000	20-30	2100-4130	340-450		22-36	
Tanaidacea		1130	6	900	22600-56500	NB	23500-57400	**		2	
Thermosbaenacea		7	0	1	5		6			54	
other Crustacea	**21086**								**55604-107594**	**20-38**	
Branchiopoda		90	3	0	0	0	0			100	
Cephalocarida		12	0	0	10	NB	10			55	
Amphionidacea		1	-	0	0	0	0			100	
Euphausiacea		86	42	0	0	0	0			100	
Stomatopoda		468	19	52	200		252			65	
Leptostraca		49	2	50-100	200-600		250-700			7-16	
Branchiura		44	12	2-3	50-80	NB	52-83			35-46	
Copepoda		10000	17	1500-2000	28500-48000	125	30125-50125	**		17-25	
Mystacocarida		13	0	1	10	NB	11			54	
Pentastomida		10	-	?	?		-			-	
Tantulocarida		36	0	60	1000	NB	1060			3	
Thecostraca		1400	7	?	100-200	NB	100-200			88-93	
Ostracoda		8853	7	1000-2000	1625-32000	NB	2625-34000	**		21-77	
Remipedia		24	4	8	20-50	5-9	33-67			26-42	
Hexapoda (Insecta and Collembola)	**2037**	2037	15	30-60	30-100	NB	60-160	110-250	**2097-2197**	**93-97**	**30**
Myriapoda	**61**	61	58	?	190		190		**251**	**24**	**2**
Brachiopoda	**388**	388	-	0	?		-	65-175	**388**	?	**21**
Bryozoa	**5900**	5900	9	?	2450-4250	350-950	2800-5200	**	**8700-11100**	**53-68**	**599**

Cephalorhyncha	**284**							**	**2667-3772**	**8-11**	**47**
Kinorhyncha		228	0	250-350	1000-2000		1250-2350			9-15	
Loricifera		32	0	123	1000		1123			3	
Nematomorpha		5	0	?	10-15	NB	10-15			25-33	
Priapulida		19	-	?	?		-			-	
Chaetognatha	**128**	128	54	6-9	44	0-256	50-309	**	**178-437**	**29-72**	**11**
Chordata											
Cephalochordata	**33**	33	-	?	?		-		**33**		
Tunicata	**3020**							2700-4300	**4100-5100**	**59-74**	**391**
Ascidiacea		2874	43	500	500-1000	0-500	1000-2000			59-74	
Larvacea		67	53	4	63	NB	67			50	
Thaliacea		79	0	5	8		13			86	
Pisces (incl Agnatha)	**16733**	16733	49	500	4200-4300	200-300	4900-5100	6700-10700	**21633-21833**	**77**	**1577**
Mammalia	**135**							0-11	**137-143**	**94-99**	**3**
Carnivora		44	14	0	0		0			100	
Sirenia		4	89	0	0	0	0			100	
Cetacea		87	93	0	1-5	1-3	2-8			92-98	
Reptilia	**110**	110	82	?	20-30		20-30		**130-140**	**79-85**	**6**
Aves	**641**	641	-	30-50	30-50	0	60-100	0-9	**701-741**	**87-91**	**1**
Cnidaria											
Hexacorallia	**3155**							**	**3979-5108**	**62-79**	**286**
Actiniaria		1096	24	?	?	NB				-	
Antipatharia		250	11	50-75	50-100	NB	100-175			59-71	
Ceriantharia		141	12	4-6	15-25		19-31			82-88	
Corallimorpharia		47	13	?	?	NB	0			-	
Zoanthidea		101	78	30	180-380	60-760	270-1170			8-27	
Scleractinia		1520	61	93	342	0-142	435-577			72-78	
Octocorallia	**3171**							**	**4871**	**65**	**290**
Alcyonacea, Helioporacea		2951	18	100	1500	NB	1600			65	
Pennatulacea		220	51	20	80	NB	100			69	
Cubozoa	**37**	37	20	10-20	20-50		30-70		**67-107**	**35-55**	
Hydrozoa	**3426**	3426	27	50-100	500-1500	1000-2500	1550-4100	**	**4976-7526**	**46-69**	**304**
Siphonophorae	**173**	173	75	50-60	50-60	0	100-120		**273-293**	**59-63**	
Scyphozoa	**201**	201	1	38-80	77	22-25	137-182		**338-383**	**52-59**	
Staurozoa	**48**	48	24	10-12	30-50	0-3	40-65		**88-113**	**42-55**	
Ctenophora	**190**	190	24	25-50	100-250	0-10	125-310	7-57	**315-500**	**38-60**	3
Cycliophora	**2**	2	0	3	10-125		13-128		**15-130**	**2-13**	1
Echinodermata	**7291**							230-300	**9617-13251**	**55-76**	297

Asteroidea		1922	65	125-200	200-500		325-700			73-86	
Echinoidea		999	37	20-50	45-150	306-1080	371-1280			44-73	
Ophiuroidea		2064	34	260-300	200-400	100-150	560-850			71-79	
Crinoidea		623	32	20-30	50-100		70-130			83-90	
Holothuroidea		1683	29	200-400	800-2600		1000-3000			36-63	
Echiura	**175**	175	14	5-10	30-40		35-50	12-44	**210-225**	**78-83**	5
Entoprocta	**193**	193	13	30	1000	NB	1030	16-57	**1223**	**16**	18
Gastrotricha	**434**	434	18	310	1000-1500	500-1000	1810-2810	**	**2244-3244**	**13-19**	86
Gnathostomulida	**98**	98	10	15-20	200	NB	215-220	**	**313-318**	**31**	9,00
Hemichordata	**118**	118	7	10	?		10	0-2	**128**	**92**	4
Mesozoa (Orthonectida, Dicyemida)	**134**	134	1	40-50	500-1000	100-500	640-1550	84-305	**774-1684**	**8-17**	34
Mollusca	**43689-51689**							**	**135887-164107**	**28-32**	**4022**
Bivalvia		9000	55	2000	3000		5000	**		64	
Caudofoveata		133	8	?	500		500			21	
Cephalopoda		761	-	150	500		650			54	
Gastropoda		32000-40000	75	35000-45000	50000-60000		85000-105000	**		23-27	
Monoplacophora		30	-	3	50		53			36	
Polyplacophora		930	52	50	50-100		100-150			86-90	
Scaphopoda		572	33	55	500	NB	555			51	
Solenogastres		263	21	20-30	320-480		340-510			34-44	
Myxozoa	**700**	700	7	100-250	6300-8400	71-468	6471-9118	600-1200	**7171-9818**	**7-10**	**93,00**
Nematoda	**11400**							500-700	**61400**	**19**	**295**
Nematoda - free-living		6900	9	?	50000	NB	50000			12	
Nematoda - parasitic		4500	-	?	?		-			-	
Nemertea	**1285**	1285	20	200-400	500-1000		700-1400	170-320	**1985-2685**	**48-65**	**85**
Phoronida	**18**	18	56	0	0		0		**18**	**100**	**0**
Placozoa	**1**	1	0	18	0	10-100	28-118		**29-119**	**1-3**	**0**
Platyhelminthes	**11690**							3000-3900	**35296-73441**	**16-33**	**1142**
Cestoda		1393	31	300	2000		2300	**		38	
Monogenea		1626	-	200-300	10000-15000	500-5000	10700-20300	2300-2700		7-13	
Aspidogastrea		18	25	0	6		6			75	
Digenea		6000	20	600	4000-8500	400-900	5000-10000	**		38-55	
Catenulida		12	0	5	20		25			32	
Rhabditophora		2641	9	500-700	5000-28000	75-420	5575-29120	820-1130		8-32	
Porifera	**8553**	8553	22	2300-3000	15000	NB	17300-18000	**	**25853**	**32-33**	**621**
Rotifera	**114**	114	-	20	?	300-2500	320-2520	20-140	**434-2634**	**4-26**	**17**
Sipuncula	**150**	150	90	3-5	10-25	30-200	43-230	2-20	**193-380**	**39-78**	**0**

Tardigrada	**183**	183		?	1120		1120	40-280	**1303**	**14**	**16**
Xenacoelomorpha	**401**							**250-360**	**4501**	**9**	**74**
Acoela		391	35	100	4000	NB	4100			9	
Nemertodermatida		8	20	?	?	NB	0			-	
Xenoturbellida		2	0	0	?	NB	-				**0**
	223490-231490			**58248-72300**	**415155-630472**	**9053-39692**	**482406-741464**		**705896-972954**	**23-32**	

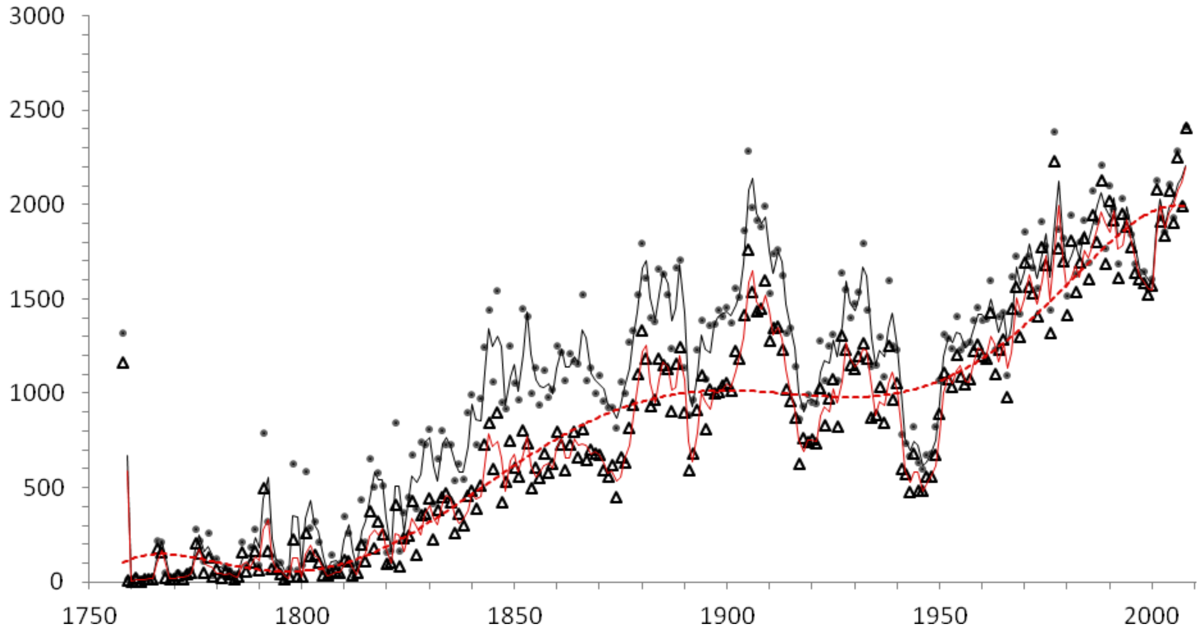

Fig. 1a. The number of species described per year (●, black line) vs currently recognised as valid (Δ, red lines). Trend lines in all figures are 2 year moving averages, and the 6th order polynomial for valid species ($r^2 = 0.869$; red dashed line) is also shown.

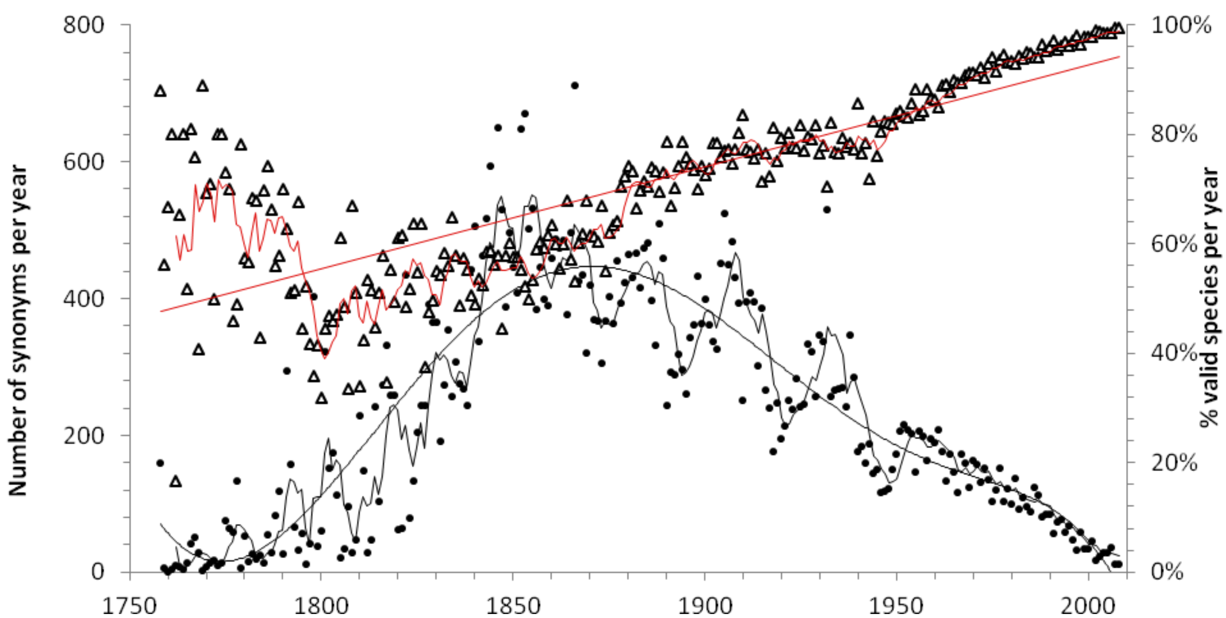

Fig. 1b. The number of synonyms per year (●, black solid line and 6th order polynomial), and the % of species that are now recognised as valid (Δ, linear curve, r^2=0.638).

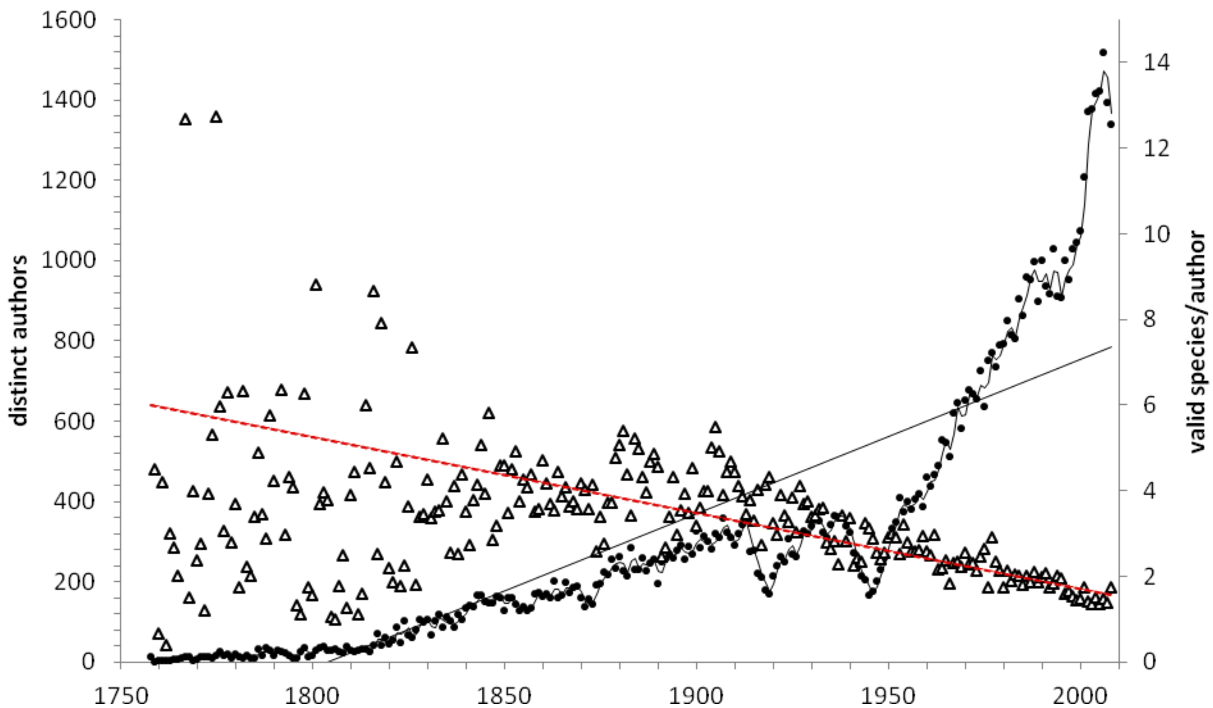

Fig. 2. The number of distinct author names per year (● black lines, linear with r^2=0.721) and the number of valid species per author (Δ, red dashed line, r^2=0.056).

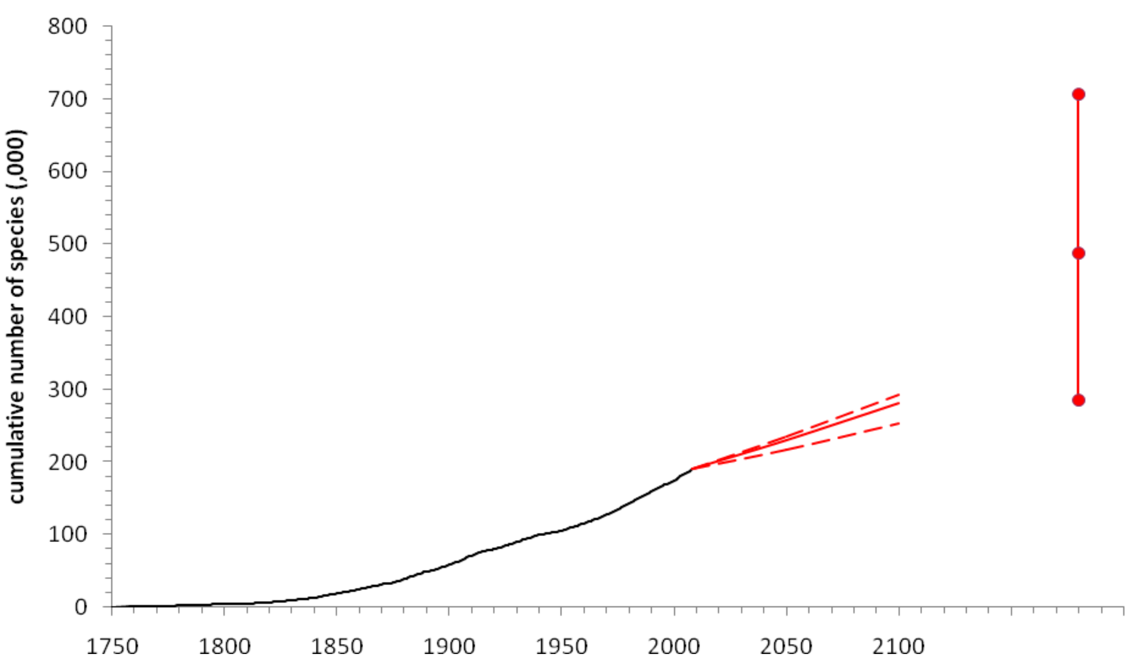

Fig. 3. Predictions (in red) from fitting the logistic curve model of Wilson and Costello (*12*). The predicted total number of marine species that will be discovered is 490,000, with bounds of 280,000 to 710,000. The red dashed-line is the 95% confidence interval.

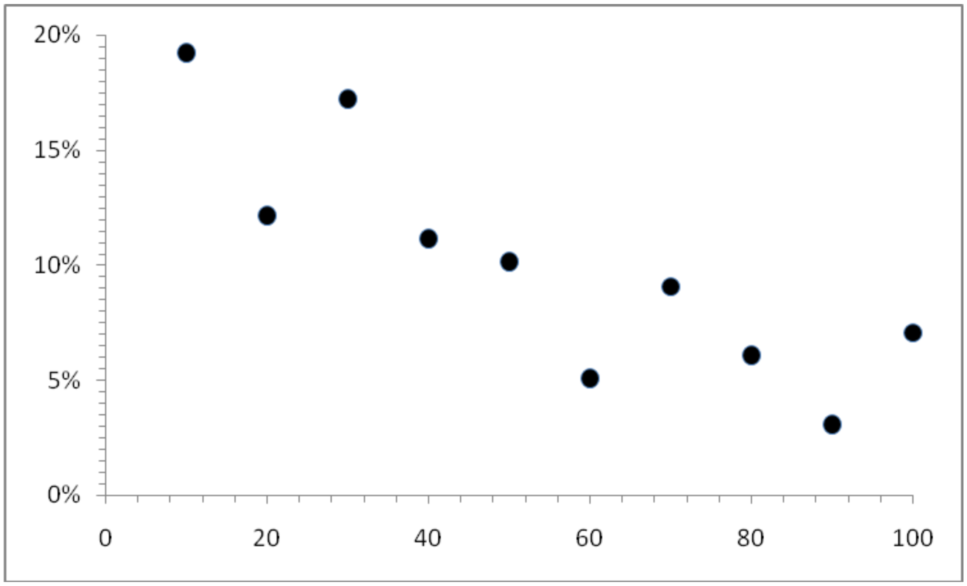

Fig. 4. The frequency distribution of the proportion of undescribed species in samples from Table S2 (divided in 10% intervals).

Supporting Online Material

Tables

Table S1. An overview of the estimated numbers of marine species described and those that may exist, as published in the literature.

Table S2. Proportions of undescribed marine species found for particular taxa and locations.

References to Tables S1 and S2

Table S3. Comments on data on particular taxa in Table 1.

Supporting Tables

Table S1. An overview of the estimated numbers of marine species described and those that may exist, as published in the literature.

Number of species described	Reference
150,000	van der Land [*S1*]
204,000	Gibbons *et al*. [*S2*]
230,000	Bouchet [*S3*]
250,000	Winston [*S4*]
274,000	Reaka-Kudla [*S5*]
Number of existing species	
300,000	Costello et al. [S6]
500,000	May [*S7*]
>1,000,000+	Winston [*S4*]
1,500,000	Bouchet [*S3*]
2.200,000	More et al. [S8]
5,000,000	Poore & Wilson [*S9*]
>10,000,000+	Grassle & Maciolek [*S10*]

Table S2. Proportions of undescribed marine species found for particular taxa and locations. The total estimated number of undescribed species is 10,715 (34%) of 31,259 collected (N° of species).

undescribed	N° of species	Taxon	Location	Reference
67%	184	Peracarida	Mid-Atlantic Continental Slope, USA	Grassle & Maciolek [S10]
37%	106	Mollusca		
64%	367	Polychaeta		
95%	459	Copepoda associated with other species	Madagascar, New Caledonia, Moluccas (note that the Madagascar samples were collected over several years)	Humes [S11]
33%	372	Polychaeta	Georges Bank	Carlton [S12]
71%	158	Polychaeta	Hawaii	
42%	320	Gastropoda	Philippines	
55%	564	Gastropoda	New Guinea	
79%	29	Harpacticoida	Gulf of Mexico	
92%	134	Turbellaria	Great Barrier Reef	
80%	2000	Mollusca	New Caledonia	Bouchet [S13]
64%	14	Hydrozoa	Seamounts, Tasmania	Koslow et al. [S14]
12-27%	33	Octocorallia		
0-28%	29	Annelida		
43-57%	14	Bryozoa		
30%	10	Mollusca		
35-62%	37	Decapoda		
69-88%	32	Other Crustacea		
4-9%	22	Asteroidea		
8-31%	36	Ophiuroidea		
18-45%	11	Other Echinodermata		
>14%	28	Pisces		
30-40%	>2000	Nematoda (free-living)	European seas	Lambshead & Boucher [S15]
ca. 90%	158	Foraminifera	Deep regions of the Atlantic sector of the Southern Ocean	Brandt et al. [S16]
56%	57	Nematoda (free-living)		
70%	100	Ostracoda		
86%	674	Isopoda		
27%	295	Polychaeta		
22%	76	Porifera		
31%	65	Bivalvia		
5%	1222	Pisces	Tropical eastern Pacific	Zapata & Robertson [S17]
>90%	365	Isopoda	Australia	Poore et al. [S18]
>30%	524	Decapoda	Australia	Poore et al. [S19]
83%	1409	Turridae (molluscs)	New Caledonia	Bouchet et al. [S20]
61%	79	Tubificidae (oligochaetes)	Western Australia	Erséus ([S21] and references therein)

5-24% (average 14.3)		Azooxanthellate Scleractinia corals	Most of world's oceans.	Cairns [S22]
0-18% (average 6.1)		Zooxanthellate Scleractinia corals	Australia, Carribbean, Japan, Red Sea, Vietnam	
25%	450	Ciliophora (free-living)	Chinese coastal regions of the Bohai Sea and Yellow Sea	Song, Warren, Hu [S23]
64%	14	Rhabdocoel flatworms	Uruguay (July-August 2004)	Van Steenkisten et al. [S24]
61%	71	Rhabdocoel flatworms	Lanzarote (October 2011)	Artois [unpubl. data]
78%	40		Panama (December 2011)	
76%	34	Proseriate flatworms	Lanzarote (October 2011)	Curini-Galletti [unpubl. data]
90%	30		Pacific Panama (December 2011)	
56%	30	Octocorallia	Records of the Western Australian Museum	Alderslade [S25]
60%	50	Octocorallia	New Caledonia and adjacent islands	Grasshoff [S26]
28%	19	Octocorallia	Sinai coast and the Strait of Gubal, Red Sea	Grasshoff [S27]
64%	34	Octocorallia	Indo-Pacific	Van Ofwegen [S28]
40%	15	Octocorallia	Palau, Micronesia	Van Ofwegen [S29]
42%	59	Tubificidae (oligochaetes)	Belize	Erséus [S30]
41%	37	Tubificidae (oligochaetes)	N. T., Australia	Erséus [S31]
41%	41	Tubificidae (oligochaetes)	Western Australia	Erséus [S32]
24%	99	Ascidiacea	Guadeloupe	Monniot [S33-S36], Monniot [S37-S40]
38%	208	Ascidiacea	New Caledonia	Monniot [S41-S46], Monniot [S47-S54]
50%	211	Ascidiacea	Tropical Western Pacific	Monniot [S55], Monniot[S56-S59]
29%	180	Ascidiacea	South Africa	Michaelsen [S60], Millar [S61-62], Monniot et al. [S63]
19%	16	Ascidiacea	California continental shelf	Lambert [S64]
0%	11	Sipuncula	Antarctic Waters	Cutler et al. [S65]
0%	5	Sipuncula	The deep Angola Basin	Saiz Salinas [S66]
40%	10	Pycnogonida	Melanesia	Bamber [S67]
30%	10	Pycnogonida	Taiwan	Bamber [S68]

19%	16	Pycnogonida	Melanesia	Bamber [S69]
23%	13	Pycnogonida	Melanesia	Bamber [S70]
20%	5	Pycnogonida	Ecuador	Bamber & Takahashi [S71]
7%	15	Pycnogonida	W Australia (shallow)	Bamber [S72]
17%	12	Pycnogonida	S Australia	Staples [S73]
15%	13	Pycnogonida	Queensland	Bamber [S74]
17%	6	Pycnogonida	Azores	Bamber & Costa [S75]
14%	50	Pycnogonida	Caribbean Colombia	Muller & Krapp [S76]
24%	17	Pycnogonida	W Australia (deep)	Arango [S77]
7%	204	Ophiuroidea	New Caledonia region	O'Hara & Stöhr [S78], Stöhr [S79]
2%	130	Ophiuroidea	North Atlantic, below 200 m	Martynov & Litvinova [S80]
8%	55	Crinoidea	Bahamas (July 2009)	Messing [unpubl. data]
6%	456	Nematoda	Southern Bight of the North Sea	Vincx [S81]
12%	114	Nematoda	Strait of Magellan and Beagle Channel (South America)	Chen [S82]
27-38%	250-350	Nematoda	Manganese nodule field off Peru, southern part of East Pacific	Bussau [S83]
88%	65	Tanaidacea	SE Australia	Blazewicz-Paszkowycz and Bamber [S84]
92%	26	Tanaidacea	W Australia (shallow)	Bamber [S85]
69%	29	Tanaidacea	Queensland	Bamber [S86]
46%	266	Tanaidacea	Antarctic	Blazewicz-Paszkowycz [unpubl. data]
28%	320	Bryozoa	New Zealand deep sea >500 m (including sea mounts)	Gordon [unpubl. data]
0-100% (avergae 41.3)	2 to 13	Zoantharia (order)	Galapagos, Singapore, Japan, B ritish Columbia, Cape Verde, Taiwan	Reimer et al. [S87-S96]
92%	26	Leucothoidae (Amphipoda)	Japan	White and Reimer [S97-S98]
24%	17	Echinoidea	North Atlantic	Mortensen [S99-S101]
19%	16	Echinoidea	Gulf of Thailand	Mortensen [S102]
41%	17	Echinoidea	South Atlantic, Antarctic coast & deep water	Mortensen [S100,S103]

29%	14	Echinoidea	Southwest Atlantic coast, Antarctic coast	Mortensen [S100,S104]
29%	14	Echinoidea	Northwestern Australia	Mortensen [S105]
33%	18	Echinoidea	New Zealand & Auckland-Campbell Islands	Mortensen [S106]
22%	144	Echinoidea	Philippines and adjacent regions	Mortensen [S107-S110]
14%	7	Echinoidea	Caribbean deep water	Mironov [S111]
3%	36	Echinoidea	Philippines and Makassar Strait	David & de Ridder [S112]
0%	31	Echinoidea	Antarctic coast, Subantarctic shelf and Kerguelen Islands	de Ridder et al. [S113]
25%	17135	All taxa	New Zealand	Gordon et al [S114]

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Table S3. Comments on data on particular taxa in Table 1.

Chlorophyta, Rhodophyta, Cryptophyta, Haptophyta, Phaeophyceae, Bacillariophyceae, Chrysophyceae, Euglenozoa [Michael D. Guiry, Olivier De Clerck]	**Described + nominal** Data on described species and the percentage of synonyms are based on AlgaeBase (Guiry & Guiry, 2012). **Undiscovered** Several papers have previously addressed algal diversity and provided detailed estimates on the number of species, known and unknown, for various algal groups (e.g. Andersen, 1992; John, 1994; Norton et al., 1996; John & Maggs, 1997; Adl et al., 2007). The numbers presented in these papers are the result of censusing taxonomic experts for specific groups. The total number of recognized species ranged from approximately 29.000 (Adl et al. 2007; lower estimate) to 43.400 (Andersen 1992; upper estimates). Even though on average estimates of global diversity were about 2-fold higher than the currently recognized number of species, the estimates differed widely among studies and groups. Most notably, estimates of diatom richness ranged from 100.000 species to 10 million, which would indicate that 90-99% of diatom species remains unknown to date. But estimates for other groups also display large variation. The Eustigmatophyceae for example, were considered to comprise between 1000 and 10.000 species by Andersen (1992) and John (1994), while Adl et al. (2007) go for a more modest global estimate of 30 species. Important, the abovementioned studies address global algal diversity and hence the numbers presented refer to the combined marine, freshwater and subaerial diversity. The percentage of marine species differs widely among groups. While, Chlorarachniophyta, Dinophyta, Haptophyta, Rhodophyta and Phaeophyceae are predominantly to exclusively marine, other groups are much more speciose in freshwater habitats (e.g. Chlorophyta, Chrysophyceae and Euglenozoa) (Dring, 1982; Van Den Hoek et al., 1995; Edvardsen & Medlin, 2007; Ishida et al., 2007; Moestrup & Daugbjerg, 2007). The Diatoms are predominantly marine or marine/brackish (63%) (Mann, 1996), but about 25% is exclusively restricted to freshwater habitats. These differing ecologies among groups make it difficult to tease out the marine components and complicate comparison of algal species richness. The estimates of unknown diversity are those presented by Adl et al (2007), except for Chlorophyta and Bacillariophyceae. Numbers have been adjusted for the fraction of marine taxa. These numbers are rough estimates that depend critically on the estimates of total richness, the percentage of marine taxa and equal taxonomic effort in freshwater and marine environments. For two groups of algae, Chlorophyta and Bacillariophyceae, extrapolation of the data by Adl et al. (2007) yielded unrealistically high species numbers that await description. Estimates of $1\text{-}2.10^5$ Chlorophyta, 13.8% of which is marine (Dring, 1982), are probably overly enthusiastic. We estimate a maximum of 2,500 marine Chlorophyta, 1,200 of which remaining to be described. Likewise, an estimate of 2.10^5 Bacillariophyceae (Mann, 1999; Adl et al., 2007) with 63% of the genera being marine (Mann, 1996), would leave more than $1.2.10^5$ marine species to be described. We concur with David Mann (1999) in that there are indeed a lot of diatom species, but

extrapolation of freshwater diversity patterns to the marine environment, is likely to overestimate the marine diversity. A maximum of 50,000 is therefore suggested.

Cryptic

With the notable exception of Adl et al. (2007), estimates of algal diversity largely predate the wide-scale application of molecular sequence in phycology. Sequencing of target genes in individual organisms or more recently by environmental sequencing has revolutionized algal systematics at every taxonomic level. At lower taxonomic levels gene sequences have confronted phycologists with the notion that algal genetic diversity is in many cases inadequately reflected by the morphology of the organisms. This mismatch between genetic diversity and morphology has been the focus of a whole body of research over the past two decades. Regardless of the taxonomic group, adequately sampled datasets nearly always reveal a plethora of cryptic or in some cases pseudocryptic species. (Lajeunesse, 2002; Montresor et al., 2003; Saez et al., 2003; De Clerck et al., 2005; Saez & Lozano, 2005; Sarno et al., 2005; Saunders & Lehmkuhl, 2005; Evans et al., 2007; Lilly et al., 2007; Medlin et al., 2007; Kooistra et al., 2008; Leliaert et al., 2009; Verbruggen et al., 2009; Boo et al., 2010; Gomez et al., 2011; Piganeau et al., 2011).

Undescribed, collected

The main challenges, however, nowadays are not set by disclosing diversity, but consist of linking genetic diversity to names in the literature and ultimately to the specimens housed in herbaria. The 'low morphology' problem (Vanoppen et al., 1993) of single-celled photosynthetic eukaryotes and seaweeds does not only complicate diversity assessments of living organisms, it also makes accurate interpretation of type material and historical collections a daunting task. With our current knowledge it is therefore nearly impossible to predict how many species have been collected but await formal description. The numbers of Bebber et al. (2010), predicting that more than half of the undescribed flowering plant species has been discovered and stored in herbaria already, probably hold up for algae as well. If one interprets 'discovered' as being recognized as undescribed, this number is probably very low.

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Mangroves	**Described + Nominal**

[Farid Dahdouh Guebas, Koedam Nico]	It is important to highlight that the list of Mangrove associates is never-ending and if one refers to mangroves one should consider only the species that are either Minor or Major mangrove components. Some people who live in one part of the world argue that in their part of the world mangrove-associate or even terrestrial trees are considered mangroves, but this lead to absurd situations in which the number of mangroves "explode" at the expense of the management of true mangroves (minor + major). **Undescribed, collected** My best guestimate is that there are none, or at least they might be the same as the ones under undiscovered. **Undiscovered** My best guestimate is that in countries where congeneric species are present, there might be undiscovered hybrids. An analysis on the geographic data in the Mangrove Reference Database and Herbarium (Massó i Alemán et al, 2010) leads to the guestimate of the theoretical hybrids below. This means that the putative parents occur in the same country and may therefore have crossed. However there are 3 caveats, 2 of which I can resolve if the resolution of the other marine species that you are investigating is higher and if I have more time: (1) I did not take into account country size (more likely to have undiscovered species or hybrids in large countries with large mangrove areas), and (2) co-occurrence in a country does not necessarily imply co-occurrence in the same forest. Guestimate of number of totally new species : 0-5 Potential undiscovered hybrids : 54 hybrids, being Between *Acanthus ebracteatus*, *A. ilicifolius* and *A. xiamenensis* : 3 hybrids Between *Acanthus ilicifolius* and *A. volubilis* : 1 hybrid Between *Acrostichum aureum*, *A. danaeifolium* and *A. speciosum* : 3 hybrids Between *Aegiceras corniculatum* and *A. floridum* : 1 hybrid Between *Avicennia integra* and *A. marina* : 1 hybrid Between *Avicennia alba*, *A. marina*, *A. officinalis* and *A. rumphiana* : 6 hybrids Between *Avicennia germinans* and *A. schaueriana* : 1 hybrid Between *Bruguiera hainesii* on one hand and *B. cylindrica*, *B. gymnorrhiza*, *B. parviflora* or *B. sexangula* on the other : 4 hybrids Between *Bruguiera cylindrica*, *B. exaristata*, *B. gymnorrhiza*, *B. parviflora* and *B. sexangula* : 9 hybrids (excl. the ones documented already) Between *Camptostemon philippinense* and *C. schultzii* : 1 hybrid Between *Ceriops australis*, *C. decandra* and *C. tagal* : 3 hybrids Between *Excoecaria agallocha* and *E. indica* : 1 hybrid Between *Heritiera fomes*, *H. kanikensis* and *H. littoralis* : 3 hybrids Between *Heritiera globosa* and *H. littoralis* : 1 hybrid Between *Kandelia candel* and *K. obovata* : 1 hybrid Between *Rhizophora stylosa* on one hand and *R. mucronata* or *R. samoensis*

	on the other hand : 2 hybrids Between *Sonneratia hainanensis* on one hand and *S. alba*, *S. caseolaris* or *S. ovata* on the other hand : 3 hybrids Between *Sonneratia alba*, *S. apetala*, *S. caseolaris* and *S. griffithii* : 5 hybrids (excl. the ones documented already) Between *Sonneratia alba, S. caseolaris, S. lanceolata* and *S. ovata* : 3 hybrids (excl. the ones documented already) Between *Xylocarpus granatum* on one hand, and *X. mekongensis* or *X. moluccensis* : 2 hybrids The 3rd caveat is related to the question: if these hybrids exist wouldn't someone have noticed it by now in these well-populated coastal ecosystems? Is this theoretical analysis, even though based on occurrence data, not an overestimation? I believe it is, and if based on discovery of hybrids over the last 20 years I tend to say the guestimate should be closer to 5-10 than to 50! **References** Massó i Alemán, S.; Bourgeois, C.; Appeltans, W.; Vanhoorne, B.; De Hauwere, N.; Stoffelen, P.; Heughebaert, A.; Dahdouh-Guebas, F. (2010). The 'Mangrove Reference Database and Herbarium' Plant Ecol. Evol. 143(2): 225-232
Ciliophora [Alan Warren]	I made estimates based on the arguments proposed by Finlay et al. (1996, 1998) and Foissner et al. (2008), and following extensive discussions with Genoveva Esteban (co-author of Finlay et al., 1996, 1998). **Undiscovered** This, of course, is highly debatable, and especially difficult to estimate for parasitic or commensal forms as we know little about their host species specificity. Basically, the number of undiscovered species of such forms may depend on the number of unknown host species. The 'moderate endemicity' model (Foissner et al, 2008) states that the total number of ciliate species is significantly underestimated largely due to: (1) undersampling; (2) previously unrecognised morphological variation, and; (3) the existence of sibling species, a lack of understanding of the genetic species diversity, etc. When these factors are taken into account it is estimated that 83 – 89% of free-living ciliate diversity remains undiscovered (Foissner et al., 2008). Maximum bounds: (1) Habitat studies (undersampling) suggests that the number of species should be doubled: using the upper limit of described species (2,421) gives a revised total of 4,842. Using the lower limit (2,115) gives a revised total of 4,230. (2) Unrecognised morphological variation suggests that this figure should increase by a further 50%. Based on the upper limit value (4,842), the number should be increased by 2,421 giving a further revised total of 7,263.

	Based on the lower limit value (4,230) the number should increase by 2,115 giving a further revised total of 6,345. Minimum bounds: According to Esteban (pers. comm.) a 50% synonymy rate should be applied to the total estimated (morpho)species diversity. Thus for the lower limit value (6,345), a 50% synonymy rate results in 3,173 undiscovered (morpho)species. Thus, the maximum and minimum bounds for the estimated total numbers of marine ciliate (morpho)species are: maximum - 7,263; minimum - 3,173 **Cryptic** According Foissner et al. (2008), genetic and molecular evidence suggests that the ciliate (morpho)species diversity must be doubled or trebled. Maximum bounds: Trebling the maximum number of (morpho)species (7,263) gives 21,789. Thus, if the number of (morpho)species is 7,263 then the number of cryptic molecular species is 14,526. Adding these together gives a maximum total of 21,789 marine ciliate species. Minimum bounds: According to Foissner et al.'s (2008) lower estimate, the number of cryptic molecular species is the same as the number of (morpho)species, i.e. the latter value must be doubled to give the total species number. Thus, the number of (morpho)species (before applying the 50% synonymy rate) is 6,345. Doubling this gives 12,690. However, according to Esteban (pers. comm.) a 50% synonymy rate should also apply to the number of cryptic molecular species. Thus of the 12,690 cryptic species, 6,345 are redundant. Subtracting this from the 12,690 cryptic species gives a total of 6,345 marine ciliate species. Therefore, the maximum and minimum bounds for the estimated total numbers of marine ciliate species are: maximum - 21,789; minimum - 6,345. Note, all this assumes that the estimates derived for free-living species also apply to non-free-living species. **References** Finlay, B.J., Corliss, J.O., Esteban, G. and Fenchel, T. (1996). Biodiversity at the microbial level: the number of free-living ciliates in the biosphere. The Quarterly Review of Biology, 71: 221-237. Finlay, B.J., Esteban, G. & Fenchel, T. (1998). Protozoan diversity: converging estimates of the global number of free-living ciliate species. Protist 149: 29-37. Foissner W., Chao, A. & Katz L.A. (2008). Diversity and geographic distribution of ciliates (Protista: Ciliophora). Biodiversity and Conservation 17: 345-363.

Foraminifera [Bruce Hayward]	**Described** We have Ellis and Messina catalogue of published foram species and descriptions. There are nearly 50,000 species described and named - but that includes a majority from the fossil record. Species described from the modern are not separated out and many species described from the fossil are still extant. John Murray (2007) recently published an estimate based on the data he assembled world-wide for his book. However, I have little faith in his methodology or assumptions. His initial number is based on specimens recorded stained (ie contained protoplasm) in studies. Fewer than 20% of studies on modern forams have stained their specimens in processing. As a result fewer than 50% of the species recorded from NZ for example are in his count and even lower percentage from the deep sea. I disagree with him that only 50% have been described - I think the number is a lot higher, except for cryptic taxa that can only be identified by molecular studies. I also think far greater percentage is cosmopolitan but this is obscured by multiple descriptions and namings from different regions. I think around 5,000 species is reasonable, which is not far off Murray's maximum. Only one small family is complete - one that I monographed 20 years ago and no new species have been found since then, even in the fossil record. Clearly we will never have a precise answer to your questions but even a near accurate estimate is still some time (years?) away. **Nominal** Would be >10,000 **Undescribed, collected** Might be <1000 **Undiscovered** If molecular species are excluded then <500. I will watch these numbers change over time. **References** Ellis and Messina catalogues, New York: Micropaleontology Press, AMNH. Available from http://www.micropress.org/e_m.html
Radiolaria (polycystine) [David Lazarus]	**Described + Nominal** There are a total of ca 570 polycystine radiolarian species names collated from the plankton literature of the last ca 30 years by various people, including Demetrio Boltovskoy and Kozo Takahashi, the list provided by EOL to Jane Dolven, Annika Sanfilippo and myself, and additions by other contributors. Of these, 400 are considered by us to be valid, 160 are thought to be synonyms, and around 10 have not been resolved yet. This implies a synonym percentage of 29%. Note that we are explicitly excluding the many hundreds, probably >1,000, additional names for presumed living

	polycystine species introduced in the 19th century but not used in any of the modern literature sources. Most of these early names are either clearly artificially split species or nomen dubia, having minimal description, no illustration, and no type material. Many of these early names may not even be really from the plankton but from sub-fossil material (e.g., up to a few thousand years old) present in the surface sediments, or even older fossil material reworked into younger layers. Please also note that we are discussing only the polycystine radiolarians. There are two other groups often referred to as 'radiolaria' - the Phaeodarians and the Acantharia. We do not have any useful summary data on diversity yet for either of these groups, though neither group is as diverse as the polycystines. **Undiscovered** Although I do not work with the plankton directly myself, only with the surface sediments, I can confirm the comment made earlier by Kozo. It is highly unlikely that there are more than ca 10% truly 'undiscovered' (i.e. unsampled) living polycystine taxa - plankton provinces are large and have been sampled repeatedly by many workers, both directly in the water column and even more intensively from surface sediments. **Cryptic** What is still largely unknown is how many cryptic species there are. This is a major problem for protists. All genetic studies so far find very high levels of cryptic or pseudo-cryptic species. The number of biological species, to the extent this concept applies in protists, may be much higher than the morpho-species count - possibly twice as much and protists diversity may grow significantly in the future, not from unsampled material but by refined (genetic) character analyses.
Fungi [Paul Kirk]	**Described** From the recently published Marine Fungi (E.B.G. Jones) there are 1035 'obligately' marine species - by this I mean they occur in marine environments by 'choice' rather than by accident ... they are not 'contaminants'. **Nominal** Add heterotypic names and that figure rises to 1156. **Undescribed, collected** I guess there are about 200 undescribed species from collection based on an estimate of the collecting activity and the number of new species described in recent years. There may be more than this from environmental sampling but this is an area where I have no information as little has been published. **Undiscovered** If we assume that there are a global total of 1.5m fungi and we currently know 100k then we can apply the same ratio to marine fungi and arrive at an estimate of 1,000 x 15 = 15,000.

Acanthocephala [David Gibson]	The number of undescribed and undiscovered species are complete guesstimates. **Cryptic** There is genetic evidence, as far as I am aware, from only one 'species'. My estimates range from 50-150.
Polychaeta [Geoffrey B. Read.]	**Described and Nominal** 12,632 accepted (includes 659 unchecked, 259 yet to be entered in WoRMS), and 6696 unaccepted, including 9 homonyms, plus (another category outside 'unaccepted') 122 Nomen dubium, 13 Nomen nudum, thus a total number of nominal species of 19,463. Since 1758, the beginning year of Linnaean nomenclature, the current total of nominal species (about 19,500) has accumulated at a modest overall average of around 90 Polychaeta described per year, with the number varying from fewer than 5 (mostly back in the 18th century) to a startling peak of 685 per year (in 1866). We would hope for an increasing pace in modern times with steadily more taxonomists interested in the group and working, but as yet this trend is not pronounced. WoRMS data shows that for the last 50 year period with full figures, 1956 to 2006, the average has been 130 per year, with the most species described in this period of 248 in 1972. The most productive years for polychaete taxonomy were back in the era 1860–1880 which contained four years with over 300 species described per year. This is because major monographs by Quatrefages, Kinberg, Schmarda, etc, were published during that time. **Undescribed, collected** Glasby et al (2009) reported 34 % known undescribed species documented in collections for New Zealand seas in 2000, the year of their assessment, and estimated the likely number of species was double the then total of 763. Since most of the world apart from well-explored coasts such as along the northwestern Mediterranean and North Sea, are probably less or equivalently explored for Polychaeta as New Zealand, it seems conservative to extrapolate that 80 % of worms in collections worldwide are described, making a world total undescribed in collections of an additional 3,158 species. New Zealand museums are expected to have a somewhat higher number of undescribed species than elsewhere (large offshore collections in New Zealand have not been described). A further conservative extrapolation merely doubling the total described and known undescribed gives about a world fauna of around 19,000 (18,948) Polychaeta species, but a total of 25,000 to 30,000 species would not be surprising. **Cryptic** Based on the experience in recent papers there would be between >1 to >5 molecular cryptics for every valid name, conservatively (one paper found 10), with mostly towards the lower limit applying. As usual the Polychaeta

	are so disparate that the proportion is likely to fluctuate wildly between families, and there simply has not been sufficient of this work done to assess the situation overall, so a more precise estimate is not possible. Noting that people tend to look for cryptics when they're already suspicious. **Reference**: Glasby, C. J.; Read, G. B. ; et al. 2009: Phylum Annelida. Bristleworms, Earthworms, Leeches. In D. P. Gordon (ed.) The New Zealand Inventory of Biodiversity: Volume 1. Kingdom Animalia: Radiata, Lophotrochozoa, and Deuterostomia. Christchurch, New Zealand. Canterbury University Press. p. 312-358.
Hirudinea [Jürgen B. Kolb]	**Described and nominal** The range of names as I have today is 249 of which 179 accepted species, so a range of 150-200 known species living in marine waters can be assumed to be realistic. **Undescribed, collected** Chances are slim to find many marine fish leech specimens in existing collections as the conventional sampling techniques leading to their existence make it nearly impossible to catch these parasites before they detach and fall of their hosts. Leeches are either lost while trawling, bringing the sampling equipment to surface and on board or during the subsequent handling on deck. Furthermore, there is often very little time during an expedition to look at many fish host individuals, into their gill chambers or even other temporary hosts to find the often small and inconspicuous animals. Nevertheless, sporadically some leech specimen is found in a collection alongside with another species and thus it could be suggested that a possible further 10-20% of yet to be described species lie hidden in the collections around the world. So I assume 25-50 potential new species in collections. **Undiscovered** The leeches living in the marine environment are elusive parasites and very difficult to sample, thus, our knowledge to their true number is very limited. Many areas in particular in the North Atlantic and the polar regions are hard to sample or have not been studied for their leech fauna at all. If one considers that new marine species, particularly in coastal habitats, are still discovered with reasonable frequency by only a few experts working in this specific taxonomic field, the actual number of species in the marine world could well be 100% greater than currently known. So min-max undiscovered morpho-species: 50-100. **Cryptic** The cryptic diversity is very likely to be low from what we know today but there is not a basis for a good judgment that I have read about. There might be examples to come in the future but so far the marine leeches are distinguished from each other in morphological structures and for most

	species that seems to work well in regards of phylogeny. Therefore, I would assume a 5-10% error margin for cryptic species to be identified in the future. My minimum-maximum estimate of cryptic genetic diversity would be in the range of 5 to maybe 20 species.
Oligochaeta [Christer Erséus]	**Described** The 910 currently known marine morphospecies are still a valid number, as compiled by Tarmo Timm in 2009; virtually nothing has been added since then. [I spend most of my time on molecular systematics these days, and never seem to get around describing all the undescribed marine worms I have.] **Undescribed, collected** My previous estimation of (roughly) 300 undescribed species (those present in my own collections) is up to date too, as I have not collected anything really new during the last 1-2 years. **Undiscovered** Based on a gut feeling, we probably have just described about a tenth of all species out there. Virtually nothing is known from the South-American and African coasts, and large parts of the Polar regions, Asia and the Indo-Pacific Islands. Not to mention the deep sea, from where we only have scattered records; these latter records, however, indicate a rather high diversity). If you ask for a 95% interval, it would be between 5,000 and 15,000. **Cryptic** Although I am finding cryptic species all the time, it is extremely difficult to translate this into a general percentage (or a similar measure). Today I concentrate my research on non-marine oligochaetes, and there are probably (and totally) hundreds of cryptic species among all common freshwater and terrestrial morphospecies, including the "cosmopolitan" taxa that are so popular as model organisms in research around the world. For marine worms, I have preliminary genetic evidence of cryptic speciation in at least 15 morphospecies, which is a low percentage of the about 300 marine species that I have sampled for DNA so far. Then it should be noted, however, that for the majority of my many marine species, I have sampled only one specimen or population, and I am sure that the number of sibling species will increase with wider geographical sampling. What I dare to hypothesize is that at least 10% of all marine oligochaete morphospecies known today are each containing 2 (or in many cases >2) cryptic species. Thus 10% of total morphospecies (6,000-16,000) contains at least one extra, cryptic species = >600-1,600.
Acarina [Ilse Bartsch]	**Described** Acarina: known species (end of 2010) • Prostigmata: Halacaridae 1098 marine species (1122 valid species

	minus ca 25 exclusively freshwater species) • Prostigmata: Pontarachnidae 42 species • Astigmata: Hyadesiidae 48 species • Oribatida: Ameronothroidea 30 species • Not included are species of a group called Mesostigmata; I would say, they are terrestrial rather than aquatic. The sum of that, 1218 valid species. This is the number of momently valid species, synonyms are ignored **Undescribed, collected** About 100 new (undescribed) species are hanging around in collections. **Undiscovered** In recent years, I received material from parts of the world not studied before, the result, more species than described as new have been withdrawn and also surprisingly most of the species were known from localities far away. I expect the number of undiscovered species (on the basis of morphological characters) between 1X and 1.5X that already known, accordingly between 1320-1980 species. If you exclude the 100 species in collections it would be 1220-1830 species. **Cryptic** There are some few very wide-spread species, wide-spread mainly in a biogeographical but also ecological sense and range. One may expect the one or other cryptic species amongst these species. A lot of species are known from a single locality/sample. Less than 10 % of presently described species may not be just one but two (or more) species, though actually, there is not a single record of a cryptic species. I think there aren't many cryptic species amongst the halacarid mites. Just to give a number, 3-8 % of the described species may prove to represent a cluster of species, in all perhaps 150, max 200 new species.
Merostomata [Geoff Boxshall]	**Described and nominal** There are 4 valid species but I have seen several other invalid names at various times. The only uncertainty is about synonyms. **Undescribed and undiscovered** I would say - no species awaiting description; no unknown new species predicted either.
Pycnogonida [Roger Bamber]	**Decribed** 1307 species. **Nominal** 1348 species names. **Undescribed, collected** 150-500. Based on looking at material awaiting study in Museums in

	London, Cape Town, Wellington (NZ) and Melbourne. Then multiplying by number of Museums likely to have some material (only one museum currently has an in-house pycnogonid researcher), error margins (max min) based on estimated disparity between those four collections. **Undiscovered** 979-1650. The minimum number is based on analyzing the number of new species described per year over the last 20 years for 10 sea regions where there has been study in the last 20 years (surprisingly consistent), and assuming the same value for the other regions (where there has not been study in the last 20 years), and extrapolating for the number to be found over the next 60 years in the best studied areas (about 130 years of proper study), and allowing for the fact that those less-well-studied regions have more species awaiting to be described by assuming a similar accretion rate had they also been studied already for 130 years. [Annual "accretion" curve of new species over the last 20 years does not asymptote, so this may be an underestimate!] **Cryptic** 50-100. Based on an estimate of the number of species currently far-too-widely "distributed" for a taxon with no dispersive phase, together with the number of new taxa confirmed by molecular means from the few recent studies on such "widespread" species, with "range" generated by allowance for number of recent synonymies.
Shrimp-like Decapoda: Caridea, Procarididea, Stenopodidea, Dendrobranchiata [Charles Fransen, Sammy De Grave]	**Cryptic** As for cryptic genetic diversity in shrimps, there is only one study, on a subgroup of Alpheus. This estimates that that potential species complex comprises 20 species rather than the one currently known. I would feel uncomfortable to projecting that ratio to all shrimps, as the level of cryptic species diversity must vary amongst group. Overall, there is no basis for judgment in terms of all the shrimps groups me and Charles provided numbers for. Given the high number of available synonyms in the genera for which there has been a suggestion of cryptic species diversity (based on very limited genetic evidence) and the lack of combined molecular-morphological-colour pattern-ecological studies, it is impossible for us to provide even an appropriate guestimate.
Achelata, Polychelida, Enoplometoidea, Glypheoidea, Nephropoidea (marine lobsters) [Tin-Yam Chan]	**Described, nominal, undescribed-collected** Achelata: 142 accepted species, 229 nominal species names, 10 new species residing in collection. Polychelida: 38 accepted species, 52 nominal species names, 2 new species residing in collection. Enoplometoidea: 12 accepted species, 15 nominal species names, 0 new species residing in collection.

	Glypheoidea: 2 accepted species, 2 nominal species names, 0 new species residing in collection. Nephropoidea: 53 accepted species, 71 nominal species names, 2 new species residing in collection. **Undiscovered + cryptic** For a group of generally large sized animals with high economic value, surprisingly the number of new species discovered in marine lobsters is still high even very recently. For example, nearly 11.3% of marine lobsters were only described in the last decade (i.e. since 2000). From the still very steep discovery curve, no extrapolation for total number of marine lobster seems possible. Even to the most common and commercially important genera such as Palinurus and Panulirus, new species have been added in the last few years. Recent employment of molecular tools in separating cryptic and very similar species has contributed to the discovery of more lobster species as in other decapod crustaceans under this modern trend. Nevertheless, the high discovery rate of lobsters is no doubt more related to the revived large scale expeditions in the Indo-West Pacific. It is believed that many more marine lobsters with novel morphological diversity (e.g. the new genus living fossil Laurentaeglyphea neocaledonica discovered in 2006) are still awaiting discovery. At least 14 new lobster species have already been found and awaiting formal description. Thus, it seems reasonable to assume that there are at least half more species (i.e. more than 120 species) of marine lobsters are still undiscovered, with min-max bounds of 30-70%. Genetic diversity will be responsible for 1/3 of these new discoveries. **References** Chan, T.Y. (2010). Annotated checklist of the world's marine lobsters (Crustacea: Decapoda: Astacidea, Glypheidea, Achelata, Polychelida). Raffles Bull. Zool. suppl. 23: 153-181.
Chirostyloidea and Galatheoidea [Enrique Macphearson, Kareen E. Schnabel]	**Described, nominal, undescribed** **Galatheoidea**: 715 accepted species, 773 nominal species names, 300 new species residing in collection **Chirostyloidea**: 206 accepted species, 211 nominal species names, 250 new species residing in collection **Undiscovered + cryptic** After the rate of describing new species in the Indian and Pacific Oceans along the last decades, and considering the areas poorly known or scarcely sampled, we believe that the percentage of known species is ca. 20% in Chirostyloidea and ca. 35% in Galatheoidea. We are including in these estimations the species residing in collection and

	the undiscovered species. Therefore, the total number of unknown species would be: Chirostyloidea: 250 new species residing in collections, and 580 undiscovered; Galatheoidea: 300 new species residing in collections and 830 undiscovered. The number of cryptic species is obviously a problem. There are only a few number of studies on the matter. These papers are on genera with a few number of species, e.g. *Allogalathea* that the species complex comprises 4 species rather than one, and a similar pattern is observed in the genera *Lauriea* (8 species rather than two) and *Sadayoshia* (13 species rather than eight). We are not sure if these percentages of cryptic species would exist in other genera, although we believe that the percentage will decrease in species rich genera. Therefore, a percentage of 10-15% seems adequate, considering the whole number of squat lobsters. **Reference** Poore GCB, ST Ahyong and J Taylor (eds) (2011) The biology of squat lobsters. 363 pp. (CSIRO Publishing: Melbourne and CRC Press: Boca Raton)
Galatheoidea (Porcellanidae) [Masayuki Osawa]	**Described** 280 valid species and 3 species of *incerta sedis* (Osawa & McLaughlin, 2010; all data in WoRMS). **Nominal** 416 (including 133 species under synonyms of accepted species). **Undescribed, collected** I have at least 3 species to describe as new at present. My guess is about 10 species in total. **Undiscovered** My guess is at least 20 species. **Cryptic** My guess is 10-30 species. **Reference** Osawa, Masayuki; McLaughlin, Patsy A. (2010). Annotated checklist of anomuran decapod crustaceans of the world (exclusive of the Kiwaoidea and families Chirostylidae and Galatheidae of the Galatheoidea) Part II – Porcellanidae. The Raffles Bulletin of Zoology. Supplement No. 23: 109-129
Hippoidea [Christopher B.	**Described** 81 recent + 12 fossils.

Boyko]	**Nominal species** 18 additional names are synonyms (all Recent species) so total are 100 recent names + 12 fossils. **Undescribed, collected** Max 3. **Undiscovered** Less than 10, based on rate of discovery in last 10 years **Cryptic** There are no molecular studies that have looked at this group beyond using 3 exemplars (1 from each hippoid family). So I have no evidence of cryptic species in this group at this point. **Reference** Boyko, C. B.; McLaughlin, P. A. (2010) Annotated checklist of anomuran decapod crustaceans of the world (exclusive of the Kiwaoidea and families Chirostylidae and Galatheidae of the Galatheoidea) part IV— Hippoidea. Raffles Bulletin of Zoology Supplement No. 23: 139-151.
Lithodoidea [Shane Ahyong]	**Described** 129 spp. **Nominal** 161 spp. **Undescribed, collected** 10 spp. **Undiscovered** The deepwaters of the Indo-Pacific are sampled in a very patchy way in terms of lithodid habitat. The northern Pacific has traditionally been regarded as the centre of lithodid diversity, but this seems to more likely represent an artefact of historical sampling. When expeditions to new areas in the Indo-Pacific, sampling slope depths, capture Lithodidae, these are usually new to science. Also, abyssal depths are poorly sampled worldwide, and lithodids can be expected to be present there. About 20 new species of lithodids have been described from the Indo-West Pacific in the past 5 years, based mainly on opportunistic sampling around Australia and New Zealand. The rate of discovery remains high, so a reasonable but conservative estimate would be at least 30 more species in the Indo-Pacific, especially of small sized species of Paralomis. Sampling in the Atlantic has been much more extensive historically, but new species have been described in the last few years. It could be reasonable to expect that at least 10 more species will be discovered in the South Atlantic off the coast of South America and West Africa. Therefore, a conservative estimate would be 40

	undiscovered species worldwide.
Lomisoidea [Patsy McLaughlin, Rafael Lemaitre]	This is a monotypic superfamily, family and genus, endemic to Australia. No undescribed species known to exist in any collection; no undiscovered species thought yet to be found.
Paguroidea [Patsy McLaughlin, Rafael Lemaitre]	**Described** Right now there are 1,116 valid species on the books, although those numbers will change, both up and down, as revisionary studies continue. **Nominal** There are approximately 222 primary synonyms, with a couple of homonyms thrown in for good measure. I have included in the latter count, some taxa described as varieties (old works) and subspecies, but not all when it was pretty obvious that the author simply got confused. **Undescribed, collected** The number of paguroid species in existing museum collections that have yet to be identified and studied is hard to estimate. However, even in the collections of the Muséum national d'Historie naturelle, Paris, where paguroids have been actively studied for more than 30 years, the number of species still to be described probably exceeds 50. In museums lacking paguroid taxonomic expertise, such as several in China, a count of the number of unrecognized or incorrectly identified taxa would be very considerably higher (personal observations). Add to these estimates the potential for phylogenetically recognized new taxa and the number could easily double the currently known species. So, if you take in all the other museums the number is probably closer to 150 - 200. **Undiscovered** The accuracy of extrapolations from previous estimates of species diversity can be very misleading, at least as far as species of the Paguroidea are concerned. For example, in d'Udekem d'Acoz's (1999) inventory of European decapod species, 636 were reported and he said that on average, two new species was described each year. Of those 636 decapods, only 52 were paguroids and no new species have been added since his inventory. De Grave et al's (2009) checklist of worldwide genera and species put the number of Recent genera of Paguroidea at 120 and the number of species at 1,069. Similarly, McLaughlin et al.'s checklist (2010) lists 120 genera but with 1,106 Recent species. Clearly, estimates based on European species diversity in hermit crabs would give woefully low numbers. The apparent "explosion" in paguroid speciation is the result of expanded exploration in various parts of the world's oceans, particularly the Indo-Pacific. In the last 20 years (1990—2010), 365 new species have been added to the paguroid inventory, the majority coming from the western Pacific and Indian Oceans: Diogenidae, 118 species; Paguridae, 213 species; Parapaguridae 28 species; Pylochelidae, 4 and the new family

	Pylojacquesidae with two monotypic genera. Only in the family Coenobitidae have no new species been added in the past 20 years. If exploratory efforts continue at approximately the same rate in more of the poorly known tropical and subtropical regions of the world's oceans, the number of species could easily increase to a total number of 1500. **Cryptic** Asking for a guess of genetic diversity in the superfamily Paguroidea is akin to guessing the lengths of the longest and shortest straws in a bale of hay. There is only a minuscule amount known about the genetic make-up of hermits, so any idea of that diversity is simply impossible. **References** Grave, S., De, N. D. Pentcheff, S. T. Ahyong, T.-Y. Chan, K. A. Crandall, P. C. Dworschak, D. L. Felder, R. M. Feldmann, C. H. J. M. Fransen, L. Y. D. Goulding, R. Lemaitre, M. E. Y. Low, J. W. Martin, P. K. L. Ng, C. E. Schweitzer, S. H. Tan, D. Tshudy & R. Wetzer, 2009. A classification of living and fossil genera of decapod crustaceans. Raffles Bulletin of Zoology, Supplement 21: 1–109. McLaughlin, Patsy A.; Komai, Tomoyuki; Lemaitre, Rafael; Listyo Rahayu, Dwi. (2010). Annotated checklist of anomuran decapod crustaceans of the world (exclusive of the Kiwaoidea and families Chirostylidae and Galatheidae of the Galatheoidea) Part I – Lithodoidea, Lomisoidea and Paguroidea. The Raffles Bulletin of Zoology. Supplement No. 23: 5-107 Udekem d'Acoz, C. d', 1999. Inventaire et distribution des crustacés décapodes de l'Atlantique nord-oriental, de la Méditerranée et des eaux continentals adjacentes au nord de 25°N. Patrimoines naturels (M.N.H.N./S.P.N.), 40: 1–383.
Brachyura [Peter Ng, Peter Davie]	**Described** Anno June 2010: 1330 valid genera with 389 synonyms; 6978 named species with 1958 synonyms; 1330 valid genera with 389 synonyms. **Undescribed** Peter Ng: we easily have at least 100 plus species in our collections which remain undescribed. Peter Davie: I have at least 60 species I know of, and then if we work on the estimate that there are about 50 new species discovered per year (that are not from our own groups), and make the assumption that these take 3 years from discovery to formal description (probably an underestimate), than we could add another 180 from the rest of the world. So 100+60+150 = 310. **Undiscovered + Cryptic** Peter Ng: the last 20 years has seen an average of 60-80 new genera and species every year (average one quarter are genera, rest are species). The number of new species recognised now versus what was recognised in the

	1950s has seen a 57% increase. On these trends, and assuming we have another 40-50 years of good sustained progress, an increase of another ca. 3000 can be expected. A grand total of 10,000 is therefore not unreasonable. Cryptic [Peter Davie] As for the cryptic Brachyura – the following is the basis for a reasonable guesstimate. Of about 5650 marine species – if we guess 10% as being widespread IWP = 565 Recent genetic and morphological studies we have done on two widespread IWP commercial crabs show that each includes 4 cryptic species. And this is reinforced as a more widespread decapod phenomenon, by similar results on a scyllarid lobster (5 cryptic species in the complex). So if we were to extrapolate as a minimum of 2 cryptic species per widespread taxon (e.g. one Indian Ocean basin and one Pacific Basin), then we would potentially have around another 560 unrecognised forms. If we were to allow each to include 4 cryptic species (which, as shown, is not unreasonable), then this would blow out 1700 extra. So let's say for the Brachyura: minimum cryptic species c. 550 maximum cryptic species c. 1700 However, 1) this is based on a simple rough guess of 10% being widespread – we haven't had time to assemble the basic distributional data for all species yet (hopefully later this year)t, so this may be either an under- or overestimate. 2) I don't have any personal experience of what level of cryptic speciation is likely/possible in the Atlantic. I haven't discussed this directly with Peter Ng, and he may well have a better handle on this – so please bear in mind he might suggest some modification of these numbers. The take-home message, however, is that cryptic speciation is going to be an important factor in understanding marine brachyuran biodiversity. [Peter NG] Agreed. Peter Davie has taken a semi-conservative approach here with ranges of 565-1700 for the 6000 species we have now. The Americans think we have much more and think that there could be as many as the total! Instinctively, I am more inclined to agree with Peter D's estimate as on the ground taxonomists generally tend to be more conservative. But the truth as usual is often in-between. So I would say that for operational reasons, we can take the higher end and go for say two times what Pete may suggest. I suggest this on the grounds also that many of these widespread species may have up to four "cryptics", more species are found to have wider ranges than expected with better surveys (so increasing the chance of cryptics), and we are still finding many new species at a high rate. So a higher number may be more realistic.
Gebiidea [Gary Poore]	**Described** 203 species

	Nominal 203 accepted + 22 synonyms = 225 species names. **Undescribed, collected** wild guess ~50 **Undiscovered** ~100 – many areas especially deep water are unexplored, cryptic species are probable and the habitats in which these burrowers are found are hard to sample.
Axiidea [Gary Poore]	**Described** 455 species. **Nominal** 455 accepted + 51 synonyms = 506. **Undescribed, collected** A wild guess ~50. **Undiscovered** ~200 – many areas especially deep water are unexplored. Eg, Poore & Collin 2009 added 50% to the known fauna of Australia following sampling in WA and similar increments could be anticipated in other of the Pacific, the centre of diversity for this group. The probability of cryptic species in some widely applied names is high, and the habitats in which these burrowers are found are hard to sample.
Amphipoda [Jim Lowry]	**Described** Based on my checklist/catalogue there are currently 9,215 accepted species, of which 2,000 freshwater; 6,947 marine; 268 terrestrial (this includes the supralittoral beach-hoppers). **Nominal** Until we get full synonymies for all species the answer to this question is not known. **Undescribed, collected** Even in my own collection at the Australian Museum I don't know how many undescribed species are present. **Undiscovered** In a 4 year project we just finished, looking at about 30 genera in 7 families around the entire Australian coast and off-shore islands, we identified about 450 species of which about 120 were new – about 37.5%. We just got a new grant to describe those species. In the recent Great Barrier Reef project we identified about 230 species and about half were new species. However the majority of described species identified from the GBR study were new

	records for Australia. This was the first serious study of amphipods in tropical Australian waters and in fact the sampling was limited. In Australia we have now described about 1,150 species. If the unknown species rate is about 40% then we might expect 1,600+ species in shallow Australian waters. But if you add in new records of exotic species then it becomes less predictable and much higher. So that is kind of Australia. Probably the majority of world species come from Europe, North America, Japan, Madagascar/South Africa, New Zealand, Australia and Antarctica. If you start to look at all the places that are not well studied, including the deep sea, maybe you would double the current figure and estimate to about 20,000 species.
Cumacea [Sarah Gerken]	**Described** The number of species I have in my database at the moment is 1444. **Nominal** There are very few species name synonymies (30-40 names), but there are lots of generic revisions and generic synonymies (~150). **Undescribed, collected** I have in hand at least 45 undescribed species, 27 of which are in the process of being described at the moment. **Undiscovered** Excepting the North Atlantic and a few other relatively small well-studied regions, collections usually include 80-100% new species. If there are an estimated 1450 valid species, then that suggests that the number of undiscovered species, conservatively, is around 6000.
Isopoda [Gary Poore, Niel Bruce, Christopher W. Boyko]	**Described** 6,345 species. Figures were extracted from WoRMS and Schotte et al. (2008) by accumulating numbers of accepted marine species in Asellota (2114 excluding Asellidae, Stenasellidae), Phoratopodidea (1 species), Cymothoida (2615, including crustacean symbionts [fide C. Boyko] and excluding freshwater species defined by NL Bruce), Microcereberidea (27 marine of 48 according to Wilson (2008a)), Limnoridea (61), Sphaeromatidea (776, excluding freshwater species according to Bruce), Valvifera (603, excluding freshwater species), Oniscidea (148 in Ligiidae, Actaeciidae and Tylidae). Phreatoicidea were excluded. **Undescribed, collected** 3,400 known but this could well be an underestimate because only some of the known collections were included : Antarctica 674*86% + 600 + 70 [Brandt, Loerz], Australia 320 SE slope, 118 WA slope, 50 SE shelf, 50 subtidal, 50 NW shelf [(Poore, et al., 1994), Poore, Bruce unpublished], NZ 300 [Brenke], some coral reefs 200 [Bruce], Gulf of Mexico 59 [(Wilson, 2008b)], Atlantic [284, DIVA, BIOZAIRE, MAUD, NODINAUT provided by CeDARMAR], MNHN, 71 [Bruce]. Family based estimates:

	Anthuroidea: 100; Sphaeromatidae: 100; Bopyroidea: 350, and Cryptoniscoidea: 100 [Boyko pers. comm.]; Missing data: Pacific deep-sea [Blake, Wilson], other museums. **Undiscovered** Using data from the deep sea that are largely Asellota Poore & Wilson (1993) estimated that less than 5% of species are known and recent samples in Australia suggest the figure is closer to 1% for asellotes but 17% for non-asellotes. CeDAMAR scientists believe for the Atlantic the figure is more like 10-20%. I would bias the figure more towards the lower figure to represent the larger and less sampled Pacific (5%). It could be argued that for non-asellotes in shallow water we have a better handle although many tropical species remain undescribed. Use 10% for these. So, undiscovered species, 2114/5% + 4231/10% = 85 000. I would give a range of 60,000 to 120,000. How realistic is this? Many surveys in new areas turn up 100-300 new species. Meaning we could get another 79,000 species with 263-790 surveys. Sounds like a lot and there is a risk of faunal overlap. But (1) the world is a big place (2) the surveys we are talking about range in sampling size from 10 to 100,000 square metres (3) all are dominated by rare species and species accumulation curves that don't asymptote. It is worth remembering that sampling in the vast deep Pacific and Indian Oceans is only just beginning and asellote isopods dominate this habitat. Sampling in temperate and tropical Asia and Australia has consistently turned up numerous new species in the few families have been covered well. And as Niel Bruce reminds us "As far as Isopoda are concerned the highly diverse area of the 'Indo-Malaysian triangle' is not collected". As endemism is high there would be a large number of undescribed species in this region, easily into the 400 to 600 range if it as diverse as the Great Barrier Reef. East African coral reefs are similarly lightly collected, and indications are that these will be as diverse as the GBR. The flaw in my argument is that there is bound to be overlap between so many surveys. But one third of the fauna turns over along 3,000 km of the southern coast of Australia (in one biogeographic zone, see O'Hara & Poore 2000), and 80-90% from S to N Australia and again from Australia to Japan, and probably from Australia to Africa etc. **Cryptic** You introduce interesting practical and philosophical questions when asking for an estimate of undiscovered cryptic species. In the best study of the subject on isopods, Raupach et al (2007) discovered as many as 5 species within a moderately widespread deep sea asellote nominal species. One could be tempted to multiply our estimate of morphological species by 5. The reason I would not is the fact that most described (and undescribed but recognised morphospecies) species are known only from a few individuals

	from the type locality or nearby. And there is plenty of evidence rapid species turnover with distance for deep-sea isopods, and probably other taxa. Cases of multiple identifications over a wide geographic range are surprisingly few, relative to the number of species described. No cases like Raupach's are known from common widespread species in Europe or the US. There is some genetic variation in *Idotea balthica* but still only one species as far as is known. So what you are asking is – would I recognise a new species on the basis of morphology if I found one in a new region? My guess is probably yes. Raupach did not re-examine the morphology of his notional species but I would be surprised if they couldn't be distinguished. Morphologists are learning to look harder. There are plenty of examples of species swarms differentiated by slight morphological differences in Australia – see my work and that of Just, Wilson, Bruce. Plus, there are plenty of examples of so-called widespread species being later divided on the basis of morphology. So in conclusion the number of species which you could justify multiplying by 5 or any other number is small, possibly <100 at a guess, a trifling number compared to 60,000-120,000. If you want a figure: 50-500 is as good a guess as any. **References** O'Hara, T.D. & Poore, G.C.B. (2000) Patterns of distribution for southern Australian marine echinoderms and decapods. *Journal of Biogeography*, 27, 1321-1335. Poore, G.C.B., Just, J. & Cohen, B.F. (1994) Composition and diversity of Crustacea Isopoda of the southeastern Australian continental slope. *Deep-Sea Research*, 41, 677-693. Poore, G.C.B. & Wilson, G.D.F. (1993) Marine species richness (with reply from R.M. May). *Nature*, 361, 597-598. Raupach MJ, Malyutina M, Brandt A, Waegle J-W (2007) Molecular data reveal a highly diverse species flock within the munnopsoid deep-sea isopod Betamorpha fusiformis (Barnard, 1920) (Crustacea: Isopoda: Asellota) in the Southern Ocean. Deep Sea Research Part II 54:1820-1830. Schotte M., Boyko C. B, Bruce N. L., Poore G.C.B., Taiti S., Wilson G.D.F. (Eds) (2008 onwards). World List of Marine Freshwater and Terrestrial Isopod Crustaceans. Available online at http://www.marinespecies.org/isopoda Wilson, G.D.F. (2008a) Global diversity of Isopod crustaceans (Crustacea; Isopoda) in freshwater. *Hydrobiologia*, 595, 231-240. Wilson, G.D.F. (2008b) Local and regional species diversity of benthic Isopoda (Crustacea) in the deep Gulf of Mexico. *Deep Sea Research Part II: Topical Studies in Oceanography*, 55, 2634-2649.

Mysida & Lophogastrida [Kenneth Meland]	**Described** 1,180 species of mysids and 56 species of Lophogastrids (data from WoRMS). **Nominal** 1,743 mysids and 74 lophogastrids (data from WoRMS). **Undescribed, collected** Considering that there are few taxonomists actively working with Mysida, and that they are regularly describing new species upon discovery, we do not expect many undescribed species laying in their "private" collections? A quick enquiry to five taxonomists suggests approximately a total of 50 undescribed species in their collections (Brattegard, Meland, Murano, Hanamura, Price, pers. com.). On the same note, pertaining to the fact that only very few researchers work with Mysida taxonomy, we expect that benthic surveys might result in collections with unidentified Mysida specimens, albeit not so many, a wild guess would therefore be 80-100 undescribed already collected Mysida. The majority of Lophogastrida species are pelagic and when captured quite conspicuous. Owing to their obvious appearance as of being neither Caridea nor Mysida they do not go unnoticed and are usually identified and verified by Crustacea taxonomists. We therefore do not expect many undescribed species to be found in collections. On the other hand, considering the magnitude of pelagic sampling being conducted worldwide one can expect unsorted material in several collections that do contain Lophogastrida new to science; a conservative estimate would be approximately 10 undescribed species. **Undiscovered** Opposed to number of "already collected" undescribed species, the number of undiscovered Mysida waiting to be found is definitely much higher. When including Lophogastrida and freshwater species previous estimates of described species are as follows; 520 (Gordan 1957), 765 (Mauchline & Murano (1977), 1076 (Wittmann 1999). When compared to the current estimate of 1180 described marine species, we can safely say we are experiencing a steady increase of new species and there is no indication of saturation. According to Wittmann (1999), we expect that only 25% of known Mysida is described. This estimate is based on the idea that, on a global scale, less than 3% of the continental shelf has been sampled for Mysida. Here one must also bear in mind that the majority of benthic sampling is conducted with a grab, which is highly insufficient for capturing Mysida and therefore suggests a high degree of undersampling. Large areas of both the South

American and Africa shelves, as far as Mysida are concerned, are practically unknown. Not to mention the deep-sea. In comparison, species diversity in well sampled areas (Mediterranean Sea, Caribbean Sea, North Atlantic and Pacific Oceans) are 3-5 times higher than a randomly selected shelf area, which suggests 2000-4000 undiscovered marine Mysida.

As the Lophogastrida are mostly found in the bathy- and mesopelagic zones of the world's oceans, they are quite often frequented in pelagic surveys. Recent sampling (MarEco project, 2005) between the Azores and Island as deep as 1000–4000 meter depths revealed an enormous biomass of five Gnathophausia and five Eucopia species. Interestingly only two of these are new to science, whereas the other eight species represent an expansion of geographical distribution from the South Atlantic, Gulf of Mexico, and Pacific Ocean. Similar results were also found in a study from the Gulf of Mexico revealing nine already described Lophogastrida species (Burghart et al 2007). In effect, regarding pelagic Lophogastrida biodiversity, their taxonomic history reveals increased distribution ranges and species synonomies resulting in an overall decrease of species numbers.

On the other hand, we are discovering new species of benthic living Lophogastrida. In this regard, owing to lower sampling efforts on the ocean floor, and vast areas not yet explored, following the same line of argument as in the Mysida (see Mysida section) (Wittmann 1999), species diversity of benthic Lophogastrida in well sampled areas (Mediterranean Sea, Caribbean Sea, North Atlantic and Pacific Oceans) are expected to be 3-5 times higher than a randomly selected shelf area. In effect a conservative estimate based on approximately 30 described benthic species suggests up to 120 undescribed Lophogastrida.

Cryptic
For cryptic species estimates very little has been published on "mysids", but we do have some personal observations that are useful in giving us the possibility to sketch some very rough ideas.

For Mysida, studies reveal that some species with relatively broad distributions (approximately 50 Mysida species can be considered to have a global distribution) had a genetic variation that resulted in splitting into separate species, more so for freshwater species (Audzijonyte 2005). But the opposite is also true; working with deep-sea benthic species I have found that a select few so-called cosmopolitans from the Atlantic and Pacific are remarkably identical in several genes. Also, I think we should bear in mind that although not "splitters", mysida taxonomists do have a tendency of hunting for variation resulting in establishment of new species. And taking into account that our estimates suggest that only 28% of all Mysida are currently described, this sort of limits the possibilities of finding cryptic species.

For the Lophagastrida, the majority being pelagic, and with up to 15

	cosmopolitans, one would expect that many of these actually are cryptic. Nothing is published on Lophogastrida, but I have a fairly good genetic sampling of *Gnathophausia* and *Eucopia* species from several water bodies. When receiving your most recent enquiry on new estimates I hurriedly compiled this genetic data. What the DNA sequences reveal, which I must admit was a bit surprising to me, is that the genetic distance between Indian Ocean, Atlantic Ocean, and Atlantic is surprisingly low. There are differences, but it takes the discussion more in the philosophical direction of how to define species in the context of genetic variation. In other words no clear cut geographical separation in genes on broadly distributed Lophogastrida species, which forces me, considering their distribution patterns, to give a very conservative estimate of few expected cryptic species. Again, regarding cryptic species in Mysida and Lophogastrida, we know very little. Summing up, in the marine environment, we generally expect to find more species and maybe not so much splitting of what we have already described. For freshwater and cave systems, now that's a different matter. Much more needs to be done, and for the pelagic Lophogastrida and cavernicoulos Stygiomysida, I expect more research in the near future, only time will tell. **References** Audzijonytė, A. & R. Väinölä. 2005. Diversity and distributions of circumpolar fresh- and brackish-water *Mysis* (Crustacea: Mysida): descriptions of *M. relicta* Lovén, 1862, *M. salemaai* n. sp., *M. segerstralei* n. sp. and *M. diluviana* n. sp., based on molecular and morphological characters. Hydrobiologia, 544(1): 89-141. Gordan, J. 1957. A bibliography of the Order Mysidacea. Bulletin of the American Museum of Natural History, 112 (4):279-394. Mauchline, J., & M. Murano. 1977. World list of Mysidacea, Crustacea.Journal of the Tokyo University of Fisheries, 64:39-88. Wittmann, K.J. 1999. Global biodiversity in Mysidacea, with notes on the effects of human impact. Pages 511-525, In: Schram, F.R., & J.C. von Vaupel Klein (eds.), Crustaceans and The Biodiversity Crisis: Proceedings of the Fourth International Crustacean Congress, July 20-24, 1998, volume I. Koninklijke Brill NV, Leiden, Netherlands. Burghart et al 2007. The bathypelagic Decapoda, Lophogastrida, and Mysida of the eastern Gulf of Mexico. Marine Biology, 152:315–327
Tanaidacea [Magda Blazewicz, Gary Anderson]	**Described** We have 1,153 species already described (data in WoRMS and Anderson, 2011). **Nominal** After going through my Peracarid database (Anderson, 2011), I have determined that there are about 70 subjective synonyms for various tanaids, and this is cross-checked with WoRMS.

	Undiscovered Based on the collections I have studied, 5% of tanaids might be known in the Antarctic and the Atlantic (relatively well studied regions). In contrast, the Pacific is less studied and probably only 2% is known. Following this there might be from 22,600 to 56,500 species of tanaids in world ocean. **Cryptic** I assume that some 10-15% (of described species?) might be cryptic taxa, but there is not enough evidence to underpin this. There is only one paper separating two species based on CO1. So there is no reliable data to let me judge how many cryptic species can be in tanaids, but in theory there should be many; otherwise how can you explain the cosmopolitan distribution of some taxa that are almost immovable, have no planktonic larvae and a short-life history? **References** Anderson, G. (2011). Tanaidacea Taxa and Literature <http://peracarida.usm.edu/>. Accessed on May 2011.
Thermosbaenacea [Damià Jaume]	**Described** Most species of this group appear in coastal oligohaline wells and caves. But these should not be considered as marine. The criterium is having been recorded in polyhaline (18-30 ppt) or euhaline waters. In that case there are 7 marine species. **Undescribed, collected** As regard numbers of marine taxa waiting in vials for a name, I have only a Tulumella from Caicos, and no news of others.
Copepoda [Geoff Boxshall]	**Described** 10,000 valid marine copepod species is an estimate and it is a conservative estimate because the 16,422 in WoRMS still includes so many synonyms. However, Ferrero et al. (2006) give an estimate of 12,000 for marine copepod species. The maximum figure I've seen for all copepods is 13,000 valid species and there are approaching 3,000 freshwater copepods. The number is obviously going to jump up (or down when synonyms recognized?) when the cleaning is finished. **Undiscovered and collected but undescribed** In terms of the estimates of minimum and maximum numbers of unknown species out there, I suggest min: 30,000 and max 50,000 species. The bulk of the numbers coming from meiobenthos. The CeDAMar programme within the Census of Marine Life reported 800 different copepods from the Angola Basin (most of them new species), 300 new species from Crozex and another 300 new species from Nodinaut :-

	http://www.isa.org.jm/files/documents/EN/Workshops/2010/Pres/CEDEMAR.pdf In shallower seas Ferrero et al. (2006) reported over 300 meiobenthic copepods from intertidal and subtidal sediments off Kuwait, virtually all of them new species. Outside of Europe Seas and in deeper waters, knowledge is very fragmentary. A significant number of new species will be parasitic or associated forms living symbiotically with vertebrate or invertebrate hosts. Justine et al. (2010a, b) estimated that the number of described species of metazoan taxa, including copepods, parasitic on fish hosts represents about 3% of the total species richness. Currently we know over 2000 species of fish parasitic copepods, this may increase by an order of magnitude. **Cryptic** Ann Bucklin's work on near-surface pelagic copepods showed that some the so-called cosmopolitan species were hitherto unrecognized species complexes, but in other cases there really was global scale mixing and there was no evidence of cryptic species complexes. This applies to the surface plankton only - for virtually all benthic and parasitic copepods there are no data from which an estimate can be made. **References** Ferrero , T.J., Barnes, N., Arroyo, N.L., Bennell, G., Cornelius, P,. Huys, R., Lee, C., Mustapha, M., Olaffsson, E., Sebastian, S. & Bamber, R.N. 2006. A Guide to the Meiofauna of Kuwait's Intertidal and Subtidal areas. RSKENSR Group, 73pp. Justine J.-L., Beveridge I., Boxshall G.A., Bray R.A., Moravec F., Trilles, J.-P., & Whittington I.D. 2010. Parasite biodiversity in coral reef fish: an annotated list of parasites (Isopoda, Copepoda, Monogenea, Digenea, Cestoda and Nematoda) collected in groupers (Serranidae, Epinephelinae) in New Caledonia. Folia Parasitologia 57: 237-262.
Tantulocarida [Geoff Boxshall]	**Undiscovered** Tantulocaridans were only recognised in 1983 and have since been discovered as ectoparasites on a wide range of peracaridan, leptostracan, ostracod and copepod crustacean hosts. Tantulocaridans occur from the tropics to the poles and at all depths. They are easily overlooked on the host and it is the discovery of the free-living larval stages in the marine meiofauna that has given insight into true level of species richness. Mohrbeck, Martinez Arbizu & Glatzel (2010) found 30 new species in a single series of samples from Drake Passage in the Southern Ocean. In depths exceeding 5,000m in the SE Atlantic, Mohrbeck and Martinez Arbizu reported the collection of 386 tantulocaridan larvae, and a high proportion of putative species were represented by single individuals. On the basis of only two quantitative analyses it isn't possible to robustly estimate global species richness; however an estimate of 1,000 seems quite conservative.

	References Mohrbeck, I., Martínez Arbizu, P. & Glatzel, T. 2010. Tantulocarida (Crustacea) from the Southern Ocean deep sea, and the description of three new species of *Tantulacus* Huys, Andersen & Kristensen, 1992. Systematic Parasitology, 77: 131-151. Mohrbeck, I. & Martínez Arbizu, P. Biodiversity of deep-sea Tantulocarida from the Southeastern Atlantic Ocean – First results of DIVA 2. Book of Abstracts 14th International Meiofauna Conference, Ghent, Belgium. VLIZ Special Publications 44: 57.
Euphausiacea [Siegel Volker]	**Described** 86 valid species worldwide. **Nominal** 148 species. **Undescribed, collected** None. **Undiscovered** None. Over the past 50 years only 3 new species have been described; this group of Crustacea is quite well studied and new species are hardly expected.
Stomatopoda [Shane Ahyong]	**Described** 468 spp. **Nominal** 580 spp. **Undescribed, collected** 52 spp. **Undiscovered** A conservative estimate is at least 200 more. Many widespread species appear to show regional variation that will likely prove to be distinct species. Molecular data will probably help uncover species flocks. Also, many species can be expected to be discovered de novo as coral reef habitats, especially those at moderate depths in the coral triangle are explored, and deeper, level habitats are sampled. New species are present in almost every collection to new or relatively unsampled areas. Significant parts of the western Pacific remain to be sampled as do many parts of the western Indian Ocean (generally poorly sampled). Moreover, stomatopods are rarely specifically targeted in sampling programmes and existing collections are largely the result of opportunistic or general sampling. Therefore, the diversity of stomatopods is much underestimated, and in many habitats, unsampled.

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<tr><td></td><td></td></tr>
<tr><td>Leptostraca [Genefor Walker-Smith]</td><td>
Undescribed, collected
<table>
<tr><th>Genus</th><th>Number undescribed species</th><th>Locality</th><th>reference</th></tr>
<tr><td>Paranebalia</td><td>1</td><td>Southern Australia</td><td>Walker-S 1993</td></tr>
<tr><td>Sarsinebalia?</td><td>3</td><td>Two species from Australia</td><td>Dahl, 198</td></tr>
<tr><td>Nebalia or Sarsinebalia (?)</td><td>1</td><td>Southern Australia</td><td>Walker-S 1993</td></tr>
<tr><td>Nebalia</td><td>1</td><td>Southern Australia</td><td>Walker-S 1993</td></tr>
<tr><td>New Genus</td><td>1</td><td>?</td><td>Haney & Martin, 2</td></tr>
<tr><td>Nebalia</td><td>2</td><td>Eastern Mediterranean</td><td>Kocak et 2009</td></tr>
<tr><td>Nebalia</td><td>1</td><td>Zanzibar</td><td>Olesen, 1</td></tr>
<tr><td>Paranebalia</td><td>1</td><td>Zanzibar</td><td>Olesen, 1</td></tr>
<tr><td>Nebalia</td><td>2</td><td>La Jolla Submarine Canyon, California, USA</td><td>Vetter, 19</td></tr>
<tr><td>Total</td><td>13</td><td></td><td></td></tr>
</table>
In addition to the table above, the following literature refers to undescribed species held in various collections:

The presence of several undescribed leptostracan taxa from Friday Harbour, Pacific coast USA (Haney & Martin 2000)
Multiple undescribed species in America (including Alaska), Mexico, Canada and Brazil (Haney & Martin, 2005)
Various authors referring to undescribed species (e.g. Thiele, 1904; Wakabara, 1965; Johnson, 1970; Vetter 1996b).

Based on this data, plus my own knowledge of the Australian collections, I estimate there are at least 50 undescribed species held in museum collections, world-wide. It is possible this is an underestimate and the number may be closer to 100.
Undiscovered
In the literature there are many references to the fact that the order Leptostraca is probably extremely diverse and that the low number of described species is a reflection of limited taxonomic effort and geographically limited sampling (e.g. Haney & Martin, 2004; 2005). Dahl (1985), Ledoyer (1997) and Kocak et al. (2009) note that few species of Leptostraca have been described from the Mediterranean, while Olesen (1999) report the western Indian Ocean leptostracans remain poorly studied. Haney et al. (2001) suggest the east coast of the USA is an understudied region, as is north coast of Australia (G. Walker-Smith pers.comm.). While it is difficult to estimate the number of uncollected, undescribed
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	leptostracan species I believe sampling needs to be more targeted if the "true" number of taxa is ever to be uncovered. Leptostracans are known to congregate in areas of high detritus (Vetter, 1995) and they are also known to be scavengers of dead and rotting animal carcasses (e.g. fish and crustaceans) (J.K. Lowry pers. comm. and G. Walker-Smith pers. observ.). Therefore I believe if sampling specifically targeted Leptostracans, either by collecting in areas where the benthic detrital load is high, or by using baited traps, it may be possible to collect several hundred undescribed species. In addition, as leptostracans have previously be recorded from the intertidal zone to depths exceeding 6000 m (Haney & Martin, 2005), if these depth ranges were fully explored world-wide, many, many more new species could be discovered. **References**
Ostracoda (halocyprids) [Martin V. Angel]	**Described** I can only respond with regard to the halocyprids for which the number of accepted species is 254. **Undescribed, collected** I have on my shelves awaiting description ~60 species (of which I have made inroads into describing ~20). The majority of these are deep bathypelagic/abyssopelagic/benthopelagic. On the recent CMarZ cruises we sampled pelagically down to 5000m - we caught no novel species in the upper 2000m but 10% of the species caught below 2000m were novel (or undescribed). I would not expect to add any new species in the polar oceans in the upper 2000m, but in the Indian and Pacific Oceans novel species would be found. There was no sampling of the benthopelagic realm during CMarZ, but at the old IOS we started sampling to within 10m of the sea-bed to depths of 5500m - one sample from close to the NW African slope at 4000m caught 25 novel species. I have been looking at similar samples collected in the Southern Ocean during the AnDeep programme on the Polarstern and these contain another 10-15 novel species. No benthopelagic sampling has been carried out in the Indian Ocean or the Pacific. There seems to be a handful of benthopelagic species that occur both in the Atlantic and in the Southern Ocean, but my guess is that there is generally little in common between these communities in the major ocean basins of the World. Since I do not have a credible figure for the Atlantic where I know there are at least 50 and the total might be >100. So maybe in the Pacific and Indian Oceans one might expect similar numbers - maybe more in the Pacific because of its much greater area. So in the benthopelagic faunas we might expect at least a further 500 species. **Undiscovered** I have just had a paper published in Deep-Sea Research ll 57 2173-2188 in which I conclude there are 153 species in the Atlantic. Almost no novel species where found at depths <1000m but from depths >3000m about 10% of the species were novel. The Atlantic has been well studied (as have the

Polar oceans), but the Indo-Pacific is poorly known and almost nothing is known about the deepwater faunas. We know nothing about the scale of geographical distributions in deep sea communities - so is the Indo-Pacific one big unit or several. The distributions of the mid-water faunas tend to reflect the large scale circulation patterns (i.e. water masses). So my intuition is that the deep water gyres in the Indian and Pacific Oceans will have their own assemblages of species - some of which (I guess <50%) will be shared. The Pacific is large enough for there to be and east/west divide - the Atlantic is not yet there do appear to be some small differences between east and west on either side of the mid-Atlantic Ridge. Delving into the circulation patterns is complex in the Atlantic, but more clear cut in the Pacific because of its shear scale. There are major differences in water column environments between east and west in the Pacific (there is strong oxygen depletion in the eastern tropical Pacific) .
So what - I would predict that the diversity in the Pacific and Indian Ocean are similar to that in the Atlantic. In the Atlantic when the benthopelagic fauna is fully known I would expect the numbers of species to increase to 200. I would expect the diversity in the Indian Ocean to be slightly smaller (after all it has very little northern Hemisphere), but it will be greater in the Pacific - especially as there are greater north/south and east/west divides. So let us guess that the total fauna in the Indian Ocean is around 150 and that of the Pacific is 400. The latter could be a gross underestimate if seamounts have their own specific faunas (certainly true for benthic species and maybe benthopelagic species). So than what is the communality between the different oceans - total guess 50%. Then we derived a total estimate for halocyprids of 200 (Atlantic) + 75 (Indian Ocean) + 150 (Pacific - assuming there is communality between the IO and PO). The Southern Ocean adds another 50 and the Arctic 5. - which gives a ball park estimate of ~480 halocyprid species - which is about double the number currently described.

Note that pelagic species have flexible boundaries to their distributions and are moved around by water currents and eddies. The ranges of benthic species will be far more restricted and the graininess of their distributions more complicated because of bottom topography. So the species richness of benthic species in both deep and shallow water can be expected to be much higher - perhaps by around an order of magnitude.

Cryptic
There is strong evidence for cryptic species in the halocyprid ostracods. In many 'species' there are differently sized populations that are segregated either geographically or bathymetrically. Recognising this segregation depends on the sampling regimes and often the bathymetric segregation goes unnoticed. Also routine processing of samples can lead to these size differences being missed. In all cases where these size differences are analysed morphologically good evidence is found to describe the different sizes as distinct species. Recent sequencing studies have confirmed this segregation whenever it has been possible to check them out. The situation in the Atlantic is now reasonably under control and many (?most) of these

	cryptic species have been separated - although there are a number of complexes that remain unresolved. Examination of species from the NW Indian Ocean shows many species look 'similar' but show variations with the Atlantic forms. There have been no sequencing checks performed yet to see if my suspicions that many of the species are indeed different. Samples from around Indonesia (Celebes Sea) again yield species that kind of look the same but I suspect that careful analysis would show them to be different. I have been looking at samples from the N.E. Pacific and these impressions are even stronger - many species look sufficiently familiar for me to attach names but again I am convinced that given time and effort I can show them to be different.
Ostracoda [Simone Nunes Brandao]	**Described** In WoRMS, there is around 5800 recent, described species and a total of 5396 accepted species. Therefore, 93% of the described species are valid. Using this percentage, I estimate that from 7,000 to 9,500 described species, there are from 6,510 to 8,835 valid species described so far. **Nominal** Different previous estimations range from 7,000 to 9,500 (7,000 from Cohen & Morin, 1990; 8,000 from Horne et al., 2002; 9,500 from Cohen et al., 2007). **Undescribed, collected** from 1,000 to 2,000. **Undiscovered** Based on the data below (see Examples), from 20 to 78% of the ostracod species collected for a certain study are new to science. Using the numbers above this would mean that from 1625 to 32,000 ostracod species remain to be discovered. Examples: Machado et al (2005) found 31 new species (46% of the total of 67 species) in 43 sediment samples from a small area (of 1 degree latitude, and 20' longitude) on the continental shelf off southeastern Brazil. Even for the most sampled and best well know area of the world oceans, the North Atlantic, 32% (28 species) of all 87 species were found to be new to science (Yasuhara et al., 2009). Fifteen species were found in 2 corers collected from the Southern South Atlantic, three (20%) of these species were described as new. In deep waters of the Atlantic sector of the Southern Ocean, concerning the superfamily Bairdioidea 7 new species /78% of the total 9 species) collected during the ANDEEP project (Brandão, 2008). The ANDEEP samples also provided 16 new species (73% of the total of 22 species) (Brandão, 2010) In shallow waters of the Sea of Japan, a total 35 new species (59%) were found from a total of 59 species (Zenina & Schornikov, 2008). In the Polynesian islands Huahiné and Rangiroa, 8 new species (44%) were described from a total of 18 collected species (plus six species left in open

	nomenclature because of scarcity of the specimens). **Cryptic** Estimating the number of cryptic species of marine, benthic ostracods is very difficult, because I only know of 2 papers (Yamaguchi, 2000 and Brandao et al, 2010) dealing with marine genera or species groups. I did a search in Science direct and in our literature database in Hamburg, but did not find any new paper on this topic. Most (of the few) ostracod DNA studies at this level involve freshwater taxa. I don't think we should base our estimates on the freshwater papers because most (if not all) studied last taxa show asexual and mixed (asexual+sexual) reproduction, while marine ostracods reproduce sexually only. Marine and freshwater taxa should therefore show distinct genetic patterns. One of the works comprising COI sequences of a marine genus (Yamaguchi, 2000) don't cite the term "cryptic species" but do find in their tree geographically isolated, monophyletic and highly supported clades for all 4 species they studied. The number of monophyletic clades was always equal to the number of localities sampled for each species (i.e. vary from 2 to 7). However, distinct mitochondrial lineages may be the result of other "forces" (e.g. natural selection, hybridization, incomplete lineage sorting) than speciation. Only in the case of speciation would these geographically distinct clades be cryptic species. The second study was part of my PhD and is on 1 Southern Ocean genus. There were 7 morphospecies, 6 showed no evidence of cryptic species, while 1 morphospecies (also the most morphologically variable) showed evidence for the existence of four cryptic species. But again this pattern was observed only in COI gene. I conclude that, while both papers do show some evidence for cryptic species, extrapolating the number from 2 papers (2 to 7, or 0 to 4) to the entire marine realm is too risky. I would not dare saying any number. **References** Yamaguchi, 2000. Phylogenetic and Biogeographical History of the Genus Ishizakiella (Ostracoda) Inferred from Mitochondrial COI Gene Sequences.Journal of Crustacean Biology, 20, 357-384. Brandão, S.N., Sauer, J. & Schön, I. (2010) Circumantarctic distribution in Southern Ocean benthos? A genetic test using the genus Macroscapha (Crustacea, Ostracoda) as a model. Molecular Phylogenetics and Evolution, 55, 1055-1069.
Remipedia [Stefan Koennemann]	**Described** 24 species. **Nominal** 25 species.

	Undescribed, collected We have 8 specimens waiting description. **Undiscovered** We are describing 1-2 species per year; since I began working on the group in 2002, the number of species has more than doubled from 11 to 24 (not counting the 8 undescribed species). The exploration of new cave systems (within the main Caribbean distribution range) regularly yields new taxa, and I would expect as yet undiscovered remipedes in particular on Cuba and Jamaica, but also many other West Indian islands. However, we are also finding new species in well-explored caves. For example, we have identified three cryptic species using DNA taxonomy in more or less well-explored cave systems. Moreover, one of the enigmas concerning Remipedia is the fact that they occur sympatrically (with 4 to 6 species) in many caves. Based on a rough estimate of the number of (scientifically) unexplored caves + undiscovered occurrences of cryptic species + the possibility that remipedes may have a deep sea distribution (in addition to the "tip of the iceberg", the known anchialine caves at or slightly below sea level, as suggested by Boxshall, Iliffe and others), I could imagine that the currently known taxa might be 50% or even less of what is still out there. So this should give a min-max range of 20-50 species. **Cryptic** Ca 20% or between 5-9 species. With only 24 described species, the class Remipedia is small enough to give a fairly accurate estimate of cryptic species.
Hexapoda (insects and Collembola) [Lanna Cheng]	**Described** 2,037 species. **Nominal** 2,400 species names. **Undescribed, collected** I would hazard a guesstimate of around 30-60 undescribed species in collections around the world. **Undiscovered** It is difficult to guess how many marine insects remain to be discovered since very few entomologists work in marine environments. I guess we could use a conservative guesstimate of 30-100 species. Assuming there are some 2,000 marine insect species and some 30-60 (~2%) remain undescribed in various collections. These are likely to be 'accidentally' collected by non-entomologists. It is not unreasonable to assume that at least another 2% could be discovered as more marine habitats were to be visited by entomologists in the future. My guesstimate: 30-100

	Cryptic I really have no idea how many cryptic species will turn up in marine insects. A recent molecular study on 3 species of Pontomyia (Chronomidae) indicated that there may be several (less than 10) cryptic species. Ditto an earlier study on 1 oceanic species of Halobates. I am not aware of any similar studies on other species of marine insects. **References** Andersen, N.M., L. Cheng, J. Damgaard and F.A.H. Sperling. 2000. Mitochondrial DNA sequence variation and phylogeography of oceanic insects Hemiptera: Gerridae: Halobates spp.). Marine Biology. 136: 421-430. Huang, D. and L. Cheng, 2011. The flightless marine midge Pontomyia (Diptera: Chironomidae): ecology, distribution, and molecular phylogeny. Zoological Journal of the Linnean Society. 162, 443–456.
Myriapoda [Anthony D. Barber]	It is often difficult to be clear as to whether myriapods found in or close to the littoral zone are, to use Silvestri's (1903) terminology myriapodi halofili genuini i.e. confined to such habitats (obligate halophiles), myriapodi halofili indifferenti i.e. occurring in both terrestrial and littoral habitats (facultative halophiles) or myriapodi halofili accidentali i.e. chance occurrences (accidental halophiles). Such a situation may well be true of all "terrestrial" groups in which some species have invaded the littoral zone. Myriapods are essentially terrestrial groups of arthropods but representatives of all four classes from different orders, families and genera have colonised sea shore habitats and the situation is made more complex by species which appear to be genuini in one region but occur inland in another. The geophilomorph centipede Hydroschendyla submarina, for instance, is only ever recorded from seashores in northern Europe, the Mediterranean and Bermuda and is clearly genuini whilst Pachymerium ferrugineum is clearly indifferenti in much of its range. However, in many cases, where species are described from a single littoral site no such clarity is possible and the list in WoRMS may include some species which may later be considered accidentali. Class PAUROPODA About 500 species have been described altogether of which 5 seashore species are reported, all from Europe. The total number of littoral species in world must be much greater but impossible to estimate (? 40+); These are elusive animals, less than 2mm long, and are not often found by standard sampling techniques. Class SYMPHYLA About 200 species have been described in total; 4 (?5) apparently halophilic species are reported from England, Bulgaria and California. The total number of littoral species in the world must be much greater but impossible

	to estimate (? 30+); these are difficult animals to study and are not often identified to species level. Class DIPLOPODA Of the 10,000 or so described species of millipede four clearly halophilic species are reported from NW Europe, the Mediterranean Region, USA, Far-eastern Russia and Tasmania. In addition, two penicillate or bristly millipedes are also recorded; Polyxenus lapidicola by Silvestri from the Mediterranean (no subsequent definite records) and a Chilexenus sp. is reported from South Africa by Lawrence (1984). Total world halophilic species may be 20 or more as there are no records at all from western North America, Central & South America and the Caribbean, all of Asia and most of Oceania and littoral diplopods are often difficult to find. Class CHILOPODA About 3,000 species of centipedes have been described worldwide of which about 1,000 are members of the order Geophilomorpha which contains a number of littoral species. The total number of halophilic geophilomorphs recorded in a recent list (Barber, 1999) is 45. Most of these are from Europe, Western United States, the Caribbean, South America, Japan and Australia/New Zealand. There are few records from the Atlantic coast of USA or from Canada, very few African records and little from much of Asia other than Japan, Korea and Taiwan. It is highly improbable that there are no species occurring on these coasts. In addition it is possible that some species for which no habitat data is given (e.g. for California / Baja California, South Africa, New Zealand) may well be halophilic and also finding littoral species in some habitats (e.g. rock crevices) is not always easy. An estimate of 100 plus species from around the world seems reasonable.
Brachiopoda [Christian Emig]	**Described** 388 species. **Nominal species** # is not available. **Undescribed, collected** None. **Undiscovered** Not estimated. **Cryptic** Not estimated.
Bryozoa [Dennis Gordon, Phil Bock]	**Described** As ever, the main problem is the number of species described in the 19th century which have never been revised/revisited, and no-one knows what

	would be the best genus for them now. At least they are available names. **Undiscovered + Cryptic** I have been saying for a few years that the bryozoan fauna for Australia is about 1,000 accepted, and that I think there are about 1,000 yet undescribed, mainly not yet sampled. This would give 50% known; New Zealand is better known, with better sampling density , and more recent major revisions by Dennis; Europe is much better known; the Caribbean would have many undescribed (in the Smithsonian), and many uncollected; the rest of the tropics are going to prove very productive when they are thoroughly sampled. After my field experience in the past two years, I can report that coral reef environments below 20 metres are particularly rich in bryozoans, with sampling by SCUBA the only way to recover these samples. And there has been so little done across the reefs of the world that we cannot estimate the variation between near or distant reef groups. Certainly the fauna from the northern Great Barrier Reef (Lizard Island) and the southern Great Barrier Reef (Heron Island region) show major differences. Tilbrook (2006) determined that 20-30% of bryozoan species from newly sampled areas of the tropical Indo-Pacific are new. I am finding a similar percentage for the NZ deep sea, in some cases higher. We would estimate 2,800-5,200 undiscovered species of Bryozoa, of which the cryptic component might be 350-950. Although, the latter is difficult to estimate. Cryptic species discovered in the past by genetic means (predominantly Ctenostomata like some species of Alcyonidium) have subsequently been discovered to have discriminating life-history or anatomical features that were previously overlooked, so that they cease to remain cryptic as defined. In this case it is a matter of failing to perceive characters. Generally bryozoans have reliable morphological characters and workers are getting better at discriminating species. I would expect the greatest proportion of cryptic species to be among the orders Ctenostomata and Cyclostomata in which there is a relative paucity of characters, confounded by homoplasy, compared to the Cheilostomata.
Cephalorhyncha Nematomorpha [Andreas Schmidt-Rhaesa]	**Undescribed, collected** rough estimate: 70 species. **Undiscovered** From temperate regions, there are about 10% new species in samples, in tropical regions these are up to 50%. Considering which regions have been sampled I estimate that the species number is about twice as high as the known number (around 600). **Cryptic** There are no studies on cryptic species in this taxon, but sampling is highly accidental and therefore incomplete.

Kinorhyncha [Birger Neuhaus]

Described
180 species based on description of adult specimens + 48 species based on description of juvenile stages (valid in the sense of ICZN but usually not accepted by scientists, because many species based on the description of juveniles may/will turn out as synonyms of species based on the description of adults)

Nominal
ca. 228.

Undescribed, collected
The largest collections of undescribed kinorhynch specimens are housed by the National Museum of Natural History, Smithsonian Institution, Washington D.C., the Museum für Naturkunde Berlin, and the Zoological Museum, Natural History Museum of Denmark, Copenhagen. It is estimated that these collections include 250-350 new species.

Undiscovered
Only the coastlines of Europe and North America have been sampled for the meiobenthic Kinorhyncha in some detail with individual records from all over the world (Zelinka 1928; Higgins 1983; Adrianov & Malakhov 1999; Neuhaus & Higgins 2002). Almost every haul on the continental shelf or in the deep sea reveals new species of Kinorhyncha (Hoernle et al. 2003; Neuhaus & Blasche 2006; Sørensen 2006, 2007, 2008; Sørensen et al. 2000, 2007, 2009, 2010a, b ; Sørensen & Rho 2009; Sørensen & Thormar 2010; Werner et al. 2009). Therefore, at least 1,000-2,000 species of Kinorhyncha can be expected to live in marine environments.

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Loricifera [Antonio Todaro; Reinhardt Møbjerg Kristensen]	**Described** 32 species described and valid **Nominal** 32. **Undescribed, collected** 123 specimens. **Undiscovered** About 1000.
Chaetognatha [Erik V. Thuessen]	**Undiscovered** Total Number of Living Chaetognath Species is guesstimated to be ~180. **Cryptic** Two species of chaetognaths have been investigated for cryptic speciation,

Parasagitta setosa (Peijnenburg et al., 2006) and Caecosagitta macrocephala (Miyamoto et al., 2010b). Mitochondrial DNA data suggest that cryptic species exist for both of these species. Two cryptic species are inseparable from Parasagitta setosa based on morphology and nuclear DNA (Peijnenburg et al., 2006), and similarly, two cryptic species are inseparable from Caecosagitta macrocephala using morphological and nuclear DNA analyses (Miyamoto et al., 2010b). If every chaetognath species displays the same amount of cryptic speciation as P. setosa (a neritic species from the eastern North Atlantic Ocean) and C. macrocephala (a cosmopolitan deepsea species), the estimated number of cryptic chaetognath species would be 256, tripling the number of total chaetognath species. This high number is based on COII and COI data for P. setosa and C. macrocephala, respectively. On the other hand, using the results of nuclear DNA analyses, a low estimate of the number of cryptic chaetognath species would be zero. Due to the extremely small mitochondrial genome size -the smallest in the Animal Kingdom- (Faure and Casanova, 2006; Miyamoto et al., 2010a) and the likely occurrence of ribosomal DNA allopolyploidy (Telford and Holland, 1997; Barthelemy et al., 2007), much more work needs to be undertaken in order to ascertain whether or not cryptic speciation has actually taken place in the Chaetognatha.

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Ascidiacea	**Described**

[Adriaan Gittenberger, Marc Rius, Noa Shenkar, Rosana Moreira da Rocha, Gretchen Lambert]	2,865 (Shenkar & Swalla, 2011; Shenkar et al., 2012). **Nominal** Estimate = 5,000 (based on WoRMS). **Undescribed, collected** estimate = ~ 500. Many collections from different places in the world held in museums and research institutions remain to be studied. The most recent ones include alcohol preserved vouchers amenable to genetic analysis, though most museum samples were first preserved in formalin and then transferred to ethanol. Thus, a substantial number of species presently undescribed are likely to surface from the study of these collections. If DNA analyses protocols can be optimized to also include formalin preserved tunicate material (as was successfully done in other marine taxa; Palero et al. 2010) we expect that this will greatly nuance studies of the Ascidiacea. **Undiscovered** Rosana Moreira da Rocha conducted a review of 37 articles on ascidian fauna published between 1980 and 2009: “8 articles with less than 10% of new species, 15 with 10-30% of new species, 10 with 30-50 % and only 4 with more than 50%”. Based on these numbers, we all agree that projecting 100% of increment beyond the known species is too much. Since there are almost 3000 valid species, 4000-4500 is a better estimate of the number of ascidian species. Examples per region Africa (Marc Rius): The ascidians inhabiting African waters are poorly studied. This is demonstrated by the fact that every time a taxonomist studies a particular region in Africa, a number of new species are described. For example, 10 and 17 new species were described by Millar (1955) and Millar (1962) respectively when he studied samples from South Africa. The same trend has been found when different taxonomists revise a particular region - Monniot et al. (2001) described 22 new species from South Africa. This is not region-exclusive and taxonomic studies conducted in different parts of Africa have shown similar trajectories (e.g. Monniot & Monniot 1994 described two new species from the central west African coast; Pérez-Portela & Turon 2008 found a new species inhabiting waters of Kenya, Tasmania and Madagascar; etc.). Australia (Williams et al., 2010: table 1): About 33% of the ascidians found during a recent inventory of species in Australia, were found to be unknown to science. Central & South America (Rosana Moreira da Rocha): We still have many species to be discovered in the Caribbean, since most of the islands were never surveyed and we see that we have at least 1-2 endemic species each every time we start collecting. So, we may have a

	very conservative guess calculating 2 new species per island or country. Panama: There are 80 spp. In the Bocas del Toro region (Caribbean side) among which more than15 species (20%) are to be described (2 *Pyura*, 1 *Symplegma*, 1 *Eudistoma*, 1 *Ecteinascidia*, 10 didemnids, 1 Clavelinidae, 1 *Eusynstyela*). Venezuela: In only one site surveyed in April 2009 we found 29 species among which 1 or 2 new *Styela*, 1 new Botryllid, 1 new *Lissoclinum* (but it is the same species in Panamá) (~14% new sp). Brazil: We have around 110 registered and more than 20 species in our collections to be described that we already know are new species (~15%) (2 *Aplidium*, 10 didemnids, 1 *Distaplia*, 2-3 Botryllids, 1 *Rhopalaea*, 3-4 *Eudistoma*). Ecuador: We also have material from Galapagos with lots of new species to be described: 3-4 *Eudistoma* , 5-6 *Aplidium*, 4 *Ascidia*, 2 Botrylids, 2-3 didemnids). California, U.S.A. Continental Shelf: (Gretchen Lambert) A U.S.A. Department of the Interior Minerals Management Service 1983-89 conducted an assessment of long-term changes in the biological communities of the Califfornia Continental Shelf from the Santa Maria Basin and western Santa Barbara Channel. It was the only sampling of these areas since 1904 in which ascidians were identified. Of the 20 species collected, 16 were identified to species, the other 4 only to genus, 3 were new species (Lambert, 1993). Six of the 16 identified to species were the same as collected in 1904 from these areas (Ritter, 1907). Of the 14 species collected in 1904, 4 were abyssal and not found in the present study. Thus only 4 of Ritter's (1907) 14 described ascidian species were ones that he found but were not collected at similar depths about 90 years later (Lambert, 1993). Mediterranean (Xavier Turon): The number of new species described or recorded in the Mediterranean sea has leveled off during the last couple of decades (Coll et al. 2010 Fig 13D), but is still increasing, particularly due to the application of new molecular techniques to unsolved taxonomic problems. So, even in the “well-known” Mediterranean, with 229 species described (Coll et al. 2010, Appendix S2), we estimate that 30-50 species remain to be discovered. Red Sea and Mediterranean (Noa Shenkar): There still are quite a few new species to be discovered. Tel Aviv University includes ~500 specimens from the Red Sea and Mediterranean coasts of Israel. There are 2 recently described new species (Shenkar 2012). Brunetti published last year a new *Botryllus* sp. from the Mediterranean coast of Israel, and there are 2 new species from the Red Sea of *Rhopalaea* and *Ascidia* that still need to be

described.

General (Gretchen Lambert): Most of us have estimated that there are about 3000 extant spp., with several hundred in this number yet to be discovered/described. The ascidian fauna of the tropical West Pacific is however still very poorly known, with recent works featuring overall ~50% of species being new to science (e.g. Monniot & Monniot 1996, 2001, 2008). Just as Rosana Moreira da Rocha is finding new spp. around each island in the Caribbean, so this is true in the W. Pacific only on a much more gigantic scale. Therefore, we asked the opinion of Françoise Monniot, in France. She said "In my opinion (with approximate information from my own data base) about 4,000 species may be valuable ones. It is impossible to evaluate the number of unknown species, many are described every year and so many parts of the world have never been investigated!".

Cryptic
We discussed the number of species that may be discovered in the future with molecular techniques. We all agree that molecular techniques have shown that cryptic speciation is frequent in ascidians, and that they are excellent tools to discover new species. However, molecular techniques should not be considered without also considering the morphology of the species. Recent studies on ascidians revealed that the coupling of genetic and morphological approaches is fruitful and that there are always morphological characters that can distinguish among the species (e.g., Perez-Portela et al 2007).

We believe that there should not be a distinction between a "morphological perspective" versus a "molecular perspective", as both methods contribute to taxonomy. Adding 500 species that may be discovered based on molecular techniques sums up our estimation to 4000-5000 species.

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Larvacea [Russ Hopcroft]	**Described** 67 valid species (all in WoRMS). **Nominal** 75 subjective synonyms (all in WoRMS). **Undescribed, collected** I have 2, I know of 2 others at MBARI (California) from ROV video records. Most new ones are deep-water and require collection by an ROV. There are probably less than 5 other people capable of knowing if they have discovered something new!

	Undiscovered 63, based on Hopcroft (2005). I stick with those numbers - especially when one considers they do not include cryptic species that would show up based on genetic work. **Cryptic** There is likely to be high cryptic diversity in the larvaceans, because many species have very broad distributions, with occurrences in multiple oceans. Thus far, no one has been able to find a COI primer that works for this group, so there is no information on how extensive cryptic species might be! Based on what I've seen for other groups this could be in the order of 2-5 folds. **References** Hopcroft, R.R. (2005). Diversity in larvaceans: How many species?, in: Gorsky, G. et al. (2005). Response of marine ecosystems to global change: ecological impact of appendicularians. pp. 45-57
Thaliacea [Laurence P. Madin]	**Described** 79 species in 27 genera: Doliolids: 10 genera, 26 spp, Salps: 14 genera, 45 spp. Pyrosomes: 3 genera, 8 spp. **Nominal** Same as described. **Undescribed, collected** I'm not aware of any undescribed species already collected, but would guess not more than 5. **Undiscovered** I doubt there are more than another 10% of the current thaliacean species yet to be discovered, or about 8.
Pisces [William Eschmeyer]	**Described + nominal + Undiscovered** See Eschmeyer et al. 2010. New values of described and valid genera and species can be found online via Google (Catalog of Fishes) or at http://research.calacademy.org/ichthyology/catalog. New taxa in 2011 were 340 new species and 25 new genera. New online versions of the Catalog of Fishes are posted online about every 6-8 weeks. **Undescribed, collected** I would estimate that the number might be 500 (10% of the 5,000). Some would be in combination with new discoveries - find new species from new specimens, then reinforce with museum specimens. **Cryptic**

	The number of cryptic species in fishes is probably small and mostly among reef species. Recent papers reveal a few, maybe 15 in the last 5 years. There will be more, but not too many. Let's say less than 200-300. Fish have many characters, and most are fairly easy to define as so-far known. **Reference** W. N. Eschmeyer, R. Fricke, J.D. Fong, D. Polack (2010). Marine fish biodiversity: A history of knowledge and discovery (Pisces). Zootaxa. 2525, 19-50
Sirenia [Caryn Self-Sullivan, Daryl Domning]	**Described** 4 recent marine sirenia spp. Trichechus inunguis is only found in fresh water and in that sense is not a "marine" species. However, it is found along the seaward edge of the Amazon River's delta and is thus "marine" in the geographic sense, even though that coastline is always bathed in fresh water due to the Amazon's enormous discharge. **Nominal** 35 nominal species names, data from WoRMS. **Undescribed, collected** None. **Undiscovered** None. **Cryptic** For Sirenia (Mammalia), there are 4 recognized living species, and I would estimate zero cryptic species, based on the fact that a fair amount of work has been done on phylogeography of the 3 manatee species using mtDNA (and some work on the dugong), and no signs of cryptic species have turned up that I know of. Also, large mammals in general are not known to be prone to a lot of cryptic speciation, so a priori I wouldn’t expect it in sirenians.
Cetacea [William Perrin]	**Described** The number of accepted species is 87. **Nominal** There are 1,271 species names of Cetacea in WoRMS. **Undescribed, collected** No new species at present. **Undiscovered + Cryptic** Based on the description of four new species in the last two decades, there may be a couple more out there. It has been suggested that the killer whale and the common bottlenose dolphin should each perhaps be split into two or

	more species. To give a number: 1-5 species for undiscovered/unknown for Cetacea, and 1-3 cryptic species.
Reptilia [Peter Uetz]	**Described** ~ 110 marine reptiles. **Nominal** ~ 600 (including misspellings). **Undescribed, collected** Just out of experience, I am sure that there are undescribed species, but it is almost impossible to guess that number. **Undiscovered** The rate of new reptile species described/discovered has been steady for over a hundred years, in fact, accelerating, so it is pretty much impossible to predict how long this trend will last. Of the 100+ marine reptiles, about 4% (4) have been described during the past 10 years. However, during the 20 years before that, only 6 new species were described but all of them by the same author (Kharin). That is, someone just made an effort and found single-handedly all new species described in 20 years. There may be up to another dozen truly marine species and another dozen undiscovered species occurring in coastal/brackish/mangrove habitats, but probably not more than that. The longer I think about it... maybe you should put 20-30 undiscovered species down, instead of 10. It is a long shot, but it sounds unlikely that the huge oceans harbor only 10 new species. Again, it is really unpredictable.
Aves [Mark Tasker]	**Described** 641 species (based on WoRMS). **Nominal** My guess is quite a low number of synonyms though- seabirds tend to be large and reasonably well described. **Undescribed, collected** My guess is 30-50 species, but many taxa have been described in the collections, just not at species level. **Undiscovered** My guess is also 30-50 species. One or two of these may presently be known from specimens but assumed extinct. **Cryptic** Only very few bird species seem to be discovered by genetic analysis; more often these are found by plumage or song variation, which may then be backed up by genetics. So I would say on the basis of current track record

	that there are very few extra cryptic species to be discovered using genetics.
Antipatharia [Dennis M. Opresko, Tina Molodtsova]	**Described** There are about 250 valid described species. **Nominal** If we include synonyms, and taxa that cannot be identified - about 280 species. **Undescribed, collected** From our examination of collections yet to be published on, we are estimating that there are 50 to 75 new taxa **Undiscovered** We think that there may be as many as 50 to 100 still to be collected. **Cryptic** Concerning the Antipatharian corals, genetic diversity estimates would be very difficult at this time because most of the genetic studies to date have been conducted on mitochondrial markers which, for anthozoan cnidarians, do not provide an adequate level of variation to identify cryptic species.
Actiniaria, Corallimorpharia [Daphne G. Fautin]	**Cryptic** Just as I was reluctant to estimate unknown diversity at all in anemones, I have no basis for providing a number for this. I am aware of only two anemones that have been described relying on molecular data, and those were both species long considered different by many people based on biology and morphology. People had been reluctant to accept them being termed different species based on conventional criteria, but when molecules gave the same result, they were immediately embraced as different.
Ceriantharia [Tina N. Molodtsova]	**Described** 137 species. **Nominal** 160 species names. **Undescribed, collected** 4-6 species. **Undiscovered** 15-25 species.
Zoanthidea [James Davis Reimer]	**Described** 101 species. Likely low but on the safe side, the reason this is lower than currently in WoRMS is I am certain Palythoa and Zoanthus have many synonymous names.

	Nominal 453. This is a number I feel confident in. **Undescribed, collected** 30. Undoubtedly more than this in reality, but based on my firsthand knowledge of specimens. **Undiscovered** 180-380, based on the rates at which we are finding new species, total derived from estimated and conservative numbers of undiscovered species for each genus. Thus, the total minimal number of species in this order looks to be (101+30+180) around 300 species, with conservative estimates, but could be up to 500 based on what happens with putative synonyms, etc. The biggest problem facing zoanthid taxonomy is the very large number of potential synonyms. Thus, for many species, I really have no idea if they are valid or not, particularly in Palythoa, Zoanthus, and Epizoanthus. Still, based on observations of Zoanthus and Palythoa, I think it is very likely there are many synonymous species in this order. Also, there appear to be many species still undiscovered, from the deep sea, or other unexamined localities and ecosystems. So, the taxonomy of this order can be characterized as: a. chaotic! b. much synonymy, specimens redescribed from different localities, etc. c. much remaining diversity to be discovered. **Cryptic** The ratios for the zoanthids is 1.2-2.5 per morpho-species ; but we only have some limited molecular evidence for this. So if total morpho-species = 311-511, than 1.2-2.5 means the number of add-on cryptic species is (311*0.2)=62 and (511*1.5)=766 (rounded to 60 and 760).
Scleractinia [Bert Hoeksema; Stephen Cairns]	**Described** Azooxanthellate: 720. The number at the end of 1999 (Cairns et al., 1999) was 669. Since then, 48 51 species have been described, 7 synonymized, and 10 added from previously forgotten sources, for a net gain of 5154. The actual rate of growth is 4851/110.5, or 4.6 species per year. This is down from an annual rate of 7.03 based on 30 years - 1968-1998 (Cairns, 1999) and 6.9 based on 7 years - 2000-2007 (Cairns 2007), consistent with a projected decline in the growth rate predicted by Cairns in 1999. But, the growth rate is highly dependent on how many people are actively engaged in the study of zooxanthellate taxonomy, which today is one (Marcelo Kitahara). Nonetheless, I persist that the growth rate will continue to decline and the species accumulation curve will become more horizontal. During

the same time, 4 new genera were described and one synonymized, for a net gain of 3: 117 to 120.
Zooxanthellate: 860 (minus ca. 60 that are likely to be synonymized again) = 800. Many taxonomic changes at family and genus level are foreseen to take place in the near future as a result of molecular methods (e.g. Benzoni et al. 2007, 2011; Fukami et al. 2008; Nunes et al. 2008; Huang et al. 2009, 2011; Budd et al. 2010; Kitahara et al. 2010; Gittenberger et al. 2011).

Nominal
Azooxanthelate: 720 + 365 junior subject synonyms (and a few junior homonyms), or 1,085 names. The synonymy rate is thus 365/1085, or 33.6%, a similar percentage (34.1%) reported by Cairns (2001).
Zooxanthellate: 800 x 3.5 = 2,800 (based on 2 taxonomic revisions (Hoeksema 1989, Wallace 1999) I come to an average of 3.5 names per species.
Note the difference in synonyms between deepwater corals and the easily accessible reef corals.

Undescribed, collected
Azooxanthelate: Number of undescribed new species based on collections in hand: Marseille (6), James Cook/Paris Museum (9), NMNH (73), or a total of about 88, some of which were published as species A, B, C, etc (see Cairns in Roberts, et al., 2009).
Zooxanthellate: 5 that I need to describe. (There are 10 categorized as nomen nudum but I do not know whether they are present in collections, and that is why they are still nomen nudum).

Undiscovered
Azooxanthelate: In my 1999 paper I used three methods to estimate this number, which I have now re-evaluated.
A. Partial Inventory Method, based on percentage of new species occurring in large unworked collections: In 1999 this method estimated a total of 781 species; now the estimate based on this method is 768. (I think this occurred because many of the undescribed species are singletons or just confusing, so they are put aside and did not contribute to a higher percentage of new taxa in a previous revision.)
B. Method of Hammond (1992), which is based on the yearly growth over the last decade compared to the overall growth rate since 1758, and then some rather subjective guesses. These numbers suggest 800-1,440 total species, or an additional 80-720 species. C. Intuitive: having worked with the group for 35 years I feel as though there are about 1,050 total species, or another 330 to describe.

Zooxanthellate: 100. Since 1999, 142 species have been described as new. Several of these are to become synonymized. New species are sibling species (discovered by DNA analysis), strict endemics, or based on old-fashionedstandard collection revision work. Most are the result of increasing fieldwork activities worldwide, including remote places, and more an

	increasing number of observer's people (divers, photographers) are being aware of 'strange-looking' species thanks to field-guides. We cannot say that the last decade can be seen as is part / start of a trend, because the majority (103) of the new species has been published by Veron (2002) and they are the result of many field trips sponsored by nature conservation organizations or they are material donated to the taxonomist by other scientists. Because of the anticipated synonyms I cannot give a good rationale but only a rough guess. Another problem is that fewer taxonomists will be around to verify whether a newly collected strange-looking coral is a real new discovery. **Cryptic** 0-142. My guess is that the number of cryptic scleractinian species to be discovered through molecular analyses is practically zero. It is still difficult to get markers that work at species level (for some families easier than for others).If we do have them, we use them for phylogenetic research mostly. Deep sea corals are difficult to obtain for molecular research (counting appr. 50% of the total). I do not expect that we find sibling species easily. Mostly we check for species by molecular support if we find morphological indications. In contrast to Bert Hoeksema's view, Stephen believes that for the deep water coral species, this is 20% of the known deep water species: 0.2 x 711 = about 142. **References** Benzoni F, Stefani F, Stolarski J, Pichon M, Mitta G, Galli P. 2007. Debating phylogenetic relationships of the scleractinian Psammocora: molecular and morphological evidences. Contributions to Zoology 76: 35-54. Benzoni F, Arrigoni R, Stefani F, Pichon M. 2011. Phylogeny of the coral genus Plesiastrea (Cnidaria, Scleractinia). Contributions to Zoology 80: 231-249. Budd AF, Romano SL, Smith ND, Barbeitos MS. 2010. Rethinking the phylogeny of Scleractinian corals: a review of morphological and molecular data. Integrative and Comparative Biology 50: 411-427. Cairns, Stephen D. 1999. Species richness of Recent Scleractinia. Atoll Research Bulletin, 459: 1-12. Cairns, Stephen D. 2001. A brief history of taxonomic research on azooxanthellate Scleractinia (Cnidaria: Anthozoa). Bull. Biol. Soc. Wash., 10: 191-203. Cairns, Stephen D. 2007. Deep-water corals: an overview with special reference to diversity and distribution of deep-water scleractinian corals. Bull Mar. Sci. 81(3): 311-322. Cairns, Stephen D. 2009. Cold-Water Corals, Online Appendix: Phylogenetic list of 711 valid recent azooxanthellate scleractinian species, with their junior synonyms and depth ranges. On line supplement to Cold-Water Corals, Roberts, J. M., A. Wheeler, A. Freiwald, and S.D. Cairns, Cambridge University Press, London

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Octocorallia [Leen P. van Ofwegen]	**Described** 2,951 species. **Nominal** 3,577 species names. **Undescribed, collected** 100.

	Undiscovered Recent five largest papers dealing with alcyonaceans of the Indo-Pacific and deep water, which together house about 90% of all alcyonaceans, had 50% of the species new to science. Therefore I estimate another 1,500 species await description. **Cryptic** Our octocoral research is not yet advanced enough that we can reveal cryptic species only on the basis of DNA. So currently nothing is known about cryptic species in octocorals.
Pennatulacea [Gary C. Williams]	**Described** 220 accepted species. **Nominal** 450 species names. **Undescribed, collected** One that I know of in the past 25 years, so I'll make a wild guess and say 20. **Undiscovered** Average of one new species per year in the field resulting from new findings and improved technology regarding deep-water collecting, so let's make another wild guess of 80. **Cryptic** No basis for judgment.
Cubozoa [Allen Collins]	**Described** 37 species. **Nominal** 46 species names. These numbers come from recent updates I have made to the cubozoan entries in WoRMS. There might be a couple of other nominal species, but this should be quite close to correct (at present). **Undescribed, collected** I am aware of 9 additional species of cubozoans, whose descriptions are in progress (3 as part of submitted manuscripts), as well as one case where a nominal species will be synonymized. I would think that 10-20 would serve the purposes of our analyses. **Undiscovered** This is quite difficult to estimate, but I would not be surprised if we have perhaps 20-50 additional species to discover in this group. This would be my guess, but it is not based on any sort of analysis.

Hydrozoa [Peter Schuchert]	**Described** 3,521 marine species (Schuchert, 2011). **Nominal** Unaccepted species of Hydrozoa in WoRMS (1,000) multiplied with about 1.5 (very rough estimate!). **Undescribed, collected** This is almost impossible to say as it is not known what collection are available, though not many I guess, new species are more likely discovered by studying living material (esp. in medusae). I guess 50-100 species. **Undiscovered** Difficult to answer, see my paper of 1998, my feeling is that about 20% more are to be discovered based on morphology, many more with molecular methods (perhaps 100%) ⇨ morphospecies to be discovered: 500-1500 species. **Cryptic** ⇨ 1000-2500 species. **References** Peter Schuchert (2011). World Hydrozoa database. Available online at http://www.marinespecies.org/hydrozoa. Consulted on 2012-01-12 Schuchert, P., 1998. How many hydrozoan species are there? Zool. Verh. Leiden 323: 209-219.
Siphonophorae [Phil Pugh, Gill Mapstone]	**Described** There are c. 173 valid species of siphonophore, with c. 8 species inquirendae. **Nominal** The number of synonyms for these species is at least 510, making an average of 3 synonyms per species; but the distribution is very uneven as, for instance, the Portuguese Man O'War, Physalia physalis, has about 50 junior synonyms. **Undescribed, collected** The number of known but undescribed species lies in the region of 50-60. **Undiscovered** Between the 1810s and the 1990s the increase in new species descriptions is almost linear, but in the last decade there has been an upturn, which probably will continue as the c. 50 known new species are described. I would estimate that the number of as yet undiscovered species lies within a similar range. The average number of species described per year, since 1758 is 0.68 (max 12 min 0), or 6.8 per decade (max 20 min 0).

	Many, but not all, of the early researchers used dip nets or buckets to collect their material from superficial waters, so that before 1900 4 cystonect, 22 physonect, and 35 calycophoran species had been described. However, most of the 20th Century authorities relied on material collected by nets. Because of their fragility, and the fact that they are comprised of a myriad number of individuals, physonect siphonophores are often destroyed by or extruded through the netting, and the pieces that remain are often difficult to identify. Many calycophoran species, however, have relatively small nectophores that are fairly robust, and each colony is comprised of only one or two of them, and in the latter case they have different morphologies. These differences between the physonects and calycophorans are exemplified in the breakdown of the 73 siphonophore species described between 1900 and 1982; 1 cystonect, 19 physonects, and 54 calycophorans. With the advent of in situ collecting methods, SCUBA, submersibles, ROVs it was now possible to collect complete specimens of the fragile physonect species; while on the other hand the collection of the smaller calycophoran species depended greatly on the visual acuity of the collector. Thus, particularly in deeper waters, one tends to observe more physonect specimens that calycophorans, and this is, again, reflected in the number of new species described in recent years, namely 21 physonects and 17 calycophorans. The fact that, with an increasing rate of publication of descriptions of new siphonophore species, 80% of the estimated number of known but undescribed species is physonects indicates that we have only just begun to appreciate the significance of this group of siphonophores. It should also be noted that the deeper living populations of siphonophores have only been investigated, using in situ techniques, in a limited number of areas. In my case this is The Bahamas, the Cape Cod region, and Monterey Bay. In addition Dhugal Lindsay has been investigating the seas around Japan. **Cryptic** As far as I am aware there are no cryptic species.
Scyphozoa [Michael N Dawson, Liza Gómez-Daglio]	**Described** 201 accepted described marine species. Based on the summary of species listed on The Scyphozoan website (archived ca. 2007) appended with more recent species descriptions found by querying the Zoological Record database for TITLEsearch “Scyphozoa AND new AND species” ==> zero additional TITLEsearch “jellyfish* AND new AND species” ==> zero additional TITLEsearch “Scyphozoa AND sp. AND nov.” ==> 1 additional TITLEsearch “jellyfish* AND new” ==> 1 additional, 1 cryptic TITLEsearch “scyphozoa* AND new” ==> 4 additional ANYWHEREsearch “scyphozoa* AND new AND species” ==> 0 Also appended with one publication not yet in ZR.

	Nominal 204 nominal marine species. Preliminary molecular analyses suggest *Phyllorhiza peronleseuri is* same as *P. punctata*. Morandini & Marques (2010) – suggest several nomen dubium, species inquirenda from Gershwin & Zeidler (2008). **Undescribed, collected** = (a) 80, to (b) 38 (a) We calculated the number of taxa in published papers that were not identified to species but were stated in the publication as being a distinct taxon or awaiting description (e.g. Gershwin 2003; Holland et al. 2004; Dawson et al. 2005; Bayha & Dawson 2010; Bayha et al. 2010; and taxa listed as "sp." in Kramp (1961) and Segura-Puertas (1984, 2003) [N.B. spp. classed as single sp.]). (b) Enumerated lots that are identified (and unidentified) in several natural history collections (CAS, CRRF, MCZ, NMNH, ZMB). Enumerated identified species. From these numbers we estimate how many species may be in the unidentified lots assuming new species are randomly distributed among all lots, but that lots from the same region and time likely contained similar medusae. N.B. We consider this likely an overestimate because the most interesting lots will have been worked on first, leaving replicates, poorly preserved specimens, etc as the majority of unidentified lots, especially in well-visited museums. More obscure collections may have higher proportions of undescribed species. To try to offset the potential overestimate by counting lots, we asked Allen Collins to look in SI collection for unidentified lots earmarked for description of new species by one person or another. Allen returned his best estimate as 3 (three) undescribed species compared with 91 described species at NMNH, i.e. 96.7% of species in collections are described (from a well-known, well-visited museum). These six estimates were averaged (19%) and multiplied by the accepted current number of described species to give our estimate of 38 undescribed species in collections. **Undiscovered** 77 undiscovered marine species not yet collected. In the last two years, Liza has conducted extensive collections from Mexico to Panama, a previously moderately-to-poorly studied region. Segura-Puertas (1984) and Segura-Puertas et al. (2003, 2010) recorded 6 species of scyphozoan from the Tropical Eastern Pacific and Alvariño (1969) reported *Stomolophus* from Gulf of California. Liza found 14 species (excluding 2 invasives) of which 7 are previously unknown records and likely species. This indicates in moderately sampled regions currently described species may represent ~50% of all species present. Assuming fewer species

(tending toward zero) remain to be found in well-sampled regions, and more species remain to be found in poorly-sampled regions (tending toward 65%), and that these regions are more-or-less evenly sized and distributed around the world w.r.t. biodiversity, we use 38% as our estimate of the number of species remaining to be collected.

Cryptic

Our estimated percentage of morphospecies that are cryptic is 7%.
This figure was calculated as (number of taxa known to be highly divergent on the basis of only molecular data) / (number of valid species) * 100, and does include multiple cryptic species within a single morphospecies in some cases. This means we'd expect to find an additional 7% * 316-358 cryptic taxa (bringing the total count to 338-383 species of scyphozoans). We do think the 7% figure is a little low, but our guesstimate developed over the years was that the number of scyphozoan species might double (i.e. to ~400; e.g. Dawson 2004; Hamner & Dawson 2009), so we were reasonably comfortable with these numbers calculated various ways. Please also note that the estimated percentage of morphospecies that are cryptic (7%) is much less than the number of species that we expect will be discovered by applying molecular techniques. This is because by focusing on species that are morphologically different, we've shunted a good proportion of species that were originally discovered using genetics and subsequently distinguished morphometrically from the "cryptic" to the "undescribed" categories. Ultimately, the total estimate of species richness is about the same, but the way we get there different.

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Staurozoa [Claudia Mills, Allen Collins]	**Nominal** 55 (as reflected in recent updates to WoRMS). **Undiscovered** It seems to me a fair estimate of undiscovered stauromedusae is to double the present "about 50" to about 100 to be expected in the course of science as we know it. Certainly the last decade has indicated that new stauromedusae just aren't that hard to find yet. **Cryptic** min-max: 0-3 based on preliminary data from six species showing no indication for any cryptic species.
Ctenophora [Claudia Mills, Allen Collins]	**Described** 190, although I doubt if they are all good, but no one has revisited most of the described species. **Undescribed, collected** Those of us who know the deep sea undescribed species continue to talk about writing descriptions, but we haven't done any yet. Steve Haddock is

	doing a molecular phylogeny as he gets the opportunity - many of his "species" for this phylogeny are undescribed. There remain perhaps one-third of the described species (a wild guess) that we don't know whether or not they are real and I've seen a manuscript this week that will extinguish one of those. Ctenophore taxonomy is not a very active field, although there are a few of us on the sidelines thinking about it. **Undiscovered** The amount of open ocean that has been searched amounts to some small "pencil lines" of transects, and we continue to easily find undescribed species. So I would ballpark the estimate of undiscovered new species of Ctenophores, as I did with the Stauromedusae, as about double what we know now, which translates to about 200-300 species.
Cycliophora [Reinhardt Møbjerg Kristensen]	**Described** 2 species. **Nominal** 2 species. **Undescribed, collected** 3 species. **Undiscovered** 10 - 125 if all clawed lobsters have Cycliophora?
Asteroidea [Christopher Mah]	**Described** 1,922 species (based on WoRMS). I find this pretty reasonable **Nominal** 5,549 species (based on WoRMS). **Undescribed, collected** Based on my museum sampling over the last few years approximately 125-200 specimens are undescribed new species. Especially in the Goniasteridae. **Undiscovered** 20-25% of Goniasteridae species were described in the last 10 years. 25% of the genus level diversity. Based on this and estimates from the new species in collections, approximately 10 to 25% may remain to be discovered. This estimate is much higher if you factor in considerations of cryptic species uncovered by DNA population studies. The monotypic Acanthaster planci has been interpreted as being composed of up to 3 or 4 species based on recent phylogeography studies. Other widely discovered taxa may show similar hidden diversity.
Echinoidea	**Described**

[Andreas Kroh]	999 valid extant species (Kroh & Mooi, 2011). Estimating the number of known echinoid species was relatively straightforward, it is based on the number of species considered valid by Mortensen (1928-1950), plus those described after completion of the last volume of his Monograph. The latter were based on data taken from Kier & Lawson (1978) for period of 1951-1970, and Kroh (2010) for the years 1971-2008. Additionally, online and offline resources were scanned for extant echinoid species described in 2009 and 2010. For the purpose of the present estimate, subspecies were excluded, thus possibly underestimating true echinoid biodiversity. An up-to-date classification of the Echinoidea and a list of currently accepted genera can be found in Kroh & Smith (2010). **Nominal** Currently 1598 extant nominal echinoid taxa (accepted + unaccepted) are recorded in our database (Kroh & Mooi, 2011). Although additional disused 19th century species continue to be occasionally found, most are now included. Please note that this differs from the number of different names under which echinoids have been cited (i.e. different combinations), which amount to about 3,000 names. **Undescribed, collected** This may range from 20 to 50. Based on a survey of a number of recent papers describing new extant echinoid taxa, it seems likely that up to 30 % of the taxa yet to be described are already present in the collections. **Undiscovered** This may range from 45 to 150. To estimate the number of species yet to be discovered is fraught with difficulties. Here the discovery rate of extant echinoid species during the last 60 years was calculated by polling the number of species established in each decade and comparing subsequent decades with each other. This results in a mean discovery rate of 0.92, indicating that a lot of extant echinoids are still being discovered. Using this rate to model future taxon discovery results in 110 species of extant echinoids still to be discovered, 90% of which are expected to be described till the year 2250. It has to be cautioned, however, that the variance of the discovery rate during the last 60 years is high for extant echinoids and that these figures are only crude estimates. Additionally, being a small group, both in terms of species and research community, any intense single person effort is bound to drastically affect future discovery rates, much like Mortensen’s work on the Monograph of Echinoidea (1928-51) strongly increased discovery rates and accounted for about 60 % of all newly discovered species during that period. Mortensen alone described about one fifth of all accepted extant echinoid species. **Cryptic species** Investigation on this issue is just starting in echinoids and the estimates presented below thus poorly constrained. About a third of the extant echinoid species examined hold complexes (pers. comm. Gustav Paulay,

	24.1.2011). In the studies on *Echinometra*, the only taxon investigated in relation to cryptic speciation in echinoids, three cryptic species were discovered, out of 8 morpho-species in that taxon. Based on this I would estimate importance of cryptic speciation as low to moderate in echinoids, i.e. 1 to 3 cryptic species per morph-species holding species complexes. Calculation used to estimate number of cryptic species: Min. cryptic species = 1135 (min. morpho-species) * 0.3 (percentage of echinoid species supposed to harbor complexes) * 1 (min. est. no. of cryptic species per morph-species holding species complexes) = 306 Max. cryptic species = 1270 (max. morpho-species) * 0.3 (percentage of echinoid species supposed to harbor complexes) * 3 (max. est. no. of cryptic species per morph-species holding species complexes) = 1,080 (Basis: No. of morpho-species (min-max): 1020-1200 [known + unknown]) **References** Kier, P. M. & Lawson, M. H. 1978. Index of living and fossil echinoids 1924-1970. Smithsonian Contributions to Paleobiology 34, 1-182. Kroh, A. 2010. Index of Living and Fossil Echinoids 1971-2008. Annalen des Naturhistorischen Museums in Wien, Serie A 112, 195-470. Kroh, A. & Mooi, R. (2011). The World Echinoidea Database – Version 2.0. Available online at http://www.marinespecies.org/echinoidea [accessed 2012-01-22]. Kroh, A. & Smith, A. B. 2010. The phylogeny and classification of post-Palaeozoic echinoids. Journal of Systematic Palaeontology 8, 147-212. Mortensen, T. 1928. A Monograph of the Echinoidea. I. Cidaroidea. C. A. Reitzel & Oxford University Press, Copenhagen & London, 551 pp. Mortensen, T. 1935. A Monograph of the Echinoidea. II. Bothriocidaroida, Melonechinoida, Lepidocentroida, and Stirodonta. C. A. Reitzel & Oxford University Press, Copenhagen & London , 647 pp. Mortensen, T. 1940. A Monograph of the Echinoidea. III, 1. Aulodonta, with Additions to Vol. II (Lepidocentroida and Stirodonta). C. A. Reitzel, Copenhagen, 370 pp. Mortensen, T. 1943. A Monograph of the Echinoidea. III, 2. Camarodonta. I. Orthopsidæ, Glyphocyphidæ, Temnopleuridæ and Toxopneustidæ. C. A. Reitzel, Copenhagen, vii+553 pp. Mortensen, T. 1943. A Monograph of the Echinoidea. III, 3. Camarodonta. II. Echinidæ, Strongylocentrotidæ, Parasaleniidæ, Echinometridæ. C. A. Reitzel, Copenhagen, 446 pp. Mortensen, T. 1948. A Monograph of the Echinoidea. IV, 1 Holectypoida, Cassiduloida. C. A. Reitzel, Copenhagen, 371 pp. Mortensen, T. 1948. A Monograph of the Echinoidea. IV, 2. Clypeasteroida. Clypeasteridæ, Arachnoidæ, Fibulariidæ, Laganidæ and Scutellidæ. C. A. Reitzel, Copenhagen, 471 pp. Mortensen, T. 1950. A Monograph of the Echinoidea. V, 1. Spatangoida I. Protosternata, Meridosternata, Amphisternata I. Palæopneustidæ,

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Ophiuroidea [Sabine Stöhr]	**Described** 2064 species (Stöhr, O'Hara & Thuy 2012). **Nominal** >3100 species names (Stöhr & O'Hara, 2011). **Undescribed, collected** 260-300 species have been putatively identified as undescribed by the leading experts. **Undiscovered** 200-400 species. The rate of species descriptions has been about 10 per year in the last decade, compared to twice that many during the most prolific time (1870-1940) of ophiuroid description. Description rates do however not decrease linearly over time as the number of species to discover declines. They also strongly depend on opportunity and personal interest of the respective researchers. In addition, species definitions change over time and any estimate of undiscovered species numbers can only be an indication of magnitude, rather than absolute numbers. **Cryptic** 100-150. My estimate may be more conservative than what geneticists expect. Ophiuroids are less well studied than echinoids, with currently a small fraction of the number of sequences in GenBank than there are for echinoids. Published and still undergoing genetic studies suggest that some species are complexes of two or more species (Boissin et al. 2011). However, there may be a selection bias, because certain groups are much more variable and difficult to understand than others and molecular studies tend to focus on these. Extrapolating from those groups will overestimate diversity. There is also a problem with definitions of cryptic species. Often, morphological (and other) differences are recognized when molecular data indicate separate lineages in a morpho-species, resulting in the delimitation of two morpho-species (Stöhr & Muths 2010). These are then no longer cryptic and probably never where, just understudied and unrecognized. Therefore the terms undiscovered and cryptic species overlap and should be viewed together. **References** Boissin, E., Stöhr, S. & Chenuil, A. Did vicariance and adaptation drive cryptic speciation and evolution of brooding in *Ophioderma longicauda* (Echinodermata: Ophiuroidea), a common Atlanto-Mediterranean ophiuroid? Molecular Ecology 22: 4737-4755.

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Crinoidea [Charles Messing]	**Described** My best estimate of the number of living crinoids is 623, although I expect quite a number to be synonymized and at least a few to be separated from within named taxa. **Nominal** I estimate around 300 synonyms exist (not including nomina nuda and misspellings). **Undescribed, collected** I currently have 5 undescribed species in my possession, but I have no good idea what might be lying about in museum collections (especially in Paris). **Undiscovered** I expect between at least 50 and 100 crinoid species remain to be discovered. New species and genera continue to be found on a regular basis, particularly from deep water. The known crinoid fauna of the tropical western Atlantic numbers approximately 55 species (the status of a few subspecies remains uncertain), with the great majority described before 1950. However, during a 10-day submersible cruise to the Bahamas in 2009, I found what appear to be four new crinoid species chiefly in ~600 m depth, which increases the regional fauna by 7%.
Holothuroidea [Gustav Paulay]	**Described** Number of accepted species: Bit fuzzy, as synonymies vary and some are old. In the database I have there are ~1710-1740 accepted names depending on how you cut it (and considering some unchecked things). I suspect this is an overestimate and once I trace the fate of a number of these the real number will be closer to 1,600. Data from WoRMS: 1,683 valid marine holothuroid species. **Nominal** 2,347 available names at present and this is probably pretty close. Does not include nomina nuda, suppressed names, or any not-available name. **Undescribed, collected** No good estimate possible. Cryptic species are a huge issue, collections are full of them, but they need to be tested genetically as often there are no discernible morphological differences in preserved specimens. This is

	presently difficult at best for old specimens. In terms of morphologically recognizable species, I would guess about 200-400 are in collections, but I have not seen some of the largest collections, so this is a bit of a wild guess. **Undiscovered** We are finding cryptic species to be a huge issue, especially in deep sea material. I would guess at least as many species remain undiscovered as have been described, but this estimate is very poorly constrained.
Echiura [John Pilger]	**Described** Presently the number of described and accepted echiuran morphospecies is 175. However, many descriptions are incomplete or ambiguous so the number could vary considerably after a thorough review of types. **Nominal** I estimate 29 synonyms and 7 as *incertae sedis*. **Undescribed, collected** Based on may personal collection and discussions with others I estimate that there are 5-10 collected but undescribed species. **Undiscovered** I estimate that roughly 70-80% of the species have discovered. Based on the number of described and accepted species, 175, there could be 35-50 species that are undiscovered. In the past, when there were more people studying echiurans, specific collecting expeditions were conducted. More recently echiurans are discovered incidental to regional and site-specific benthic surveys.
Entoprocta [Claus Nielsen, Tohru Iseto]	**Described** There are 143 valid names in the Loxosomatidae. Colonial forms: about 50 valid names. **Nominal** About 5 Loxosomatidae are synonyms and about half of the colonial forms are probably synonyms. **Undescribed, collected** Tohru has about 30 undescribed species in his collection. **Undiscovered** Our conservative guess is 1,000 undiscovered species (but the number may well be higher). **Cryptic** There is no evidence for cryptic speciation in the Entoprocta.
Gastrotricha	**Undescribed, collected**

[Antonio Todaro; William Hummon	About 310 (this number includes information from Antonio Todaro (96 spp), William Hummon (180 spp) and other 5 colleagues active on marine Gastrotricha (collectively 36 spp). **Undiscovered** These estimates (based on morphology) comes out considering: a) several new species are still found in areas quite well sampled (Mediterranean-Italy and northern Europe); b) 200 undescribed species are known from areas that have barely been sampled: Middle Atlantic, Hawaii, North Carolina, New England, the Pacific Coast of US and the Middle East. In this areas the number of present species can be doubled easily e.g. sampling different habitats; c) there are many other places on the earth that have not been sampled at all. Form my experience (Brazil and Kuwait) 80% of species collected in new areas are new to science. **Cryptic** Cryptic genetic diversity (in known species) may range from 56 to 81%. These last estimates come from the following reasoning: (1) so far there are only two studies in this regard, both carried out by me and co-workers. (2) The first study (based on the mitochondrial COI and RFLPs analysis) indicated that 3 populations of the transatlantic *Xenotrichula* intermedia may in fact be four cryptic species. The other, very recent, (based on comparisons of sequences of the mitochondrial COI) indicated that four putative populations of *Turbanella cornuta* from the North Sea, Tyrrhenian sea, Adriatic sea and Persian Gulf are in fact four different species (p-distance: intrapopulation < 2%, inter-population >15%). The take home message from these studies is: species known to have a wide geographic range are in fact species complex; the number of species of these complexes varies depending on taxon and amplitude of its putative range. Considering that about 15-20% of the know marine gastrotrich species are anphiatlantic and/or regional cosmopolitans, and estimating that each of these taxa may be composed in average of 4 species (a different species for each basins) we'll get a 244-352 additional species i.e. cryptic genetic diversity in known species may range from 56 to 81%. **References** Todaro, M. A., Fleeger, J. W., Hu, Y. P., Hrincevich, A. W. & Foltz, D. W. 1996. Are meiofauna species cosmopolitan? Morphological and molecular analysis of Xenotrichula intermedia (Gastrotricha: Chaetonotida). Marine Biology 125: 735-742. Dal Zotto M., Ghiviriga S., Kånneby T., Jondelius U. & Todaro M.A. 2010. Probing Gastrotricha taxonomy with DNA barconding. Proc. XIV International Meiofauna Conference, Gent 12/15 July 2010

Gnathostomulida [Wolfgang Sterrer]	**Described** 98 species (latest addition by Sterrer 2011). **Nominal** 98+11=109 species names. **Undescribed, collected** 15-20 species. **Undiscovered** 200 species. Over the past decade, my collecting (Sterrer, in prep.) on Indo-Pacific coasts (from S. Africa to Red Sea, Hong Kong, Japan, NW America and Galapagos) will bring the total number of species known from the Indo-Pacific from 38 to 74 species, including 18 species new to science. **Cryptic** No basis for judgment. **References** Sterrer, W. (2011) Two species (one new) of Gnathostomulida (Bursovaginoidea: Conophoralia) from Barbados. Proc. Biol. Soc. Washington 124(3):141-146.
Hemichordata [Billie Swalla, Noa Shenkar]	**Described** The final number of Hemichordate species described now is 118 species. However, this number represents only a small portion of the true richness of hemichordate species, and reflects the low sampling effort invested in this group (Cannon et al. 2009). The number of undiscovered and undescribed species is high, probably at least 500, if not over 1,000. Recent deep sea expeditions have found a number of new species in the recently described family Torquaratoridae (Osborn et al. 2011) and many more species are being described from the extensive Bullock collections by Chris Cameron and colleagues (Cameron et al. 2010; Deland et al. 2010). Interesting points from mapping the biogeography of hemichordates: 1) The striking low numbers of hemichordates from tropical waters, an environment that represents the highest marine biodiversity suggest that many new species remain to be discovered, and 2) The high number of species described based on a single specimen and a single site. **Nominal** In the Hemichordata there are only few cases of synonymy in comparison to other marine groups (less than %10). More cases of synonym may be revealed in the future by combining molecular methods with classic morphological parameters (e.g., the case of *Saccoglossus kowalevskii* and *S. bromophenolosus*, King et al. 1994). **Undescribed, collected**

	Dr. Chris Cameron from the University of Montreal in Canada is describing the extensive enteropneust collection from the deceased Dr. Theodore Bullock at Scripps Institute (Cameron et al. 2010; Deland at al. 2010). Osborn et al. 2011 describe 4 new genera (A-D) of the deep sea family Torquaratoridae, that is a sister clade to the Ptychoderidae. They also reported 18 undescribed enteropneust species from their recent expeditions, suggesting that there is a large diversity of deep sea hemichordates. Noa Shenkar reports a collection stored at the National Collections of Natural History at Tel Aviv University, Israel. This collection includes a wide variety of samples from different Red Sea expeditions and Mediterranean coasts surveys. The few hemichordate specimens (<10 jars) are not identified to species levels. Dr. Billie Swalla at the University of Washington has a collection of several undescribed enteropneust worms and also a collection of tornaria larvae that are being sequenced and described morphologically. **References** Cameron, C. Deland, C. & Bullock T. (2010) A revision of the genus Saccoglossus (Hemichordata: Enteropneusta:Harrimaniidae) with taxonomic descriptions of five new species from the Eastern Pacific. Zootaxa 2483: 1-22. Cannon, J.T. Rychel, A.L. Blasczyk, H. Halanych, K.M. & Swalla, B.J. (2009) Molecular phylogeny of Hemichordata. Mol. Phylo. Evolution 52, 17–24. Deland, C. Cameron, C. Rao, K. Ritter W. & Bullock T. (2010) A taxonomic revision of the family Harrimaniidae (Hemichordata: Enteropneusta) with descriptions of seven species from the Eastern Pacific. Zootaxa: 1-30. King, G.M. Giray, C. & Kornfield, I. (1994). A new hemichordate, *Saccoglossus bromophenolosus* (Hemichordata: Enteropneusta: Harrimaniidae) from North America. Proceedings of the Biological Society of Washington 107: 383-390 Osborn KJ, Kuhnz LA, Priede IG, Urata M, Gebruk AV, Holland ND. (2011) Diversification of acorn worms (Hemichordata, Enteropneusta) revealed in the deep sea. *Proc R. Soc. Biol.* Published on line November 16, 2011
Mesozoa (Orthonectida, Dicyemida) [Hidetaka Furuya]	**Described** 134, data based on WoRMS **Nominal** Only 1%. **Undescribed, collected** We have at least 40 and maximum 50 undescribed species in our collections now. **Undiscovered**

	Roughly estimated, there are at least 1,000, maximum 1,500 species in total. In Japanese waters, we may find the maximum of 100 species. Similar waters are counted from 10 to 15 in the world. **Cryptic** May count for 100-500 species.
Bivalvia [Gary Rosenberg]	**Described** At the moment WoRMS has 8,081 accepted species of bivalves. From this should be subtracted 27 fossil only and 35 freshwater only, and at least 100 duplicates (judging from remaining non-checked items that have Chemnitz as author or lack authority altogether). So we take 7,900 valid species in WoRMS as the basis for estimating number of bivalve species. Regarding how many Tellinidae and Galeommatidae are missing: galeommatids comprise 11.5% of the New Caledonian bivalve fauna in Bouchet et al. (2002) and tellinids 9.8%. The ratio of those two groups to other bivalves is 111/408 = 27%. WoRMS already has 301 accepted tellinids and 409 accepted galeommatoids. If we subtract those from 7,900 we get about 7,200 bivalve species. If we then add 27%, we get an estimate of 9,144 species. However, the New Caledonia figures include undescribed species, which for galeommatoids in particular biases the result to be too high. In the Japanese fauna, based on Higo & Goto (1999), galeommatoids are 4.8% and tellinids 6.7%, or 168/1304 = 13%. This gives an estimate of 8,136 species. In the Eastern Pacific fauna using Keen 1971 gives 116/676 = 17%, which estimates 8,424 species. If we allow for a generous 10% missing in the latter figure, the estimate would be 9,266. Given the uncertainties involved, the estimate should have only one significant digit, so the choice is between 9,000 or 10,000. The evidence we have suggests that 9,000 is closer to the mark. **Reference** Bouchet, P.; Lozouet, P.; Maestrati, P.; Heros, V. (2002). Assessing the magnitude of species richness in tropical marine environments: exceptionally high numbers of molluscs at a New Caledonia site Biol. J. Linn. Soc. 75(4): 421-436 Higo & Goto (1999)
Caudofoveata [Oscar Garcia-Alvarez, Philippe	**Described** 133 species (data in WoRMS)

Bouchet]	**Nominal** 145 species (data in WoRMS) **Undescribed, collected** We have on 5 unstudied new species; is difficult to say but at least another 10-15 more species. Philippe Bouchet prefers to but a question mark. **Undiscovered** Ocar believes approximately 65% is still not known of Caudofoveata. However, Philippe estimates 500 undiscovered spp.
Gastropoda [Serge Gofas, Gary Rosenberg]	**Described** A complete list of gastropod species is not yet available, and estimates are based on a gastropod/bivalve ratio. In Bouchet et al (2002), the ratio was found to be 4.2:1. With 9,000 bivalves, there would be 37,800 gastropods. For estimates for all taxa, it would probably better to give a range than a single number, *e.g.* 36,000 +/- 4,000. Note that there are thousands of names listed as valid even though no one has studied them for 100 years. Many of them could have been marked as species inquirenda. **Undiscovered** Based on the following "hard" data: • Bouchet, Heros, Lozouet & Maestrati (2008) Mémoires du Muséum 196: All deep-water papers in the MNHN cruises, 743 new species representing half of total studied (in "large" families e.g. Muricidae, Tonnoideans...) • Peñas & Rolán (2010) Mémoires du Muséum 200: Pyramidellidae (Turbonillini) 239 identified species, 209 new to science (87%) in a size range < 10 mm • Peñas & Rolán (submitted): Pyramidellidae (Chrysallidini) 235 identified species, 214 new to science (91%) in a size range < 10 mm • Bouchet, Heros, Lozouet & Maestrati (2002) Biological Journal of the Linnean Society, 2002, 75, 421–436 (their figure 4), 51,91% (about half) of species are less than 8.7 mm so same size-range as Pyramidellidae This can be extrapolated to some extent. To be refined, we would need to know the ratio of "deep" versus shelf/shore species but to start with we could assume equivalent numbers. We also have to assume that the size ratios nearshore are equivalent to those in the deep. Next, to assume that the

	ratio of undescribed depends on size. Then, considering 40,000 known Gastropods, this would give: In the "deep" realm: 20,000 known species of which 10,000 "large" known by 50% and 10,000 "small" known by 10% so (20,000 total known + 10,000 unknown "large" + 90,000 unknown "small") -> total estimated 120,000 In the "shallow" realm, the "unknown number could be anything between 0 and 50% so the most conservative estimate (assuming everything known) would give 120,000 to 140,000 gastropod species overall. **References** Bouchet, P.; Lozouet, P.; Maestrati, P.; Heros, V. (2002). Assessing the magnitude of species richness in tropical marine environments: exceptionally high numbers of molluscs at a New Caledonia site Biol. J. Linn. Soc. 75(4): 421-436 Bouchet, P., Héros V., Lozouet, P. & Maestrati, P. (2008). A quater-century of deep-sea malacological exploration in the South and West Pacific: Where do we stand? How far to go? In: Héros V., Cowier, R.H. & Bouchet, P. (eds.), Tropical Deep-Sea Benthos 25.- Mémoires du Muséum National d'Histoire Naturelle, Paris, vol. 196, p. 9-40. Peñas, A.; Rolán, E. (2010). Deep water Pyramidelloidea of the tropical South Pacific: Turbonilla and related genera. Mémoires du Muséum national d'Histoire naturelle (1993), 200. Publications Scientifiques du Muséum: Paris. ISBN 978-2-85653-642-1. 436 pp.
Polyplacophora [Enrico Schwabe]	**Described** Should be 930. **Nominal** ca. 1,950. **Undescribed, collected** I may only estimate this roughly from what I saw. It’s difficult as I do not know all institutions. I guess there might be additional 50 species (also taken species into account, which occur in my database as Genus sp.) **Undiscovered** This is even more difficult, as usually no quantitative sampling efforts were undertaken to collect chitons. Fact is that intensive collection in different regions (even well examined) often yield new species, but depending on the environment the number may differ considerably. Unexplored deep-water regions may provide a higher number, than shallow water regions. Having a quick look on what was ongoing during the last decade, I guess we speak

	also of about 50-100 new species, but as explained before is more a belly-feeling rather a statistic base.
Scaphopoda [Victor Scarabino]	**Described** 572 species (data: WoRMS up to 20.1.2012, http://www.marinespecies.org/aphia.php?p=taxdetails&id=104) **Nominal** Steiner & Kabat (2004) consider 517 (recent) valid species, 311 synonyms and other combinations. Studies carried on after 2004 (2, 3, 4, 5, 6, 7, 8) new combinations and synonyms were submitted, and 63 nsp were described, reaching to 572 valid species. **Undescribed, collected** 55 species, most at the care in the collections of the MNHN and in the NMNH are identified as new (12 dentaliida and Gadilida 43, (VS mid-2011). **Undiscovered** Even that sounds ambitious, in my opinion, 500 species is a coherent number. This assumption is based on the lack of updated records from large ocean areas, such as the western and central Indian Ocean, the tropical eastern Pacific and in deep-water realms around the world (most of the Scaphopoda distributes in the slope to abyssal environments, ± 66%, based on live records of confirmed in several institutional collections (VS pers obs). **Cryptic** I prefer to state "no evidence / lack of information." Evidence could be available after processing of materials ready for barcode studies (mainly at the care of MNHN). **References** Caetano, CHS., V. Scarabino & R. Absalao, 2006. Scaphopoda (Mollusca) from the Brazilian continental shelf and upper slope (13º to 21ºS) with descriptions of two new species of the genus *Cadulus* Philippi, 1844. *Zootaxa* 1267: 1–47. Caetano CHS, Scarabino V, Absalao RS, 2010, Redescoberta de *Gadila elongata* comb. nov. (Mollusca, Scaphopoda, Gadilidae) e morfometria da concha para as espécies do gênero *Gadila* ocorrentes no Brasil. *Zoologia*, 27(2): 305-308. Scarabino V. 2008, New species and new records of scaphopods from New Caledonia, *in* Héros, V., Cowie R. H. & P. Bouchet (eds), Tropical Deep-Sea Benthos 25. *Mémoires du Muséum national d'Histoire naturelle* 196: 215-268. Scarabino, V. & CHS Caetano, 2008, On the genus *Heteroschismoides* Ludbrook, 1960 (Scaphopoda: Gadilida: Entalinidae), with descriptions of two new species. *The Nautilus* 122(3): 171–177

	Scarabino, V. & F. Scarabino, 2010. A new genus and thirteen new species of Scaphopoda (Mollusca) from the tropical Pacific Ocean. *Zoosystema* 32 (3) : 409-423. Scarabino, V. & F. Scarabino, 2011. Ten new bathyal and abyssal species of Scaphopoda from the Atlantic Ocean. *The Nautilus* 125(3): 127–136. Scarabino, V., CHS. Caetano & A. Carranza, 2011. Three new species of the deep-water genus *Bathycadulus* (Mollusca, Scaphopoda, Gadilidae). *Zootaxa* 3096: 59–63 Steiner & Kabat (2004) Catalog the names of the groups of fossil and recent species Scaphopoda (Mollusca) *Zoosystema* 26 (4): 549-726.
Solenogastres [Oscar Garcia-Alvarez]	**Described** 263 species (7 with doubts). **Nominal** 335 species names (263 acceptad species + 72 synonyms). **Undescribed, collected** I know directly 18 species, is difficult to say but at least other 20-30 more species. **Undiscovered** If we suppose, as is indicated in the literature, that still around 60% of the diversity in solenogastres is not known, than we would have 320-480 species unknown.
Myxozoa [Stephen W. Feist, Matt Longshaw	**Described** The most recent review of myxozoan genera was compiled by Lom & Dyková (2006). To that date a total of 2,180 myxosporean species, belonging to 62 genera were recognized. Of these 37 genera were regarded as exclusively marine with a further 8 genera containing species infecting marine and freshwater fish species, the remainder being exclusively freshwater. Since 2006, several new myxosporean genera have been erected following the discovery of previously undescribed species (at least 4) but each genus contains only the single type species. The current estimated number of described marine myxosporeans is 700. **Nominal** For several myxosporean genera, for example Myxobolus (approximately 800 species reported in the literature), there is increasing evidence of widespread synonomy between species. For this predominantly freshwater genus this appears to be particularly prevalent but there have been insufficient molecular studies to confirm. However, most genera of marine myxosporeans contain fewer than 60 species with several genera containing a single type species. Including synonyms it is estimated that there are approximately 750 marine myxosporeans.

	Undescribed, collected There are few collections of marine myxosporeans awaiting descriptions although several researchers around the world will have obtained material of a few species. Estimates for these based on contacts from scientific networks such as http://www.myxozoa.org/ suggest that there are relatively few undescribed species already collected, perhaps fewer than 100 with a maximum of 250. **Undiscovered** The number of undiscovered species is certain to be substantial. Only a small percentage of the available hosts, ie all fish species and potentially marine reptiles, have been investigated and many geographic areas such as the polar regions, deep sea environments, Middle East are practically uninvestigated for myxosporean species. It is reasonable to suggest that on the basis of numbers of fish hosts alone at least 30-40% are likely to harbor species new to science. This could equate to between 6,300 to 8,400 species (assuming 21,000 known and unknown marine fish species). **Cryptic** As for 'cryptic diversity', we estimate this as being low, between 1 and 5%. **References** Lom, J. & Dykov á (2006) Myxozoan genera: definition and notes on taxonomy, life-cycle terminology and pathogenic species. Folia Parasitologica 53, 1-36.
Nematoda (free-living) [Jan Vanaverbeke]	**Described & nominal** 6,900; and 710 synonyms based on NeMYS (Deprez T. et al, 2005) **Undescribed, collected** Unknown. **Undiscovered** The most recent estimates of marine nematode species numbers very between 10,000 -20,000 species (Mokievsky & Azovsky, 2002) and 104 – 106 (Lambshead & Boucher, 2003). The method in Mokievsky & Azovsky (2002) is a rough calculation based on extrapolating alfa-diversity within relatively small plots (by species-specimen relations or rarefaction procedures), taking into account the effects of area, biotope and historical-geographical processes). Lambshead & Boucher's (2003) estimate is based on 21 cores of five stations along a N-S transect in the Pacific. When the species-accumulation curve up from north to south, they come to 10 million, and from south to north to 100, 000. This is caused by a productivity gradient, which affects the shape of the curve. In addition, Lambshead & Boucher (2003) mention that about 30-40% of the nematode species encountered in European waters are new to science. On the very well studied Belgian Part of the North Sea (surface: 3600 km², 74 sampling stations), 443 species were identified and 52 new species were recorded.

	(Vanaverbeke, pers. comm.). In less investigated coastal areas, the amount of undiscovered species is even higher. In a recently finished PhD on Vietnamese mangrove systems, Nguyen (2009) found 115 species; about 40% could not be fully identified and are probably new to science. In Cuban coastal waters, a recent survey resulted in 4 nematode genera new to science, on a total of about 80 genera recorded during the survey (Armenteros, 2009). In addition to this, it is well accepted that nematode diversity in the deep sea is far from known due to lack of basic taxonomic studies (Fonseca et al., 2006). In conclusion, 10-20,000 seems too conservative, and >1,000,000 too high. Considering the high dispersal and survival of nematodes in poor conditions, 50,000 could well be right. Anyway, all this suggests that the actual number of described free-living marine species does not at all cover the amount of species that can be encountered in marine sediments. **Cryptic** Besides Derycke et al . (2008) almost nothing is known on cryptic diversity in nematodes. This paper discovered many cryptic species in Pelioditis marina in the Westerscheldt, but it is impossible to scale this up to all the remaining (cosmopolitan) species. **References** Deprez, T. & all (2005). NeMys. World Wide Web electronic publication. www.nemys.ugent.be, version (12/2011) Nguyen D.T. (2009) Seasonal and spatial patterns in meiofauna community structure of the Can Gio mangrove forest (Vietnam) with a focus on nematoda and their role as bioindicator. PhD thesis, Ghent University, 242 pp Armenteros M (2009) Ecology and taxonomy of free-living marine nematodes from Cienfuegos Bay, Carribean Sea. PhD thesis, Ghent University, 204 pp Mokievskey V, Azovsky AI (2002) Re-evaluation of species diversity patterns of free-living marine nematodes. Mar Ecol Prog Ser 238: 101-108 Fonseca G, Decraemer W, Vanreusel A (2006)Taxonomy and species distribution of the genus Manganonema Bussau, 1993 (Nematoda: Monhysterida). Cah Biol Mar 47: 189-203 Lambshead PJD, Boucher G (2003) Marine nematode deep-sea biodiversity – hyperdiverse or hype? Journal of Biogeography 30: 475-485 Derycke, S.; Fonseca, G.; Vierstraete, A.; Vanfleteren, J.; Vincx, M.; Moens, T. (2008). Disentangling taxonomy within the Rhabditis (Pellioditis) marina (Nematoda, Rhabditidae) species complex using molecular and morphological tools Zool. J. Linn. Soc. 152(1): 1-15
Nemertea [Jon Norenburg]	**Described** 1275 as of Kajihara et al (2008). About 1285 now. **Nominal**

	My best estimate is 1600 marine species (actual count is 1604 but the margin of error could be as much as 25, or more). **Undescribed, collected** 200/400 **Undiscovered** 500/1000 **References** Kajihara H, Chernyshev A V, Sun S-C, Sundberg P, Crandall F B. 2008. Checklist of nemertean genera and species published between 1995 and 2007. Spec. Diver., 13:245-274.)
Phoronida [Christian Emig]	**Described** 18, of which 10 adults and 8 larval species **Nominal** 41, of which 25 adults and 16 larval species **Undescribed, collected** none **Undiscovered** Probably none
Placozoa [Bernd Schierwater]	**Described** 1 **Nominal** 1, *Trichoplax adhaerens* (but see below for different view). **Undescribed, collected** Genetic data, particularly from the mitochondrial 16S gene (published) as well as from ND1, CO1, and ITS1-2 (unpublished), suggests substantial diversification is present within Placozoa. The number of distinct haplotypes reported for this marker has risen to 18. The relationship between these divergences and species differences is still unknown, primarily due to a lack of documented morphological divergences, but a conservative estimate would be that at least 18 species corresponding to 8 well-supported relatively deeply diverging clades exist within Placozoa. A reasonable estimate for the maximum number of known undescribed species would be 18, the number of distinct 16S haplotypes known. This is because whole genome sequencing and ultra-morphology studies have revealed distinct differences even between the two most closely related known 16S haplotypes. The first identified morphological differences between *Trichoplax adhaerens* and the closely related haplotype H2 (Guidi et al. 2010) will soon lead to a description of a second placozoan species. A

	formerly reported species, *Trichoplax reptans*, was insufficiently described, never found again and its existence must be doubted. **Undiscovered** Considerable uncertainty would exist about the total species richness of Placozoa, but Eitel and Schierwater (2010) estimate that the number of 16S haplotypes could total anywhere from several dozen to "in the hundreds", based on the relationship between sampling sites and haplotypes uncovered. Keeping in mind that the relationship between 16S haplotypes and species is still unknown, one might roughly guess that the number of undiscovered species could range anywhere from perhaps 10 to more than 100. Differences between the genomes and the ultrastructures of epithelia cells of the most closely related 16S haplotypes suggest that all currently known haplotypes represent different species. Unfortunately, sharp ecological differences between different haplotypes and clades hinder straightforward culturing and examination of the different lineages and make resolving placozoan systematics a burdensome and slow process. **Cryptic** For Placozoa all new species are "cryptic species" and they can yet only be identified by genetics. **Reference** Eitel M, Schierwater B (2010) The phylogeography of the Placozoa suggests a taxon rich phylum in tropical and subtropical waters. Molecular Ecology 19: 2315–2327.
Monogenea [David Gibson]	These estimates are, judging from the published estimates in local areas, based on the number of fish species still unexamined and the average number of parasites on each examined fish species. **Cryptic** Any evidence comes from freshwater taxa. On the marine side, lots of new species are currently being described based on minuscule differences in the copulatory and other hardparts. Such work, which usually occurs after genetic differentiation, likely reduces the number cryptic species. So a complete guess on my part would be 500-5,000.
Digenea [Thomas Cribb]	**Described** There are probably in the vicinity of 6,000 species described. I know of over 4,000 from marine (or brackish) fishes and my records are not complete. So to allow for the species I do not have and those from other host groups (all much less important than fishes), I think 6,000 species would be reasonable. **Nominal** I would add 1500 species for synonyms. **Undescribed, collected**

	Perhaps 600 species. **Undiscovered** 4000-8500 species. I think that undiscovered species can double the present number. Even well-studied places like the Mediterranean still produce new species regularly and there are still very large numbers in my part of the world. **Cryptic** 400-900 undiscovered, not collected molecular cryptic species. I think 5-10% cryptic is a reasonable stab in the dark. The problem is not huge, but not insignificant either.
Catenulida [Tom Artois, Wolfgang Sterrer]	**Undiscovered** As to the number of undiscovered species, I think the number given by Wolfgang is realistic. I based myself on a personnal communication with Karolina Larsson, who was unable to find a single specimen of marine catenulids during several years of sampling at the Swedish and the Belgian Coast. The number of undiscovered species of Catenulida is probably very few. Wolfgang estimates there are probably 20 species undiscovered.
Rhabditophora [Tom Artois, Marco Curini-Galletti]	**Described** Up to now, 2641 valid species have been described. Counts are based on Tyler et al. (2006 - 2011) and a comprehensive literature survey. **Nominal** There are 261 subjective synonyms. The number of nominal species is, therefore, 2902. The percentage of synonyms is 9%. **Undescribed, collected** The total number of already collected but yet undescribed rhabditophoran species lies between 500 and 700. **Undiscovered** For the estimate of the number of undiscovered species,we have used the division of the world's coastal areas into ecoregions as was proposed by Spalding et al. 2007. They recognise 232 ecoregions, and only from 81 of these localities, rhabditophorans are described. This means that species are known from 34% of the regions. In our experience, samplings in new regions, almost always result in a species list with between 80 and 100% of new species. So it is safe to suppose that 90% of the species found in a randomly chosen ecoregion which has never been sampled before is new to science. 2,641 species are known. Therefore, simple calculation leads to an estimate of 4,597 species still to be discovered. However, here we have taken the assumption that in the 80 ecoregions from which flatworm are known, all species that occur there are known (i.e. that we know the entire turbellarian fauna from that ecoregion). We know this is absurd. Most of these ecoregions are very poorly sampled, most only once or twice, and then

	mostly only a limited amount of taxa were described (e.g. only polyclads) and even in many very-well known regions as e.g. the Western Mediterranean, up to 60% of the species collected are new to science. Furthermore, even in comparatively well known areas, samples have mostly, if not exclusively, been taken in shallow water habitats. The few records from deeper waters, or from marine caves, revealed species not present at shallower depths, casting doubts of the representativity of present, local census of rhabditophoran diversity. Thus, with the exception of the North Sea coast, the Baltic and the Swedish Coast, which are adequately known, for most of the already sampled ecoregions we think an (even conservative) estimate of 75% of undiscovered species in a random sampling campaign is a reasonable estimate. Following this assumption about sampled ecoregions and the 90% rule for unsampled regios explained above, this brings us to an estimate of 28,321species still to be described, which in our view is much more realistic then the 4,597 species of the first calculation. **Cryptic** Integrative taxonomy approach, combining morphological, molecular, karyological information, as well as cross-breeding experiments, has recently revealed that genera in the morphologically simple Monocelidinae(Proseriata: Monocelididae) include previously undected complexes of cryptic species – as in the cases of the *Pseudomonocelis ophiocephala* and *P. agilis* species complexes (Casu & Curini-Galletti, 2006; Casu et al., 2009). The phenomenon may occur in other taxa of Proseriata, lacking or with 'simple' sclerotised structures of the copulatory organ. Such taxa, however, are comparatively few, and most proseriates have complex copulatory structures, which usually aid species discrimination. As to rhabdocoels, data are even less available then in proseriates. In the "species" *Gyratrix hermaphroditus* real cryptic speciation seems rampant (according to a large amount of molecular data we collected from populations worldwide), although we still have to see to which extent they cannot be distinguished morphologically. For freshwater rhabdocoels, we have (only incomplete) data, that show that the same rule applies as given above: in taxa with few species-level diagnostic characters, there are species that can be identified on molecular grounds only. We, therefore, propose that the number of really cryptic species in Proseriates is limited, less than 1.5 % of morphologically recognised species. Should this be extended to all the other rhabditophorans, this would give a range of cryptic species between 75 and 420 (if the multiplication value is minus or equal 1.5%). **References** Casu M., Curini-Galletti M. (2006) Genetic evidence for the existence of cryptic species in the mesopsammic flatworm Pseudomonocelis ophiocephala (Rhabditophora : Proseriata). Biological Journal of the Linnean Society 87: 553-576.

	Casu M, Lai T, Sanna D, Cossu P, Curini-Galletti M. (2009). An integrative approach to the taxonomy of the pigmented European Pseudomonocelis Meixner, 1943 (Platyhelminthes: Proseriata). Biological Journal of the Linnean Society 98: 907-922. Tyler S., S. Schilling, M. Hooge and L. F. Bush. (2006-2011). Turbellarian taxonomic database. Version 1.7. http://turbellaria.umaine.edu
Porifera [Rob van Soest, Nicole de Voogd]	**Described** 8,553accepted species (mind you, these include those that have not been listed as synonym in any taxonomic study). **Nominal** 10,967 species names. **Undescribed, collected** based on our collections (assuming they are representative of the world's museum collections) we estimate 25-35% undescribed, so that would amount to approx. 2300-3000 new species still hiding in the museum collections. **Undiscovered** An 'old' guess of John Hooper from 1994 is 15,000 species of sponges in world's oceans. We have no reason to adjust this number, but it remains a guess. With on average 50 species described this will be described in 100-150 years. **Cryptic** There are a few studies on cryptic genetic diversity in some widespread Porifera species, but unfortunately the knowledge base is far too small to extrapolate this into an educated guess of overall cryptic diversity in the phylum. I think that naming a figure (e.g. based on the occurrence of approx. 15% of 'widespread species' you could argue that these are the most likely taxa to contain cryptic diversity and you could arrive in that way at several thousand cryptic species) is not a scientifically responsible action at this moment in time. We need more cases and more elaborate studies of what the genetic clades that appear in the investigated cases really represent: cryptic 'species' are usually based on percentage of sequence diversity observed among investigated individuals and translating these into biological entities that may be recognized morphologically is usually omitted. **References** Rob W.M. Van Soest, Nicole Boury-Esnault, Jean Vacelet, Martin Dohrmann, Dirk, Erpenbeck, Nicole J. De Voogd, Nadiezhda Santodomingo, Bart Vanhoorne, Michelle Kelly, & John N.A. Hooper. Global diversity of sponges (Porifera). Submitted to PLoSONE.
Rotifera	**Described**

[Hendrik Segers]	114 marine and brackish water species (Segers, 2007). **Nominal** 3570 (Segers et al., 2012). **Undescribed, collected** ca. 20. **Undiscovered** Undefined. However, cryptic speciation is very important; can amount to a factor 10, see Segers & De Smet (2008). **Cryptic** My guesstimate of cryptic diversity in rotifers, based on available studies, is between 3 to 20 times that of currently known diversity. **References** Segers, H. 2007. Annotated checklist of the rotifers (Phylum Rotifera), with notes on nomenclature, taxonomy and distribution. (Zootaxa 1564). 104 pp. Segers, H., W.H. De Smet, C. Fisher, D. Fontaneto, E. Michaloudi, R.L. Wallace & C.D. Jersabek, 2012. Towards a List of Available Names in Zoology, partim Phylum Rotifera. Zootaxa, in press (to be published very soon) Segers, H; De Smet, W.H. (2008). Diversity and endemism in Rotifera: a review, and Keratella Bory de St Vincent. Biodivers Conserv. 17: 303–316
Sipuncula [José Ignacio Saiz-Salinas]	**Described** 150 (all in WoRMS). **Nominal** 150 valid + 1,366 synonyms = 1,516 species names. **Undescribed, collected** Very roughly between 3-5 new species. In the period 2000-2010 only 2 new species have been proposed (+ 1 new subspecies). If we take into account the existence of about 5 active taxonomists, we could calculate an average number of 5 new species in a short term of 10 years. Anyway, this last number is quite optimistic in my opinion. **Undiscovered** This is difficult to say. Sipunculans, as many other non-polychaete 'worms', are lacking many anatomical characters to split species. We can say sipunculans are quite cryptic species by the simplicity of their anatomy. Just soft invertebrates without parapodia, nor chaeta. On the other hand, we should admit the existence of large areas in the oceans not well sampled, which could give further new taxa. By forcing us to estimate numbers: I

	would say from 10 to 25 species still undiscovered based on classical methods in identification (dissection + microscope). Based on this classical method, the rate of new species would remain strikingly low. **Cryptic** However, by using DNA analysis, some species ('= cosmopolits' + eurybaths + circumtropical + or present in several oceans at the same time) could be splitted into several new clades. There are about 30-50 species with very wide horizontal + vertical distribution. If we assume a range of 2-5 clades as average, we can guess around 60-250 new clades by molecular methods. From this range: 60-250 minus 30-50 = 30-200 additional species by using genetics. Note that Kawauchi & Giribet (2010) published on a single species of Sipuncula, in which they identified 4 cryptic species with wide distribution. **References** Kawauchi, GY & G Giribet (2010). Are there true cosmopolitan sipunculan worms? A genetic variation study within Phascolosoma perlucens (Sipuncula, Phascolosomatidae). Mar Biol 157:1417–1431
Tardigrada [Reinhardt Møbjerg Kristensen]	**Described** There are 973 species of tardigrades of which only 183 species (and subspecies) are marine, however on genus level the marine tardigrades are more divers than the terrestric/limnic tardigrades. Arthrotardigrada are all marine except for one species Styraconyx hallasi - which is found in a salt spring in Westgreenland. There are 5 families in Arthrotardigrada. I have 158 accepted species; some of them were described as subspecies. Echiniscoidea are most terrestric - however 1 family is tidal/marine. 18 species have been described. Eutardigrada are all terrestric/limnic except for one genus Halobiotus which contain 6 species. Furthermore one species of Isohypsibius has been recorded from a marine beach! I know two more species of Halobiotus. **Undescribed/undiscovered** We know about 500 undescribed Arthrotardigrada species - I estimate about 1000 undescribed Arthrotardigrada will exist.I estimate the family Echiniscoididae has about 100 undescribed species, we already know 20 undescribed species of the genus Echiniscoides and I will not expect more than 20 undescribed species of Eutardigrada.
Acoela [Tom Artois, Seth Tyler]	**Described** 391 species. **Nominal** 605 species. **Undescribed, collected**

	100 species. **Undiscovered** 4,000 species. Same rationale as for the Rhabditophora. [Seth] I fully concur with Tom and Marco. I expect similar estimates could be applied to the Acoela, but with them, the number of ecoregions sampled is probably far fewer than 81 - on the order of 20, I would guess; and again, except for those famous regions such as the Baltic, North Sea, Western Mediterranean, and Southeastern Brazil, the sampling has been haphazard at best. So the number of undiscovered species may be even proportionally higher in Acoela than Rhabditophora, but I am not prepared to hazard a guess. **Cryptic** We haven't seen any evidence for cryptic species in the acoels; in fact, we've seen evidence to the contrary (Matthew Hooge, pers comm.). We would suspect that cosmopolitan species (e.g., *Childea groenlandica*), and those found over a wide geographical area (e.g., *Hofstenia miamia*) might actually be species complexes, [but] molecular studies have supported the monophyly of these species. It also seems relevant to note that the acoel species usually have limited geographic distribution.
Nemertodermatida [Tom Artois, Wolfgang Sterrer]	**Described** 8 species. **Nominal** 10 species. **Undescribed, collected** See undiscovered. **Undiscovered** As to the Nemertodermatida, I think the number of undiscovered species is much higher than 10. In a recent sampling campaign with Ulf Jondelius in North Sardinia (only 8 days), Ulf found 5 species of Nemertodermatida, 4 of which he thinks(!) are new to science. To have certainty about that, molecular data should back this up, and this research has just been started. The number of undiscovered species is difficult to estimate. These species are extremely difficult to distinguish morphologically. Molecular techniques probably will reveal a much larger biodiversity, which I think is kind of illustrated by this recent sampling campaign with Ulf. That's why we propose to keep the number of undescribed and undiscovered species for Nemertodermatida in the table with a question mark.
Xenoturbellida [Serge Gofas]	There are only two species in this group. For a taxon with such a low number, it is not reasonable to venture a guess about undescribed/undiscovered species.
