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A World of SCIENCE

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EDITORIAL

Bringing fisheries on board

They may not be cute like seals or colourful like clownfish but they play a crucial role in protecting the oceans. Scientists refer to them as 'keystone species:' remove them from the top of the food chain and the food web will collapse.

We are referring to sharks, of course. Unlike human fishing techniques, which tend not to discriminate between sick and healthy specimens, sharks are selective: they target weakened prey, thereby keeping fish populations healthy and strengthening the gene pool. By keeping numbers down, they avoid overpopulation around coral reefs.

Even their intimidating behaviour has an ecological purpose. Scientists in Hawaii (USA) discovered that, in the absence of patrolling tiger sharks, turtles overgrazed seagrasses until these were destroyed. When their predator returned, the turtles grazed over a wider area.

The public tends to perceive sharks as man-eaters, yet shark attacks on humans are rare: about 100 are recorded each year, few of them fatal. Humans pose much more of a threat to sharks than the reverse: 17% of more than 1000 assessed shark species are threatened by fishing and bycatch, according to the Red List of the International Union for the Conservation of Nature. The growing popularity of shark's fin soup has encouraged the cruel practice of 'shark finning,' whereby the fins are cut off a live shark which is then left to die in agony. An estimated 26–73 million sharks are killed each year to supply the global shark's fin market.

Fortunately, there is a growing awareness of the value of sharks for the health of our oceans. A Memorandum of Understanding on the Conservation of Migratory Sharks was concluded in 2010 under the UN Convention on Migratory Species (CMS). Last September, 50 signatory countries adopted a new conservation plan to catalyse regional initiatives. Crucially, industry representatives, NGOs and scientists will be involved in implementing the plan.

International conventions are an essential tool for protecting marine biodiversity, given the lack of physical barriers in the ocean to confine species to a single zone. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was adopted in 1973, followed by the CMS in 1979 and the Convention on Biological Diversity in 1992. Importantly, these conventions are today working with industry to incite it to adopt more sustainable practices.

A Blueprint for Ocean and Coastal Sustainability provided the third Earth Summit (Rio+20) with valuable input last June, for it traced a roadmap for combining conservation with greening the blue economy. This interagency publication was produced by UNESCO's Intergovernmental Oceanographic Commission, in conjunction with FAO, IMO and UNDP.

The story beginning overleaf assesses the implications for marine biodiversity of transgressing planetary boundaries, due to human-induced changes to the climate system, pollution and ocean acidification, as well as more direct threats like invasive species, overfishing and habitat destruction. It then outlines a strategy for protecting biodiversity from irreparable harm.

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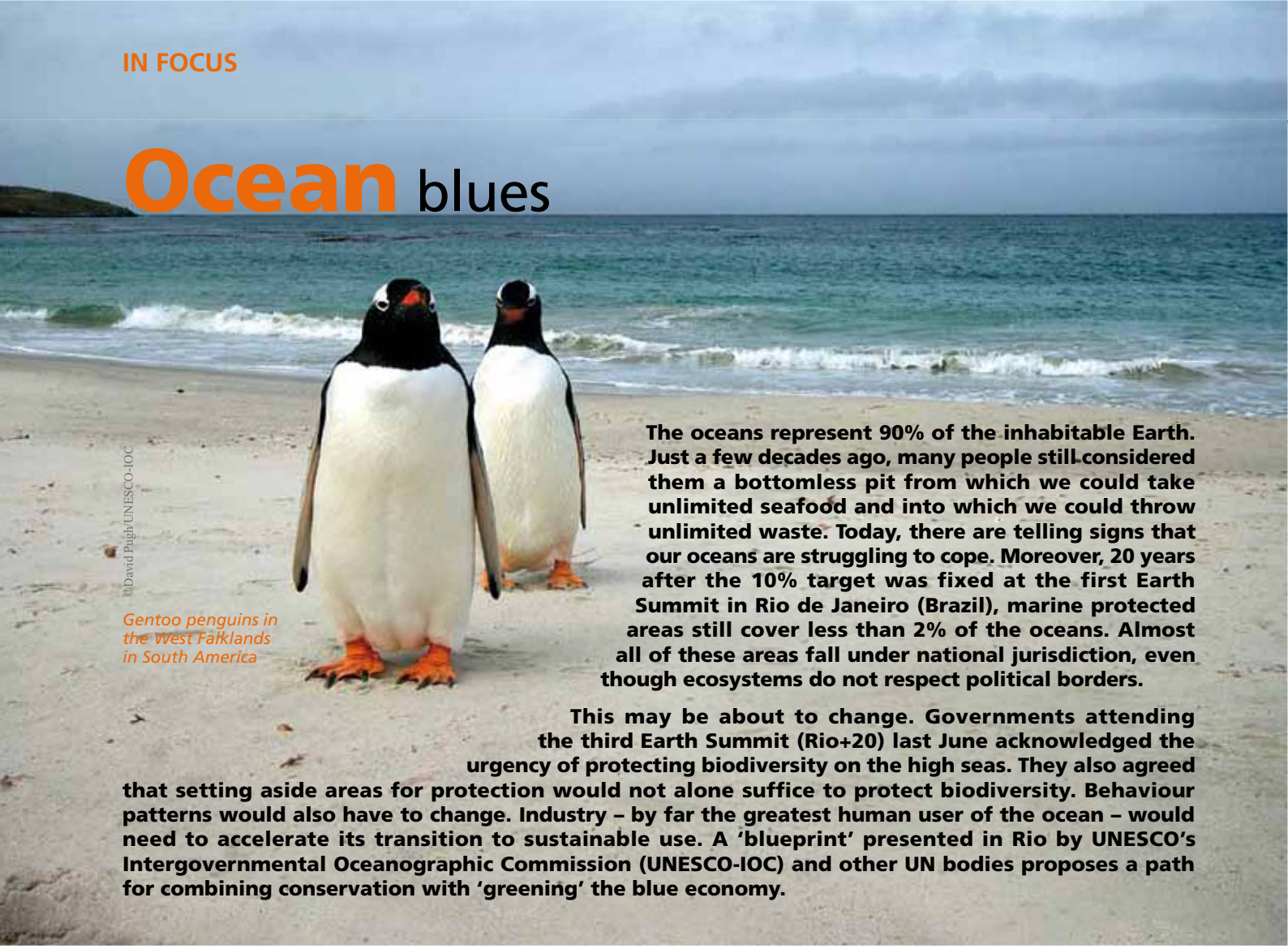
Ocean blues



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Gentoo penguins in the West Falklands in South America

The oceans represent 90% of the inhabitable Earth. Just a few decades ago, many people still considered them a bottomless pit from which we could take unlimited seafood and into which we could throw unlimited waste. Today, there are telling signs that our oceans are struggling to cope. Moreover, 20 years after the 10% target was fixed at the first Earth Summit in Rio de Janeiro (Brazil), marine protected areas still cover less than 2% of the oceans. Almost all of these areas fall under national jurisdiction, even though ecosystems do not respect political borders.

This may be about to change. Governments attending the third Earth Summit (Rio+20) last June acknowledged the urgency of protecting biodiversity on the high seas. They also agreed that setting aside areas for protection would not alone suffice to protect biodiversity. Behaviour patterns would also have to change. Industry – by far the greatest human user of the ocean – would need to accelerate its transition to sustainable use. A 'blueprint' presented in Rio by UNESCO's Intergovernmental Oceanographic Commission (UNESCO-IOC) and other UN bodies proposes a path for combining conservation with 'greening' the blue economy.

If we were to characterize planet Earth in two words, they would be *water* and *life*. Water is linked to the origin of life. It was the primordial oceans which protected early organic molecules from temperature swings and the sun's destructive ultraviolet rays. It was in this aquatic environment that molecules could move around freely, combine and evolve into the first cyanobacteria about 3.4 billion years ago. The Earth's atmosphere was saturated with carbon dioxide at the time, like planet Mars today. The oxygen produced by these cyanobacteria combined with water vapour to change the Earth's atmosphere,[1] paving the way for the evolution of life. We ourselves are the distant descendants of organisms which once inhabited the primordial ocean.

The importance of marine biodiversity in maintaining a healthy balance between the concentrations of oxygen (O_2), carbon dioxide (CO_2), nitrogen (N_2) and phosphorus (P) in the atmosphere may be a stronger argument for conservation than the usual justifications based on food security or access to sources of genetic material for cosmetics and drugs *(see box overleaf)*. Approximately 93% of the Earth's CO_2 is stored and recycled through the oceans and about 50% of the carbon in the atmosphere that becomes sequestered in forests, wetlands and other natural systems is also recycled through the seas and oceans. The remainder is sequestered in marine sinks like mangroves, seagrasses and salt marshes. The current decline in marine biodiversity is therefore a valid cause of concern for anyone worried about climate change.

There is another compelling reason to conserve marine and coastal biodiversity. Biodiversity protects ecosystem resilience, both locally and globally. Resilience refers to the speed with which an ecosystem returns to equilibrium following a perturbation, such as a fire or oil spill. This concept is based on the argument that, the greater the diversity of genes and species, the more numerous the pathways for adaptation. Despite the utility of this concept, we still are only partially capable of measuring the consequences of the loss of ecosystem resilience.

Ensuring a safe operating space for humanity

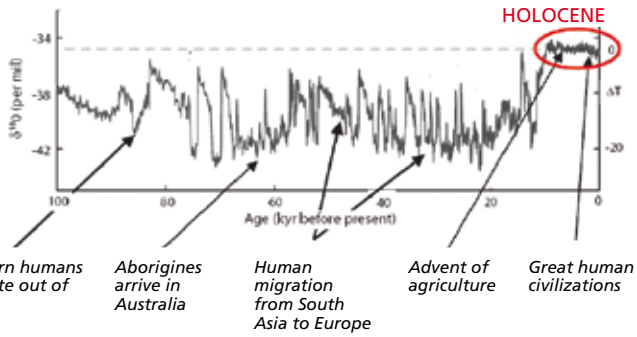
We rely on environmental stability to support our societies and economies. Over the past 10 000 years, the Earth's climate has remained remarkably stable *(see figure)*, during what is known as the Holocene period. This stability has enabled humans to thrive and their population to soar from a few million to 7 billion. The Holocene should normally continue for a few more thousand years yet but there are signs that this period of stability may already be coming to an end. The planet appears to be entering a new period that has been termed the Anthropocene, to reflect the fact that human beings have become the main driver of environmental change.

We know that there is a safe operating space within which the Earth's main systems remain stable: the climate system, stratospheric ozone, the phosphorus and nitrogen cycles,

biodiversity, etc. In 2009, Rockström *et al.*[2] identified nine interlinked boundaries that we need to respect to remain a safe distance from dangerous environmental thresholds, also known as tipping points *(see table)*. The consequences if we don't could be catastrophic, for we could then expect to see abrupt changes in the Earth's subsystems, such as a drop in the productivity of marine ecosystems.

Earlier this year, the UN Secretary-General Ban ki-Moon tasked UNESCO with setting up and hosting a scientific advisory board to the United Nations. The decision follows a recommendation by the UN Secretary-General's High-level Panel on Global Sustainability for governments and the scientific community to take practical steps to strengthen the interface between policy and science, including through the preparation of regular assessments of the science encapsulated in such concepts as planetary boundaries, tipping points and environmental thresholds.

Temperature fluctuations over the past 100 000 years



Source: Adapted from Young and Steffen (2009). In Rockström et al *(2009)*

Planetary boundaries

Earth system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	1) Atmospheric CO_2 concentration (parts per million by volume)	350	387	280
	2) Change in radiative forcing (watts per metre squared)	1	1.5	0
Rate of biodiversity loss	Extinction rate (number of species per million species per year)	10	100	0.1–1
Nitrogen cycle (part of boundary with phosphorus cycle)	Amount of N_2 removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle (part of boundary with nitrogen cycle)	Quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5–9.5	~1
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation rate of aragonite* in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km^3 per year)	4 000	2 600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	Low
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis	To be determined		
Chemical pollution	For example, amount emitted to, or concentration of, persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste in the global environment, or the effects on ecosystem and functioning of Earth system thereof	To be determined		

** Aragonite ($CaCO_3$) is also known by other names: calcium carbonate, limestone, chalk, etc.*

Source: Rockström, Johan et al. *(2009) A safe operating space for humanity.* Nature, *vol. 461|24 September 2009*

Solid waste in the Estuary of Santos in São Paulo, Brazil, including numerous plastics.

Nearly 4 billion years of evolution

Today, the oceans cover more than 70% of the planet, extend to an average depth of 3 700 m and represent more than 90% of the inhabitable Earth.

Despite this, just 13% of all known species live in the oceans.* Two actors help to explain this. Firstly, our knowledge of both the deep ocean and the most common forms of marine life – micro-organisms, bacteria and microalgae – remains very fragmentary. New methods are helping to remedy this. Ocean sequencing, for example, manages to filter all the DNA present in a given sample of water; about 80% of the samples obtained using this method tend to be new to science. The second reason for the apparently small marine biodiversity is the lack of geographical barriers in the ocean, which predisposes less to endemism than on land. Cyanobacteria can be found throughout the ocean, whereas large species tend to have a more limited geographical range.

There may be less biodiversity in the oceans than on the continents but the evolutionary ties among different life forms (phylogenetics) are much more varied in the sea than on land. This is a heritage of the ocean's ancestral history, as the first life forms developed in the sea. Today, 12 of the 31 phyla (large taxonomic groups) within the Animal Kingdom live exclusively in the oceans, including brachiopods and starfish. Bacteria in the ocean sub-surface alone represent 10% of all the carbon-based biomass on the planet and phytoplankton more than 50%!

The ocean environment played a key role in the evolution of life and climate on Earth that remains just as important today. The oldest traces of carbon of biological origin date back 3 850 million years (Ma). They were found in sediment rocks on the island of Akilia in south Greenland. Stromatolites, which still form today, contain the most ancient known fossils of micro-organisms – cyanobacteria – which conquered the oceans about 3400–3200 Ma. Oxygen first appeared in the atmosphere about 3 500 Ma, thanks to the breakdown of CO_2 by photosynthesis, but it would take another 300 Ma for it to permeate the ocean. Oxygen levels rose spectacularly in the superficial ocean about 2 300 Ma then again about 800–542 Ma. For about the past 100 Ma, the atmosphere has been composed of 21% oxygen. The apparition of sexual reproduction in the oceans accelerated the evolutionary process by favouring a wider gene pool. The explosion of life during the Cambrian (beginning about 542 Ma) saw the first animals leave the oceans for life on the land. About 430 Ma, the first vascular plants appeared, as well as the first arthropods (insects, crustaceans, etc) and primitive jawless fish.

In 2008, our industries took 160 million tonnes of aquatic species from the oceans, according to FAO. Two-thirds (93 million tonnes) came from fishing and the remainder (67 million tonnes) were produced by aquaculture. Yet, the ancestral species which populate our oceans and seas have not only given us food but also more than 15 000 medicines, most of them from marine sponges: antibiotics, anti-tumour drugs, immunostimulants, immunosuppressors, growth hormones, bone regenerators, etc. Marine species that are often considered insignificant have proven indispensable to the advancement of medicine and biology by helping us to understand the processes of carcinogenesis and ageing, among others.

Gilles Bœuf**

Adapted from an article published in UNESCO (2012) Tracking Key Trends in Biodiversity Science. *Proceedings of UNESCO Conference on Biodiversity Science, January 2010.*

* *In 2010, the Census of Marine Life estimated the total number of known marine species at between 230 000 and 250 000. See: www.coml.org*

** *Pierre and Marie Curie University and French National Museum of Natural History*

How will transgressing planetary boundaries affect marine biodiversity?

We appear to have already overstepped three planetary boundaries: those for climate change, the nitrogen cycle and the rate of biodiversity loss. All nine boundaries being interlinked, overstepping any one will influence the others. The rise in atmospheric CO_2 concentrations is driving ocean acidification, for example. By absorbing the excess CO_2 present in the atmosphere, the oceans are alleviating global warming in the biosphere. However, as CO_2 dissolves in seawater, the pH of the water decreases, making it more acidic. As the oceans become more acidic, the availability of carbonate minerals will diminish. This will make it more difficult for corals, calcareous phytoplankton, mussels, sea urchins, shellfish, starfish and other marine organisms to secrete calcium carbonate ($CaCO_3$) to construct their shells or skeletons. It is projected that, by 2100, 70% of corals will be exposed to corrosive waters.

The rise in atmospheric CO_2 concentrations is also warming the oceans, which absorb almost 90% of the excess heat present in the atmosphere. Over the past 40 years, zooplankton, fish and other marine fauna have shifted to cooler waters at higher latitudes, or stayed in the same general area but moved into deeper waters; they seem able to find places where their chances of survival as a population are greater. Among marine species which cannot move elsewhere, however, we are seeing a higher mortality rate, slower growth and a change

Release of sewage into Delray Bay, Florida, USA. Daily, about 57–76 million litres of sewage are discharged into this bay, which lies upcurrent of a coral reef. Sewage contains a wide range of pollutants, including nitrogen and phosphorus, toxic chemicals, natural and synthetic hormones, pharmaceuticals, pathogens and organic matter.

in reproduction patterns, suggesting a poor capacity to adapt rapidly to a changing environment and climate.

The accepted target of a 2°C increase in average global temperatures this century could be an acceptable threshold for terrestrial ecosystems but it is probably too high for marine ecosystems. Even if the increase is limited to 2ºC, we shall see significantly more days with peak sea-surface temperatures of over 28−30ºC, particularly in the coastal waters of subtropical regions and in closed seas like the Mediterranean.

The impact of nitrogen and phosphorus on the oceans

A third boundary concerns nitrogen and phosphorus levels. The discovery of how to convert natural gaseous nitrogen into a reactive form for use as fertilizer in agriculture has led to excess nitrogen seeping into soils and groundwater, polluting the environment and eventually ending up in the sea. According to Rockström *et al.* (2009), the manufacture of fertilizer converts 'around 120 million tonnes of nitrogen (N_2) from the atmosphere per year into reactive forms.' Humans are now adding more reactive nitrogen to the environment than all natural processes combined. Nitrous oxide (N_2O) also happens to be one of the most important greenhouse gases.

Sewage contains both nitrogen and phosphorus. It is by far the most abundant source of waste dumped in the world's oceans. Millions of tonnes of mined phosphorus also find their way into the oceans each year.

What happens once nitrogen and phosphorus reach the sea? They become nutrients for phytoplankton, which grow, multiply then fall to the sea floor when they die. Here, the cells are broken down by bacteria, in a process known as bacterial respiration. The problem is that, although phytoplankton use CO_2 and give off oxygen during photosynthesis, bacteria use oxygen and give off CO_2 during respiration. Bacterial respiration thus depletes dissolved oxygen in bottom water. The lack of oxygen in turn creates dead zones with low biodiversity: on average, a minimum concentration of 60 µmol of dissolved oxygen per litre of water is necessary for the survival of many marine fauna, including fish, crustaceans, bivalves and gastropods.

The number of dead zones is perpetually growing along the world's coastlines. At last count, there were about 500. Since 1960, low-oxygen layers of waters at intermediate depths (300–700 m) have expanded in the equatorial Indian Ocean and East Pacific Ocean. Models predict that the concentration of dissolved oxygen in the oceans will decline further as the climate continues to warm.

The scourge of chemical pollution

Chemical pollution has been identified as another planetary boundary. In the past 20 years, more than ten big oil tankers have been wrecked in coastal areas of France, the UK, Spain and the USA (Alaska and Gulf of Mexico), among others. Field experiments have demonstrated that ecosystems had recovered only partially many years after the initial perturbation.

The entire fringing red mangrove forest in Punta Cana in the Dominican Republic was demolished in 2008 to make way for a new holiday resort, even though these mangroves are an essential nursery habitat for coral reef species.

Development has altered the coastal landscape and ecosystems in Southern California, USA.

Most chemicals are soluble in water, which makes pollution an overarching threat to marine biodiversity. Some chemical pollutants continue to circulate in the water column where they reach the food chain, becoming a threat to both marine biodiversity and humans. These pollutants can cause deformities and disease and weaken the gene pool. Plastics and other debris accumulate in 'ocean rubbish heaps' fed by the marine current. The biggest of these rubbish heaps can be found in the North Pacific Ocean; it is thought to be twice the size of the US State of Texas.

In *The Future We Want* adopted at 'Rio+20' last June, some of the strongest wording concerns chemical pollution of the oceans. Governments 'commit to take action, by 2025, to achieve significant reductions in marine debris', especially plastics, and to reduce other forms of marine pollution, such as persistent organic pollutants, heavy metals and nitrogen-based compounds.

Biodiversity loss: another planetary boundary

We have already transgressed the planetary boundary for the rate of biodiversity loss, according to Rockström *et al.* Coastal ecosystems are among the richest repositories of biodiversity on Earth, yet they are threatened by development projects along almost half of the world's coasts, such as urbanization and the poor waste management which often accompanies it or the destruction of mangroves to make way for hotel complexes.

The modification or destruction of habitat is one of the main causes of biodiversity loss. There are about 1 200 major estuaries worldwide, covering 500 000 km^2. Human exploitation has caused 95% of species depletions and 96% of extinctions in coastal zones, often in combination with habitat destruction. Humans have destroyed over 65% of seagrass and wetland habitat, degraded water quality and accelerated species invasions. Mangroves cover an area of approximately 152 000 km^2, 19% less than in 1980; the largest of these ecosystems are located in Asia and Africa, followed by North and Central America. Coral reefs have likewise lost 19% of their original area; 15% are seriously threatened with loss within the next 10–20 years and a further 20% are under threat of loss within 20–40 years. The good news is that 46% of the world's coral reefs are regarded as being relatively healthy and not under any immediate threat of destruction – with the exception of the 'currently unpredictable' global climate threats of warming and acidification.

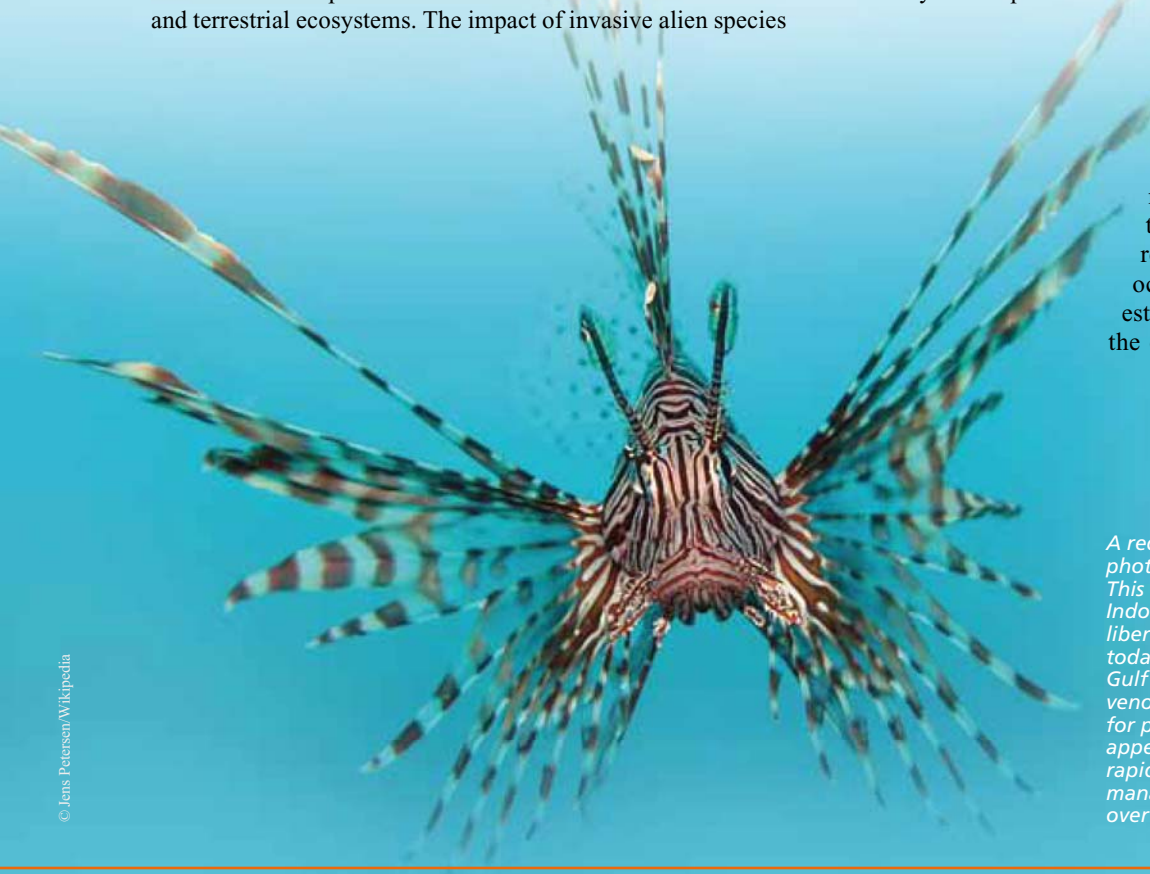
Invasive species are another major direct cause of biodiversity loss. Many severe cases of invasive marine species have been recorded up until now but few have been properly monitored. We still need to evaluate the process through which invasive species reduce the resilience of both marine and terrestrial ecosystems. The impact of invasive alien species has been particularly high on islands. In coming decades, these species will affect biodiversity in inland waters and coastal areas especially.

Destructive fishing practices are another direct cause of marine biodiversity loss. Fifty years ago, the public expected the oceans to provide them with an unlimited source of food. In recent years, overfishing and 'accidental fishing' (the trapping of unwanted fish in nets, known as bycatch) have reduced populations of fish stocks on the high seas to less than 10% of their size just a few decades ago. These practices have driven some species to the brink of extinction. An estimated 52% of marine fish stocks are fully exploited, 19% overexploited and 9% are depleted or recovering from depletion, according to FAO (2009).

Centuries of intensive fisheries extraction exacerbated by more recent coastal degradation have put oyster and other shellfish reefs near or past the point of functional extinction worldwide. Oyster reefs are in poor condition, having declined more than 90% from historic levels in 70% of bays and 63% of the world's marine ecoregions. In *The Future We Want,* governments vow to eliminate subsidies that contribute to overfishing but do not fix any specific targets.

Deep-sea ecosystems occupy 60% of the Earth's surface. Their inhabitants are extremophiles, accustomed to living in either very cold waters or extremely hot ones, as in the case of species which thrive around hydrothermal vents. Marine extremophiles are accustomed to high pressure and, in some cases, toxicity. These deep-sea ecosystems are rich in species, most of which are still unknown to science. They are also very fragile, as they comprise species which grow very slowly, live long and have low fecundity. They will probably recover slowly, if at all, from any severe perturbation.

Many cold-water coral reefs have been damaged by bottom-fishing but the extent of this damage has not been quantified for the simple reason that we do not know the extent of cold-water coral reefs worldwide. Found in deep oceanic waters, these cover an estimated 284 300 km^2, mainly on the edge of continental shelves or



A red lionfish (Pterois volitans), *photographed in Indonesian waters. This coral reef fish native to the Indo-Pacific either escaped or was liberated from private aquaria and today poses a serious problem in the Gulf of Mexico and Caribbean. Its venomous spines make it inedible for predators. It also has a voracious appetite for prey and reproduces rapidly. Over a short time, it has managed to fill the niche of the overfished snapper and grouper.*

© A.D. Rogers *et al*, in *PLoS Biology*

In January this year, Rogers et al. *related the discovery of hydrothermal vents on the East Scotia Ridge in the Southern Ocean. The authors wrote in* PloS Biology[3] *that these were, 'to our knowledge, the first to be discovered in Antarctic waters. The chemosynthetic ecosystems hosted by these vents are dominated by a new species of yeti crab (*Kiwa n. sp.*, pictured), stalked barnacles, limpets and snails, sea anemones and a predatory seven-armed starfish.'*

on seamounts. Cold-water corals can form large reefs, occur singly or in tree-like thickets.

Hydrothermal vents were first discovered more than 30 years ago. These chimneys form on the seafloor at depths of up to 3 700 m when tectonic plates converge or move apart. They continuously spew hot water of up to 400°C into the cold surrounding water. This is the result of fluids from the ocean seeping into subterranean chambers where they are heated by the magma beneath the crust. The spewed fluids contain metal sulphides, including copper, gold, lead, silver and zinc, which accumulate on the seafloor and just beneath it. There may be up to about 100 million tonnes of these deposits, a prospect that has excited considerable interest in the mining industry. Although this form of exploitation does not yet exist, it is moving closer to becoming a reality, at least within national economic exclusion zones.

Hydrothermal vents support exceptionally productive biological communities, with vent fauna ranging from the predominant tiny chemosynthetic bacteria to tube worms, giant clams and crabs *(see photo)*. Some 91% of species living in and around vents are endemic. The InterRidge Hydrothermal Vent Database lists 212 separate known vent sites but there are likely to be more. Our knowledge of where hydrothermal vents occur and how extensive they are is far from complete, as is our knowledge of their biodiversity and ecology.

Could we be headed for a sixth major extinction?

Throughout its geological history, the Earth has seen five episodes of mass extinction. Each time, the cataclysm that destroyed much of life on Earth marked the boundary between geological periods. Around 440 Ma, 85% of marine species perished at a time marking the transition from the Ordovician to the Silurian period. The next cataclysm marked the transition from the Devonian to Carboniferous about 375−355 Ma. Two sharp mass extinctions, or a series of smaller ones, wiped out 70% of marine invertebrates at this time. The worst extinction of all happened about 250 Ma, when 95% of all animals perished. This marked the transition from the Permian to the Triassic. Some 203 Ma, another mass extinction took a toll on sea creatures primarily but also on some land animals. During the fifth cataclysm 65 Ma, three-quarters of all species − including the dinosaurs − were eliminated, marking the transition from the Cretaceous to the Palaeogene period.

Could a new extinction cycle be happening now? And if so, could it mark the transition from the Holocene to the Anthropocene? There is solid evidence that we are now moving towards another mass extinction that could rival the past big five. A sixth mass extinction is plausible. By the year 2100, more than half of the world's marine and land species will be on the brink of extinction.

Greening the blue economy

In Rio last June, the UNESCO-IOC presented *A Blueprint for Ocean and Coastal Sustainability*, a compilation of ten proposals for greening ocean industries which it had prepared specifically for the Earth Summit (Rio+20) along with IMO, FAO and UNDP.

The *Blueprint* argues that global economic earnings from ocean industries are estimated at between US$3 trillion and US$6 trillion a year and are expected to grow substantially in the future. In comparison, global non-market ecosystem services provided by the Earth's biosphere (climate, water, soil, nutrients, etc.) have been estimated at US$33 trillion a year. Of these services, 63% derive from marine systems, one half each from coasts and the open ocean.

These services should be treated as if they were produced and consumed as market activities, argues the *Blueprint*. It advocates working with existing international carbon markets to define and implement a blue carbon market to protect marine and coastal carbon sinks and set targets for habitat protection. It proposes developing methodologies to assess the economic value of blue forest ecosystem services like those provided by mangroves and coral reefs. It also proposes creating mechanisms within international climate change policy instruments to allow carbon credits to be used in future for marine and coastal ecosystem carbon capture and storage.

The *Blueprint* stresses that, for there to be a real shift towards green ocean management, the private sector and public–private partnerships will need to play a central role in developing technologies and changing current behaviour patterns. For example, the Pacific Island nation of Palau has declared its waters a sanctuary for sharks. It estimates the value to the tourism industry of an individual reef shark at US$1.9 million over its lifetime, compared to US$108 per shark in direct fishing revenue.

Here is how some other key ocean industries might evolve within the green blue economy:

Fishing and aquaculture

Greening fishing and aquaculture will likely include the development of off-shore large scale aquaculture and the better management of fisheries, also covering foreign vessels in domestic waters. Green practices in aquaculture should promote the growth of extractive species (seaweeds and filter feeding shellfish), for instance, and greater farming of herbivorous species which convert food to fish protein more efficiently than carnivorous species. In parallel, measures need to be put in place to reduce fish takes in order to preserve stocks locally, such as via quotas.

Desalination

The Arabian Gulf counts about half of the world's desalination capacity. With some countries being especially dependent on desalination – 90% of Kuwait's potable water comes from the sea – and with the desalination technology becoming more affordable for developing nations and small island developing states, we expect to see it adopted more around the world, thereby decreasing freshwater shortages and increasing the need for clean marine waters. As saline residues from desalination can be detrimental to marine ecosystems, proper management regimes will need to be put in place to minimize this side effect. Desalination also tends to be very energy-intensive, so countries dependent on desalination will need to pursue aggressive low carbon energy strategies in parallel.

Shipping

With the increase in trade has come a parallel rise in demand for international maritime transport. In July 2011, IMO adopted measures to improve energy efficiency on ships: the first-ever mandatory regime for greenhouse gas reduction for an international industry. This measure has been fully embraced by shipping. Other measures required by international treaties or yet to come into force internationally include preventing the spread of invasive species through ballast water and hulls and safe and environmentally sound ship recycling. Pollution from ships has dropped considerably over the past three decades, thanks to better hull design, alternative sources of ships' fuel, better fuel efficiency and greater concern for the environment.

Marine energy sources and minerals

Some 30% of global oil and gas supplies come from offshore production, a share that is growing as technological progress allows deeper oil and gas exploration and drilling. The impact of fossil fuels on climate change accentuate pressure on the sector to invest in alternative renewable technologies. Governments and the public alike will also expect improvements in technology to avoid loss of oil and gas during extraction and transportation. Offshore wind farms can generate more electricity than those on land, as the winds are stronger offshore and more reliable. Tidal power is now also becoming a viable option but remains marginal owing to the prohibitive cost and a lack of access to technologies. Proper pricing of carbon emitted by fossil fuels will be essential to level the playing field and make many marine renewable energy technologies more economically competitive with fossil fuels.

New technologies are making deep-sea mining of minerals more viable, such as phosphate, manganese nodules and crusts, hydrothermal sulphide deposits *(see photo page 7)*, and precious and specialty metals like rare earth elements. Through UNCLOS, a regime is in place to manage deep-sea mining in areas beyond national jurisdiction through the International Seabed Authority.

Genetic resources and biotechnology

Marine biotechnology and the protection of related intellectual property rights will be an important part of the future green economy. Alongside greater investment in scientific research and commercialization of pharmaceuticals, food and aquaculture, we can expect better protection of biodiversity both within national jurisdictions and beyond. There is some debate as to whether marine genetic resources are covered under the seabed mining provisions of UNCLOS. Vast ocean regions remain almost entirely unexplored and there is growing concern that we are losing many of the oceans' untold resources before we even fully understand them.

Nitrogen- and phosphorus-producing industries

Two of the most damaging pollutants are nitrogen and phosphorus, which deprive coastal areas of oxygen and favour harmful algal blooms. Nitrogen pollution is estimated to cost the European Union's economy £280 billion per year. The increasingly global nature of nitrogen underscores the urgency of implementing strategies which make the polluter pay for the cost of preventing or mitigating environmental degradation. Policy and regulatory instruments could include more strict regulation of nutrient removal from wastewater, mandatory nutrient management plans in agriculture and enhanced regulation of manure. Economic instruments could include taxes on fertilizer and/or agricultural and wastewater emissions, cap and trade frameworks on nutrient emissions and/or fertilizer production, as well as subsidies that encourage nutrient recycling.

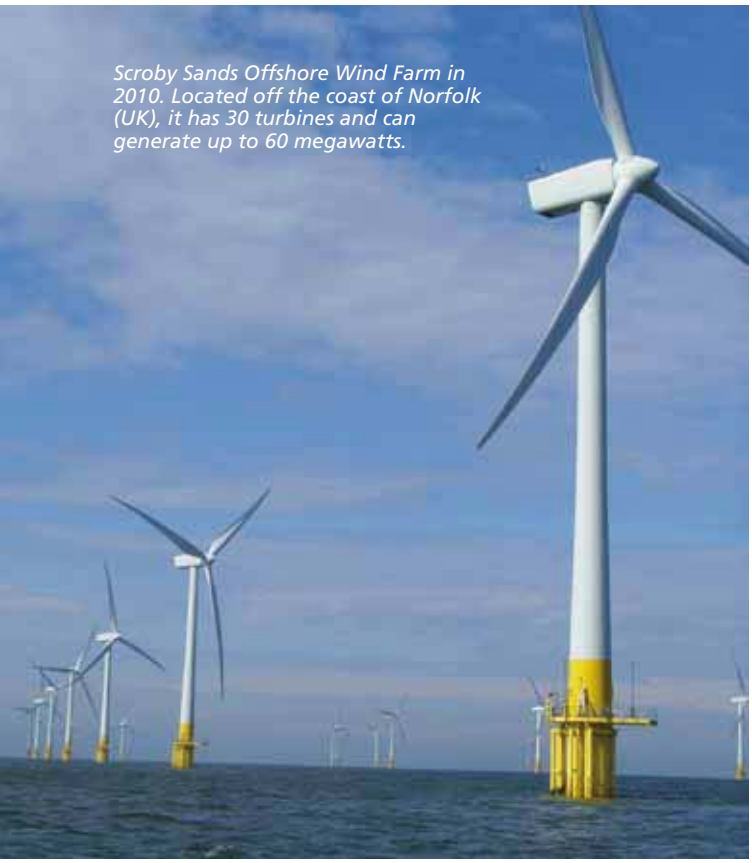
Read the *Blueprint:* www.unesco.org/new/ocean_blueprint

Swimmers and a Monk seal share a beach on Kauai Island in Hawaii (USA)

© Gerick Bergsma/Marine Photobank

With better planning, the future can be brighter

In 2009, the UNESCO-IOC published a step-by-step approach to ecosystem-based management of the oceans.[4] This guide to *Marine Spatial Planning* painted the following picture of what the situation might look like in another 20 years. 'Human activities in many areas of the ocean will have increased significantly. Traditional uses, such as marine transportation, sand and gravel mining and marine recreation will continue to grow in importance. Oil and gas development will continue to push further and deeper offshore with many of its operations occurring only underwater. Fisheries will continue to exist but at lower levels, due to the diminished stocks, and in more restricted areas because of competition for ocean space. New uses of the ocean, such as offshore renewable energy and offshore aquaculture, will compete with traditional uses for space. Climate change will have modified species distribution and habitats; increasing ocean acidification will raise new concerns about the survival of some species. Increasing public concern about the health of the ocean will lead to significant areas being set aside for nature conservation. Conflicts among human activities will increase, such as collisions of ships with wind turbines or between wave parks and surfers and sailors.'



Scroby Sands Offshore Wind Farm in 2010. Located off the coast of Norfolk (UK), it has 30 turbines and can generate up to 60 megawatts.

© Eleanor Partridge/Marine Photobank

The guide suggests that, with ecosystem-based marine spatial planning, the future could be brighter. Society could derive more benefits from the use of the marine environment than previously, while protecting its natural diversity better. Climate change would still be affecting the environment and the way in which people use the oceans, with offshore renewable projects and carbon capture and storage in the oceans no doubt being commonplace. However, the cumulative environmental effects of using the marine environment would be managed in a manner which took into account the increasing acidity and temperature of our oceans and seas, while preserving the integrity of marine ecosystems. Marine industries would have access to certain places but consumer pressure would incite them to ensure that their operations were ecologically sustainable and that the environmental and social cost of offshore renewable energy generation, seafood harvesting, mining and the like remained acceptable *(see box)*.

The way forward: marine protected areas

If, under an ecosystem-based approach, some places will remain accessible to marine industries for sustainable use, others will be reserved for conservation. The concept of representative networks of marine protected areas is not new. It is echoed both in the Convention on Biological Diversity (1992) and the *Johannesburg Plan of Implementation* adopted at the World Summit on Sustainable Development (2002). However, in the past decade, the concept of marine protected areas has evolved from a series of small isolated coastal areas mostly linked to small islands into a more complex ecological concept. Current thinking is that marine protected areas should be integrated into networks that extend into the open oceanic waters and/or the deep sea and that protection should encompass large areas located beyond national jurisdiction. In other words, rather than favouring a political organization (national territorial waters), the objective is to respect the ecosystem's biological organization and integrity.

The UN Convention on the Law of the Sea (UNCLOS) is the only binding instrument with jurisdiction over international waters. The Convention on Biological Diversity has

This vessel from Chinese Taipei was apprehended by Palau law enforcement personnel because shark-fishing is prohibited within Palau's 200-mile exclusive economic zone.

very limited jurisdiction over the high seas, as Article 4 of the Convention applies only to biological diversity in areas within the limits of national jurisdiction. This is one key reason why current protected areas tend to be limited to areas within national jurisdiction.

The advantage of UNCLOS is that it takes a regional approach, an appropriate scale for protecting the marine environment. Although UNCLOS does not mention biodiversity explicitly, it introduces the concept of the 'common heritage of mankind'. Although this concept applies to mineral resources on the high seas, it could possibly be extended to include marine biogenetic resources and, more generally, biodiversity. This could give stronger grounds for protecting biodiversity on the high seas than the Convention on Biological Diversity, which advises only on the sustainable use of marine resources.

In *The Future We Want*, the document adopted by the third Earth Summit (Rio+20) in June this year, governments 'commit to address, on an urgent basis, the issue of the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction, including by taking a decision on the development of an international instrument under the UN Convention on the Law of the Sea.'

According to national reports submitted to the Convention on Biological Diversity, almost all countries now have one or more marine protected areas. Many of them have established national networks. However, distribution remains uneven. According to recent estimates, most marine and coastal protected areas are on the continental shelf and in coastal waters, with 4.3% of shelf areas to a depth of 200 m being protected. About 65% of the total protected area lies in the tropics (between 30°N and 30°S), with most of the remainder being in the northern hemisphere. Least well protected are the Intermediate latitudes (30°N to 50°N) and the southern temperate and polar latitudes.

Currently, less than 2% of the oceans are covered by marine protected areas. While this figure falls short of the 10% target fixed by the Convention on Biological Diversity and reiterated in the Nagoya Biodiversity Compact (2010), it nevertheless demonstrates that countries have taken energetic steps to conserve the marine environment, either individually or collectively. It also demonstrates that deep-sea and open ocean areas beyond national jurisdiction remain some the most underprotected regions on Earth.

The national and voluntary reports submitted to the Convention on Biological Diversity in 2008 and 2009 reveal that a number of countries are planning or developing national networks, including Australia, Brazil, Canada, Colombia, Estonia, Portugal and Spain. In most cases, these networks set out to be both representative and comprehensive. Some projects

are already well advanced. For example, Spain reports a marine protected area of 251 139 ha and the Nationally Representative System of Marine Protected Areas in Australia now covers 900 000 km^2. On 14 June 2012, Australian Environment Minister Tony Burke announced plans to create the world's largest network of marine parks. The network will cover 3.1 million km^2 of ocean and include the Coral Sea, home to a World Heritage property, the Great Barrier Reef.

World Heritage sites currently occupy one-third of the surface area of existing marine protected areas. The UNESCO-IOC is working with World Heritage properties to promote the use of ecosystem-based approaches and marine spatial planning. It is also willing to collaborate with countries in preparing their site nominations for the World Heritage List.

Only a handful of protected areas on the high seas

Very few marine protected areas presently exist beyond national jurisdiction. One exception is the vast network of unique and ecologically sensitive areas protected in the wider Atlantic. In a bold move in September 2010, the ministers of 15 European countries[5] responsible for administering the OSPAR Convention (1992) decided to establish six marine protected areas covering a total area of 285 000 km^2. These areas encompass a series of seamounts and sections of the Mid-Atlantic Ridge which host a range of vulnerable deep-sea habitats and species. Four of the marine protected areas have been established in collaboration with Portugal. One such zone is the Charlie-Gibbs Marine Proected Area, stretching over 2000 km from the Azores to Iceland. It was cited as one of ten exemplary sites by the High Seas Gems Project (*see box overleaf*).

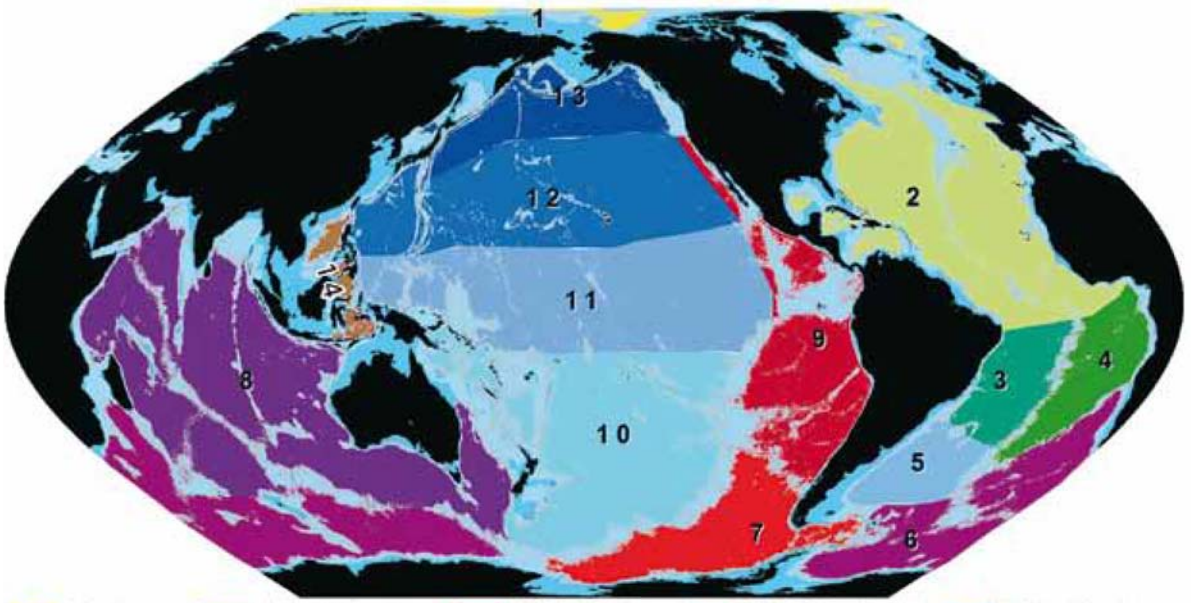
Regional fisheries management organizations have also taken measures to implement the resolution adopted by the UN General Assembly in 2006[6] to protect vulnerable marine ecosystems from bottom-fishing on the high seas.

Sites based on sound science

Site selection is an essential step in designating marine protected areas but it must be done on the basis of sound science. The UNESCO-IOC is working with various partners to develop a global inventory of ecologically or biologically significant marine areas in need of protection. This led in 2009 to the publication of the[7] *Global Open Ocean and Deep Seabed (GOODS) Biogeographic Classification (see map below).*

This global inventory will be dependent on scientific information. The UNESCO-IOC is part of a broad effort within the scientific community to assess and map the distribution and abundance of marine species. An essential tool in this endeavour is the Ocean Biogeographic Information System (OBIS), which emanated from the decade-long Census of Marine Life programme to 2010. OBIS now falls under the patronage of the UNESCO-IOC. The OBIS members are continually updating a comprehensive global database of all marine species. This powerful tool will continue to be openly accessible to the global community.[8] The UNESCO-IOC has incorporated OBIS into its own International Oceanographic Data and Information Exchange.

The Secretariat of the Convention on Biological Diversity also offers scientific guidance in selecting areas to establish a representative network of marine protected areas, including in the open ocean and deep sea. Areas must be ecologically



Source: UNESCO-IOC (2009) Global Open Ocean and Deep Seabed (GOODS) Biogeographic Classification

Classification of areas with a sea floor at a depth of 3500–6500 m (abyssal provinces)

and biologically significant, representative, viable and show connectivity and replicated ecological features. The next challenge will be to use these criteria and seven others identified by the Convention on Biological Diversity to justify protecting sites in marine areas beyond the limits of national jurisdiction. One attempt to do this is the High Seas Gems Project.

Two new reporting processes on the marine environment

In recent years, the UN General Assembly has established two processes for regular reporting on the state of the environment. The first concerns the oceans and the second biodiversity and ecosystem services.

The first World Ocean Assessment[9] is due to be completed by 2014. The secretariat for this process is provided by the UN Division for Ocean Affairs and the Law of the Sea within the Office of Legal Affairs. The Secretary-General has invited the UNESCO-IOC, UNEP, IMO and FAO to provide this process with technical and scientific support.

The second process will be led by the new Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), which only established its secretariat in Bonn last April. Sponsored jointly by UNEP, UNESCO, FAO and UNDP, IPBES will function in much the same way as the Intergovernmental Panel on Climate Change. Via regular reporting, it will strive to ensure that decisions are made on the basis of the best scientific information available on the conservation and sustainable use of biodiversity and ecosystem services. OBIS can contribute significantly to IPBES by quantifying biodiversity on regional and global scales.

The more than 90 governments which established IPBES this year have stressed the need for the new platform to establish synergies with other relevant scientific assessments, including that on the state of the marine environment.

Luis Valdés[10] and Wendy Watson-Wright[11]

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1 *Today, the Earth's atmosphere is composed of 78.07% nitrogen, 21.0% oxygen, 0.9% argon and just 0.03% carbon dioxide.*
2 *Rockström et al (2009) Planetary boundaries: exploring the safe operating space for humanity.* Ecology and Society *14(2): 32: www.stockholmresilience.org*
3 *www.plosbiology.org/article/info:doi/10.1371/journal.pbio.1001234*
4 *See: www.unesco-ioc-marinesp.be*
5 *Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and UK*
6 *See Resolution 51/105 on sustainable fisheries: www.un.org*
7 *See: http://unesdoc.unesco.org/images/0018/001824/182451e.pdf*
8 *See: www.iobis.org*
9 *See : www.un.org/Depts/los/global_reporting/global_reporting.htm*
10 *Head of Ocean Sciences at UNESCO: jl.valdes@unesco.org*
11 *Assistant Director-General and UNESCO-IOC Executive Secretary*

The High Seas Gems Project

Within this project, scientists around the world have selected ten priority sites on the high seas which fulfill the seven criteria adopted by the Secretariat of the Convention on Biological Diversity in 2009 to justify protecting biodiversity both in coastal areas and on the high seas. These seven criteria are:

- Uniqueness or rarity
- Special importance for life-history stages of species
- Importance for threatened, endangered or declining species and/or habitats
- Vulnerability, fragility, sensitivity or slow recovery
- Biological productivity
- Biological diversity
- Naturalness (areas that have suffered little, if any, human disturbance or degradation)

The High Seas Gems project added two other criteria to this list: feeding and breeding grounds of migratory species. On the basis of these nine criteria, it chose the following ten sites:

- Ross Sea in the Southern Ocean;
- Lord Howe Rise in the Southern Pacific Ocean;
- Emperor Seamount Chain in the Pacific Ocean;
- East Pacific Rise Hydrothermal vents;
- Saya de Malha Banks in the Indian Ocean;
- Sargasso Sea in the middle of the North Atlantic – the only sea without shores;
- the Southeast Shoal of the Grand Banks off Newfoundland in Canada;
- Charlie-Gibbs Fracture Zone in the Atlantic Ocean;
- Pelagos Sanctuary for Mediterranean Marine Mammals;
- Gakkel Ridge in the Arctic Ocean.

© NOAA

The Ross Sea consists of a deep bay in Antarctica with an island to the west and Ross Ice Shelf to the south. The nutrient-rich sea abounds in planktonic life which in turn feeds fish, seals, whales, penguins and other birds. A 10 m-long squid weighing 495 kg was captured in the Ross Sea in 2007.

These ten sites exemplify the wide range of habitats in the world's oceans and house an immense amount of biological diversity, much of which remains poorly described or even undiscovered. The project is a collaboration between the cosmetics company Chantecaille, IUCN, the World Commission on Protected Areas and the Marine Conservation Biology Institute.

For details: www.mcbi.org

Four additions to geopark network

The Global Geoparks Network now counts four new members, with the addition of sites in China, Hungary, Indonesia and Spain.

The new sites bring the total number of geoparks belonging to the network to 90 in 26 countries. They were admitted by the Global Geoparks Network Bureau between 19 and 21 September, during the 11th European Geoparks Conference in Arouca (Portugal).

The first new site is **Sanqingshan Global Geopark (China).** This mountain massif in southeast Jiangxi Province displays abundant geological outcrops and distinctive Sanqingshan-Type granite-dominated landforms. A World Heritage site since 2008, Sanqingshan displays a unique blend of granite geology, landscape and wildlife. People and nature have co-existed here harmoniously for 1 600 years, under the influence of the traditional Taoist culture. Sanqingshan is considered to be the cradle of Gan Opera and the Folk Barn Lantern Performance.

Bakony-Balaton Global Geopark (Hungary), in the northwestern part of the Carpathian Basin. It is rich in sharp cliffs and hot springs, volcanoes and basalt columns. Dinosaur fossils from the Jurassic and Cretaceous can be found here, as well as tropical tower karst. The site encompasses Lake Balaton, the largest in central Europe, home to endemic species of molluscan fauna which are unique among ancient lake sediments in the Earth's history. Gorges and karst plateaux reveal 700 caves, hundreds of sinkholes, a 9-km-long maze of thermal water under a town and more than 1 600 clear-water springs. This geological wonderland counts 5000 years of human occupation.

Batur Global Geopark (Indonesia) is centered around an active volcano in northeast Bali. The volcano lies in the middle of two large concentric volcanic craters (calderas) which formed about 22 000 years ago during cataclysmic eruptions which created a deep volcanic lake within the caldera's walls. The Batur volcano belongs to the Pacific 'Ring of Fire' and forms part of a long chain of similar active volcanoes in Indonesia. It is a typical cone-shaped stratovolcano, built up by alternating layers of pyroclastics and lava flows. The active cone of Batur volcano has erupted at least 22 times since the 1800s.

The **Central Catalonia Global Geopark (Spain)** coincides with the Geological and Mining Park of Central Catalonia. The best-known and most abundant fossils are of organisms which lived in the warm shallow seas covering the region 55 million years ago. The Catalan Potassic Basin is one of the largest potassium salt-mining areas in Europe. It shows some of the best examples globally of sedimentary deposits resulting from the evaporation of seawater (evaporite rocks). Mining of rock salt (halite) lasted here from the Neolithic to the time of the Roman Empire. Today, traditional kiln and tile workshops are major tourist attractions.

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© Patrick McKeever/UNESCO

Pleasure boats on the lake in the Batur caldera

20 biosphere reserves join global network

For the first time, biosphere reserves have been inscribed in Haiti, Kazakhstan and São Tome and Principe this year. These were among 20 additions to the World Network of Biosphere Reserves between 9 and 13 July, including two transboundary biosphere reserves.

The new sites were approved by the International Coordinating Council of UNESCO's Man and the Biosphere (MAB) Programme during its meeting in Paris. These additions bring the number of sites within the network to 620 in 117 countries, including transboundary sites.

Four existing biosphere reserves were also extended or rezoned:

- *Fray Jorge Biosphere Reserve* (Chile) incorporates a wider transition area and enlarges the buffer zone. The new extension surrounds the Bosque Fray Jorge National Park with a new zoning system to implement the MAB Programme's Statutory Framework.
- The *Iles et de la Mer d'Iroise Biosphere Reserve* (formerly Iroise) in France now includes a marine park and the island of Sein. With the extension, the site now covers 99 149 ha for a population of 1 324.
- The extension to *Doñana Biosphere Reserve* (Spain) triples the size of the reserve, a major wetland area. Beaches and chain dunes alternate with forests, centenary pine trees and complex lagoon systems. The enlarged transition area now counts 190 000 inhabitants in la Comarca municipality, with tourism swelling the population to 500 000 in the summer.
- In *Sierra Nevada Biosphere Reserve*, Spain is rezoning the transition area to include the inner mountain nucleus of the Cordillera Penibética mountain range which counts the Spanish Peninsula's highest peaks, including Mulhacen peak (3 482 masl.) The steep mountain slopes are a reflection of its past, modelled by glacial erosion.

The 20 new biosphere reserves

Salzburger Lungau and Kärntner Nockberge Austria	An inner-alpine landscape 600–3000 masl, spread over two provinces. The Kärntner Nockberge part is a national park covering 149 000 ha. A permanent human population of 33 350, of which 21 000 live in small towns. More than 50% of jobs are in the construction industry, public health sector and commercial goods industries (cosmetics, luxury food, wood, rubber, plastics).
West Polesie Transboundary Belarus/Poland/Ukraine	Characterized by boreal coniferous forests and temperate zone deciduous forest. A number of lakes, mires, meadows, swamp and lake complexes with rare and endangered species. The main economic activities are agriculture, tourism, weekend recreation, sustainable forestry and fishing.
Jinggangshan China	Sports a mid-subtropical humid monsoon climate and diverse landscapes of mountains, valleys, structural basins and karst features 381–1779 masl. The largest continuous area of primary broad leaf forest ecosystem in the whole sub-tropical zone, with 3 415 higher plant species (with mutant species). Local residents live off agriculture and forest industries: rice, potato, vegetables, bamboo tea-tree oil cultivation. Tourism is boosted by historical sites linked to China's revolution.
Niubeiliang China	Located in eastern segment of Qinling Mountains, with more than 94% covered in a typical temperate broad-leaved mixed mountain forest system shared by three administrative counties. An important region for water conservation. Many endangered species, including Golden Takin *(Budorcas taxicolor bedfordi)* and Dwarf Musk Deer *(Moschus berezovskii)*. Transition area sports rural tourism, agriculture, animal husbandry, forest products. Active cooperation with colleges and institutes for research, monitoring, public awareness and training programmes.
Mura-Drava-Danube Croatia/Hungary	A transboundary reserve that includes Central Europe's largest floodplain system. The areas along the Danube and Drava Rivers form a continuous stretch of habitats extending across the state border. The Mura–Drava River contains some of the most threatened wet habitats in Europe: alluvial forests, wet grasslands, gravel and sand bars, oxbow lakes, abandoned riverbeds. Major activities include agriculture, forest management, sand and gravel extraction, industry and ecotourism, with potential income from floodplain management.
Sheka Ethiopia	Forests, bamboo thickets, wetlands, agricultural lands, rural settlements and towns cover 238 750 ha. More than 38 threatened species of flora and fauna. The forest in Sheka, part of the Southwest Highlands Forests of Ethiopia, is important for the conservation of the Afromontane Rainforest and Alpine Bamboo thickets especially. Ecologically sustainable agriculture is well-established.
Bassin de la Dordogne France	Encompasses the Dordogne watershed of 24 000 km^2, with one of Europe's biggest estuaries. The Dordogne's catchment area shelters great biodiversity and represents a range of mountainous landscapes. Population density is low and there are no large cities. Tourism based on natural and cultural heritage cohabits with agriculture and forest exploitation. One of France's three biggest centres for hydroelectric power production, which puts considerable pressure on the aquatic ecosystems.
La Selle Haiti	Includes mountain, plain, tropical dry forest and coastal ecosystems, as well as protected areas like La Visite or Forêt-des-pins, with the endemic species *Pinus occidentalis*. Located in the ecological continuum of the Jaragua–Bahoruco–Enriquillo Biosphere Reserve of the Dominican Republic; contributes to Caribbean Biological Corridor. Home to 4% of Haitians, who practice agroforestry, fisheries, tourism and handicrafts.
Achanakmar-Amarkantak India	Topography ranges from high mountains to shallow valleys and plains, with 63% of the area covered in moist deciduous forests. The core area consists of protected forest land. Some 27 tribal and non-tribal communities in 418 villages live off agriculture (including production of medicinal plants) and non-timber products produced in the buffer zone and transition areas. Ecological studies on the restoration of degraded forest land, the conservation of medicinal plants and their sustainable harvesting are being conducted at Achanakmar-Amarkantak.
Wakatobi Indonesia	Includes the four main islands of Wangi-Wangi, Kaledupa, Tomia and Binongko, with about 590 fish species and 396 reef species. Diverse ecosystems with many marine and coastal species of seagrass, coral reefs, fish used both for consumption and for sale, sea birds, turtles, cetaceans and mangroves. Wakatobi wishes to become a learning laboratory for researchers and other stakeholders.
Aya Japan	In eastern part of Japan's southern Kyushu Island, harbours one of the country's largest remaining lucidophyllous forests. The total area of 14 580 ha includes Aya Town in the transition zone with a population of 7 283. The core area is made up of the Kyushu Central Mountains Quasi National Park, which has never been used for human activities and is the object of scientific studies on the structure, function and dynamics of the lucidophyllous forest. The transition zone is used mainly for organic agriculture. Ecotourism includes 'forest therapy' and forest environmental education.
Korgalzhyn Kazakhstan	Freshwater and saline lakes embedded in the dry steppe zone of Eurasia make it a key wetland site for migratory water birds, including the rare Siberian white crane, Dalmatian pelican and Pallas' fish eagle. Korgalzhyn State Nature Reserve is also a cluster of the World Heritage site of Saryarka – Steppes and Lakes of Northern Kazakhstan. The area covers 1 603 171 ha and is home to 12 500 people. Pilot projects are addressing human emigration caused by unsustainable use of water, biodiversity and tourism: sustainable pasture management, ecotourism, the creation of fishing and hunting farms and of alternative power sources.

Tehuacán–Cuicatlán Mexico	Located on an arid mountain and highlands system, with one of Mexico's highest rates of biodiversity and endemic species. The most emblematic of the old landscapes of Mesoamerica, host to eight different ethnic groups. Includes the original domestication sites for maize, pumpkin, avocado and beans. Sports a densely wooded expanse of arborescent cactus species (bosque de cactáceas columnares) and tropical dry forest *(Selva baja caducifolia)*.
Bashkirskiyi Ural Russian Federation	Covers 345 700 ha in the southern Ural. Landscapes range from mountain river gorges to mountain steppes, meadows, floodplains and reservoirs. More than 1 650 plant species (44 endemic) and 2 000 animal species. Five different protected areas, including national parks and forestry districts. Unique archaeological sites linked to the Bashkir people, as well as the cult cave of Shulgan Tash, preserved since the Stone Age. The population of 14 957 practices forestry and small-scale farming, traditional bee-keeping and, increasingly, tourism: 180 000 visitors from May to September.
The Island of Príncipe São Tome and Principe	Comprises entire emerged area of the oldest of three oceanic volcanic islands in the Gulf of Guinea, plus its islets and the Tinhosas islands. Important for the reproduction of sea turtles, seabirds and cetaceans. Agriculture, fishing and tourism. Could serve as a model for promoting integrated ecotourism development on similar islands and as the basis for a larger marine and terrestrial buffer zone.
Ferlo Senegal	A biodiverse area of 1 150 000 ha, despite threats to the ecosystem caused by drought and human activities. Home to emblematic species like the redneck ostrich, red-fronted gazelle and endangered African blackwood *(Dalbergia melanoxylon)*. Traditional pastoralism and agriculture. Ecotourism, aquaculture or sustainable forestry will be promoted to diversify sources of income. Ferlo hosts several research institutions.
La Gomera Spain	An island of the Canary archipelago with the Garajonay National Park at its centre. Alto de Garajonay rises to 1 487 masl. However the central plateau (1 000 masl) and the formation of radial and deep ravines is the result of intense erosion. The humidity and cloud from the sea is often stopped on this plateau. The park is also a World Heritage site and is noted for its laurisilva rainforest ecosystem. A landscape modelled by agricultural terraces.
Las Ubiñas–La Mesa Spain	Located in the central zone of the Cantabrian Range, encompasses an old-growth forest which maintains pristine conditions and high biodiversity. The area has protected species: Cantabrian brown bears, woodpeckers and endemic species. Las Ubiñas–La Mesa Park includes human settlement sites dating back to the Neolithic period. Surrounded by other biosphere reserves, such as Babia, Los Valles de Omaña y Luna, Alto Bernesga and Somiedo.
East Vättern Scarp landscape Sweden	Sweden's second-largest cold-water lake and the fifth-largest lake in Europe: 105 520 ha. Almost 40 000 inhabitants; agriculture and forestry predominate. Several large farms and manors, as well as three urban areas. The core areas consist of existing nature reserves, protected forest habitat and shorelines. Climate change mitigation and adaptation are a key objective.
Galloway and Southern Ayrshire United Kingdom	Result of the merger of two biosphere reserves, covers 520 000 ha: open field landscapes, lochs, moorlands, arable lands, pastures and afforested areas. Low human density with fewer than 100 000 inhabitants, who have suffered from the closing of local mining and textile industries. Large populations of grouse, golden eagles and mountain hares. The core area is composed of various protected areas under the management and ownership of the Scottish National Heritage. Tourism is growing, with more than 850 000 visitors a year.

Ferlo Biosphere Reserve in Senegal

Romania to host Chair

A UNESCO Chair on Science and Innovation Policies has been established at the National School of Political Studies and Public Administration in Bucharest (Romania).

The agreement was signed on 9 July at UNESCO headquarters in Paris by UNESCO Director-General Irina Bokova and Remus Pricopie, Rector of the National School.

The new UNESCO Chair will serve as a think tank and 'bridge-builder' between researchers, trainers, entrepreneurs and policy-makers. The Chairholder is Professor Adrian Curaj, Director-General of the Executive Agency for Higher Education, Research, Development and Innovation Funding, which will be implementing the programme jointly with the National School.

Professor Curaj will be responsible for designing postgraduate programmes and short-term courses in futures studies and technology foresight, science governance and management of innovation. In parallel, he will train students, policy-makers and managers while conducting research in these same fields.

The Chair will also be expected to produce strategic foresight studies relevant to South-East Europe, the Black and Caspian Seas and Danube region for wide dissemination. In order to develop proficiency in this field at both the national and inter-regional levels, Professor Curaj plans to organize a series of regional foresight exercises.

The Chair will also be responsible for organizing workshops, conferences and summer schools in relevant fields.

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26 new World Heritage sites

It was only fitting that the World Heritage Committee should inscribe a Russian site on UNESCO's World Heritage List this year, given that it was meeting in Saint Petersburg. Lena Pillars Nature Park (*pictured*) was the last of 26 sites to be inscribed, on 2 July. For Chad, Congo, Palau and Palestine, this was the first time one of their sites had joined the List.

Four other natural World Heritage sites were inscribed by the Committee: Lakes of Ounianga (Chad); Sangha Trinational (Cameroon, Central African Republic, Congo); Chengjiang Fossil Site (China) and; Western Ghats (India). Rock Islands Southern Lagoon (Palau) was inscribed as a mixed natural and cultural site.

In all, 20 cultural sites were inscribed this year: Pearling, Testimony of an Island Economy (Bahrain); Major Mining Sites of Wallonia (Belgium); Rio de Janeiro, Carioca Landscapes between the Mountain and the Sea (Brazil); The Landscape of Grand-Pré (Canada); Site of Xanadu (China); Historic Town Grand-Bassam (Côte d'Ivoire); Nord-Pas de Calais Mining Basin (France); Margravial Opera House Bayreuth (Germany); Cultural Landscape of Bali Province: the *Subak* System as a Manifestation of the *Tri Hita Karana* Philosophy (Indonesia); Masjed-e J mé of Isfahan; Gonbad-e Q bus (both Islamic Republic of Iran); Sites of Human Evolution at Mount Carmel: The Nahal Me'arot/Wadi el-Mughara Caves (Israel); Archaelogical Heritage of the Lenggong Valley (Malaysia); Rabat, Modern Capital and Historic City: a Shared Heritage (Morocco); Birthplace of Jesus: Church of the Nativity and the Pilgrimage Route, Bethlehem (Palestine); Garrison Border Town of Elvas and its Fortifications (Portugal); Bassari Country: Bassari, Fula and Bedik Cultural Landscapes (Senegal); Heritage of Mercury Almadén and Idrija (Slovenia/Spain); Decorated Farmhouses of Hälsingland (Sweden); Neolithic Site of Çatalhöyük (Turkey).

Five World Heritage properties were also inscribed on the List of World Heritage in Danger: Liverpool Maritime Mercantile City (UK); Fortifications on the Caribbean Side of Panama: Portobelo-San Lorenzo (Panama); The Birthplace of Jesus: Church of the Nativity and the Pilgrimage Route in Bethlehem (Palestine); the town of Timbuktu and the Tomb of Askia in Gao (Mali).

On 25 July, the World Heritage Committee established a Special Fund to support Mali's efforts to safeguard Timbuku and the Tomb of Askia. These properties have been subjected to destructive attacks since they were occupied by armed rebel groups in April this year. In Timbuktu, nine mausoleums had been desecrated as of July, including two at the Mosque of Djingareyber, the most important mosque in Timbuktu. The fund will help the government to assess damage to the sites and carry out reconstruction and rehabilitation projects once the security situation allows.

On 30 September, UNESCO Director-General Irina Bokova deplored the destruction by fire of hundreds of shops in Aleppo's souk (markets) the previous day, during fierce fighting for control of the Syrian city. The Ancient City of Aleppo has been a World Heritage site since 1986, in recognition of its 'rare and authentic Arab architectural styles.' It is one of six such sites in Syria. Ms Bokova reminded all parties of the country's obligations under the 1954 Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict, to which Syria is a signatory. 'As soon as security permits, I will send a team there to assess the situation and provide emergency assistance for the protection of this heritage,' she said.

For details: http://whc.unesco.org; Special Fund for Mali: www.unesco.org/new/en/special-account4mali

In the new Lena Pillars World Heritage site in Russia, temperatures range from -60°C in winter to +40°C in summer. The resulting freeze–thaw action of water has widened the gullies between the rock pillars.

China inaugurates STI policy centre

The International Research and Training Centre for Science and Technology Strategy (CISTRAT) was inaugurated in Beijing (China) on 24 September. The centre will operate under the auspices of UNESCO.

The ceremony was attended by Wan Gang, Chinese Minister of Science and Technology, and UNESCO Assistant Director-General for Natural Sciences Gretchen Kalonji, as well as by 16 trainees who were in Beijing to participate in the centre's first international seminar on 9–28 September. The trainees hailed from Botswana, Colombia, Democratic People's Republic of Korea, Egypt, Lebanon, Panama, Republic of Korea, Sri Lanka, Tanzania, Thailand and Vietnam.

China credits its growing capacity in science, technology and innovation (STI) for much of its meteoric economic rise in recent years. Now, it wishes to share its experience with developing countries through South–South cooperation. Trainees attending the September seminar were familiarized with the methods used by China to compile its own recent STI policies, including the national consultation on strategic areas for research.

In 2006, China set itself the target of becoming an innovation-driven country by 2020. 'Capacity-building for national innovation has become the core of the country's national strategies, marking an important shift in policy,' explained the *UNESCO Science Report 2010*.

One of the main thrusts of China's policies for fostering innovation is to augment investment in research and development (R&D) to 2.5% of GDP by 2020. By 2009, China was devoting 1.7% of GDP to R&D, compared to 1.4% three years earlier. Via tax deductions, the government has assumed a 12.5% share of enterprise expenditure on R&D, among other incentive measures.

Other policies provide a framework for government procurement of the product of endogenous innovation, such as for major construction projects; the assimilation of imported advanced technology; capacity-building in generating and protecting intellectual property rights; an ambitious infrastructure-building programme and; a recruitment programme of foreign experts.

The first Director of CISTRAT is Professor Wang Yuan, Executive Vice-President of the Chinese Academy of Science and Technology for Development. He was appointed by CISTRAT's Governing Board on 24 September.

The new centre will design and conduct international cooperative research programmes, offer professional training programmes, provide technical assistance, develop effective policy tools and foster networking and cooperation among governments, academia and industry.

The focus for cooperative research and training will be on: S&T indicators and statistical analysis; STI strategy and planning methodology; the methodology and application of technology foresight and road-mapping; poverty alleviation using STI; S&T input and financing policies for innovation; science parks and industrial clusters; promoting innovation and the development of small and medium-sized enterprises; training of S&T personnel; developing a response and management system for S&T risks and natural disasters; strategies for addressing climate change and; STI for sustainable development.

It was in September 2009 that China first proposed creating the international centre under the auspices of UNESCO. A feasibility study undertaken by UNESCO in April 2010 proved conclusive, leading to the centre's approval by UNESCO's General Conference in November 2011.

For details: www.cistrat-unesco.org

Okapi appeal raises nearly US$40,000

An emergency appeal launched after poachers armed with AK47 rifles attacked the headquarters of the Okapi Wildlife Reserve on 24 June has raised £24,179 (US$38,269).

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Fifteen okapi were killed in the June attack.

During the attack on the village of Epulu in northeast Democratic Republic of Congo, seven park staff and their family members were killed; others were taken hostage or remain unaccounted for.

Led by the notorious elephant poacher known as Morgan, the attackers torched buildings and destroyed equipment in their search for elephant tusks. The reserve's entire infrastructure was destroyed and the 15 okapi at the Epulu Breeding and Research Station were all killed. The breeding programme has played a critical role in preserving the gene pool of this rare forest giraffe by serving as a genetic reservoir for global conservation programmes.

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The attackers set fire to buildings in Okapi Wildlife Reserve on 24 June.

The appeal was conducted as part of the Rapid Response Facility set up jointly by UNESCO and the NGO Fauna and Flora International to raise funds for this type of emergency. All the proceeds of this latest appeal have been handed over to the NGO Wildlife Conservation Society.

The funds raised should cover about 30% of needs. Buildings will be reconstructed and equipment repaired or replaced. The funds will also help to revive the reserve's successful okapi breeding programme. Re-establishing a functional Epulu ranger station will

also benefit the area's elephants, whose population has been declining rapidly because of ivory poaching. Perhaps most importantly, the families of those who were killed will receive financial support.

Okapi Wildlife Reserve has been on the List of World Heritage in Danger since 1997.

For details: g.debonnet@unesco.org; l.maziz@unesco.org; www.rapid-response.org

Coastal erosion from sea-level rise underestimated

The effect of sea-level rise on coastline erosion in the vicinity of inlets such as river mouths, estuaries and lagoons has been dramatically underestimated up until now, according to researchers from the UNESCO-IHE Institute for Water Education, Delft University of Technology and Deltares Institute. A team led by UNESCO-IHE scientist Rosh Ranasinghe has developed a model which produces a more accurate projection.

The anticipated rise in sea levels owing to climate change will result in coastlines receding worldwide through erosion. This is a known phenomenon that can, in principle, be calculated and predicted on the basis of given sea-level rise, by means of the so-called Bruun effect.

However, things get a little more complicated when it comes to coastlines in the vicinity of inlets. This is because inlets are affected by other factors, such as changes in rainfall due to climate change and certain compensating effects like basin infilling.

With the new model, it becomes possible to make accurate predictions within minutes of how the coastline will evolve in the vicinity of inlets.

The new model has been applied to four representative coastal areas in Vietnam and Australia. According to projections, Vietnam will see a rise in rainfall to 2100, whereas rainfall will drop in Western Australia. The study revealed that only 25−50% of anticipated coastline change in these areas could be predicted using the Bruun effect (*see image*).

Model prediction of coastline change by 2100 at Tu Hien inlet in Vietnam, where rainfall is projected to rise. Purple line: Bruun effect alone; yellow line: Bruun effect plus basin infilling; red line: Bruun effect, basin infilling plus the effects of rainfall and runoff combined.

Any future coastal management projects launched by the UNESCO-IHE will be able to use this new model.

The scientists published their research in *Nature Climate Change* on 2 September.

For details: r.ranasinghe@unesco-ihe.org; www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate1664.html

Prehistoric dentists could fill a cracked tooth

Therapeutic dentistry may have been around much longer than we thought. An international research team led by scientists from UNESCO's Abdus Salam International Centre for Theoretical Physics (ICTP) and Sincrotrone Trieste ELETTRA has reached this conclusion after studying a cracked tooth from Slovenia that is nearly 7 000 years old.

The tooth is from a jawbone that was found in a cave near the village of Lonche. The researchers have determined that the jawbone belonged to a man aged between 24 and 30 years who lived 6 500 years ago.

The researchers determined the age and composition of a resinous filling detected inside the tooth, using a combination of modern physics tools that include three-dimensional, high-resolution x-ray and radiocarbon dating with accelerator mass spectrometry, as well as infrared spectroscopy. The analysis showed that the tooth was filled with beeswax. This would likely have alleviated the pain of chewing on a cracked tooth, providing the earliest-known direct evidence of a therapeutic dental filling.

'Bee products were used by prehistoric communities for technological, artistic and medical purposes but it is thanks to the finding in Lonche that we can now imagine men doing dentistry in Neolithic Europe,' said the study's lead author, Federico Bernardini, a postdoctoral fellow at ICTP's Multidisciplinary Laboratory.

'Evidence of the earliest-known practice of dentistry was discovered some years ago in a 9 000-year-old graveyard in Pakistan but until now there was no evidence of tooth-filling,' added Claudio Tuniz, co-author of the study and a coordinator of the ICTP/ELETTRA x-ray imaging laboratory.

ICTP and Sincrotrone Trieste used funding from a € 600,000 grant provided by the local government of Regione Friuli Venezia Giulia to develop a new portfolio of instruments and methodologies to study objects from the past. The two institutes have developed compact, portable x-ray devices capable of analysing the structure and chemical composition of ancient bones, buildings and art objects in a non-destructive fashion. These devices are the first of their type in Italy devoted to anthropological research.

For details: mwilliams@ictp.it; on the research: www.plosone.org

Hayat Sindi

‘Science is a universal language’

This year, *FastCompany* magazine in the USA designated Diagnostics for All one of the world’s ten most innovative biotech companies. This non-profit company was recompensed for developing a series of low-cost diagnostic tests for use in the health and agriculture sectors in developing countries. Diagnostics for All shipped its first tests to India last year and is currently running a field trial in Vietnam. Dr Hayat Sindi, a Visiting Scholar at Harvard University, co-founded Diagnostics for All and sits on the Board. On 1 October, she became a UNESCO Goodwill Ambassador for science education.

In her teens, Dr Sindi left Saudi Arabia for the UK, where she battled the odds to become the first woman from the Gulf to earn a PhD in biotechnology. She has studied at some of the world’s most prestigious institutions: King’s College London and Cambridge University in the UK and the Massachusetts Institute of Technology (MIT) and Harvard University in the USA. Throughout her career, she has been driven by the desire to link science to social progress. Today a respected scientist, philanthropist and entrepreneur, her dream is for success stories like hers to become a lot less exceptional.

How did Diagnostics for All get off the ground?

In 2007, I co-invented a piece of paper the size of a postage stamp with the capacities of a diagnostic lab, together with colleagues from the laboratories of Professor George Whitesides at Harvard University. The paper-based screening kit requires little training to use and no electricity or additional equipment, making it ideal for lesser developed countries where electricity is often lacking and sanitary conditions are poor. Thanks to microchemistry, the results obtained from testing a drop of blood reveal themselves within minutes. The paper is also environmentally friendly, as you can simply light a match to dispose of it.

In 2007, I enrolled in a two-year business course at Harvard University, the first such course where half of students were scientists or medical doctors and the other studying for a Master of Business Administration degree. There, I put together a team with a variety of skills to develop a business model for the paper invention.

In 2008, I entered two competitions, one organized by MIT, the 100K competition, and the other organized by Harvard University, the social enterprise competition. I knew that I would stand a much greater chance of attracting funding for my invention if I won both competitions, which I did.

It was the first time in 12 years that a Harvard invention had won the Harvard competition and the first time in 19 years that a non-profit enterprise had won at MIT; the previous winners had all been commercial companies. When people asked why I did not wish to found my own commercial enterprise, I explained that a commercial undertaking would take 15 years to spread a technology that a non-profit company could do in a much shorter time.

We then successfully applied through Harvard to the Bill and Melinda Gates Foundation for a US$10 million grant to commercialize my invention over the next five years.

Why focus on a diagnostic kit for liver function?

I interviewed numerous doctors to ascertain where a cheap diagnostic kit would be needed most. I learned that 3–4 million patients die every year in the developing world from the side-effects of the potent drugs used to treat HIV and tuberculosis, as these drugs can be toxic for the liver. In the USA, just 80 patients die every year. Why the big difference? Because patients in the USA can be monitored via a simple blood test every week or two, unlike patients in the developing world where screening is too costly and instrumentation is lacking. My patterned, paper-based liver enzyme diagnostic test can assess liver health in about 15 minutes from a single drop of blood taken from a pricked finger. There is no need for a needle, so no risk of contamination.

We are currently working on other applications that could benefit the developing world.

In 2011, the Bill and Melinda Gates Foundation granted Diagnostics for All US$3 million to develop three tests for agriculture. How will these work?

The first diagnostic test will screen for milk spoilage by detecting the presence of bacteria. Most tests currently measure the acidity of milk. In Africa, many small farmers contribute their herd’s milk to dairy cooperatives. Inaccurate testing means a single farmer’s spoiled contribution can contaminate an entire pool. The paper low-cost tests, which can be administered by

farmers themselves, can also help pinpoint which farmer's milk has gone bad, potentially helping identify cows with bacterial infections.

A second test will screen for the presence of aflatoxin, a poisonous substance produced by mould in maize. This mould can develop during growing, harvest or storage of the maize. Besides lowering the market value of the maize, it can lead to hepatitis or potentially liver cancer in consumers. Children are particularly vulnerable to aflatoxin and can become stunted and more susceptible to infectious diseases after exposure. Current tests for aflatoxin cost about US$6, a prohibitive price for many farmers. The paper test would cost less than 50 US cents.

A third test will determine when cows are pregnant or in heat by measuring hormone levels. Currently, farmers either rely on watching their cows for behavioural changes or perform a potentially dangerous physical examination.

Why are you now turning your attention to helping young Arab inventors?

Saudia Arabia spends US$40 billion a year on education and training, yet 43% of 20–24 year olds are unemployed. In the wider Arab population, four in ten people are 18 years old or younger and 70% plan to go abroad in the pursuit of studies and jobs.

There has to be a brighter outlook for budding young inventors in the Gulf. There is no reason why science cannot flourish in the Arab world. Science is a universal language and it is not as if we don't have our share of problems that science could help to solve.

Through the new NGO I have just founded, i2, I intend to help young Arab men and women realize their potential by creating a network of world-class mentors from the scientific and business worlds to accompany these young inventors at the incubation stage of their project. I should stress that i2 is not a business incubator, though. Rather, it helps young inventors package their idea and attract funding through several interlinked programmes.

How do young inventors apply for these programmes?

Our first call for applications will take place in November. We shall be inviting Master's and PhD students to apply to i2 for a grant in one of four areas: water, energy, health and environment. We shall select 50 candidates who already have a local and international patent for their idea. These 50 candidates will then pitch their idea next February to an international jury made up of scientists and business leaders. Ultimately, just 12 fellows will be selected to share a grant of US$3–4 million; each will be assigned a mentor to help him or her develop a business plan.

These 12 fellows will then participate in three other programmes run by i2. The first is the entrepreneur programme, run jointly with Harvard and MIT professors. The second is the social science programme. Here, they will meet other fellows who have specialized in social innovation, such in as the provision of clean energy or water. All 12 fellows will be asked to come up with a solution to a specific social problem. The aim of this exercise is to give them confidence in their ability to take on new challenges.

The third programme is designed to develop the i2 fellows' communication skills. They will learn how to sell their project to different audiences and how to speak in public. At this third and final stage, potential investors familiar with the market will be invited to a conference to hear the fellows present their respective projects.

How important is self-confidence in an inventor?

Extremely important. That is why the mentor plays such a key role. Even the most talented inventor needs encouragement. An inventor can be blessed with imagination and ingenuity but if he or she lacks self-confidence, they will give up at the first obstacle.

When I entered that competition at Harvard, the first question the examiner asked me was how many of my companies had failed! For him, if you hadn't failed at least once, there had to be something wrong with you. Unlike in the Middle East, there is no stigma attached to a failed business in the USA. An entrepreneur who has declared bankruptcy is expected to pick themselves up and start again, until they get it right.

What I intend to do is to give young Arab inventors the self-confidence not to fear failure. I want them to consider failure as an opportunity to learn from their mistakes and do better next time, rather than as the end of all their dreams.

What will be your first steps as UNESCO Goodwill Ambassador?

If I am to be a role model for young people, I need to be able to sit down and talk to them. As UNESCO Goodwill Ambassador, I hope to be invited to visit many schools and universities. I already know that I enjoy this kind of exchange, so much so in fact that I have even asked schools to invite me on occasion! I tend to begin the session by asking children to draw a scientist. In 99% of cases, they will draw an ageing man with spectacles or a bald head! They are quite astonished when I tell them that I am a scientist.

My main message for girls in particular is that science needs them. They simply have to follow their dream, their passion. I like to tell the story of how the man who invented the airbag only thought to install it on the driver's side, as he was always the one who drove the family car. Had the inventor been a woman, I say, she would have immediately thought to place an airbag on both sides at the front and in the back because women tend to think of their family's needs rather than solely their own.

I encourage girls and young women to aim for decision-making positions, be it in a company, a university or government, for it is only once it has become the norm for women to occupy positions of power that decision-making will pay greater heed to women's needs. I tell girls that this day will come, even if there is sometimes a strong macho tradition to overcome. After all, it has only been a few years since the first woman was appointed rector of Cambridge University, 800 years after the university was founded!

Interview by Susan Schneegans

For details: www.dfa.org; www.i2institute.org

Bridging the digital divide

CERN's Jean-Yves Le Meur, second from the right, teaching participants in Rwanda in 2009 how to install the digital library system on their computers

Although digital libraries are spreading rapidly across the globe, many librarians and information technology (IT) engineers in Africa have not followed relevant training. This poses a real challenge. To help remedy the situation and encourage the development of digital libraries, the European Organization for Nuclear Research (CERN) and UNESCO have organized a series of training workshops over the past three years in Rwanda, Morocco and Senegal. These have been attended by librarians from more than 15 African countries. After each five-day school, 'champions' are selected for a one-month intensive course at CERN in Switzerland to broaden their knowledge.

The first CERN–UNESCO digital library school took place in 2009 in Rwanda. 'Many African countries are in the process of digitizing their libraries,' explains John Ellis, CERN's former coordinator for non-Member States. 'A workshop was organized in September 2009 by CERN in Rwanda to help familiarize librarians there with the library software we have at CERN, with the idea of deploying it and cloning it in these countries.'

UNESCO's Natural Sciences Sector and CERN's Scientific Information Service and Information Technology Department were able to provide librarians with face-to-face training in digital library software developed at CERN that is known as the Invenio platform.

A new repository for African theses

Jens Vigen, head of CERN's Scientific Information Service, was one of the organizers. 'African librarians are fully aware of the strengths of digital libraries and the importance of open-access publishing,' he says, 'but training and information exchange is needed. The particle physics community is driving many of the developments in this field, so colleagues in university libraries are very keen to take advantage of our experience. The Invenio platform is open source, which corresponds with UNESCO's and CERN's goals of knowledge and technology transfer.' Rwanda was chosen for its strong IT profile.

Around 30 librarians and IT specialists participated in the five-day programme, which was divided into two main topics: the principles of open access, discussed by Vigen, and the more technical part, taught by Jean-Yves Le Meur from CERN's IT Department. Everyone learned how to install and parameterize the system. 'Our African colleagues have large collections of theses across all subjects,' says Vigen. 'These are currently held in digital form on compact disks. By adding these theses to their new repository, our African colleagues will be making this research visible worldwide.' He adds that 'they are also interested in including material from CERN, such as the Academic Training Lectures and the Yellow Reports[12].' The goal is to create a self-sustaining programme that can be handled at the local level.

Bridging the culture gap between IT engineer and librarian

The second digital software workshop took place at the National Centre for Scientific and Technical Research in Rabat (Morocco) in November 2010. It drew 30 librarians and IT engineers from Benin, Cameroon, Senegal, Tunisia and the host country. Annette Holtkamp, who is both a physicist and a librarian at CERN, was one of the instructors. 'It has become clear that what is obvious to an engineer is not obvious to a librarian and vice versa,' she observed. The workshops offer a unique opportunity for IT engineers and librarians to work together.

In Africa, it often happens that documents are inaccessible or cannot be found due to a lack of appropriate infrastructures. 'These workshops are an opportunity for the participants to analyse and compare their situation and to acquire knowledge that can help to offset these shortcomings,' explains Jérôme Caffaro, an IT engineer at CERN and another of the workshop's organizers. As in Rwanda, practical exercises in Morocco enabled the participants to come to grips with installing and maintaining library management software and the various processes for which it can be used.

'Invenio is able to manage large quantities of documents and the number of documents to be handled can only increase in Africa, as in the rest of the world,' observes Peter Amoako-Yirenkyi, a former student who is currently professor of mathematics at Kwame Nkrumah University of Science and Technology in Ghana. Peter was on hand at the Morocco workshop to set up the software in conjunction with the team of specialists.

A portal grouping African university dissertations

The third workshop took place at the Université Cheikh Anta Diop in Dakar (Senegal) in November 2011. It attracted librarians and IT engineers from Burkina Faso, Côte d'Ivoire, Mali, Morocco and the host country.

© CERN

Ludmila Marian from CERN assisting participants during a hands-on computer session in Dakar last year.

'We plan to use Invenio to build a portal for all African university dissertations to make them accessible to the global academic community,' explains Essaid Ait Allal, network and system administrator at the Moroccan Institute for Scientific and Technical Information. 'We need a system which can harvest data from various existing platforms then convert the bibliographic records and make them available at one central point.'

Guillaume Rewende Nikiema nods. He can identify with the need outlined by Essaid, working as he does for the African and Madagascan Council for Higher Education located in Burkina Faso, which also means bringing together library information from many different sources and platforms.

'Our interest is rather different,' says Fama Diagne Sene Ndiaye, chief librarian at the University of Bambey in Senegal. 'All the original documents from the French colonial administration of what are now eight independent African states, dating from 1895 to 1958, are in Senegal. Unfortunately, the papers are slowly deteriorating due to heat, moisture and simply the passing of time. So by learning more about Invenio, we are building up the expertise to digitize these unique historical records to preserve them and make them available to researchers not just in Africa but worldwide.'[13]

Tailor-made training

After each one-week school, some of the participants are invited to CERN in Switzerland to learn more about the Invenio platform. 'It is crucial to have these follow-up sessions, which are partly financed by UNESCO', underlines Vigen. 'This way, we can enable in-depth training for selected participants in so-called "multiplier" positions. These are decision-makers and specialists in key institutions who can "multiply" and pass on the knowledge gained at CERN as part of their day-to-day work.'

The participants themselves appreciate the unique quality of this training at CERN. 'The advantage of being here is that we are sitting in offices right next to the people who develop the system and work with it every day,' explains Abdrahamane Anne from the University of Bamako in Mali. Whenever we hit a problem, Jens puts us in touch with the right person or arranges a workshop,' smiles Abdrahamane. 'That way, the training is truly tailor-made to our needs.'

'It is also an opportunity to share,' adds Eric Guedegbe from the United Nations African Institute for Economic Development and Planning. 'Sometimes, we ask the developers things they had not thought about before. We have also been able to participate in an international Invenio user group workshop. So being here has really allowed us to become active in the international Invenio community.'

A self-sustaining system

The series of digital library schools not only allows participants to put what they have learned into practice in their home institutions. It also enables them to pass on their expertise to others. Two of the teaching staff in Dakar were graduates from previous schools, a sign that the project is creating an independent capacity for further training without outside intervention from CERN.

A further benefit of the schools is the networking possibilities they offer. 'We encourage the participants to build their own international networks so that they become more and more

Five of the six 'champions' from the Morocco workshop in 2010 during their intensive course at CERN in May this year. From left to right: Essaid Ait Allal (Morocco), Guillaume Nikiema (Burkina Faso), Eric Guedegbe (Senegal), Fama Diagne Sene Ndiaye (Senegal), Abdrahamane Anne (Mali) and Jens Vigen (CERN). The sixth champion, Cécile Coulibaly (Côte d'Ivoire), is not pictured.

independent of support from CERN,' says Ludmila Marian from CERN's IT Department. The participants in the schools are active members of the Invenio mailing lists. 'African participants have already been able to respond to queries from other members of the Invenio community on the mailing list and make a really positive contribution,' observes Nikos Kasioumis, also from CERN's IT Department.

Special ties

UNESCO and CERN enjoy special ties that go back more than half a century. CERN was created under the auspices of UNESCO back in 1954 *(see box)*.

'The CERN–UNESCO Digital Library Schools programme offers CERN an opportunity to enter into contact with countries where we don't have any cooperation right now,' says Annette Holtkamp from the CERN library. 'We hope that this cooperation will then spread to the physics community.'

Subject to obtaining the necessary funding, the next school will hopefully take place in Ghana, which has just hosted the second African School on Fundamental Physics[14] in July; this major event was supported by CERN and UNESCO's Abdus Salam International Centre for Theoretical Physics, among others.

Joannah Caborn Wengler, Carolyn Lee and Laëtitia Pedroso[15]

This article is a compilation of stories published in the CERN Bulletin.
For details: www.cern.ch; s.bahri@unesco.org; m.nalecz@unesco.org

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12 This series communicates work related to a CERN activity that does not lend itself to publication in an academic journal.

13 See, for example, the academic repositories hosted by Ghana and Senegal: http://library.kpoly.edu.gh; www.unidep.org/library

14 See http://africanschoolofphysics.web.cern.ch/africanschoolofphysics

15 CERN science writers

How CERN came into being

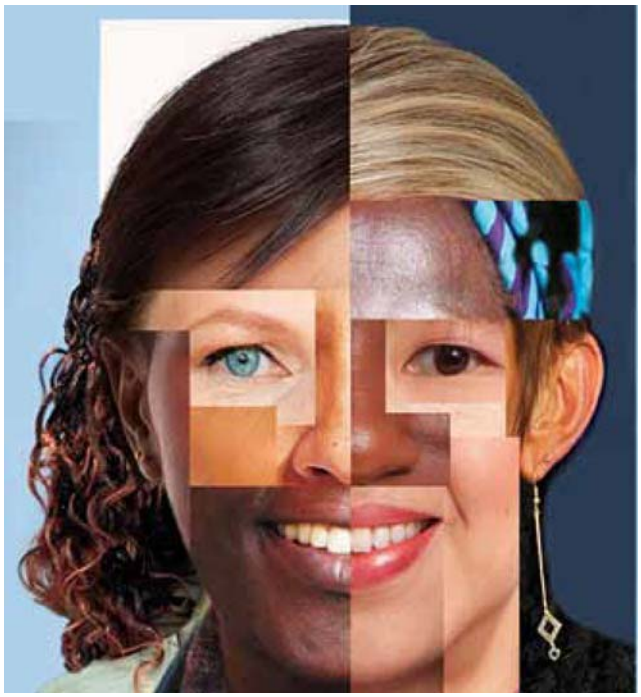
Today, few people remember that the creation of CERN was a UNESCO project. In the aftermath of the Second World War, men and women of the arts and sciences realized that scientific cooperation would be vital to rebuilding peace and security in Europe.

The project was initiated in June 1950 when UNESCO's General Conference in Florence (Italy) took up a US proposal for certain Allied countries and Axis powers which had fought on opposing sides during the war to establish a European Council for Nuclear Research (CERN). The project was refined in December that year, when it was decided to build a laboratory that would construct particle accelerators for research purposes.

In December 1951, an intergovernmental conference convened by UNESCO set up a Council of Representatives of States and several working groups to implement the project. At the second intergovernmental conference in February 1952, the interim agreement was finalized then came into force in May 1952. Within five months, the provisional council had already chosen Geneva (Switzerland) as the site for the new laboratory.

In June 1953, the official CERN Convention was signed by the 12 founding Member States: Belgium, Denmark, Federal Republic of Germany, France, Greece, Italy, Netherlands, Norway, Sweden, Switzerland, UK and Yugoslavia. All had ratified the convention by 29 September 1954, now the official birthday of what has since been renamed the European Organization for Nuclear Research.

Today, CERN's membership stands at 20, with the addition of Austria (1959), Spain (1961–1969, rejoined in 1983), Portugal (1985), Finland and Poland (1991), Hungary (1992), the Czech and Slovak Republics (1993) and Bulgaria (1999), and the withdrawal of Yugoslavia in 1961. Israel and Serbia are Associate Members, an interim stage prior to full membership. India, Japan, the Russian Federation, Turkey and the USA enjoy Observer Status, as do the European Commission and UNESCO.



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All for one and one for all: genetic solidarity in the making

In the 1980s, UNESCO was one of the first to support the Human Genome Project. Thirty years on, it has thrown its support behind the project's successor, the Human Variome Project. With 60% of the global population likely to suffer a genetic mutation at some point in their lives that will expose them to a chronic – and often fatal – disease and with human societies becoming increasingly mobile and multicultural, it is in everyone's best interests to share the growing volume of information and data on genetic diseases. The Human Variome Project sets out to do just that. Thanks to the establishment of a series of international databases, a doctor seeking to diagnose an unfamiliar disorder in a patient will be able to consult all the relevant material available worldwide at the click of a mouse.

Around seven million babies are born each year with serious and often deadly genetic defects; nine out of ten deaths among these infants occur in developing countries.[16] The first discovery[17] of a genetic variation that appeared to cause a hereditary disease was made in 1979; today, we know that there is at least one such mutation in 5 000 of the 20 000 human genes.[18]

Crippling genetic disorders

Of the 5 000 or so genetic diseases that have been discovered so far, the most common are cystic fibrosis (or mucoviscidosis), thalassaemia and haemophilia.[19] In a patient with cystic fibrosis, mucus builds up in the lungs, clogging the airways and ultimately leading to lung disease. According to WHO, 1 in every 2000−3000 newborns is affected in the European Union, compared to about 1 in every 3 500 births in the USA. Although reported cases of cystic fibrosis are rare in Asia, the disease is also severely underdiagnosed in the region. The median life expectancy for a person with cystic fibrosis is currently 33.4 years but many people are now living into their fifties and sixties.

In patients with thalassaemia, the gene responsible for producing haemoglobin is defective. Haemoglobin is a protein present in the red blood cells. As haemoglobin transports oxygen from the lungs to the rest of the body, the lack of oxygen leaves patients feeling tired and breathless. The most serious types of thalassaemia can stunt growth and cause organ damage, liver disease and heart failure. Severe cases may require regular blood transfusions. Thalassaemia can be cured by a bone-marrow transplant but this procedure is expensive and rarely readily available. WHO reports that a patient with thalassaemia has recently reacted well to gene therapy.

According to WHO, about 5% of the world's population are healthy carriers of a gene for haemoglobin disorders. The two main ones are thalassaemia and sickle-cell disease, which causes anaemia. These conditions are most prevalent in the tropics, although migrating populations have spread them to most countries. Thalassaemias are most common in Asia,

Polish composer Frederic Chopin (1810–1849) died of tuberculosis, according to the history books, but he was most likely a victim of cystic fibrosis, which produces very similar symptoms. Cystic fibrosis may often have been mistaken for tuberculosis, which would explain why cystic fibrosis was only diagnosed recently.[20]

Photo: Wikipedia

Photo: Wikipedia

Russian prince Alexis Nikolaïevitch suffered from haemophilia, which mainly affects boys. He is photographed here in 1917 at the age of 13.

the Mediterranean basin and Middle East, whereas sickle-cell disease predominates in Africa. Over 300 000 babies with severe haemoglobin disorders are born each year (*see map*).

Haemophiliacs lack either totally or partially an essential blood-clotting factor. This makes them bleed excessively upon injury and even spontaneously, including internal bleeding. Haemophilia is known as the Royal Disease, for Queen Victoria of England (1819–1901) transmitted it to many of Europe's royal families through her children, who were healthy carriers of the defective gene. Perhaps the most famous example is Alexis Nikolaïevitch, the only son of Tsar Nicholas II of Russia (*see photo*). Born in 1904, he was the grandson of Queen Victoria's daughter Alice. Although the boy was a haemophiliac, he did not die of the disease but at the hands of the Bolcheviks in July 1918, during the Russian Revolution, along with his parents and four sisters.

Cystic fibrosis, thalassaemia, sickle-cell disease and haemophilia are all monogenic diseases. In other words, they result from a mutation to a single pair of genes. Polygenic disorders, on the other hand, are caused by the combined action of mutations in more than one gene. Examples of polygenic disorders are hypertension, coronary heart disease, cancer and diabetes.

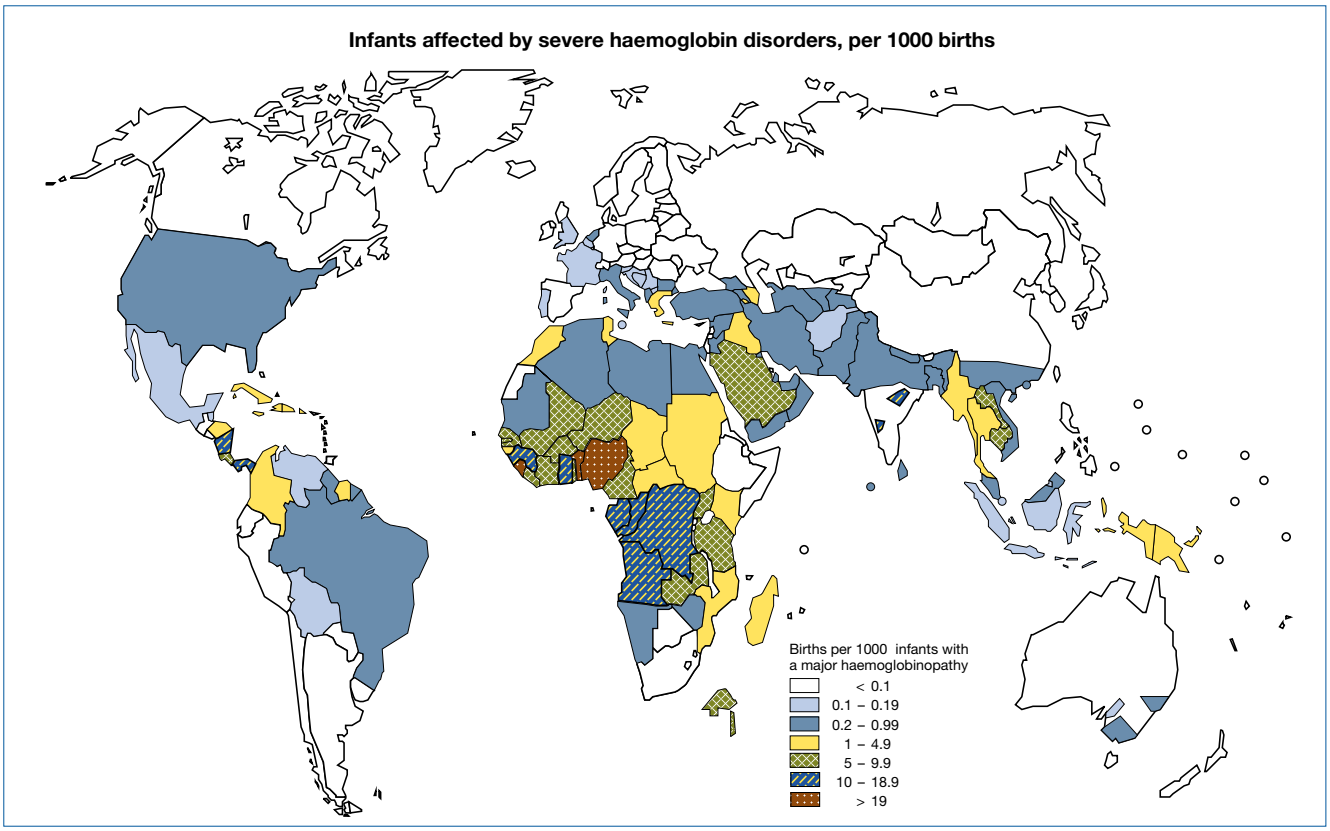
According to a population study by Baird *et al.* (1988), 60% of people will suffer a genetic mutation at some time in their lives. Genetic diseases are thus a major global health concern.

A genetic revolution

In the past, efforts focused mainly on treating the symptoms of genetic diseases. That changed with the genetic revolution, beginning with the discovery of the molecular structure of DNA (the double helix) in 1953. Another milestone was reached 50 years later with the completion of sequencing of the human genome; this involved decoding the 3 billion letters which make up 'the code of life'. The Human Genome Project was initiated by the US government in the 1980s. After the project was threatened by a private rival in 1998, the government teamed up with a UK charity, the Wellcome Trust, to ensure that the sequences would be freely available to the world's scientific community.

UNESCO was involved in the Human Genome Project at the outset. The Organization facilitated international collaboration and coordination, encouraged the participation of developing countries and stimulated debate on the project's ethical, cultural, social and legal ramifications. UNESCO's participation came to an abrupt end, however, with the USA's withdrawal from the UN agency in 1984.

It took a global consortium of thousands of scientists nearly 15 years and several billion dollars to sequence the human genome. Incredibly, that same work can now be completed in the laboratory in just a few days for a fraction of the cost,



© Adapted from WHO

thanks to quantum leaps in computer technology. Today, diagnostic tests exist for many genetic disorders. Mutation-specific therapies are being developed to manage and treat the symptoms of cystic fibrosis and other genetic disorders.

The dilemma of globe-trotting pathologies

The problem is that the avalanche of information and data coming out of laboratories on genetic variations and their effects is not being shared efficiently, either within countries or internationally, because there is no system in place to collect all of this vital knowledge and make it accessible to the world. Although developed countries have systems in place for documenting genetic diseases, the increasingly multicultural nature of modern societies means that the medical profession is being repeatedly confronted with 'new' pathologies.

Professor Finlay Macrae, Head of Colorectal Medicine and Genetics at the Royal Melbourne Hospital, had this to say about the situation in his own country:

> *The Australian population is multicultural, with more residents born outside than inside the country. Ethnic groups are diverse and countries of origin even more diverse. Frequently, in our familial cancer clinic, we are faced with branches of families where the informative genetic information is located overseas. Australian data are patently inadequate to manage these families, as key genetic information resides in repositories and registers overseas or has not yet been brought to the attention of genetic services in the country of origin.*

The Human Variome Project is born

Professor Richard Cotton, a recognized specialist of genetic variation from the University of Melbourne, realized there was an urgent need for an encyclopaedic catalogue of genetic variants in the human genome sequence. He knew that collecting and verifying genetic data worldwide for the purposes of sharing databases via Internet with the global scientific community would be a gargantuan task that could only be accomplished through international collaboration backed by substantial funding. The Human Variome Project was born.

The term 'variome' refers to the sum of all the genetic variations found in different populations of the same species. The different populations of *Homo sapiens sapiens* are remarkably similar from one continent to another from a genetic standpoint, suggesting that our species has evolved from a small original gene pool over the past 10 000 years.

In June 2006, Professor Cotton and his team divulged the Human Variome Project in Melbourne to a room filled with geneticists, diagnosticians, researchers and bioinformaticians from 30 countries. Also present were representatives of UNESCO, WHO, the Organisation for Economic Co-operation and Development (OECD) and the European Commission. The project sparked the immediate interest of specialists but, to expand its global reach, it would also need the adhesion of governments.

Photo: Wikipedia/US Air Force

Most babies in developed countries are tested for phenylketonuria soon after birth. A combination of a controlled diet and medication can limit neurological damage resulting from the disorder, which may include mental retardation and seizures.

In 2010, Professor Cotton and his team decided to found a non-profit Australian public company, Human Variome Project International Limited, in order to centralize coordination. This new structure facilitated the project's partnership with UNESCO, as the UN agency was then able to establish official relations with the nascent NGO in 2011. Subsequently, UNESCO approached governments to ascertain their interest in the project, as it had done for the Human Genome Project. Many governments reacted with enthusiasm.

The project moves into high gear

The project moved into high gear in January 2011 when the Chinese government pledged a staggering US$300 million for the establishment of an institute in Beijing which would build new databases and supplement existing ones cataloguing genetic variation implicated in hundreds of genetic diseases. 'This is an unprecedented step forward for the field of genetic health,' enthused Professor Cotton at the time.

With a population of 1.4 billion, China counts a large amount of genetic diversity. This factor alone does not explain China's strong commitment to the Human Variome Project, however. 'China has shown the world that, not only do they recognize genetic disease as a serious global health issue', said Professor Cotton, 'but that they are serious about addressing it.'

This was not always the case. During the Cultural Revolution of the 1960s, Chinese research in genetics came to a standstill after the country officially adopted Lysenkoism, a doctrine developed by Russian peasant plant-breeder Trofim Denisovich Lysenko (1898–1976) which had already stalled genetic research in the Soviet Union. Essentially, Lysenkoism dictated that we are what we learn. This environmentalism denied the role played by genetic inheritance in evolution.

Although Lysenkoism has long been discarded by both China and the Russian Federation, scientists still publish much more today in both countries in chemistry and physics than in the medical sciences. The situation is changing, however. Whereas China's world share of scientific publications in molecular biology and genetics amounted to just 1.4% in 1999–2003, according to the *UNESCO Science Report 2010* (p. 391),

L'Oréal–UNESCO laureate (2008) Prof. Lidadh Al-Gazali with a young patient at the centre for genetic disorders she set up in the United Arab Emirates, the country's first. The frequency of consanguineous marriages in the United Arab Emirates has led to a high incidence of recessive genetic disorders, in particular rare dysmorphic syndromes (causing malformations) and dysplasias (causing bone deformities).

this share climbed to 4.5% in 2004–2008; in comparison, China contributed one-fifth of all articles published in materials science in 2004–2008, 16.9% of those in chemistry and 14.2% of those in physics.

The roadmap to 2016

Every two years, the Human Variome Project updates consortium members on its plans and progresss. The third and fourth biennial meetings were hosted by UNESCO at its Paris headquarters in May 2010 and June 2012, within its International Basic Sciences Programme.

It was at the meeting in June this year that the project's roadmap to 2016 was presented. Among its targets are the completion of high-quality gene-specific and disease-specific databases for at least 3 000 genes by 2016 and for a further 5 000 genes by 2022. The roadmap also hopes to have over 40 country nodes sharing information with these international databases by 2016. So far, nodes have been established in 16 countries.[21]

At the June meeting, Professor Xitao Li, Director of the Human Variome Project Chinese Node and a member of the Human Variome Project's Board of Directors, announced that the China Country Development Programme for the Human Variome Project would be providing grants of US$75,000 to projects promoting knowledge exchange across national boundaries in medical genetics and genomics. The aim is to support the growth of a viable, sustainable network of country nodes in the developing world, in line with the roadmap.

In his closing speech, Sir John Burn, Professor of Clinical Genetics at Newcastle University in the UK, described Article 19 of UNESCO's International Declaration on Human Genetic Data (2003) as a 'fundamental document' in support of the Human Variome Project (*see box*). He stressed the importance of sharing the benefits resulting from the use of human genetic data with society as a whole and with the international community. He also underscored the significance of the Human Variome Project in protecting humanity as a common heritage. 'A journey of 1000 km begins with a single step', he said, quoting the Chinese philosopher Lao-tzu. The Human Variome Project is the first step on this journey.

Casimiro Vizzini[22] and Timothy D. Smith[23]

For details: www.humanvariomeproject.org; c.vizzini@unesco.org

16 *According to a WHO report on medical genetics (2002): http://apps.who.int/iris/bitstream/10665/67270/1/WHO_HGN_WG_02.2.pdf*

17 *See : www.ncbi.nlm.nih.gov/pmc/articles/PMC383714*

18 *See: www.hgmd.cf.ac.uk/ac/index.php*

19 *See: www.who.int/genomics/public/geneticdiseases/en/index2.html*

20 *See, for example: Reuben, Adrian (2003) Chopin's serpin.* Hepatology, *37 (2): http://onlinelibrary.wiley.com/doi/10.1002/hep.510370244/pdf*

21 *In Austria, Australia, Belgium, China, Cyprus, Czech Republic, Egypt, Greece, Kuwait, Malaysia, Mexico, Nepal, Spain, UK, USA and Vietnam*

22 *Associate Expert, UNESCO International Basic Sciences Programme*

23 *Communications Officer, Human Variome Project*

Sharing the benefits of human genetic data

Article 19 of the International Declaration on Human Genetic Data adopted by UNESCO's Member States in 2003 states that:

(a) In accordance with domestic law or policy and international agreements, benefits resulting from the use of human genetic data, human proteomic data or biological samples collected for medical and scientific research should be shared with the society as a whole and the international community. In giving effect to this principle, benefits may take any of the following forms:

(i) special assistance to the persons and groups that have taken part in the research;

(ii) access to medical care;

(iii) provision of new diagnostics, facilities for new treatments or drugs stemming from the research;

(iv) support for health services;

(v) capacity-building facilities for research purposes;

(vi) development and strengthening of the capacity of developing countries to collect and process human genetic data, taking into consideration their specific problems;

(vii) any other form consistent with the principles set out in this Declaration.

(b) Limitations in this respect could be provided by domestic law and international agreements.

See:
www.unesco.org/new/en/social-and-human-sciences/themes/bioethics/human-genetic-data

Diary

29 September – 5 October

Sustainable energy governance in UNESCO-designated sites
UNESCO regional school on innovation in European World Heritage sites and biosphere reserves, organized with UNDP Croatia, City of Dubrovnik, Croatian Nat. Comm for UNESCO. Trainees to present their work to intl conf.(4–5 October) which will help to shape future European policy. Croatian Assoc. of Historic Town, Turkish Union of Historic Towns, UNESCO Venice, etc. Dubrovnik (Croatia): *d.poletto@unesco.org*

1–2 October

Securing competitiveness for the Mediterranean
Intl workshop organized by UNESCO Venice, Global Footprint Network, MAVA Foundation for official launch of Mediterranean Ecological Footprint Trends report. Venice (Italy): *p.pypaert@unesco.org*

8–10 October

Groundwater governance
3rd regional consultation, for Arab States, of GEF–UNESCO–FAO–IAH–World Bank project to develop global framework for action. See A World of Science, January 2012 Organized by UNESCO, hosted by govt. Amman (Jordan): *c.abdalla-iskandar@unesco.org.*

12 October

Conserving sacred heritage sites
Side event during COP11 on intergenerational transfer of traditional knowledge on biodiversity for climate change adaptation at sites. GIZ, UNESCO New Delhi, Indian National Biodiversity Authority, etc. Hyderabad (India): *www.cbd.int/cop11/side-events; r.boojh@unesco.org*

13–14 October

Biodiversity conservation and education for sustainable development
Intl conf. within UN Decade (2005–2014). Organized by Indian Centre for Environment Education with UNESCO, CBD, Indian Min.Environment and Forests. Hyderabad: *www.ceeindia.org; esdbio.cop11@ceeindia.org; ; r.boojh@unesco.org*

24–26 October

A new era of Earth observation of natural and cultural heritage
4th intl conf. on remote sensing in archaeology. Co-organized by Chinese Academy of Sciences and UNESCO. Hosted by Intl Centre on Space Technologies for Natural and Cultural Heritage and Centre for Earth Observation and Digital Earth. Beijing: *r.jayakumar@unesco.org*

6–8 November

Great Apes Survival Partnership (GRASP)
2nd council meeting, co-organized by UNEP and UNESCO. Attended by partner nations, conservation bodies, research institutions, UN agencies, private supporters. UNESCO Paris: *www.un-grasp.org; n.raondry@rakotoarisoa@unesco.org; doug.cress@unep.org*

Earthquake and tsunami early warnings in Eastern Mediterranean
Intl workshop for countries bordering Dead Sea Fault, within UNESCO project to reduce earthquake losses in region. Limassol (Cyprus): *a.makarigakis@unesco.org; j.torres@unesco.org*

9 November

Celebrating Albanian women in science
Public roundtable with career mentor Dr Vita Majce, 2012 L'Oreal–UNESCO Intl Fellow from Slovenia, who will share her research experiences. Run-up to World Science Day. Tirana (Albania): *r.santesso@unesco.org; z.harasani@unesco.org*

10 November

World Science Day for Peace and Development
Theme: Science for global sustainability: interconnectedness, collaboration, transformation. Download poster in several languages: *www.unesco.org/science/psd; d.malpede@unesco.org*

12–14 November

Sustainable management of marginal drylands (SUMAMAD)
10th intl workshop within second phase (2009–2013) of SUMAMAD project. Organized by UNESCO and Universidad Mayor de San Andrés. La Paz (Bolivia): *t.schaaf@unesco.org*

14–15 November

Food security in drylands
Intl conf. Organized by Qatar National Food Security Program with support of UNESCO and other agencies. Doha (Qatar): *b.boer@unesco.org*

19–20 November

Disaster risk reduction and resilience
High Level Committee on Programmes meeting to prepare UN system-wide Plan of Action. UNESCO Paris: *k.tovmasyan@unesco.org*

20–23 November

Intl Consortium on Landslides
Joint meeting with Intl Programme on Landslides. UNESCO Paris: *k.tovmasyan@unesco.org*

21–22 November

Intl Geoscience Programme in Africa
Workshop on skills development in preparing project applications. Organized by UNESCO Nairobi Office. Nairobi (Kenya): *sf.toteu@unesco.org*

22–23 November

Strengthening STI in Southeast Europe
5th ministerial roundtable. Co-organized by Ministry of Civil Affairs and UNESCO Venice, to fix priorities and make recommendations for roadmap at national and regional levels. Sarajevo (Bosnia and Herzegovina): *m.scalet@unesco.org*

3–5 December

Climate change and the Himalayas
Intl conf. on current status and perspectives. National Institute of Science Comm. and Information Resources (NISCAIR) with UNESCO New Delhi, ICIMOD, SAARC, etc. New Delhi (India): *www.niscair.res.in/Downloadables/climate-conf-ICCCH2012.pdf; r.boojh@unesco.org*

Groundwater governance
4th regional consultation, for Asia-Pacific, of GEF–UNESCO–FAO–IAH–World Bank project to develop global framework for action. See *A World of Science*, January 2012 Organized by UNESCO-IHP. Shijiazhuang (China): *m.rubio@unesco.org*

Invent the Year's official slogan

Enter a contest to find a short, catchy slogan that encapsulates the message of the UN International Year of Water Cooperation in 2013: to raise awareness of the potential for greater cooperation in managing freshwater.

Submit a slogan of maximum 80 characters (words and spaces) in English by **15 November 2012**. The winner will be notified by e-mail before the decision is made public on 31 December 2012.

The winner will be invited to the kick-off meeting of the Year at UNESCO headquarters in Paris, France, in January 2013.

The contest is open to everyone, with the exception of UN-Water employees and their immediate family.

To enter, go to: *www.watercooperation2013.org*

New **Releases**

Groundwater and Global Change

Trends, Opportunities and Challenges
By Jac Van der Gun. Published by UNESCO within UN World Water Assessment Programme. Side Publication Series 1. One of four side publications launched in Stockholm (Sweden) during World Water Week (24–31 August), within two events organized by UN World Water Assessment Programme, namely Lessons from the World Water Development Report 4 and, secondly, Green Accounting, with a focus on world water scenarios for our future.
ISBN: 978-92-3-001049-2, English only, 36 pp.
Download*: http://unesdoc.unesco.org/images/0021/002154/215496e.pdf*

Green Accounting and Data Improvement for Water Resources

By James Winpenny. Published by UNESCO within UN World Water Assessment Programme. Side Publication Series 2.
ISBN: 978-92-3-001088-1, English only, 8 pp.
Download: *http://unesdoc.unesco.org/images/0021/002171/217165E.pdf*

Water and Sustainability

A Review of Targets, Tools and Regional Cases
By Abel Mejia, Miguel Nucete Hubner, Enrique Ron Sánchez and Miguel Doria. Published by UNESCO within UN World Water Assessment Programme. Side Publication Series 3. ISBN: ISBN 978-92-3-001094-2, English only, 48 pp.
Download: *http://unesdoc.unesco.org/images/0021/002171/217180E.pdf*

Carbon and Water Footprints

Concepts, Methodologies and Policy Responses
By Ertug Ercin and Arjen Y. Hoekstra. Published by UNESCO within UN World Water Assessment Programme. Side Publication Series 4. ISBN 978-92-3-001095-9, English only, 24 pp. Download: *http://unesdoc.unesco.org/images/0021/002171/217181E.pdf*

Protecting Water Quality for People and the Environment

Film produced by UNESCO-IHP for World Water Forum, English only. Subtitles, 8 minutes. For details and to view: *http://tinyurl.com/d9p3ndf*

The State of Broadband 2012

Achieving Digital Inclusion for All
First status report by Broadband Commission set up by ITU and UNESCO in 2010. Exists in English, 96 pp. Download: *www.broadbandcommission.org*

The Great East Japan Tsunami and Tsunami Warning Systems

Perspectives; Summary Statements
Brochure produced by UNESCO-IOC in English, French and Spanish, 8 pp.
Summarizes key findings of international symposium organized by Japan, UNESCO and UNU for 290 physical and social scientists, warning system operators, emergency and response managers, planners, journalists, policy- and decision-makers from 25 countries.
Download: *http://unesdoc.unesco.org/images/0021/002160/216072e.pdf*
(Replace the 'e' with an f' for French and an 's' for Spanish)

Shaping the Education of Tomorrow

Progress report on UN Decade of Education for Sustainable Development (Abridged)
By Rosalyn McKeown. UNESCO Education Sector. English only, 88 pp.
Second of three reports (2009, 2012 and 2014) monitoring progress made during the Decade. For details: r.mckeown@unesco.org;
Download: *http://unesdoc.unesco.org/images/0021/002166/216606e.pdf*

Climate Change, Water Stress, Conflict and Migration

Produced by The Netherlands IHP Committee. English only, 126 pp.
The proceedings of a symposium organized on 21 September 2011 in The Hague by the Netherlands IHP Committee, with case studies from Bangladesh, Niger, etc.
Download: *www.hydrology.nl*; for details: *info@hydrology.nl*

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Cover photo: Monk seal in Papahanaumokuakea, a vast US marine park and biosphere reserve in the Pacific Ocean – © UNESCO