WORLDS MARINE BIOLOGICAL DIVERSITY

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Life began in the sea, and much of the diversity in the deep branches of life's tree is still primarily or exclusively marine.

For example, 35 animal phyla are found in the sea, 14 of which are exclusively marine, whereas only 11 are terrestrial and only one exclusively so.

In contrast, our knowledge of marine diversity in the present is poor compared to our knowledge for terrestrial organisms.

The dramatic changes in marine ecosystem that have occurred in historic times is only just beginning to emerge.

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What then can we say about recent trends in the state of marine biodiversity?

What MB imply for its future?

How have and will these changes in marine biodiversity affect the provision of essential ecosystem services?

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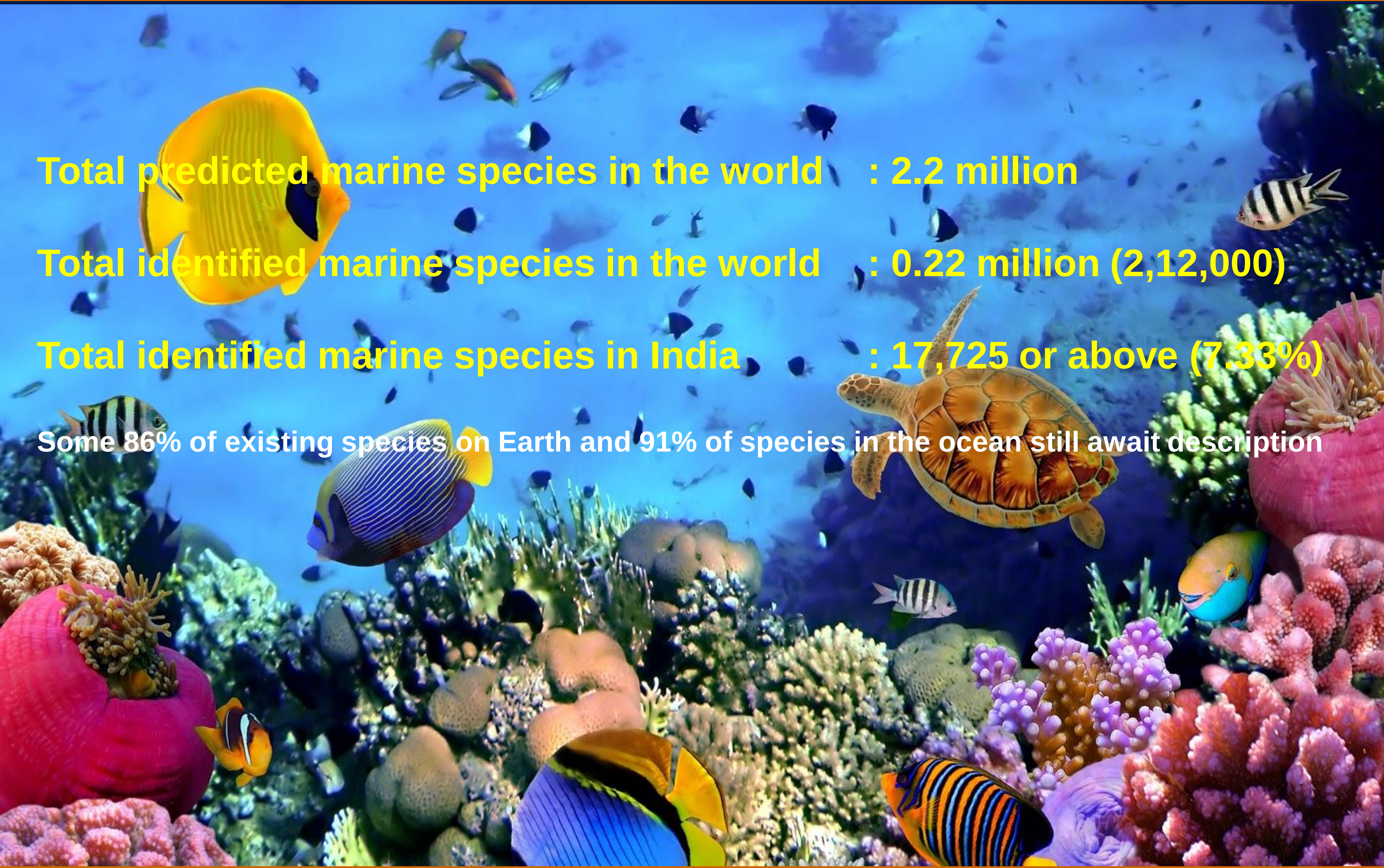
Specific goals are to

- Define marine biodiversity.
- Describe the historic trends in biodiversity unrelated to human activities.
- Review recent biodiversity trends and the role of human drivers.
- Assess the functional consequences of recent and future change, and
- Synthesize the unknowns and the unknowables of marine diversity and suggest priorities for marine biodiversity research and conservation.

Marine Biodiversity



Total predicted marine species in the world : 2.2 million

Total identified marine species in the world : 0.22 million (2,12,000)

Total identified marine species in India : 17,725 or above (7.33%)

Some 86% of existing species on Earth and 91% of species in the ocean still await description

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Taxon	Marine
Sponges	9,000+
Cnidarians	10,000
Bryozoans	5–10,000
Mollusks (Gastropods)	50,000
Mollusks (Bivalves)	11,000
Mollusks (Cephalopods)	800
Nematodes	35,000
Arthropods (Insects)	1,400 (includes intertidal)
Arthropods (Arachnids)	1–2,000
Arthropods (Crustaceans)	65,000+
Platyhelminthes	15–20,000
Annelids (Polychaetes)	9,000
Annelids (Oligochaetes)	<500
Echinoderms	6–7,000
Chordates (Mammals)	125
Chordates (Fish)	15,000
Chordates (Other vertebrates: Amphibians, crocodiles, lizards, snakes, turtles, birds)	<500 (excluding birds)
Chordates (Tunicates)	3,000
Fungi	<1,000
Plants (vascular macrophytes)	<100
Plants (other macrophytes)	10,000

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There are approximately 3,00,000 described marine species, which represent about 15% of all described species.

There is no single listing of these species, but any such listing would be only an approximation owing to uncertainty from several sources.

As a result, the total number of marine species is not known to even an order of magnitude, with estimates ranging from 1,78,000 species to more than 10 million species.

The two biggest repositories of marine biodiversity are coral reefs (because of the high number of species per unit area) and the deep sea (because of its enormous area).

Estimates for coral reefs range from 1 to 9 million species, but they are very indirect as they are based on a partial count of organisms in a large tropical aquarium or on extrapolations stemming from terrestrial diversity estimates.

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Estimates for the deep sea are calculated using actual field samples, but extrapolations to global estimates are highly controversial.

The largest estimate (10 million benthic species) was based on an extrapolation of benthic macrofauna collected in 233 box cores (30×30 cm each) from fourteen stations, although others suggested 5 million species as a more appropriate number.

Briggs argued that these enormous figures are excessive extrapolations from small-scale samples, and May suggested instead a total of 5,00,000 living marine species.

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The spatial patterns of global marine biodiversity, including species richness and endemicity, have been subject to excellent reviews.

Primary findings include well-documented gradients with respect to latitude (higher diversity in the tropical waters as has been found on land), longitude (decreasing diversity as one moves west to east in the tropical Pacific and Atlantic) and depth.

However, there are some disagreements about the reality of some patterns and enormous disagreement about the underlying causes of the patterns.

High levels of endemicity are associated with isolated islands, although again there is disagreement and the data are limited to a few well-known taxa.

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These marine estimates, inexact as they are, account only for multicellular Eucarya and do not include single-celled eukaryotes, Bacteria, Archaea, and viruses.

Microbial species richness has not been properly quantified at global scales, but recent studies suggest that microbial diversity may be enormous.

These studies suggest that even the most conservative extrapolation from small samples may yield global microbial species richness estimates on the order of millions.

HOW MANY MICROBES LIVE IN THE OCEAN?

Organisms/ml of seawater

- 10,000 Protists
- 10,00,000 Bacteria
- 10,00,000 Archaea
- 1,00,00,000 Viruses

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Our knowledge of diversity at the community level at local and regional scales is relatively poor.

Many coastal regions lack even a simple description of the zonation of shallow benthic communities, and only a limited number of regions have data on α- or β-diversity.

However, conservation efforts have prompted some excellent community and habitat mapping at regional scales, such as in the Great Barrier Reef in Australia.

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The closest attempt is the Large Marine Ecosystems (LME) project. LMEs are 64 nearshore regions characterized by depth, hydrography, productivity, and trophically dependent populations.

Although LMEs may be useful for management of exclusive economic zones at regional scales, they do not provide much insight into biodiversity at the community level.

The proposed LMEs encompass huge areas (on the order of hundreds of thousands km^2), and a single LME, such as the California current, can harbor ecosystems ranging from cold temperate to subtropical.

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Additional work has characterized large ocean floor and open ocean regions on the basis of depth, topography, temperature, and productivity.

The eco-regions obtained using those methods are also large, and because they are based mostly on physico-chemical parameters (which are easier to measure at large scales than biological parameters), they do not provide a detailed picture of biological distinctness.

RECENT AND CURRENT MARINE BIODIVERSITY TRENDS

Before humans began to significantly exploit the ocean, the only disturbances resetting the successional clock and causing sudden declines in biodiversity at all levels were environmental disturbances.

However, human activities are without doubt now the strongest driver of change in marine biodiversity at all levels of organization; hence, future trends will depend largely on human-related threats.

SPECIES/POPULATION TRENDS

The earliest and most conspicuous change in marine biodiversity due to human activities affects the abundance of individual species.

The most common changes range from population reductions to global extinction caused by overexploitation or habitat loss.

Although humans can also increase the abundance of some species through biological introductions.

GLOBAL EXTINCTIONS

- Humans have directly caused the global extinction of more than 20 described marine species, including seabirds, marine mammals, fishes, invertebrates, and algae.

- Probably the most dramatic example of human-driven extinction in the sea was the Steller's sea cow (*Hydrodamalis gigas*), a huge herbivore of the nearshore northeast Pacific that was hunted to extinction within only 27 years of its discovery by Europeans.

- Another example of rapid hunting-related extinction of a species inhabiting a large ecosystem is the Caribbean monk seal (*Monachus tropicalis*), which was heavily hunted by Europeans beginning in 1492 and last seen in 1952.

- However, not all extinctions are caused by overharvesting; for example, the eelgrass limpet *Lottia alveus* disappeared following the catastrophic decline of its required eelgrass (*Zostera marina*) habitat because of disease in the northwest Atlantic in the early 1930s.

GLOBAL EXTINCTIONS

Already lost 5% of coral reef area, and using an area-species richness power law, it has been estimated that about 1% of coral reef species have already become extinct.

Other unnoticed extinctions have undoubtedly occurred in habitats that are less known, such as in the deep sea.

Seamounts, for example, harbor huge species richness and high levels of endemicity (from 30% to 50% of endemic invertebrates per seamount).

Seamount biodiversity is threatened by large-scale commercial trawling, and repeated fishing of a single seamount could mean a large number of species extinctions. The diversity associated with deep-sea coral reefs is similarly threatened.

FUTURE OF MARINE BIODIVERSITY

Recovery of individual species may take longer than expected because of Allee effects, changes in trophic structure of the community (e.g., prey turned predators), difficult-to-reverse habitat changes, or a combination of several factors.

Recovery of diversity at the community level will take much longer, probably longer than the generation time of the longest-lived species.

In many cases, the reestablishment of native species, in particular trophic specialists, is dependent upon a facilitation process and the provision of minimum biogenic habitat requirements. Even species with high reproductive potential (e.g., the tropical sea urchin *Diadema*) have been notoriously slow to recover from catastrophic declines, which can have delayed impacts on other ecosystem components with intrinsically slower recovery potential (e.g., corals).

FUTURE OF MARINE BIODIVERSITY

In general, recovery of biodiversity is unlikely to happen at global scales as long as the multiple anthropogenic drivers of change are chronic.

Because our activities will likely increase in magnitude and extent in the future, we also should expect increasingly frequent collapses and ecosystem shifts.

FUTURE OF MARINE BIODIVERSITY

Human population is projected to grow to about 7.5 billion by 2020, with an associated coastal urbanization and migration to the coasts and subsequent increased demand for marine ecosystem services.

What will be the global footprint of the new topology of human society?

What will be the impact of wealth on biodiversity?

The synergies between human drivers, the timing and location of thresholds, the route and timescale of biological adaptation to climate change, and the resilience of marine biodiversity to human perturbations are all unknowns and probably unknowable in detail.

FUTURE OF MARINE BIODIVERSITY

we do not have a good understanding of the relationship between marine biodiversity and ecosystem services, although there is evidence indicating that more biodiversity can mean either more or less variable services in different circumstances.

Increased research in this field is a priority, and it could shed more light into the cost of biodiversity loss for biodiversity itself and for humans.

FACTS AND FIGURES ON MARINE BIODIVERSITY

The ocean constitutes over 90% of the habitable space on the planet.

The ocean has a much higher phylogenetic diversity: 30% of phyla are exclusively marine, whereas only one phylum is exclusively terrestrial.

By the year 2100, without significant changes, more than half of the world's marine species may stand on the brink of extinction.

Today 60% of the world's major marine ecosystems that underpin livelihoods have been degraded or are being used unsustainably.

Marine Protected Areas (MPAs) are essential to conserve the biodiversity of the oceans and to maintain productivity, especially of fish stocks.

World Heritage marine sites represent in surface area one third of all marine protected areas.

Approximately 12% of the land area is protected, compared to roughly 1% of the world ocean and adjacent seas.

FACTS AND FIGURES ON MARINE BIODIVERSITY

- Tiny phytoplankton provide 50% of the oxygen on earth and form the basis of the ocean food chain up to fish and marine mammals, and ultimately human consumption.

- Ocean acidification may threaten plankton, which is key to the survival of larger fish.

- If the concentration of atmospheric CO2 continues to increase at the current rate, the ocean will become corrosive to the shells of many marine organisms by the end of this century. How or if marine organisms may adapt is not known.

- Ocean acidification may render most regions of the ocean in hospitable to coral reefs, affecting tourism, food security, shoreline protection, and biodiversity.

- Coral reefs are the nurseries of the oceans, they are biodiversity hot spots. On some tropical coral reefs, for example, there can be 1,000 species per m^2.

FACTS AND FIGURES ON MARINE BIODIVERSITY

- Today, fisheries provide over 15 percent of the dietary intake of animal protein.

- Commercial overexploitation of the world's fish stocks is so severe that it has been estimated that up to 13 percent of global fisheries have 'collapsed.'

- Agricultural practices, coastal tourism, port and harbour developments, damming of rivers, urban development and construction, mining, fisheries, aquaculture, and manufacturing, among others, are all sources of marine pollution threatening coastal and marine habitats.

- Excessive nutrients from sewage outfalls and agricultural runoff have contributed to the number of low oxygen (hypoxic) areas known as dead zones, where most marine life cannot survive, resulting in the collapse of some ecosystems.

- There are now close to 500 dead zones covering more than 245,000 km^2 globally, equivalent to the surface of the United Kingdom.

FACTS AND FIGURES ON MARINE BIODIVERSITY

- Coastal systems such as mangroves, salt marshes and seagrass meadows have the ability to absorb, or sequester, carbon at rates up to 50 times those of the same area of tropical forest.

- Total carbon deposits in these coastal systems may be up to five times the carbon stored in tropical forests.

- Between 1980 and 2005, 35,000 square kilometers of mangroves were removed globally.

- Between 30 and 35 percent of the global extent of critical marine habitats such as seagrasses, mangroves and coral reefs are estimated to have been destroyed.

- Technological change and the emergence of new economic opportunities such as deep sea mining, more intensive fishing, and deeper oil and gas drilling increase risks to areas that historically were not under threat.

- Further research and collective action is needed to mitigate the underlying causes of the loss of biodiversity.