Global marine biodiversity and prediction in the context of achieving the Aichi Targets: ways forward and addressing data gaps (#34669)

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Global marine biodiversity and prediction in the context of achieving the Aichi Targets: ways forward and addressing data gaps

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In 2010, the Conference of the Parties of the Convention on Biological Diversity established updated the Aichi Biodiversity Targets for the 2011-2020 period. As this plan approaches its end, we discussed whether marine biodiversity and prediction studies have reached the Aichi goals during the 4th World Conference on Marine Biodiversity (WCMB 2018) held in Montreal, Canada. This article summarises the outcome of these discussions about how global marine biodiversity studies need to be focused to better understand the patterns of biodiversity. We discussed and reviewed eight fundamental biodiversity priorities related to nine Aichi Targets focusing on global biodiversity discovery and predictions to improve and enhance biodiversity data standards (quantity and quality), tools and techniques, spatial and temporal scale framing, and stewardship and dissemination. We discuss how identifying biodiversity knowledge gaps and promoting efforts reduced / will reduce such gaps using new tools and technology could be applied and improved in the future.

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Abstract

In 2010, the Conference of the Parties of the Convention on Biological Diversity established updated the Aichi Biodiversity Targets for the 2011-2020 period. As this plan approaches its end, we discussed whether marine biodiversity and prediction studies have reached the Aichi goals during the 4th World Conference on Marine Biodiversity (*1*) held in Montreal, Canada. This article summarises the outcome of these discussions about how global marine biodiversity studies need to be focused to better understand the patterns of biodiversity. We discussed and reviewed eight fundamental biodiversity priorities related to nine Aichi Targets focusing on global biodiversity discovery and predictions to improve and enhance biodiversity data standards (quantity and quality), tools and techniques, spatial and temporal scale framing, and stewardship and dissemination. We discuss how identifying biodiversity knowledge gaps and promoting efforts reduced / will reduce such gaps using new tools and technology could be applied and improved in the future.

Keywords: marine biodiversity, Aichi Targets, discovery, prediction, data standard, biodiversity tools and pipelines, biogeography, stewardship and dissemination.

Introduction

Biogeographical patterns and their drivers at multiple scales of space, time, and biological organization were explored in the last decade based in a part on the "Aichi Strategic Plan". This Strategic Plan for Biodiversity (2011-2020) was revised and updated during the 10th Conference of the Parties, held from 18 to 29 October 2010, in Aichi Prefecture, Japan. The Aichi plan includes five main "Strategic Goals" that are divided into 20 targets. Each target is designed to better understand and predict biodiversity dynamics, such as how biological diversity underpins ecosystem function, and how the provision of ecosystem services are essential for human well-being. Meeting the Aichi Strategic Goals ultimately contributes to local livelihoods and economic development, and is essential for poverty reduction (https://www.cbd.int/sp/targets/default.shtml).

Survey Methodology

The 4th World Conference on Marine Biodiversity (WCMB 2018) in Montreal organised a group to review and evaluate how the Aichi Targets have been met by scientists since 2011. In particular, we focused on Target 19 regarding scientific knowledge about biodiversity. To better identify and reduce biodiversity knowledge gaps we need to examine how marine biodiversity discoveries and their predictions need to be redirected from now to re-evaluate and predict how marine biodiversity knowledge will stand within the next 10 years. Here, we focus on the theme of "Biodiversity Discovery and Prediction" which identified eight important challenges for this topic to support Aichi strategic goals (Table 1). These foci arose iteratively from discussion between the group members and other groups at the conference. They address issues of (1) data standards, (2) education in data management, (3) taxonomic expertise, (4) genetic tools, (5) international collaboration, (6) identifying knowledge gaps, (7) understanding biogeography, and (8) need to reduce human pressures on marine biodiversity.

Reviewed Priorities

1. Developing, improving and enhancing biodiversity data standards, data exchange, analytical tools, and interoperability across multiple sources through novel standardized techniques to allow for better downstream analyses.

Recent marine biodiversity discoveries have been greatly enhanced by standardised open-access taxonomic and biogeographic data repositories such as the World Register of Marine Species (*2*) and Ocean Biogeographic Information System (OBIS) (*3, 4*). Large-scale improvement and enhancement of biodiversity data standards and exchange started with the Census of Marine Life (2000-2010) through the promotion of synergy of biodiversity research efforts to facilitate increased sharing and collaboration within the research community.

Biodiversity data standards, such as "Darwin Core", a data schema which provides stable terms and vocabularies for universal sharing of biodiversity data, and management techniques have been improved recently to ensure that published data have high quality and are internationally recognised. For example, now there are many available taxonomic (e.g., taxon match tool in WoRMS, http://www.marinespecies.org/aphia.php?p=match) and geographic (e.g., maptool, http://iobis.org/maptool/ and Marine Gazetteer, http://www.marineregions.org/gazetteer.php?p=search) data management tools and R packages (e.g., rOBIS (*5*)) (Figure 1). The standardization and open storage of metadata, taxonomic, genetic, and geographic data also allows a greater facilitation for stewardship by stakeholders, enhanced public awareness and education, and critically, the ability to easily share data among institutions (Figure 1).

Developing and enhancing biodiversity data standardization enable both data users and data providers to benefit from the high-quality data which later allow for more reliable and precise biodiversity analysis. The expansion of the OBIS data schema to include additional information associated with sampling events, including sampling methods and environmental data, is a significant recent advance (https://portal.obis.org/manual/dataformat/). The open-access publication of thousands of data sets integrated into OBIS, has enabled major advances in understanding global patterns of biodiversity. For example, several studies utilized open-access marine species distribution records to discover or confirm large-scale biodiversity patterns. These findings include observations that global latitudinal species richness is bimodal, and that species richness decreases with depth (*3, 6-10*). Despite considerable achievements in understanding marine biodiversity using open-access data, data mobilisation efforts are still not sufficient for some areas (e.g., ROPME Sea Area, the sea area surrounded by the eight Member States of ROPME: Bahrain, I.R. Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates) and ecosystems (e.g., deep sea) due to a lack of educational, financial, and governmental support. The contents of Aichi Target 19, namely the knowledge and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are still not widely transferred and applied.

2. Educational activities such as training workshops in order to facilitate and increase the understanding and necessity of data mobilisation by taxonomists, data users, and/or wider audiences.

Many scientists around the world are unaware of the presence and advantages of large-scale open-access databases. Even if scientists are familiar with these facilities, data preparation and submission can be complex for contributors unfamiliar with data publication protocols. These issues are more pronounced for scientists in developing countries or non-native English speakers. As a result of these data sharing obstacles, significant biodiversity and biogeography knowledge remains in personal databases and non-digital archives. The logistical hurdles and data ownership perceptions frequently stand in the way of sharing data with the broader community. To expose researchers to these resources, educational organizations including UNESCO and field-specific projects like OceanTeacher Global Academy (OTGA) (https://classroom.oceanteacher.org) provide an efficient platform of knowledge sharing to achieve sustainable development. OceanTeacher is a feature of the International Oceanographic Data and Information Exchange (IODE) Programme of the Intergovernmental Oceanographic Commission of UNESCO (IOC). OceanTeacher in combination with classroom training has trained nearly 2000 students from 120 countries since 2005 (https://classroom.oceanteacher.org/mod/page/view.php?id=2033). The OBIS training workshops hosted by OTGA help by training data providers on how to prepare, standardize, and submit their data to OBIS, and by assuring data providers that their shared data usage and citations are implemented and secured within OBIS. Organisations such as OTGA need to be financially supported by governments or member states to be able to actively educate and train data keepers and encourage them to share their data with the global community. However, unlike Aichi Target 19, convincing decision makers and financing educational programs via governments is not always easy and therefore educational activities remain limited.

3. Promoting synergy of biodiversity research efforts via increased collaboration at all levels.

In order to predict and discover biodiversity on a global scale, collaborative approaches among institutions and nations are necessary. In 2007, Guralnick *et al.* proposed a framework to use online databases and tools to improve and standardize geographic data, and to validate and highlight taxonomic data and misidentifications (*11*). It was also suggested that a global infrastructure for web-based tools would enhance the quality of visualizing and standardizing raw biodiversity data and lead to a higher degree of collaboration and sharing of knowledge (*11*).

The decade long Census of Marine Life was the largest global collaboration amongst marine biologists (*1*). Its legacy continues in OBIS with regard to data publication, but also continued international collaboration amongst polar, deep-sea and other researchers. The International Association for Biological Oceanography (IABO) is officially the organisation responsible for coordinating the marine biodiversity community (*12*). It runs the MARINE-B email list with over 1,000 subscribers, and has a World Conference on Marine Biodiversity every three years. Many other, often more specialist, conferences also serve to bring marine biodiversity researchers together. These make the introductions and help build collaborative relationships.

However, most research funding is for topics of national rather than international importance. Thus, for example, every country will not have specialist expertise in every taxonomic group. Thus, sharing of taxonomic expertise can alleviate funding deficits, allow the transfer of knowledge, and lead to international partnerships.

The number of marine species formally described each year has never been greater, and aside from naming these species, more work is required to understand their life histories and ecology, biogeography, and evolution. Costello *et al.* (2015) recommended the use of collaborative online databases, increased taxonomic effort improved through communication, easier access to specimens, engagement of non-specialists, and international collaboration (*13*). Further, Costello *et al.* (2013) advocated abandoning "data-sharing" and instead suggested requiring data publication within a journal or to online infrastructures such as OBIS, WoRMS, or Global Biodiversity Information Facility (GBIF) (*4*). Aichi Target 13, namely discovering the full extent of biodiversity in the world's oceans, may simply not be possible without international collaboration.

4. Utilization and promotion of taxonomic expertise and various identification tools (e.g. interactive keys) to better recognize and catalogue biodiversity.

"Good" taxonomy is an absolute necessity for biodiversity recognition and management (*14*). It is very important to pass on the knowledge of experienced taxonomists to the next, younger generations. In this regard, field-specific training workshops can be of great importance. As an example, two 'IceAGE amphipod determination workshops' were recently held, consisting of two weeks of work of a group of taxonomists accompanied by students, and this resulted in the identification of more than 20,000 amphipod specimens and seven papers dealing with the taxonomy, diversity and ecology of this group around Iceland .

Another problem in recognizing biodiversity is a lack of tools that can help end-users in identifying the organisms collected in their samples. The primary need is comprehensive online identification guides to all species on Earth (*15*). Targeted funding to support such resources is urgently needed to help the wider community identify species quickly and accurately, including species that may be invasive. DNA barcoding has received great publicity and interest, but the available DNA libraries (such as Barcode of Life Data Systems, (*16*)) are still far from complete. Moreover, DNA is only useful if the species has already been formally described and its DNA published in an open access database. Other tools that can help in species identification include interactive keys, but unfortunately, their preparation requires deep knowledge of the taxon concerned, and there are only such keys for a few marine taxa, and these mostly concern higher taxonomic levels (mainly families) (*17, 18*).

Along with Aichi Target 13, the exchange of knowledge between experienced scientists and young researchers as well as the use of different identification tools (e.g. interactive keys, barcode databases) will help in biodiversity recognition, and should be better supported by governments and member states.

5. Improvement and standardization of genetic, genomic, and other "omics" tools to aid in discovery, assessment, description, and cataloging of biodiversity.

In 2003, genetic tools were identified as one of several 'high-tech tools' that would be useful in the design and monitoring of marine reserves (*19*). Fifteen years later, countless studies have used genomic tools to study marine biodiversity, connectivity, and functional diversity (*20*). While data sharing, standardized sampling, metadata collection, and sequencing protocols still require significant standardization, the use of repositories such as GenBank, Dryad and Sequence Read Archive have made published data much more accessible. We expect this trend to continue as new tools, such as the Genomic Observatories Metadata database (GeOMe), streamline sequencing data and metadata submission (*21*).

Single-specimen DNA barcoding is widely used by taxonomists to help in the discovery and cataloguing of biodiversity. Identification of eukaryotic organisms relies on marker genes that can be used to identify thresholds of intra- and interspecific divergence to delineate a species (*22*). Currently, no uniform threshold value has been established for species delineation, and there is no single "universal" DNA barcode that captures all eukaryotic life. Even within a single animal order there can be large differences in this value between families (*23*). Despite these issues, DNA barcoding has helped reveal genetic diversity and is an essential tool for the description and cataloguing of new species.

Modern high-throughput sequencing (HTS) technologies have advanced DNA barcoding methods by producing millions of individual sequences per analyzed sample, enabling DNA metabarcoding from environmental DNA (eDNA) and complex community mixtures. Community and environmental metabarcoding are both useful tools to discover cryptic diversity in the marine realm, such as ambiguous morphology, small size, behavioural avoidance, and assessing ocean biodiversity in a non-invasive and high-throughput manner (*24*).

In order to obtain robust and reproducible metabarcoding results, critical methodological aspects remain to be improved (*25-27*). Studies are needed to address the biases of protocols on a sampling, molecular, and bioinformatic processing level in order to develop standardized and reliable techniques for applying these new and powerful species detection methods. Furthermore, because large fractions of marine organisms have not been genetically characterized, integrative approaches should be supported in order to fill database gaps. The continued improvement and standardization of genetic, genomic, and other "-omics" tools (e.g. proteomics, transcriptomics) will remain to be critical components in the discovery of new marine prokaryotes and eukaryotes, as well as monitoring biodiversity under changing climate fulfilling Aichi Target 19.

6. Identifying biodiversity knowledge gaps (in terms of regions and habitats) and promoting efforts to reduce such gaps.

Deep-sea biodiversity is one obvious knowledge gap. For example, deep-sea ecosystems include about 65% of the world's surface, yet less than 1% has been explored. Although deep-sea studies have increased rapidly in recent decades, there are large gaps in global sampling coverage, for example in the Indian and Pacific Oceans, and major efforts are needed to continue to be directed into offshore research (*28, 29*). The distribution and diversity of deep-sea fauna thus still remains elusive due to the sheer vastness and remoteness of deep-sea ecosystems. For example, recent studies have shown that the global latitudinal marine species richness gradient follows a bi-modal pattern related to temperature and habitat availability (*6, 9, 10, 28, 30*). However, there is still no consensus about this bimodal pattern in the deep sea, where food supply and depth are generally described as primordial in defining species distribution.

One issue in studying present and future global deep-sea biodiversity patterns is the remaining lack of publicly available distribution records and environmental data. Deep-sea expeditions began over 100 years ago, but distribution data are often still retained in old archives, sometimes in local languages of that country, and are not publically available to the global community. Additionally, data describing the distributions of deep-sea species are often limited by prohibitive costs and logistical difficulties in surveying the deep ocean. Habitat suitability modeling has thus become a cost-effective tool for identifying potential locations of deep-sea species, particularly for areas that have never been explored (*31, 32*).

Understanding how abiotic drivers influence species distributions can contribute to filling spatial gaps of biodiversity hotspots and endangered areas (*10, 28, 33*). Since some of these drivers can be observed by satellite imagery, it is possible to model community assemblages of difficult to access locations. The development of such models of species richness and cumulative anthropogenic impact distributions could be useful for conservation purposes or other spatial planning applications (*34*). However, regarding Aichi Target 3 on how environmental factors shape biodiversity patterns, this topic still remains unexplored for some marine environments including deep sea and polar regions, where our current knowledge and ability to conduct research is still limited.

7. Exploration of biogeographical patterns and their drivers at multiple scales of space, time and biological organization to better understand and predict present and future biodiversity dynamics.

The world's oceanic habitats can be divided into 30 biogeographic realms based on the distributions and endemicities of marine plants and animals (*13, 35, 36*). These realms include 18 continental-shelf and 12 offshore realms, including unique seas, such as the Baltic and Black seas, and subdivisions of the Indian, Atlantic, Pacific oceans, and polar waters. Pelagic microplankton and megafauna are the most widespread taxa among realms. Marine species diversity has historically been thought to show a unimodal distribution in species richness centred on the equator. A recent study by Chaudhary *et al.* (2016) analyzed available data from previously published studies and OBIS, and revealed bimodality of species richness at 50-55°N and 20-25°S, with a dip in species richness at the equator. Sampling effort may have slight biases on these species richness distributions, as the majority of records exist in the northern hemisphere (*6, 30*). Chaudhary *et al.* (2017) showed the bimodality remained after adjusting for sampling effort, and suggested that the equatorial region may be too hot for some species to persist. This is supported by the fossil record, which shows reduced species richness at the equator in warm periods (*37*). As such, the peaks in this bimodal distribution may become further separated under future climate change and ocean warming.

Additional studies focusing on latitudinal gradients in the southern hemisphere could help in verifying the bimodal distribution of marine species richness and help to decrease biases in sampling efforts between hemispheres. Increased sampling effort in under-sampled areas in general, such as polar oceans and the deep sea, will undoubtedly lead to new biodiversity discoveries in the marine realm. The deep sea comprises the majority of the sea-floor area, yet global patterns of species diversity in the deep sea remain unknown. Woolley *et al.* (2016) examined 165,000 distribution records of Ophiuroidea and revealed that biogeographic patterns in species richness in the deep sea are associated with chemical energy and proximity to slope habitats; however, these patterns require investigation in other taxa, from micro- to mega-fauna, epifauna and infauna (*38*). The drivers of patterns of species richness over time and space also require further exploration through increased environmental sampling, particularly under a changing climate, in order to fulfil Aichi Target 3. Costello et al. (2018) propose that sampling of the oceans should be stratified in relation to environmental variability, with more variable environments receiving more sampling focus in space and time (*35*).

8. Control the anthropogenic pressures on vulnerable ecosystems (e.g., coral reefs) impacted by climate change or ocean acidification to maintain their integrity and functioning.

Fisheries have had large impacts on marine biodiversity since ancient times (*39*). Clearly fishery management measures struggle to prevent overfishing, and trawling that destroys seabed habitats is widely permitted, while bycatch of seabirds, turtles and marine mammals is pushing some species to extinction (*40*). Progress in reducing bycatch is compromising reaching the achievement of Aichi Target 12 related to preventing species extinctions. A proven solution to reversing these trajectories are marine reserves (Marine Protected Areas (MPAs)) no take zones (*41*). However, about two-thirds of coastal countries lack even one reserve, and over 90% of MPAs allow fishing and thus prevent the recovery of biodiversity to natural conditions (*42*). This failure to conserve and help fisheries recover, despite the benefits of MPAs to nature, education, science (they act as controls for effects of fishing outside them), tourism, and fish populations defies what is best for society. With less than 3% of the ocean in reserves, there seems little hope that Aichi Target 11's goal of 10% of the oceans being protected in MPAs by 2020 will be reached. In addition, there appears to be negligible progress towards more sustainable use of the oceans, as called for in Targets 4, 6 and 7. Target 3, the reduction of harmful subsidies, has also seen little progress and too many fisheries still received indirect or direct subsidies from governments that enable further overfishing.

For most coral reef ecosystems and regions, the multiple anthropogenic pressures on coral reefs were not controlled by 2015, nor does it look possible to reach these goals by 2020, as called for in Aichi Target 10. Coral reefs suffered global-scale bleaching events in 2015-2017, resulting in massive damage to these ecosystems, including mass mortality of hermatypic corals and other zooxanthellate organisms (*43*), and associated reduced ecosystem functioning (*44*). Additionally, such events have spillover effects such as reduced tourism (*45*). Overall, the trajectory of coral reefs continues to be one of downward degradation in the face of increasing anthropogenic pressures from continued exploitation and rising human populations (*46*).

Other anthropogenic impacts on marine biodiversity include excess nutrient input, oxygen depletion, and invasive species. These are to be reduced and their management improved as part of Aichi Targets 8 and 9. Progress in management of introduced and invasive marine species has been made with the establishment of the World Register of Introduced Marine Species (WRiMS) (*3*). Because of the nature of invasive species, management of their information is most cost-effectively done at a global rather than local scale. The next steps should include access to species identification resources and a dynamic online reporting and early warning system.

Both global warming and ocean acidification are closely linked with the anthropogenic input of CO_2 and other greenhouse gases into the atmosphere, and without controlling these issues, the future of coral reefs looks bleak (IPCC 2018). Minimizing anthropogenic impacts such as increased runoff from coastal development and reducing overfishing can help delay the degradation of coral reef ecosystems, but it is estimated more than half of all coral reefs now experience medium to high anthropogenic pressures (*47*) and the extirpation of species from many coral reefs due to climate change is predicted (*48*).

There are some success stories, such as Palau, which has passed stringent legislation protecting coral reef diversity, including the world's first no-take zone for sharks (*49*), and stringent legal protection (*50*). Other regions or countries following the lead of these exemplars could help buy time for coral reef ecosystems. For instance, the Australian government implemented the Great Barrier Reef (GBR) Zoning Plan 2003 in 2004, which set aside one-third of the GBR as a no-take zone. This resulted in a significantly lower proportion of reefs being affected by Crown-of-thorns starfish outbreaks in no-take zones than in fished zones (*51*), but the trajectory of GBR coral reef ecosystems remains bleak due to global warming-associated coral bleaching (*44*).

Conclusions

While there has been considerable progress in addressing many of the priorities of the Aichi Targets, including the development and application of biodiversity tools and higher standards, as well as increased educational activity and increasing standardization of genetic and genomic tools, whether progress has been enough to reach these targets is an open question. Of the eight Aichi Target priorities we examine in detail here, we judge seven have seen fair to good progress. However, other goals such as reducing anthropogenic stressors on vulnerable ecosystems have clearly not been met, and will very likely fall short of the 2020 aims. The inability to reduce the rising pressures of a growing human population on marine biodiversity can also be seen in the rising rates of marine extinctions (*40*). With the recent announcement by the IPCC (2018) that climate change must be addressed by 2030 to avert major catastrophic changes to global and marine ecosystems, it is clear time is limited to more adequately understand and protect our marine biodiversity.

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Table 1(on next page)

Reviewed priorities addressing Aichi strategic goals

Reviewed priorities addressing four Aichi strategic goals (A, B, C, E) using nine Aichi Targets (3, 6, 7, 9, 10, 11, 12, 13, 19); Strategic Goal A (Target 3): Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society; Strategic Goal B (Targets 6, 7, 9, 10): Reduce the direct pressures on biodiversity and promote sustainable use; Strategic Goal C (Targets 11, 12, 13): To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity; Strategic Goal E (Target 19): Enhance implementation through participatory planning, knowledge management and capacity building.

1

Reviewed Priority	Aichi Target
Priority 1. Developing, improving and enhancing biodiversity data standards, data exchange, analytical tools, and interoperability across multiple sources through novel standardized techniques to allow for better downstream analyses.	**Target 19** By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.
Priority 2. Educational activities such as training workshops in order to facilitate and increase the understanding and necessity of data sharing and mobilisation processes by taxonomists, data users, and/or wider audiences.	**Target 19**
Priority 3. Utilization and promotion of taxonomic expertise and various identification tools (e.g. interactive keys) to better recognize and catalogue biodiversity.	**Target 13** By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.
Priority 4. Improvement and standardization of genetic, genomic, and other “omics” tools to aid in discovery, assessment, description, and cataloging of biodiversity.	**Target 13**
Priority 5. Promoting synergy of biodiversity research efforts via increased sharing and collaboration at all levels	**Target 19**
Priority 6. Identifying biodiversity knowledge gaps (in terms of regions, habitats, biota) and promoting efforts to reduce such gaps.	**Target 3** By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.
Priority 7. Exploration of biogeographical patterns and their drivers at multiple scales of space, time and biological organization to better understand and predict present and future biodiversity dynamics.	**Target 3**

Priority 8. Control the anthropogenic pressures on vulnerable ecosystems (e.g., coral reefs) impacted by climate change or ocean acidification to maintain their integrity and functioning.	**Target 6** By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits. **Target 7** By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity. **Target 9** By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment. **Target 10** By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning. **Target 11** By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes. **Target 12** By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

Figure 1

Biodiversity data process and standardisation

Biodiversity data processing using novel analytical standardized techniques and technologies.