Mediterranean Wetlands Observatory

THEMATIC COLLECTION
SPECIAL ISSUE
1

Biodiversity

Status and trends of species in Mediterranean wetlands

Ramsar MedWet TOUR DU VALAT

The MWO, which is coordinated by the Tour du Valat, was created in 2008 within the framework of the MedWet initiative to monitor and evaluate the status and trends of Mediterranean wetlands, and to further the knowledge of their multiple benefits. Its ultimate goal is to improve wetland conservation and management by providing information to as many people as possible, in particular political decision-makers and the general public, in line with axis 1 of the MedWet strategic vision. The MWO operates thanks to a group of partners who are committed to this vision, the Plan Bleu, EKBY, UNEP-WCMC, Wetlands International and many others - www.medwetlands-obs.org.

MedWet is a regional initiative of the Ramsar Convention, which includes in particular the 27 countries surrounding the Mediterranean. Its aim is to promote and implement the protection and rational use of Mediterranean wetlands - www.medwet.org.

The Tour du Valat, a non-profit foundation, has been developing multidisciplinary research programs on the functioning of Mediterranean wetland for over 50 years. The teams have the mission "to stop the loss and destruction of these ecosystems and their natural resources, to restore wetlands and to promote their rational use" - www.tourduvalat.org.

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FOREWORD

Mediterranean habitats sustain an impressive number of species and provide essential goods and services to humanity. Food, water, material resources and ecological services in the region depend upon our outstanding natural and social contrasts, where water is no doubt fundamental. Unfortunately, Mediterranean wetlands are probably one of the ecosystems most severely affected by habitat degradation and an associated loss of biodiversity.

A good understanding of the inter-connections between human and natural ecosystems is essential for the conservation and sustainable use of natural resources. The new urban culture needs to reestablish the link to nature for survival. This represents a major challenge for us and the next generations, in particular in the Mediterranean region. A converging point between continents and cultures, the Mediterranean needs of the commitment of different institutions and stakeholders to find new ways to share their knowledge and experiences for the achievement of an effective conservation at local, regional and national levels. The IUCN Centre for Mediterranean Cooperation applauds initiatives like this to help bring the scientific knowledge to society towards conserving the diversity of nature, and therefore ensure an equitable and ecologically sustainable use of our limited resources.

Since 2009, the Mediterranean Wetlands Observatory (MWO) has been working to provide up-to-date information on wetlands to help meet this challenge. Following the release of the first Mediterranean Wetlands Outlook in 2012 synthesizing the regional state of play, this thematic report provides in-depth knowledge on their biodiversity values across Mediterranean countries, including their conservation status and trends, threats, the services offered, and solutions to reverse the negative trends. The results are presented at regional level and broken down at sub-regional levels (Europe, North Africa, and Middle East), including case studies.

We are pleased to see that the IUCN Red Lists of Threatened Species at Mediterranean level are feeding the efforts by the Mediterranean Wetlands Observatory. In a time when we all need to contribute to save our Mediterranean, this is another step for the scientific community in our path towards a better understanding and the communication of the real value of nature to decision and policy makers beyond the traditional biology and environmental realms.

Antonio Troya
Director of IUCN Centre for Mediterranean Cooperation

↑ *Gediz delta, Turkey (© Hellio & Van Ingen).*

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1. MONITORING CHANGES IN BIODIVERSITY

1.1 GLOBAL BIODIVERSITY IN RAPID DECLINE

For two centuries, and especially since the end of World War II, the increase in human populations has been accompanied by the overexploitation of natural resources, and the transformation of ecosystems, leading to an unprecedented loss of biodiversity. Species are becoming extinct today 1000 to 10,000 times faster than the natural rate and many others show severe declines in numbers.

Wetlands are probably the type of ecosystem that has been the most severely affected by losses, and damage and by the decline in biodiversity. Ever-increasing water extraction, pollution, drainage, the canalisation of watercourses, the construction of dams, the deforestation of catchment areas, the introduction of invasive species, and overfishing have all had strong negative effects on species. However, the biological diversity of these habitats is disproportionately richer than that of other ecosystems: while wetlands amount to less than 1% of the surface of the globe, they harbour over 25% of vertebrates and, more generally, 126,000 species have been recorded there to date.

Whether coastal or inland, wetlands provide a very wide range of services, which we are still incapable of evaluating in monetary terms: sources of food, of water for domestic, agricultural, and industrial use, of medicines, and building materials, natural infrastructure protecting against flooding, erosion, and storms, suitable sites for the development of tourism, culture, and education, etc. These natural resources are used by local communities, and in many countries they are vital for the survival of those communities, especially the most disadvantaged ones.

1.2 MEDITERRANEAN WETLANDS IN DANGER

The wetlands in the Mediterranean basin are no exception to the particularly unfavourable global context for biodiversity. Long considered to be unhealthy and of no use, these ecosystems have been destroyed throughout recorded history. The destruction further accelerated in the 20th century when food security policies encouraged the development of farmland and irrigation, for which many wetlands paid the price. At the same time, urbanisation and the development of industry, hydroelectricity, and the tourism sector increased the demand for water and land. Despite recent growing awareness, the future for wetlands remains bleak. Indeed, the Mediterranean region is characterised by rapid human population growth, which generates all the more pressures on the environment that the leading development and consumption models are not ecologically sustainable. Whereas at the beginning of the 1960s, most countries had an ecological footprint that was less than or scarcely greater than their capacity for ecological regeneration (Fig. 1), in 2007 only Montenegro still had an economic model that was compatible with the preservation of natural resources (Global Footprint Network, 2011). The effects of climate change are likely to further exacerbate

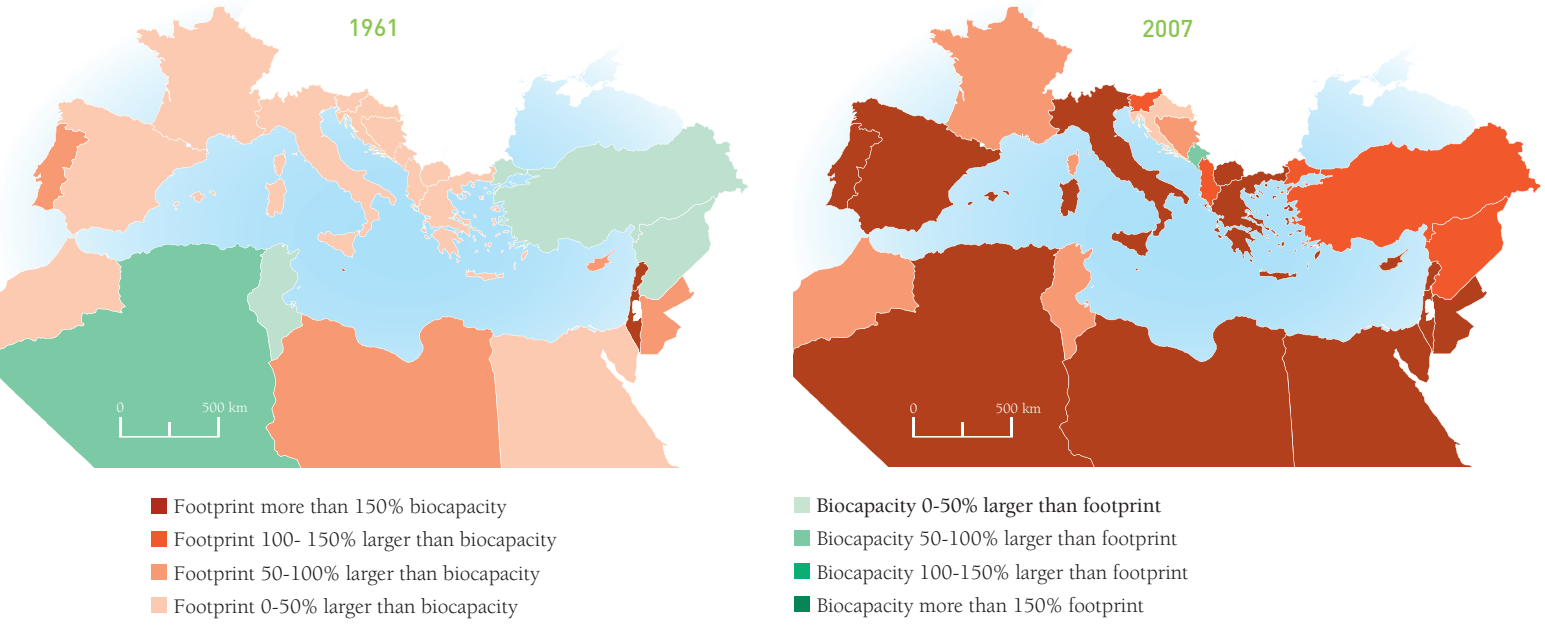
↗ *Mediterranean wetlands are very often at the centre of the conflict between economic development and the preservation of the natural heritage (Fos-sur-Mer, France - © Tour du Valat).*

the threats to wetlands. A decrease in the amount of rainfall, which has already been observed locally, is to be expected in the coming decades, and one effect could be a decrease in the amount of water available for the environment.

The challenges in terms of biodiversity are particularly important in the Mediterranean basin. The region has been identified as one of the 34 world hotspots for biological diversity, supporting for example almost as many species of flowering plants as the whole of tropical Africa (22,500 species), on a land area that is however only a quarter the size. The level of endemism here is very high with, in some groups, more than one species in two unknown elsewhere in the world! Rich, but often unshowy and therefore not very obvious, the biodiversity of Mediterranean wetlands is not well-known by the general public, with the possible exception of waterbirds, which gather in amazing numbers at some sites.

Figure 1:

Map of the ecological footprint of the Mediterranean countries (Moore et al., 2010)[1]: Relationship between consumption of natural resources and biological capacity for each country in 1961 and 2007. In 2007, all the countries were in "ecological deficit" except for Montenegro (Global Footprint Network, 2011).



1.3 INDICATORS FOR MONITORING BIODIVERSITY

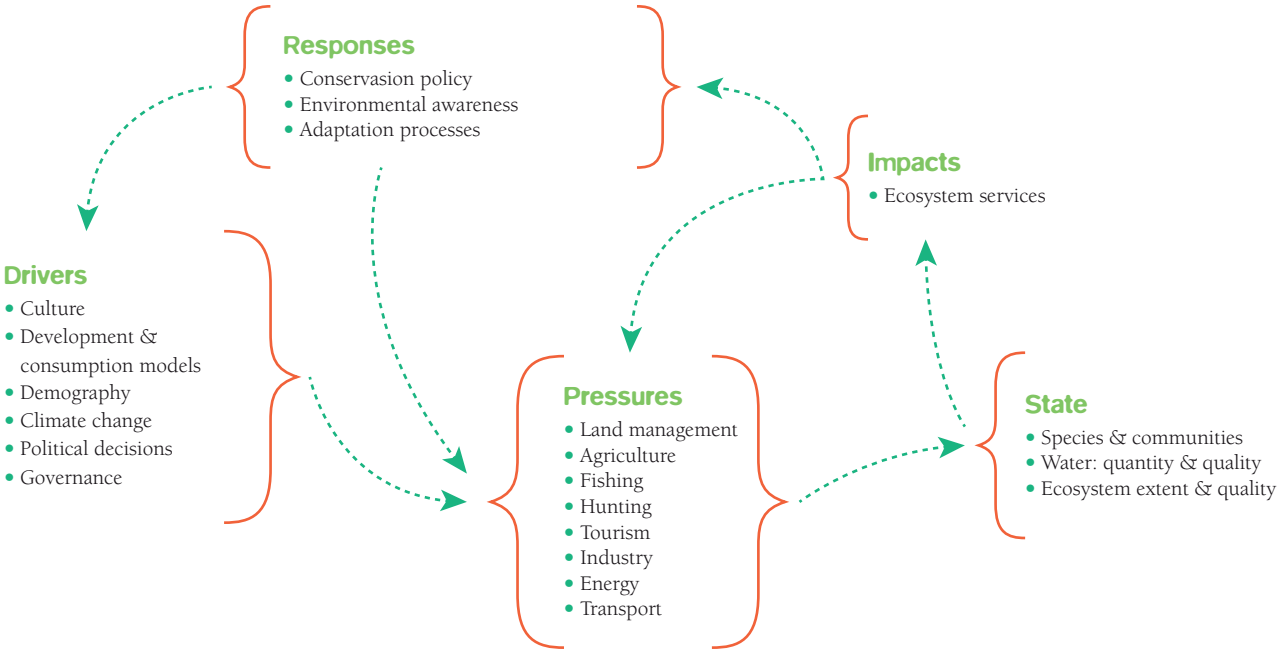
Since the Rio de Janeiro World Summit (1992), and the World Summit on Sustainable Development in Johannesburg (2002), nation states have recognised the urgency of monitoring changes in biodiversity and stemming the losses. However, biodiversity is a too complex concept[2] to aspire to exhaustive monitoring. In addition, there are insufficient human and financial resources, especially in the developing countries – where the most severe declines in biodiversity are nowadays suspected to be taking place. For these reasons, the status of biodiversity is currently being assessed via synthetic indicators, which allow the best use to be made of data from incomplete surveys, but which nevertheless provide a realistic picture of the situation. These indicators are also intended to provide information about how the pressures exerted on biodiversity evolve, and to evaluate the pertinence of the responses put in place to reverse the declining trends that are recorded (Balmford *et al.*, 2005). In order to improve the conservation and management of wetlands[3] by raising the awareness of decision-makers and the general public, the Mediterranean Wetlands Observatory (MWO) has devised a set of complementary, coherent indicators, based on a model that has already been adopted by the European Environment Agency, and is therefore well known to decision-makers: the "Drivers, Pressures, State, Impacts, Responses" model (European Environment Agency, 1999; Fig. 2).

1: Source: "Moore D., Brooks N., Cranston G., Galli A., 2010. The Future of the Mediterranean: Tracking Ecological Footprint Trends. Interim report for Comments. Global Footprint Network, Oakland. Available on-line at http://www.footprintnetwork.org/med [accessed May 2011]".

2: The concept of biodiversity extends from genes to species and ecosystems, and includes the interactions between these different levels of organisation of living organisms. In this publication, biodiversity will be essentially apprehended through the analysis of the diversity and frequency of occurrence of animal and plant species.

3: The MWO has used the Ramsar Convention definition, which defines a wetland as any ecosystem that is under water, temporarily or permanently, with the exception of marine waters deeper than six metres at low tide.

Figure 2:
Simplified model of "Drivers-Pressures-State-Impacts-Responses" for the MWO monitoring and evaluation framework.

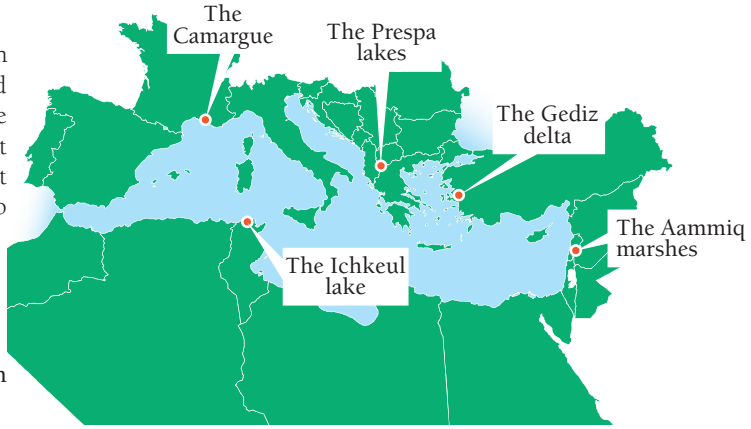


1.4 FOCUS ON FIVE KEY WETLANDS IN THE MEDITERRANEAN

Difficulty in obtaining access to data is a problem with which the observatories are repeatedly faced. Yet, it would appear that data collected as part of biodiversity monitoring are often little used, and so do not contribute to any great extent to the decision-making process (MWO, 2012). In order at least partly to solve these problems, the MWO has opted to work at the site scale, in other words at the level of the individual wetlands. The expected benefits of this local approach are many and synergistic:

- improving the MWO's database and regional analyses, especially by including data that are often difficult to access but nevertheless valuable;
- analysing data from local-scale monitoring and using them in innovative ways so as to demonstrate their usefulness, and the need to continue monitoring operations, to decision-makers and funding bodies;
- evaluating the possibility of replicating the structure and functioning of the MWO at the local level, and testing out the applicability of such a model in accordance with the quality and quantity of existing data.

Five sites have been the subject of local studies: the **Ichkeul Lake in Tunisia**, the **Camargue in France**, the **Prespa lakes in the depths of Albania, Greece and FYR of Macedonia**, the **Gediz Delta in turkey**, and the **Aammiq marshes in Lebanon**. These sites provide a diverse sample of wetlands



– deltas, freshwater and brackish lakes freshwater marshes – located in the four corners of the Mediterranean basin. These sites are very different but they are all recognised as wetlands of international importance (Ramsar), notably for the numbers of waterbirds that use them. Biodiversity monitoring takes place at all of them on a regular basis. However, the timescale and thoroughness of this monitoring varies greatly from one site to another. Our analysis has concentrated on waterbird communities, the component of biodiversity that has been best monitored at these sites. These results were discussed with regard to the qualitative data obtained for other elements of biodiversity, and for the pressure factors, impacts, and responses (Fig. 2). These results are presented throughout this document in the form of boxes.

> Ichkeul lake

Ichkeul lake is one of the most important wintering sites for waterfowl in the Mediterranean region (© Tour du Valat).

Ichkeul lake is situated in north-west Tunisia. The hydrological regime at the lake (8500 ha) and its surrounding marshes (2700 ha) is dominated by inputs of fresh water in winter and of sea water in summer. The lake is fed by six wadis, which have been steadily cut off by dams since the 1990s to allow the development of irrigated farming in the region. It also receives sea water via the Bizerte lagoon, interchanges between the lagoon and the lake being controlled by a hydraulic infrastructure set up for fishing, which is a locally important economic sector.

When enough fresh water is received by the ecosystem, extensive beds of pondweeds (*Potamogeton pectinatus*) and club-rushes (*Scirpus maritimus* and *S. littoralis*) grow in the lake and in the marshes respectively. They provide food resources which are used by several hundred thousand waterbirds in winter, especially ducks, coots, and geese, whose recorded numbers are of international importance. The areas of mudflats and the varied ecosystems around the lake are used by the Greater Flamingo and waders. Some globally threatened species such as the Marbled Duck and the White-headed Duck are sighted here, sometimes in large numbers. The ecological importance of Ichkeul lake has prompted its inclusion in three international conventions: as a UNESCO Biosphere Reserve, a UNESCO World Natural Heritage Site, and a Ramsar site. The lake also forms the heart of a national park within which live a few families with modest incomes derived from extensive stock-raising and the sale of local produce to tourists.

Although there had been occasional censuses since 1963, it was only in 1983 that they started to become more regular. It was not until 2003, and the beginning of the biological monitoring carried out by the National Agency of Environment Protection (ANPE), and the "Association des Amis des Oiseaux" (*Friends of Bird Association* AAO), that a fixed methodology, regular surveys, and thorough counts were initiated. In the context of this study, monitoring results involving 74 bird species, and extending over the period from 1984 to 2009 could be gathered.

> The Camargue

The Camargue, in the south of France, is an extensive delta plain of 145,000 hectares where the fresh water of the Rhône meets the salt water of the Mediterranean. These waters have shaped the landscapes, which have been repeatedly re-modelled over the course of history by the shifting position of the river bed. The delta offers a mosaic of lagoons and marshes, brackish and fresh, both temporarily and permanently flooded, together with dry habitats. Since the Rhône was contained within embankments in the 19th century, significant areas of wetlands have been converted to farmland and industrial sites. The salt-producing and rice-growing activities, which became more intensive during the 20th century have also profoundly modified the ecosystems, and have certainly influenced the communities of species. For example, the summer flooding of rice fields has disrupted the hydrological regime in the delta. In addition to crop growing, the raising of local breeds of cattle and horses, wildfowling, tourism, and nature protection are also important economic activities in the delta.

The Rhône delta is the most extensive wetland in France and one of the best-studied sites in the Mediterranean from the point of view of biodiversity (© Opus species, Parc Naturel Régional de Camargue).

The biological interest of the site is enormous, and includes all components of biodiversity. The numbers of birds which have been counted here are of global importance in the case of several species of gulls, terns, and herons, for the Greater Flamingo during the breeding season, and for many ducks and waders during the migration and winter periods. The importance of the Camargue has been recognised by various levels of protection, whether national – nature reserves, Regional Natural Park – or international – Natura 2000 and Ramsar sites, Biosphere Reserve.

The literature on the avifauna of the Camargue published in the 19th century (Crespon, 1840; Jaubert & Barthélemy-Lapommeraye, 1859) provides invaluable reference points for making comparisons between the time when the embankment of the Rhône had not yet been completed and the current context of a fixed, artificially managed delta. Since the 1930s, and especially the 1950s, ornithological reports have been published regularly, enabling the bird community evolution to be traced. The longest-running surveys

have been carried out by the scientific teams at the Tour du Valat, the Centre National de la Recherche Scientifique (CNRS - National Center for Scientific Research), and the Camargue National Reserve; they concern wintering ducks, herons, as well as nesting gulls, terns and waders. More irregular or more recent abundance data are available for many other species and also stem from the work of other organisations4: it has been possible to assemble 255 time series relating to 158 bird species in the framework of this study, making the Camargue one of the best-covered of our sample sites and over the longest period of time (1954-2010).

> Prespa lakes

↗ *The Prespa lakes are one of the largest areas of fresh water in the Balkans, and are notable for the presence of several endemic species as well as important colonies of waterbirds (© J. Jalbert – Tour du Valat).*

Prespa is the name given to two freshwater lakes – Megali Prespa and Mikri Prespa – that are shared between Greece, the Former Yugoslav Republic (FYR) of Macedonia, and Albania. These two lakes are connected (Mikri Prespa runs into Megali Prespa), and form one of the largest water bodies in the Balkans (300 km^2). They are situated at an altitude of 853 m, so the winter climate is rather cold, and the smaller and shallower of both lakes often freezes over. The shores of the lakes are occupied by reedbeds, wet grasslands, and areas of farmland. Large areas of woodland remain in places on the mountain slopes which surround the lakes. The landscape has been profoundly modified following the intensification of agriculture since the 1960s, more in the Greek and Macedonian sectors than in the Albanian. The surface area of wet grassland, a crucial habitat for waterbirds and fish, has decreased considerably. At the same time, the threats facing biodiversity from water pollution, overfishing, and disturbance of the bird colonies have been increasing.

The wide diversity of ecosystems present at Prespa explains the site's high level of floristic and faunistic richness. This is also a hotspot for endemism with, for example, 7 species of fish that are endemic to the lake or its tributaries. The birdlife is, of course, remarkable with, most notably, the biggest colony of Dalmatian Pelican in the world.

Prespa is protected at various national and international levels. The Macedonian part is recognised as a Ramsar site and is partly included in an ornithological reserve, the Albanian part is included in a national park, and the Greek part has been designated as a national park, a Natura 2000 site, and a Ramsar site. In addition, since 2000, Lakes Mikri and Megali Prespa and their catchment area have formed the Prespa Transboundary Park, which extends into all three countries.

Visited frequently by ornithologists since the 1960s, Lake Prespa has only received regular censuses since the 1980s in Greece and FYR of Macedonia, while they remain irregular in Albania[5]. The lack of coordination in counts between the different countries presents a real problem for analysing the data, as the location of duck and coot flocks vary from one year to another. Fortunately, it has recently become possible to organise simultaneous counts in all three countries, thanks to the establishment of the Transboundary Park. In total, 95 time series relating to 49 species have been collected for this study (1984-2010).

> The Gediz Delta

Before entering the Aegean Sea on the west coast of Turkey, the river Gediz has formed an extensive delta (40,000 ha). Four large lagoons separated from the sea by a number of islands and islets, mudflats, salt marshes, intermittently flooded grasslands, and freshwater marshes form the bulk of the natural wetlands, which occupy a third of the area of the delta. Agriculture, salt production, and commercial fishing constitute important economic activities on the local if not the national scale. The threats confronting the biodiversity of the Gediz are many and very serious. The fresh water entering the delta is highly polluted by industrial and domestic effluents. The immediate proximity of the third largest city in Turkey (Izmir) is the cause of an ongoing loss of natural habitats to urbanisation, even though in return the delta is now appreciated by many city-dwellers in search of nature.

The site is very important for waterbirds, in winter as well as in the breeding season, with numbers that are significant at the global scale for several species of gulls, terns and waders, ducks, herons and cormorants, as well as Greater Flamingo. The presence of globally

4: In particular, the "Conservatoire du Littoral" (French coastal protection agency), the "Association des Amis du Vigueirat" (friends of the Vigueirat marsh association), the "Parc Naturel Régional de Camargue" (the Camargue Regional Natural Park), the "Syndicat Mixte pour la protection et la gestion de la Camargue gardoise" (joint association for the protection and management of the Camargue gardoise), the "Office National de la Chasse et de la Faune sauvage" (ONCFS - French national office for hunting and wildlife), the "Ligue pour la Protection des Oiseaux" (LPO - Bird protection society), and the "Parc ornithologique de Pont de Gau" (Pont de Gau ornithological park).

5: These counts are coordinated by various NGOs: the Society for the Protection of Prespa (SPP), the Hellenic Ornithological Society (HOS), the Bird Study and Protection Society of Macedonia (BSPSM) and the Preservation and Protection of Natural Environment in Albania (PPNEA).

threatened species, including the Dalmatian Pelican, Red-breasted Goose and Lesser Kestrel, is noteworthy.
A wildlife reserve extending over 8,000 hectares was created in 1980 and includes part of the coastal lagoons as well as the salt pans, which flamingos in particular use for breeding. Part of the delta (15,000 ha) has been awarded the Ramsar label.

↗ *A mosaic of natural habitats and farmland, both wet and dry, the Gediz Delta supports a diverse range of bird communities, which are becoming increasingly well-known and studied (© Hellio & Van Ingen).*

Although bird counts have been carried out since the 1980s for some species of waterbirds, they have only included the whole of the delta since the beginning of the 1990s, undertaken by the NGO Doğa Derneği and by a team of scientists from the University of the Aegean at Izmir[6]. An ambitious breeding bird atlas project has been in progress since 2002 over the whole of the area, by the same team. Eventually it has proved possible to obtain a considerable number of time series – 116 time series for breeding birds (114 species), and 95 for wintering birds (74 species) – but over a short period of time (10 years).

> The Aammiq marshes

Aammiq is one of the last 5 "big" wetlands in Lebanon, although today it only occupies a residual area of 280 ha. It constitutes a veritable oasis in the middle of a valley that has undergone intensive urban and agricultural development. The site is maximally flooded in February-March due to winter rains and snowmelt. On the other hand, most of the marsh is dry in autumn. The marshes consist of extensive reedbeds interspersed with areas of open water and grazed wet grassland. Fragments of maquis and riparian woodland can still be seen in certain places, but the wetland is mainly surrounded by farmland. The threats affecting the site remain very serious. Water is diverted or pumped directly on the site for agriculture. Until the recent measures undertaken by some landowners (in particular the Skaf family) and the NGO A Rocha-Lebanon, these practices were causing the complete drying out of the marsh from the summer onward. To allow grazing by large herds of goats, the reedbeds are burnt, to the detriment of marsh birds. Hunting is one of the major pressures on birds, as Aammiq is one of the four most popular hunting areas in Lebanon. Little notice is taken of protection laws and excessive numbers are killed.
Aammiq is a typical Middle Eastern wetland: small and much degraded, it is nevertheless extremely important for biodiversity. It is situated on one of the busiest migration routes in the world, with globally important numbers of storks and raptors. Globally threatened species, such as Spotted and Imperial Eagles as well as Lesser Kestrel make regular stopovers here.
Thanks to the involvement of A Rocha since 1996 and the Skaf family, Aammiq was designated as a Ramsar site in 1999, and then as part of the *Al Shouf Cedar* Biosphere Reserve by UNESCO in 2005. A process to list it as a national reserve is in progress.

Despite the existence of some field programmes and bird censuses since the 1970s, it is only since the late 1990s that more regular monitoring of the birdlife and other taxonomic groups has been put in place. A Rocha and the *Society for the Protection of Nature in Lebanon* have undertaken this monitoring. It has been possible to obtain a total of 227 time series corresponding to as many species of birds, which is truly remarkable. On the other hand though, the time period covered is very short (1998-2008).

↗ *The Aammiq marshes constitute one of the last remaining major wetlands in the Middle East and are an obligatory staging post for very large numbers of migrating birds (© L. Chazée – Tour du Valat).*

6: Department of Biology/Museum of Natural History, the Union for the Conservation and Development of Izmir Bird Paradise.Izmir Regional Directorate of Nature Protection and National Parks also contribute to the ornithological monitoring of Gediz delta.

2. CONSERVATION STATUS AND TRENDS AMONG SPECIES: WHAT IS THE ASSESSMENT?

2.1 GENERAL ASSESSMENT

The Mediterranean basin is one of the planet's principal centres of endemism. In addition to the thousands of endemic species, species with a wide range of affinities are also found here: Euro-Siberian, Asiatic, and African. The result is a very high level of species richness. Some 2,500 species of vertebrates have been recorded and up to 10% of the world's vascular plant species, in a land area barely 1.6% of the earth's surface! For biogeographical reasons, Egypt, Israel, France and Spain are among the countries that support the basin's most diverse communities of species associated with wetlands (Fig. 3A)[7].

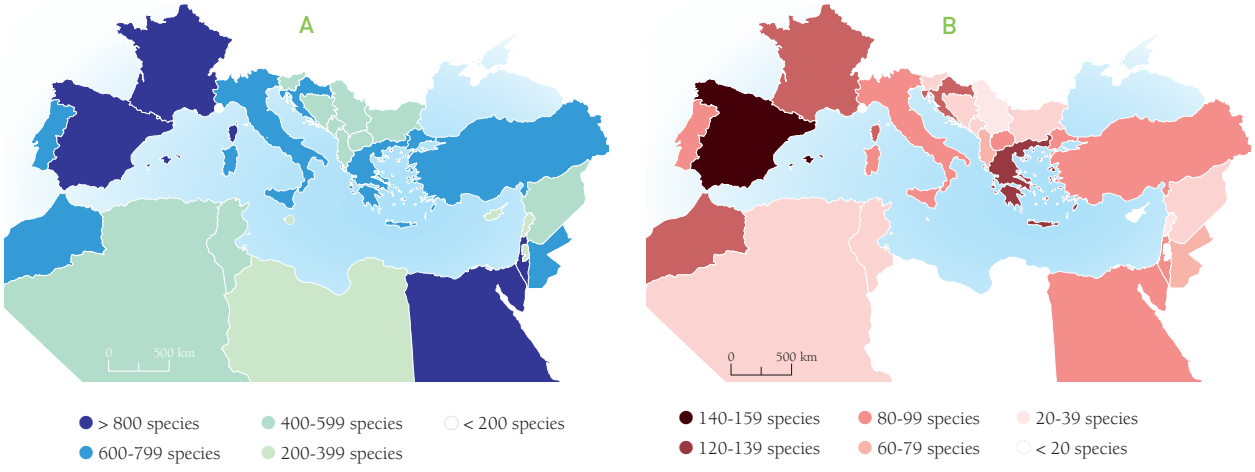
The Mediterranean region is also remarkable for its high number of species threatened with extinction. Of the 2,983 species living in the basin's wetlands and evaluated by the Red List of the International Union for the Conservation of Nature (IUCN), 896 – that is almost one species in three – are at risk of disappearing completely in the next few decades. In general, the countries with the highest numbers of endemic species also have the highest numbers of threatened species, since most of these species have a restricted range and numerically small populations. In this respect, Spain, Greece, France, Croatia, Morocco, Turkey, Israel and Italy, which each support more than 10% of the wetland endangered species, have a particular responsibility for safeguarding Mediterranean wetland biodiversity (Fig. 3).

While the conservation status of species is increasingly well known, our knowledge of the dynamics of their populations is still very fragmentary. Although they only represent a minimal proportion of the whole of biodiversity, vertebrates are still the best-known organisms, the populations of some species having been monitored for several decades. This is particularly true for birds: charismatic, easy to count, and attracting the interest of tens of thousands of enthusiasts.

The Living Planet Index (LPI) has shown a generally stable trend for vertebrate populations between 1970 and 2006 (Fig. 4). However, a stable index does not mean that

Figure 3 :

Number of wetland species (A), and number of endangered species (B) in each Mediterranean country according to the IUCN Red List.

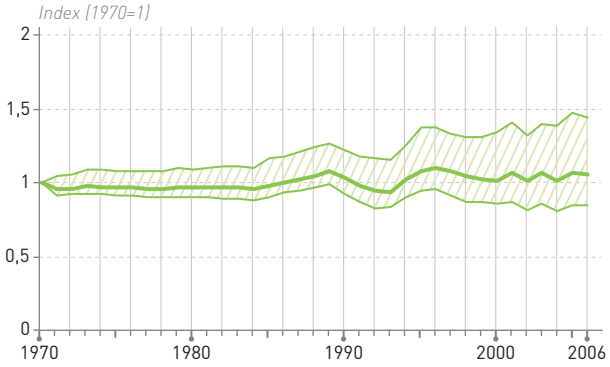


7: *In accessing the IUCN Red List of Threatened Species database (http://www.iucnredlist.org/), selection criteria have been applied for "Habitats" so that only those species inhabiting wetlands according to the IUCN experts were selected. In the context of our study, we have considered wetlands to include all the habitats included in the IUCN habitat classification categories "Wetlands – inland", "Marine Intertidal", "Marine Coastal/Supratidal", "Artificial Aquatic/Marine" and, in the category "Marine Neretic", the sub-categories "Coral reef" and "Estuaries".*

Mediterranean wetlands are in a good state of conservation. In 1970, when the LPI starts, Mediterranean vertebrate populations were already at low levels of abundance; a stable index signifies that although the decrease has not continued, no overall improvement has taken place since then.

Figure 4 :

Living Planet Index for Mediterranean wetlands (60,000 time series, involving 467 vertebrate species.The hatched area shows the confidence intervals).



The overall trend in the LPI for the Mediterranean hides some differences between taxonomic groups: bird populations have increased noticeably (about 70%) since 1970, while other vertebrates – mammals, amphibians, reptiles, and fish – have decreased on average by 40% (Fig. 5). These differences between taxonomic groups can also be seen in their conservation status. Within communities of wetland species, birds have the lowest proportion of threatened species (5%) of all the groups evaluated by the IUCN. This proportion varies from 12% among Odonata (dragonflies) to 47% among molluscs (Fig. 6).

Figure 5 :

Mediterranean wetland Living Planet Indices for birds (green) and other vertebrates, i.e. fish, amphibians, reptiles and mammals (orange).

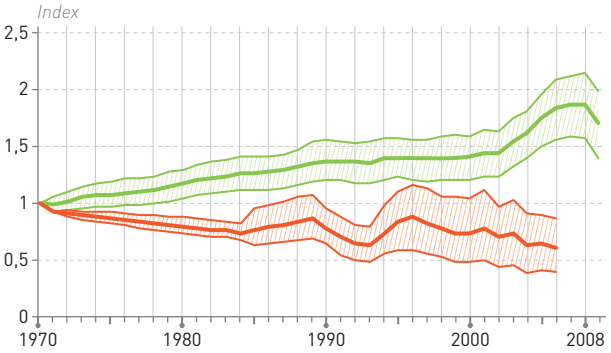
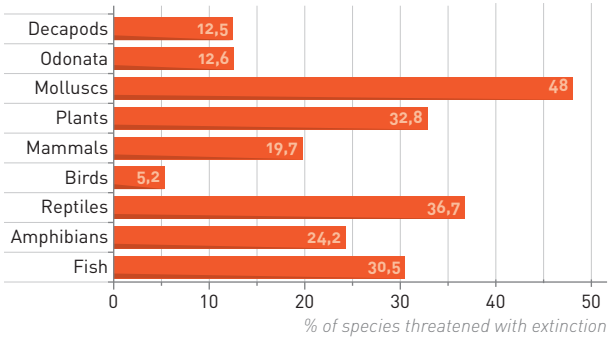


Figure 6 :

Proportion of species threatened with extinction in wetlands in Mediterranean countries by taxonomic group.



What is the Living Planet Index?

The LPI, which is promoted by the WWF, has become an international synthetic indicator that measures changes in the state of health of biodiversity over time, based on demographic variations in populations of mammals, birds, reptiles, amphibians and fish species (Loh *et al.*, 2005). A trend is calculated for each species, then these are aggregated and averaged to form an index. The year when the index began (for example 1970) is automatically assigned the reference value 1, and the changes relate to this value: greater than 1, biodiversity has increased; between 0 and 1, it has decreased.

Trends for 60,000 populations involving 464 species of vertebrates have been collected so far, mainly in the context of studies carried out by environmental NGOs, scientists, and wetland managers. The accessibility of these data is variable. Some monitoring results are published online or on paper, others remain private. Existing and future partnerships between the MWO and data collectors should help to facilitate the sharing of these raw data.

In line with the index methodology, the choice of species does not take into account their geographic distribution or their taxonomy. Birds are correspondingly over-represented in our database, while they only account for one third of the diversity of vertebrates in the Mediterranean. To counteract this bias, the LPI for Mediterranean wetlands is an aggregate of two indices: the LPI for birds, and that for mammals, reptiles, amphibians, and fish, which are given different weightings (1 and 2 respectively).

2.2 BIRDS

More birds in Mediterranean wetlands than 40 years ago

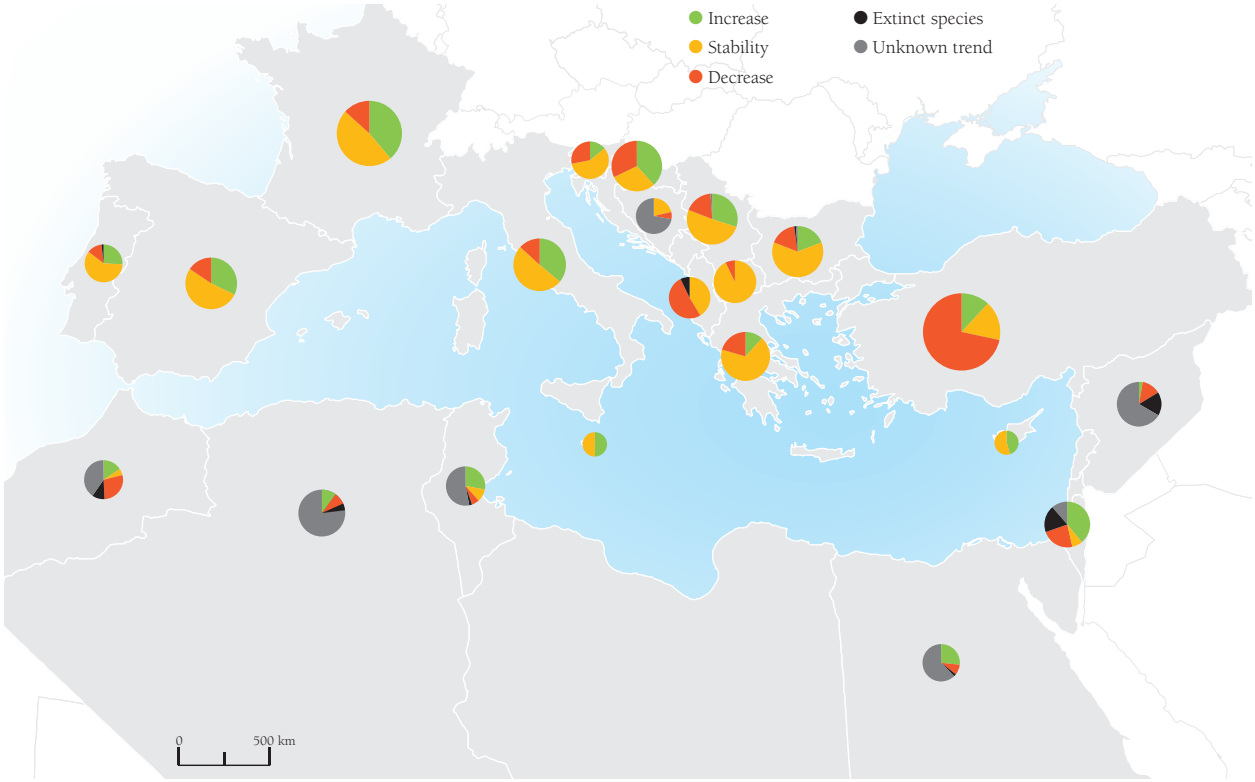
Around 600 species of birds are regularly recorded in Mediterranean countries, of which at least a third depend on wetlands, mainly ducks, geese, herons, waders, gulls, and terns. The diversity of waterbirds is similar across the whole of the Mediterranean basin, although the avifauna of North Africa and the Middle East is enriched by a number of species originating in the tropics or in Central Asia. The diversity of bird communities is greatest close to large permanent waterbodies and estuaries.

Numbers of waterbirds at Mediterranean wetlands have increased since 1970 (Fig. 5). At first sight, this finding is quite positive: several species with major conservation problems of which the numbers had previously declined have undergone remarkable increases: Dalmatian Pelican, Greater Flamingo, White-headed Duck, Purple Gallinule, Audouin's Gull, White-tailed Eagle. However, can the increase in the index be generalised to all species of waterbirds? The answer is negative if the national trends are to be believed (Baumgart, 1995; Birdlife International, 2004; Isenmann & Moali 2000; Isenmann *et al.*, 2005; Shirihai, 1996; Thévenot *et al.*, 2003). They show that in some countries half of nesting waterbird species have been in decline since 1970 (Fig. 7). The rise in the "waterbirds" LPI is therefore most probably due to a very strong increase in numbers of a minority of species, rather than an overall improvement in the conservation status of all species.

The Dalmatian Pelican is a globally threatened species whose already low numbers continue to decline. However, conservation measures have enabled a significant increase to take place in the Mediterranean population (© Z. Dindar & T. Gümüş).

Figure 7 :

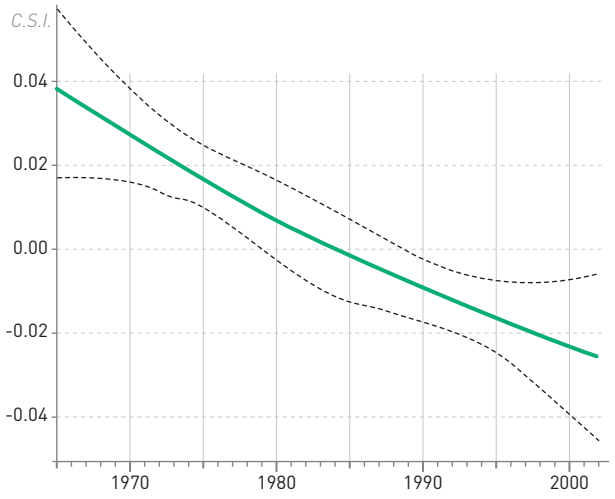
Trends in nesting waterbirds since 1970 by country. The size of the circle is proportional to the number of species of nesting birds, which is highest in Turkey, and lowest in Malta and Cyprus.



The Community Specialisation Index (CSI) shows that since 1970 the bird communities of Mediterranean wetlands have been increasingly dominated by generalist species, with a corresponding decrease in specialist species (Fig. 8). Birds qualifying as generalists are able to exploit a wide range of habitats, and are therefore able to adapt to the transformation or degradation of the wetlands they inhabit. In contrast, specialist bird species can only occupy a single habitat type – such as, for example, reedbeds or wet grassland – and do not have the ability to move to other habitats: their populations therefore decline as their habitats decrease or are degraded. Even though the LPI shows that populations of waterbirds have generally increased over the last forty years, the fall in CSI suggests that it has been mostly already common generalists that have increased. In fact, of the species that have increased strongly, many are widely distributed outside the Mediterranean region: Great Cormorant, Cattle Egret, Great Egret, Grey Heron, Mute Swan, and Greylag Goose. On the other hand, of those that have declined the most over the last 40 years, the majority are species for which the Mediterranean countries are highly responsible, as they support a significant proportion of their global numbers: Purple Heron, Marbled Duck, Collared Pratincole, and Gull-billed Tern.

Figure 8 :

Changes in the Community Specialisation Index (CSI) for birds in Mediterranean wetlands since 1970. .



What is the Community Specialisation Index (CSI)?

Synthetic biodiversity indices, such as the Living Planet Index, provide information about the general trends affecting species or groups of species. However, their interpretive value is often limited, shedding no light on the causes of the trends observed. The Community Specialisation Index defined by Julliard *et al.* (2006), evaluates whether the changes in biodiversity are directly linked to changes in land use. Birds, which are the best studied component of biodiversity, are used as models.

A Specialisation Index has been calculated for each species, reflecting its degree of habitat selectivity. Species which can use a wide range of habitats (e.g. Grey Heron) have a low specific index of specialisation, while species that are more demanding in their choice of habitats (e.g. Eurasian Bittern, confined to reedbeds) have a higher index. The CSI is the average of the specific specialisation indices for all the bird species monitored at Mediterranean wetlands. Where the data exist, it is possible to weight the indicator according to the relative abundance of the species in the community.

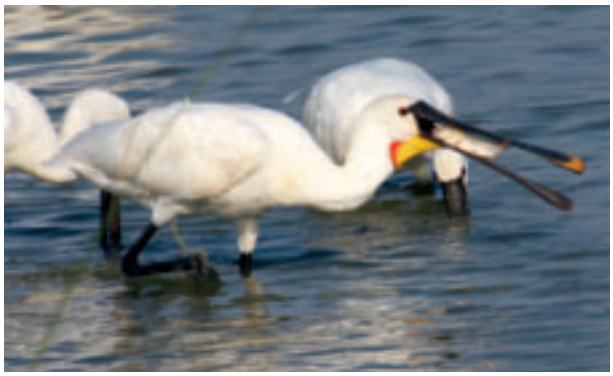
A west/east contrast

The status and trends among population of waterbirds differ between sub-regions and countries in the Mediterranean (Fig. 9): some countries, mostly situated in the western Mediterranean, show an increase in their waterbird LPI from 1970 to 2008. Conversely, the countries in the eastern part of the basin show stable or declining indices over the same period. In the west, waterbird populations have increased more in the north than in the south. For a high number of species (e.g., herons, Glossy Ibis and Spoonbill) large populations have become established in Spain, France, and Italy, a trend which has been noticed more recently in North Africa. In contrast, numbers of waterbirds are decreasing in several countries in the eastern Mediterranean: Lebanon, Cyprus, Albania, FYR of Macedonia, Bulgaria and Greece. Another source of information (Birdlife, 2004) highlights the particularly worrying situation in Turkey, where a majority of breeding species are in decline (Fig. 7). For some countries in the region, it is difficult to evaluate the trends in waterbird populations because of a lack of regular monitoring (Egypt, Bosnia-Herzegovina, Syria, Jordan and Libya). The declining trend recorded in many parts of the eastern Mediterranean is worrying, as many species are concentrated here, the western Mediterranean only playing a minor part in their conservation (Galewski *et al.*, 2011).

Does this west/east contrast simply reflect differing changes in the local habitat conditions encountered by the birds? Probably not. Winter quarters in the west and east of the Mediterranean are used by birds originating in different areas. In the west, the migrating birds come

Ibis falcinelle (© M. Thibault).

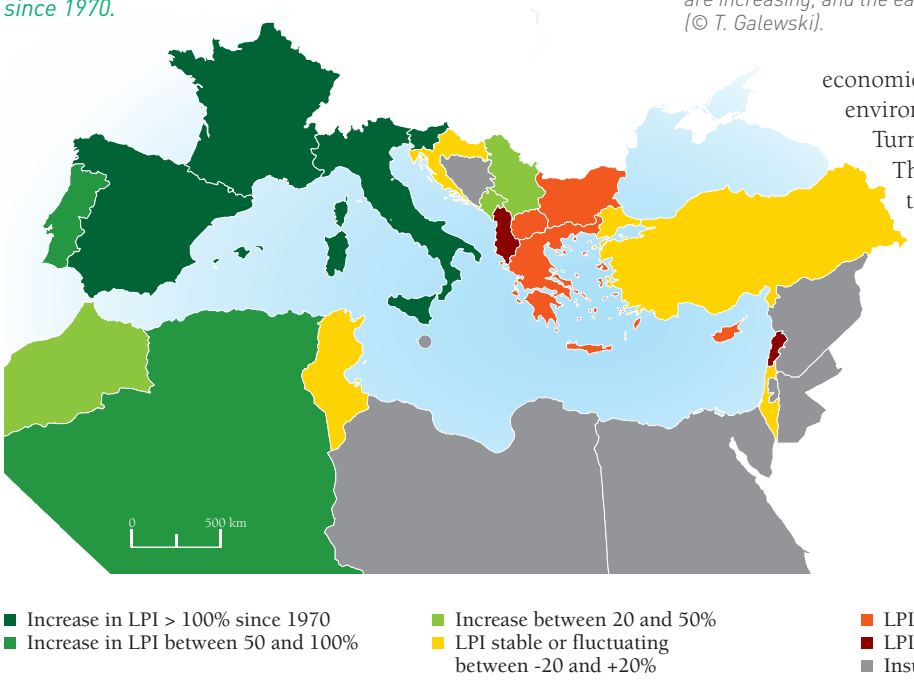
mainly from northern European countries (the British Isles, Scandinavia, Germany and Benelux), where effective protection measures have been in force for at least a few decades. The re-establishment of waterbird populations in these countries has enabled recolonisation or recovery to take place in the Mediterranean countries, as has been proven for several species (e.g. Grey Heron, Great Egret and Great Cormorant). Meanwhile, in the east, migratory birds nest in and travel through regions – eastern Europe, the Black Sea area, and the countries of the former USSR – where environmental conditions have deteriorated considerably over the last few decades following rapid economic development and inadequate environmental regulations (Carter & Turnock, 2002; Young *et al.*, 2007). These adverse conditions are likely to have accentuated the decline in waterbird populations in the eastern Mediterranean.



↗ *In common with a number of other waterbirds, spoonbills show different dynamics in the western Mediterranean, where they are increasing, and the east, where they are in decline (© T. Galewski).*

Figure 9 :

Changes in the "waterbirds Living Planet Index" by country since 1970.



2.3 FISH

Although they are by far less studied than birds, fish are nevertheless a highly varied group with a wealth of endemic species. Over 1,000 indigenous species are known in the Mediterranean countries about half of which live in inland wetlands (IUCN Red List database). In addition, a large number of marine species, more difficult to estimate, are also found in coastal wetlands: lagoons, estuaries, and shallow coastal waters.

Critical conservation status, a reflection of the degradation of Mediterranean watercourses

The species diversity of freshwater fish is highest in permanent aquatic ecosystems, primarily watercourses and lakes. It follows that fish communities are accordingly more diverse in countries that are richly endowed with hydrographic basins: thus, more species are present in southern Europe than in the Middle East or North Africa. Turkey, Croatia, Greece and Bulgaria have particularly high numbers of species, close to or exceeding a hundred. On the other hand, the Iberian Peninsula, northern Italy, the Balkans, the catchments of the Orontes and Jordan rivers (Turkey, Lebanon, Syria and Israel) and northern Morocco are notable for their high numbers of endemic species.

The conservation status of freshwater fish gives cause for grave concern, with 40% of the total number of species heading for extinction; this figure reaches 60% for species endemic to the Mediterranean basin (Smith & Darwall, 2006). At least 11 species have already disappeared, even more if one includes those that no longer exist in the Mediterranean region but are still present elsewhere. At least

60 other species might disappear completely in just a few years. This situation is a reflection of the advanced state of degradation affecting most of the rivers and lakes in the region. For example, the Nile, which supports a rich fish fauna that is unique due to its sub-Saharan affinities, has lost 21 species in recent decades.

↗ *Aphanius sirhani* is endemic to the oasis of Azraq in Jordan. This fish is in critical danger of extinction, due to overextraction of water, which has dried out the wetland, and the introduction of Tilapia that compete with *Aphanius* (© N. Hamidan).

The main problems today are found in hydrographic basins and freshwater lakes that are rich in threatened endemic species. Particularly noteworthy are the basins of the Tagus (Spain, Portugal), and the Neretva (Bosnia-Herzegovina, Croatia), as well as lakes Kinneret (Israel) and Prespa (Greece, Albania, and FYR of Macedonia).

Degradation of lagoons is harmful to marine fish

Of the 519 species that are native to the Mediterranean sea (more if the Atlantic, Black Sea, and Red Sea coasts of Mediterranean countries are included), many marine fish species extend into coastal wetlands. These habitats play an important role as nurseries, allowing young individuals to grow in environments that are rich in food and relatively free of predators. Coastal lagoons, estuaries, and the macrophyte beds found in shallow coastal waters are particularly important. The conservation status of Mediterranean marine fish is still poorly understood. However, current studies suggest that their situation is less critical than for freshwater fish. Most of the species threatened with extinction are pelagic species, which are suffering from overfishing and do not use wetlands - sharks, rays, tuna - (Abdul Malak *et al.*, 2011). Nonetheless, the worrying conservation status of several species of diadromous fish[8] (e.g. sturgeons, European Eel, shads), as well as several species of gobies *Pomatoschistus spp.* and Syngnathidae, sedentary species of coastal lagoons, suggest that the environmental conditions experienced by marine fish in the wetlands have deteriorated.

↗ *The degradation of coastal lagoons and by-catches could eventually threaten populations of the Maned Seahorse (© T. Galewski).*

2.4 AMPHIBIANS

Victims of the disappearance of smaller wetlands

Very much associated with aquatic habitats, at least while breeding and during their larval stages, salamanders, newts, frogs and toads constitute a good indicator of the ecological condition of wetlands, especially those that are of smaller size and/or temporary. In this respect, they form a complement to birds and fish. There are 119 species of amphibians indigenous to the Mediterranean countries, two-thirds of which are endemic. Their diversity is much higher in southern Europe (88 species) than in North Africa (23), and the Middle East (36). In decreasing order, Italy, Spain, France and Turkey are the countries supporting the highest numbers of species. The conservation status of amphibians gives particular cause for concern as 30% of Mediterranean species are threatened with extinction. Threatened species are found

↙ *The Natterjack Toad is well distributed over a large part of Europe. In view of the severe declines that have been recorded in the northern part of its range, the large populations in the south of France and the Iberian peninsula play a key role in the conservation of this species (© D. Cohez).*

all around the Mediterranean basin, though there are slightly more in Turkey and Italy (Cox *et al.*, 2006). For example, on the island of Sardinia alone, there are five endemic species of Urodela that are threatened with extinction. Many endangered amphibians are associated with smaller wetlands (streams and ponds).

8: A diadromous fish species makes alternative use of freshwater ecosystems (rivers for example) and marine waters, according to its breeding cycle. The eel breeds in the sea but develops to maturity in fresh water, while salmons do the opposite.

2.5 OTHER VERTEBRATES

The mega fauna has been largely eradicated from Mediterranean wetlands, following in the footsteps of the hippopotami and crocodiles, which used to live in the Nile delta (© S. Veyrunes).

Endemic species that have become very rare

Mammals and reptiles are both very diverse groups in the Mediterranean, with 356 and 279 species respectively (Temple & Cuttelod, 2009; Cox *et al.*, 2006). Most species can be found close to wetlands, but these habitats are only important for a minority of them. The Spanish or Iberian Lynx has one of its last two refuges in the delta of the Guadalquivir, while the brackish marshes along a narrow coastal band straddling Egypt and Libya play a crucial role in the survival of the Four-toed Gerboa. In this connection, we note the particular importance of dune habitats, located between lagoons and the sea, for many species of rodents, lizards, and skinks.

Some species have developed aquatic habits, including the water voles *Arvicola spp.*, the water shrews *Neomys spp.*, the European Otter and the Eurasian Beaver among mammals, as well as some grass snakes *Natrix spp.*, terrapins and marine turtles among reptiles. In the past, Hippopotamus used to haunt the Nile delta, until it disappeared there in the 15th century. The Nile Crocodile has also very much declined, but still exists in the Egyptian part of the river. Some 20% of mammals and 37% of reptiles inhabiting wetlands are threatened with extinction, mostly those associated with watercourses and coastal saltmarshes.

2.6 INVERTEBRATES

The Dark Emerald Damselfly is a species of dragonfly that is threatened in some part of its breeding range as a result of the disappearance of its favoured habitat, temporary marshes with sea club-rush (© D. Cohez – Tour du Valat).

An underestimated reservoir of biodiversity

Invertebrates undoubtedly constitute the greatest proportion of the biodiversity of wetlands, but are also the least known. Only 3 taxonomic groups have received recent studies of their conservation status in the Mediterranean region: the Odonata (dragonflies), freshwater decapods (crabs and crayfish, of which there are few species in the region), and freshwater molluscs (Garcia *et al.*, 2010; Riservato *et al.*, 2009). For this last group, only North Africa has been subject to a thorough study.

The 165 species of dragonflies and damselflies in the Mediterranean countries occupy a wide diversity of freshwater wetlands. Together with the butterflies, they are one of the few groups of insects whose conservation status and trends are well known, largely because they have received the attention of many enthusiasts. Watercourses are the favoured habitat for many species, drainage or irrigation channels sometimes providing good substitutes for these habitats. As with many aquatic groups, more species are found on the northern side of the Mediterranean basin, where hydrographic basins are more numerous. Italy is the country with the highest species diversity, which is explained by the presence of alpine species in the north and North African species in the south. France, Greece, Tunisia and Turkey also have rich dragonfly communities. Like for most flying organisms that are able to disperse for long distances, there is only a relatively low level of endemism (14%), which is, however, more pronounced in the Maghreb and the Middle East. 19% of dragonfly species are threatened with extinction at the regional scale; these species may be seen throughout the region, but especially

in Greece, north-west Algeria, and the Middle East as far as southern Turkey. Recent analysis of their conservation status reveals that three categories of Odonata are particularly at risk: tropical African species of which a few relict populations have survived in North Africa following the desertification of the Sahara, boreo-alpine species, confined to cooler habitats such as high-altitude bogs and streams, and the Mediterranean endemics.

Springs and snails: co-evolution in peril

Among the molluscs, two classes have been better studied in freshwater wetlands: the gastropods (snails and slugs) and the bivalves (e.g. mussels). They reveal a very wide diversity, with over a thousand species. They are well-represented in the permanent waters of watercourses and still water bodies, but also in springs and subterranean waters. There is a high degree of endemism mainly involving the snails of the family Hydrobiidae, which have poor capacities for dispersal, and are often known only from a single underground spring or a single well. Several species that inhabit surface waters also have ranges that are limited to a single hydrographic system, notably the pearl mussel *Margaritifera marocana*. In North Africa, the mountainous regions of the Atlas (Morocco) are real biodiversity "hotspots", rich in endemic aquatic molluscs. Although there is a wide diversity of species, the molluscs of the Nile have Afro-tropical affinities and so are widely distributed elsewhere in Africa. As the underground species with limited ranges constitute a significant proportion of the community, the conservation status of aquatic molluscs is correspondingly very unfavourable in the Mediterranean. In the Maghreb, 55% of species are at risk of extinction in the near future (Van Damme *et al.*, 2010). Over 20 species formerly present in the Mediterranean countries have already disappeared from the surface of the earth, a figure that could be a wide underestimate as many species have not been collected for more than a century, but are not yet officially considered to be extinct because of a lack of surveying.

The majority of wetland species are invertebrates. With the exception of some favoured groups, such as the Odonata and freshwater crustaceans, little or nothing is known of their conservation status (© T. Galewski).

2.7 AQUATIC PLANTS

Centres of endemism in the North African mountains

This Starfruit is an aquatic plant that is endemic to the area surrounding the Mediterranean. Losses of its habitat – temporary pools – have greatly fragmented its range and today the species is threatened with extinction (© D. Cohez – Tour du Valat).

Corresponding to the wide diversity of wetlands, there is also a great diversity of aquatic plants. An evaluation of their conservation status in North Africa (Rhazi & Grillas, 2010) included 645 species, about one-third of which are endemics and many are relics of the ice age, which only survive in the Mediterranean area, often in mountains, thanks to the presence of an aquatic environment, which limits the effects of the temperature and aridity of the climate. The principal habitats on which these species depend include temporary or permanent marshes and rivers, temporary pools, lakes, and bogs.

As for most other taxonomic groups, the diversity of aquatic plants is influenced by climate and biogeography. Rainfall and the size of the catchment areas determine the area of wetland and thus the diversity of species. In North Africa, the richest areas are accordingly the north of the Maghreb and the lower Nile valley. The importance of the mountainous areas of Morocco, Algeria, and Tunisia for aquatic plants should be stressed; here they are well-represented at smaller wetlands. In addition, it is these regions which support the highest number of endemic and threatened species (24% of aquatic plants are endangered in North Africa as a whole).

The recent report on important plant areas (IPA) in the southern and eastern Mediterranean (Radford *et al.*, 2011) reveals a conspicuous presence of wet habitats among the sites which have a high priority for conservation if the diversity of the Mediterranean flora is to be preserved. This is particularly true in Algeria, Tunisia, Libya, Egypt, Israel, and Syria. Among the wetland sites that are important for plants, we mention the Garâa Sejenane bog and the riparian woodland of the Ziatine wadi (Tunisia), several lakes in the Nile delta (Egypt), and the relict wetlands of the Hula valley (Israel), points where Mediterranean and tropical species meet.

3. WHY HAS THERE BEEN SUCH A RECENT CHANGE IN BIODIVERSITY?

3.1 THE UNDERLYING CAUSES OF THIS CHANGE

Wetland species are directly threatened by the disappearance and degradation of their habitats or excessive hunting, fishing, or harvesting. However, a recent study (MWO, 2012) highlighted the fact that these pressures are the result of deeper causes, which are acting at a national, Mediterranean, and even world wide scale.

The Mediterranean region, which is already densely populated, is experiencing strong demographic growth, particularly in countries in North Africa and the Middle East (Fig. 10 A & B). Most people – including the significant seasonal flow of tourists – are concentrated in the coastal zones and river valleys, precisely where there are the biggest wetland areas. The increasing human population has resulted in the more rapid conversion of the natural habitats into urban and agricultural zones, as well as in the over-use of the remaining natural areas. In addition, demand is higher for the hydric and biological resources which are used to meet the vital needs of local communities and tourists.

Demographic growth is greatly responsible for the decline in biodiversity when the development models chosen by governments directly impact species and the ecosystems upon which they depend. Developing countries are strongly affected because their economies are greatly based on agriculture and industry, which have a strong impact on wetlands, especially when waste and water management systems are inadequate.

The origins of the biodiversity erosion are also to a large extent political. Wetlands are not given the attention they deserve on the political agenda, and the implementation of laws and strategies to protect them has remained quite limited. As a result, there is often a lack of coordination between the conservation and development sectors, which often means that wetlands are not taken into account in economic development projects. When wetland protection laws do exist, they are not often well applied, particularly in poorer countries where there are insufficient financial and human resources. On the other hand, land-use planning processes are segmented between protected and unprotected areas, that sometime leads to conflicts between local communities and the institutions in charge of protected areas.

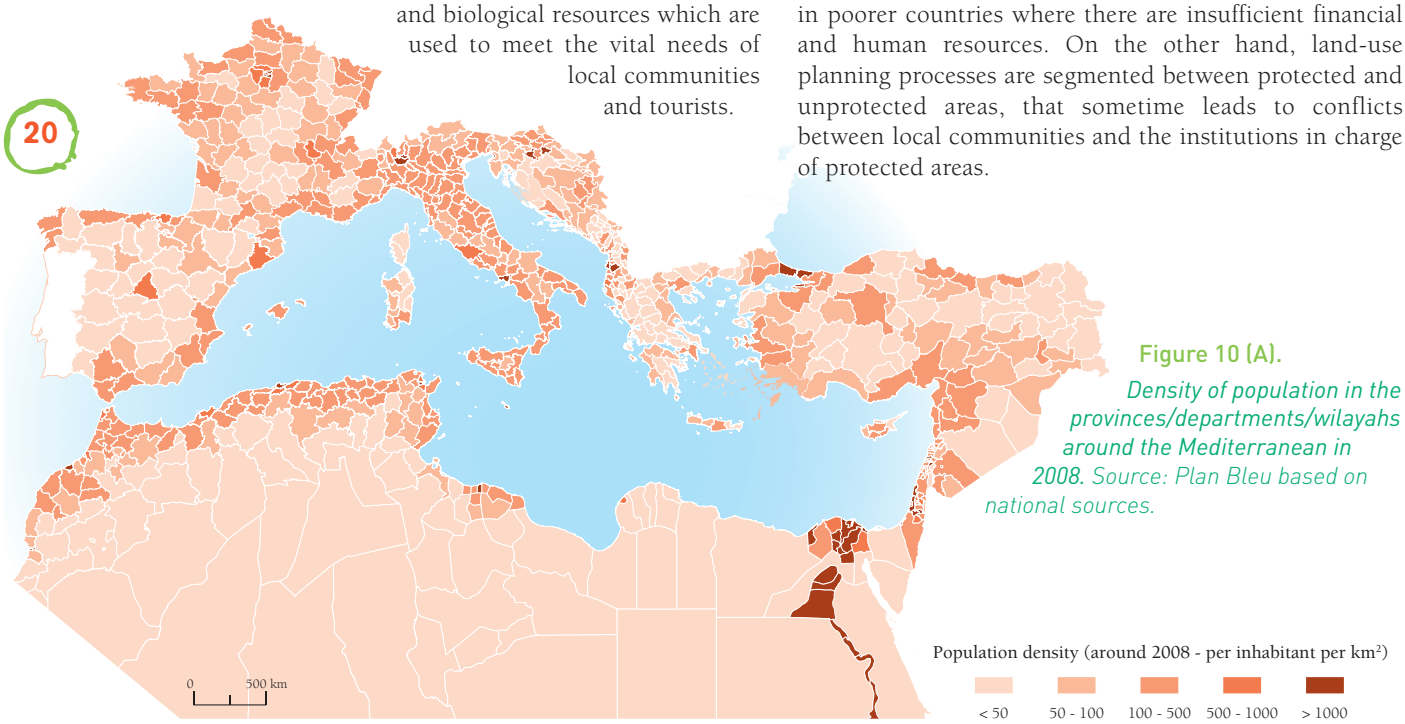
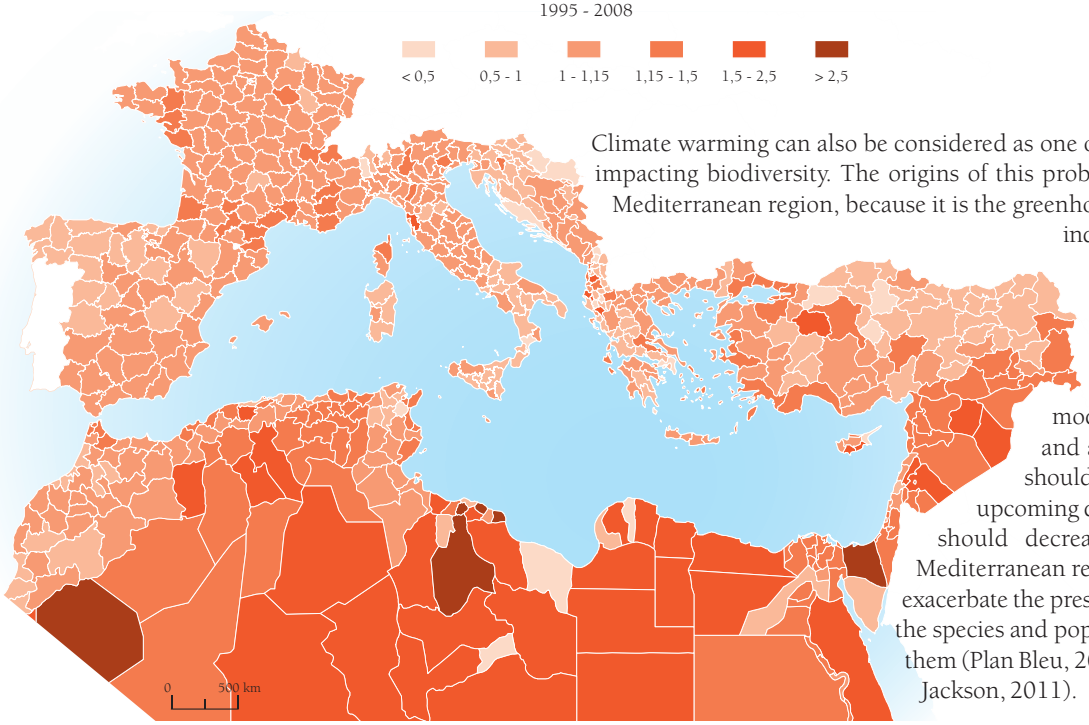


Figure 10 (A).
Density of population in the provinces/departments/wilayahs around the Mediterranean in 2008. Source: Plan Bleu based on national sources.



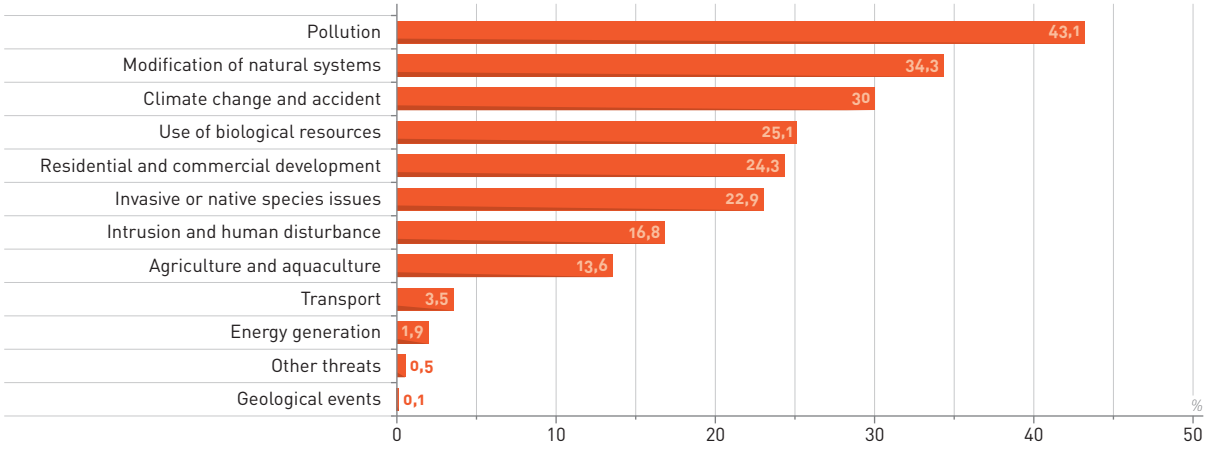
Climate warming can also be considered as one of the underlying causes impacting biodiversity. The origins of this problem are not only in the Mediterranean region, because it is the greenhouse gases emitted by all industrialised countries that are responsible for the world-wide increase in temperature. Climate warming has lead to a spatial and temporal modification of precipitation and a rising sea level, which should change even faster in the upcoming decades. Water resources should decrease even more in the Mediterranean region, which will further exacerbate the pressure on wetlands and on the species and populations that depend on them (Plan Bleu, 2009; Guardiola-Albert & Jackson, 2011).

Figure 10 (B).
Demographic growth around the Mediterranean between 1995 and 2008. Source: Plan Bleu based on national sources (the coefficient is the factor by which the population of a given district increased between 1995 and 2008).

3.2 DIRECT PRESSURES

Water pollution due to discharges from agricultural, domestic and industrial sources is the pressure that affects the biggest number of species (43%) in wetlands located in Mediterranean countries (Fig. 11). The modification of natural systems, mainly stemming from the excessive withdrawal of groundwater and the construction of dams, appears as the other most important pressure (34%). Combined with the conversion of wetland ecosystems into urban areas (24%) and agricultural zones (14%), these threats have been contributing to the loss and degradation of the habitats of thousands of plant and animal species. What used to be the leading cause of species decline, the over-exploitation of biological resources – especially fishing – now threatens approximately 25% of species. Invasive plants and animals represent a significant problem for about the same proportion of species. The over-use of certain sites for recreational purposes has also had a negative impact on 17% of the species evaluated. Finally, today climate change would appear to be one of the principal threats to the biodiversity of aquatic Mediterranean ecosystems (30%), particularly because it results in extreme climate events such as droughts and floods, which are increasingly frequent and severe.

Figure 11.
Principal threats to species in Mediterranean wetlands according to the IUCN Red List (www.iucnredlist.org).



3.2.1 Pollution

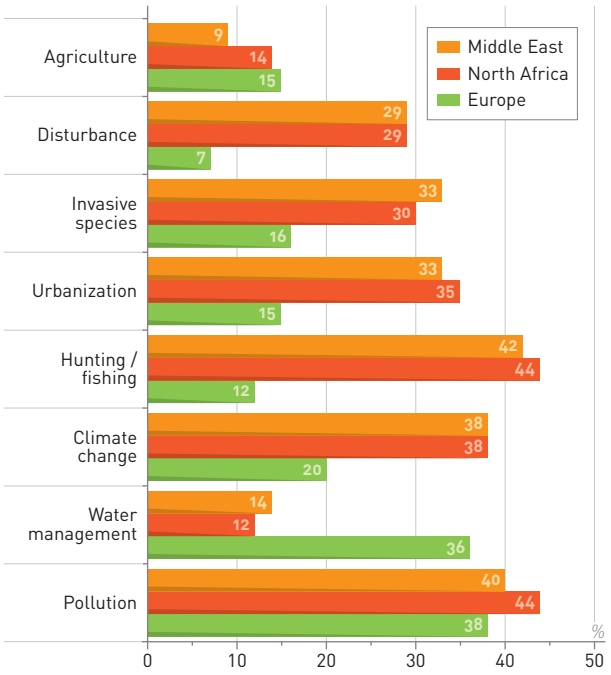
Visible and invisible pollution

Two principal categories of pollution affect wetlands and wetland species: solid waste and water soluble substances. The volume of waste produced has continuously increased over the past decades, in parallel to economic development. Those living to the north of the Mediterranean produce much more waste than those to the south of it, but they also have a much more efficient system for collecting, treating and eliminating waste (Plan Bleu, 2009). In the countries to the south of the Mediterranean and in parts of the Balkans, a high percentage of the garbage produced is disposed of in illegal dumps, which are often wetlands, or in the sea. Beyond its physical impact on natural habitats, the waste dumped in wetlands causes problems in terms of contamination of the soil as well as of surface water and groundwater.

Water quality is greatly influenced by agriculture (nitrates and pesticides), industry (heavy metals, PAHs[9], and PCBs[10]), and domestic wastewater (phosphates). Water pollution is an important threat to most taxonomic groups, particularly to organisms that spend at least one part of their life cycle in an aquatic environment, such as fish, amphibians, dragonfly, molluscs and aquatic plants. In Europe, water quality has considerably deteriorated during the 1950s and 60s, as it is the case in all developed countries (Giller & Malmquist, 1999; Pourriot & Meybeck, 1995). Nitrates are, however, a smaller source of pollution in the Balkans due to the lower use of fertilisers in agriculture and the higher amount of precipitation (dilution effect). Fertiliser consumption in Mediterranean countries of the European Union (EU) is still 5 to 6 times higher than in non-EU countries in the basin, with a few exceptions such as Turkey and Egypt (Mediterra, 2009). Nonetheless, water pollution is still one of the major threats to biodiversity in the eastern and southern parts of the Mediterranean basin (Fig.12).

Figure 12.

Threats facing wetland species by Mediterranean sub-region: Middle East, North Africa and Europe[11]



Eutrophication modifies aquatic ecosystems

Eutrophication occurs when aquatic environments receive excessive amounts of nutrients (nitrates and phosphates). It is characterised by the increased algal growth, which leads to the exhaustion of the dissolved oxygen in the water when the algae decompose. Eutrophication eliminates specialist species from highly oxygenated clear water, and consequently impoverishes the range of species living in the watercourses, lakes, sources, and subterranean water. Due to the fact that they are very diverse in Mediterranean rivers and sources, molluscs and dragonflies are particularly strongly affected by organic pollution. The fish communities in many rivers are also being modified: Salmonidae (e.g., trout) are being replaced by fish that are less sensitive to low oxygen content. Coastal habitats have not been spared: a series of hypereutrophic episodes has impacted Mediterranean lagoons and degraded seagrass beds because of the reduction of the water transparency. Many marine species are thus threatened, particularly those using coastal wetlands (Camhi *et al.*, 1998, Stevens *et al.*, 2005).

← *Eutrophication favours the proliferation of invasive aquatic plants like the Water primrose. The problems caused require human intervention (pulling them out) (© Tour du Valat).*

9: PAHs: Polycyclic aromatic hydrocarbons. Toxic compounds generally produced by the burning of automobile fuel, coal, wood and by industrial production operations.

10: PCBs: Polychlorinated biphenyls are chemical compounds that were used massively as electrical insulators in industry between the 1930s and 1970s. They are toxic and accumulate in the fatty tissues of many animal species.

11: In this report, the Middle East includes Turkey, Cyprus, Syria, Lebanon, Israel, the Palestinian territories and Jordan; North Africa includes Morocco, Algeria, Tunisia, Libya and Egypt; finally Europe refers to Portugal, Spain, France, Monaco, Italy, Malta, Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro, Kosovo, Albania, FYR of Macedonia, Greece and Bulgaria.

Meanwhile, several species have benefited from the general eutrophication of wetlands, since the increasing amounts of organic matter have provided additional food resources. Some fish in the Cyprinid family, such as the Chub, the Bleak and the Rudd have increased in numbers in eutrophicated lakes and watercourses in Europe (Maitland & Crivelli, 1996). As they are the favourite prey of many piscivorous birds (herons, cormorants and grebes), these species have also increased in number. In addition, birds are generally less negatively affected by degraded water quality, since most of their habitats are originally in naturally eutrophic bodies of water.

Contamination

Toxic pollutants, such as organochloride products, PCBs and heavy metals can completely destroy aquatic populations, or in any case greatly weaken them, by making them more sensitive to various diseases. The frequency of chemical pollution accidents has considerably increased and they have been the cause of major fish kills (Changeux & Pont, 1995). These accidents can have terrible consequences when they impact the habitat of an endemic species. For example, an industrial accident that occurred in 1998 in Andalusia (Spain) resulted in the discharge of millions of cubic meters of water contaminated by heavy metals into the River Guadiamar. This river is the principal watercourse supplying water to the Doñana National Park, a UNESCO world heritage site and a wetland of international importance for its high concentrations of birds as well as its endemic species (e.g., *Aphanius beaticus*). The pesticides found in high concentrations in watercourses eliminate sensitive species such as Plecoptera (Lubini, 2006). Pollutants also accumulate more insidiously in organisms up to sub-lethal levels, affecting their condition and reproductive success, and contaminating the entire food chain in the process.

Trends in pollution: the progress made must be continued

There has been some improvement in water quality since the 1980s, especially regarding the amount of phosphates (EEA, 2005). This positive development stems from the better access of human populations to sanitation – nearly 100% in the EU – and to wastewater treatment facilities. Although they are still insufficient, wastewater treatment technologies are also becoming more common in many southern and eastern Mediterranean countries. Given these ongoing improvements, the level of eutrophication of wetlands may diminish in the future in much of the Mediterranean basin. These good results must be qualified because nitrate levels are still high in Mediterranean rivers. Even if the amount of fertiliser used has been decreasing in south-western Europe, the trend is toward intensification of agriculture in the southern and eastern parts of the Mediterranean basin, which implies a rapid growth in the use of fertiliser in these areas. That is particularly true in countries where agriculture is very important like Turkey and Egypt, and to a lesser extent Morocco and Syria (Mediterra, 2009).

Micro-impurities (active hormonal substances, biocides and active substances in pharmaceuticals) represent a new challenge. Although they have probably increased in most Mediterranean wetlands, these contaminants are still not beingadequately monitored. Their influence on biodiversity, which may be quite negative (Pei, 2009), has not received enough attention either. For instance, a cocktail of various chemical products, some of which remain unidentified, has proven to be responsible for inhibiting the production of fish testosterone (i.e., the feminisation of males) and decreasing their reproductive capacities (Jobling *et al.*, 2009).

3.2.2 Water resource management

Over-extraction of water

Water is a vital element in wetlands. However, human populations are monopolising more and more freshwater to satisfy their needs. Agriculture, which is the principal consumer of water in the region, uses 64% of the freshwater extracted. Next in line is industry (22 %), then the domestic sector (14%), which includes the needs of local communities and tourist resorts (Plan Bleu, 2009).

At the present time, nearly half of the renewable and exploitable water resources are being used in the Mediterranean basin. This percentage is higher in North Africa, the Middle East and Spain, while it is lower in the Balkans and Turkey, especially because the water resources there are greater (Fig. 13). In other words, there is more water available for nature in the northern part of the Mediterranean region than in the southern part. The demand for water is probably going to increase in the upcoming decades in all sectors, especially in the eastern and southern parts of the basin (97% and 51% respectively; Margat, 2008). Although over abstraction of water has particularly negative consequences on biodiversity in water poor countries, such as those in North Africa and the Middle East, a very high proportion of species from the European part of the Mediterranean region is also facing this threat (Fig. 12).

The increasing demand for water has been putting more pressure on surface water and ground water, and consequently on wetlands. The overexploitation of underground water tables leads to a gradual drying up of wetlands and may also result in the intrusion of salt water and sulfur. In the most arid regions in the basin, many lakes and watercourses have become seasonal and can no longer ensure the subsistence of species that require water on a permanent basis (Garcia *et al.*, 2010). The over-abstraction of water from Black Lake in the El Kala region (Algeria) played a role in the prolonged drying up of this wetland during the 1990s, this lake being the only place in the Mediterranean region where the aquatic plant *Laurembergia tetrandra* has been found (de Bélair and Samraoui, 1994). The drying up of watercourses, artesian wells and sources due to the over-abstraction of water has been responsible for the increased scarcity and even extinction of many species of molluscs, particularly subterranean hydrobiids (Garcia *et al.*, 2010).

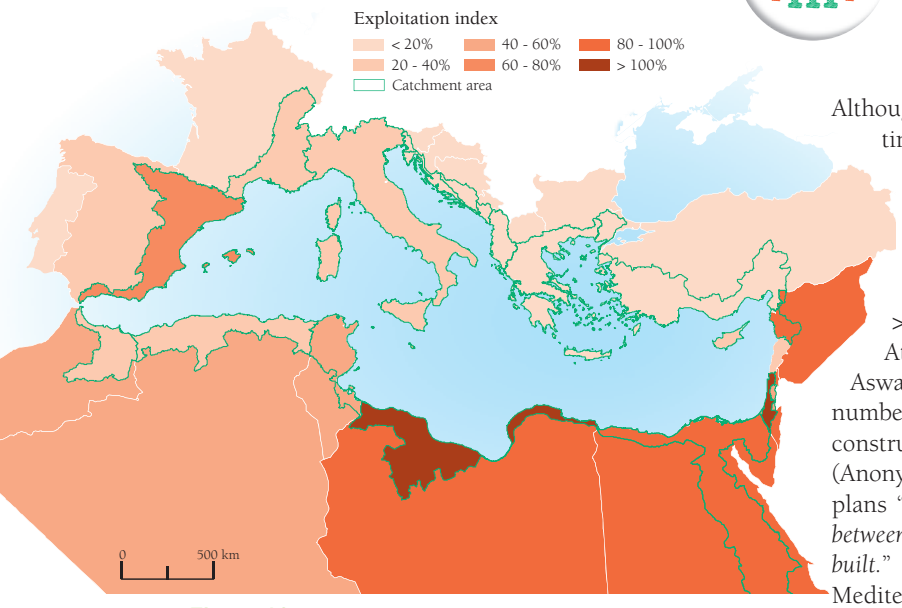


Figure 13.

Index for the exploitation of renewable natural water resources (in %), nationally and for Mediterranean catchment areas in 2005. Source: Plan Bleu from national sources completed by EEA data for Algeria, Bulgaria, FYR of Macedonia and Portugal (EEA 2010c).

A modified hydrographic system

In order to extend agricultural or urban zones and to protect them against overflowing rivers, a major part of the hydrographic system has been controlled using canals and dyke systems, which has resulted in shorter watercourses, narrowed the widths of their beds, and caused wetlands along rivers (prairies and alluvial forests) to dry out or disappear. At the same time, catchment areas have been increasingly developed, in particular to retain the meteoric waters and prevent their "loss" into rivers and wetlands.

Mediterranean rivers are also the most fragmented rivers in the world due to the construction of several thousand dams and hillside storage reservoirs (Nilsson *et al.*, 2005). These dams have been, and continue to be built in order to create water reservoirs for agriculture, industry and domestic use, and also to supply electricity.

Although the first important dams were built during Roman times in Spain (Leonard & Crouzet, 1999), their number has increased considerably as of the 1950s, in response to national policies aiming to secure water and energy supplies. At the beginning of the 21st century, in the Mediterranean basin, there were some 1,200 large or medium-sized dams (capacity >10 million m^3), including three 'giant' reservoirs: Atatürk and Keban on the Euphrates (Turkey) and Aswan on the Nile (Egypt). In spite of the already high number of dams, there are no plans to decrease the pace of construction in the near future. A recent report in Turkey (Anonymous, 2011), observes that the Turkish government plans "*to build 1,738 dams and hydroelectric power stations between now and 2023, in addition to the 2,000 dams already built.*" While the Balkans remain the last area in the Mediterranean region in which the hydrography of watercourses has been not much disturbed, there are many plans to build hundreds of big and small hydroelectric dams in Croatia and Bosnia and Herzegovina (MWO, 2012).

The degradation caused by dams includes the perturbation of river flows downstream from them, the eutrophication of waterbodies, the retention of the sediments required by wetlands downstream, the blocking of the route taken by migratory species between their reproduction and/or feeding zones (Kottelat & Freyhof, 2007). River fish are obviously the species that are the most highly impacted by this final threat. Fish communities from several countries, which were unique due to their abundance of endemic species (Spain, Croatia and Turkey) or their tropical African affinities (Egypt), have been particularly strongly impacted. The negative influence of dams can also be observed in littoral ecosystems. Fish like the flounder that live in estuaries are suffering from a reduced amount of freshwater; due to the presence of dams upstream (Abdul-Malak *et al.*, 2011). Meanwhile, because of the lack of sediments, a retreat of coast line has been observed almost everywhere, particularly in deltas, which is threatening the most important wetlands for waterbirds in the Mediterranean (Saad, 1996).

↓ *Pumping station for irrigating cotton fields, Gediz delta, Turkey (© Hellio & Van Ingen).*

Box A

The impact of water resource management on biodiversity in wetlands: the Ichkeul lake case-study

Major water resource management projects were undertaken in the Ichkeul catchment area in the 1980s and 1990s with the construction of dams on wadis' feeding the lake. The water retained in these dams has allowed the development of irrigated agriculture in the region. The reduction of freshwater inputs, coupled with low rainfall for several consecutive years, led to an increase in the lake salinity. Higher than 20 g /L most of the year, the salt concentration repeatedly reached concentrations of 70 to 80 g /L in the late 1990s and early 2000s. The consequences on the ecosystem were dramatic: almost total disappearance of pondweed, club-rush and *Ruppia* beds, impoverished algae community, and the regression of the reed and tamarisk belts surrounding the lake.The Living Planet Index calculation based on data from bird monitoring studies shows a sharp decline of the Ichkeul Lake bird community between 1990 and 2002 (Fig. A). It was mainly the herbivorous and seed-eating species that declined (up to -65% since 1984), including four species for which Ichkeul held numbers of international importance (Eurasian Wigeon, Pochard, Coot and Greylag Goose). Numbers of worm-eating and fish-eating birds remained much more stable.

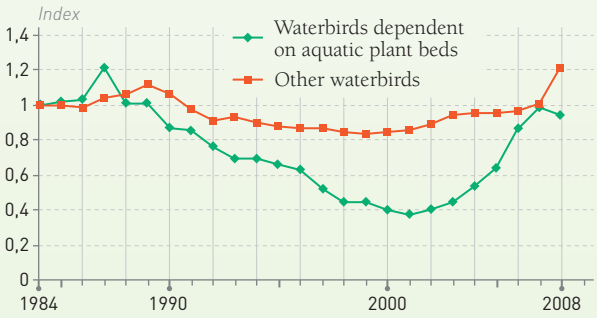
The result was a collapse in numbers of the waterbirds present on the lake in winter. A drop from an average of 140,000 birds in the early 1980s to less than 20,000 individuals between 2002 and 2004 was recorded (Tamisier *et al.*, 1992; BCEOM *et al.*, in 1994; ERI 1999). The lake was listed as World Heritage site in Danger and in the Montreux record, which lists severely degraded Ramsar sites.

A multidisciplinary study, conducted on the functioning of the lake hydrosystem, issued important recommendations regarding the management of the site. In the late 1990s, decisions were taken to safeguard the site. Implementation of these decision began in 2003 through collaboration with UNESCO. Among the measures adopted, the most important included: 1) the construction of a lock regulating the water exchange with the sea, 2) the implementation of a scientific monitoring program, and 3) the establishment of an evidence-based management plan for the Ichkeul National Park. "Ecological" water releases from the dams to the lake were also planned, but have not been realized so far.

So far, actions undertaken have been successful, helped with good rainfall. Flooding of surrounding marshes has been guaranteed and the lake salinity has been maintained at a concentration below 10 g /L for several months a year, making pondweed growth possible. Since 2003, aquatic plant beds have come back, both in space and density. Though more gradual, the return of reeds and tamarisks is underway as well. The return of birds is equally rapid (Fig. A): more than 300,000 waterfowl were counted during the winter of 2007-2008!

Figure A.

Waterbirds Living Planet Indices in Ichkeul lake.



Monitored indicators show that Ichkeul lake has recovered most of its biological and ecological values on which the site was ranked on the World Heritage List of UNESCO and the RAMSAR list. These results are very encouraging and efforts undertaken in a developing arid country should be applauded. However, problems persist. Fisheries production has remained low and some bird species have still not reached the abundance observed in 1970-80s (e.g. Greylag Goose). Furthermore, climate predictions - reduction in annual rainfall - for the next decades, as well as projects of new dams, threaten the sustainability of the system.

↑ *Common Pochard (© T. Galewski)*

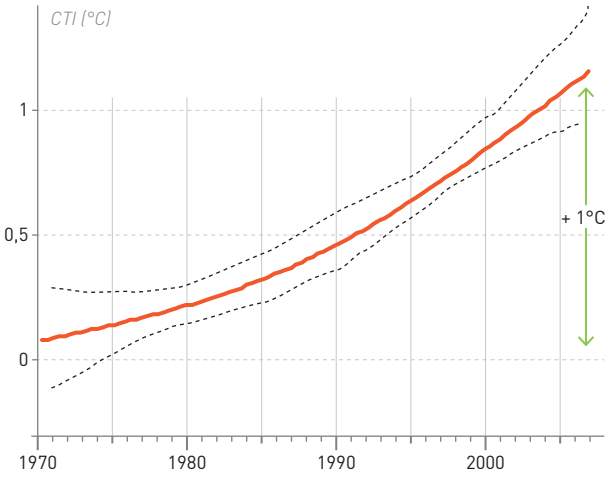
3.2.3 Climate change and accidents

Birds are moving north

On average, world temperatures increased by 0.74°C during the 20th century (IPCC, 2007), and even more rapidly in some parts of the Mediterranean region, such as the Iberian Peninsula and North Africa (Plan Bleu, 2009). This warming has been causing ecosystems to change and impacting the survival of species (Thomas *et al.*, 2004). Some species are not able to survive in the changing ecosystems, which means that they must move, otherwise they will be doomed to disappear. Among the groups demonstrating strong dispersal forces, changes are already visible. The increase in the Community Temperature Index – more than 1° C in less than 40 years – shows that the proportion of warm-dwelling species in wetland bird communities has increased since 1970 (Fig. 14). This change can be explained in particular by a general northward shift of distribution areas. This process is obvious for certain typically 'Mediterranean' species, which now breed in the northern part of the basin, all the way to the British Isles – as is true of Cetti's Warbler and the little egret. This phenomenon is also visible among other aquatic organisms such as dragonflies: several Mediterranean species are currently colonising Swiss wetlands (e.g., *Crocothemis erythraea*, *Sympetrum meridionale* (Vittoz *et al.*, 2011).

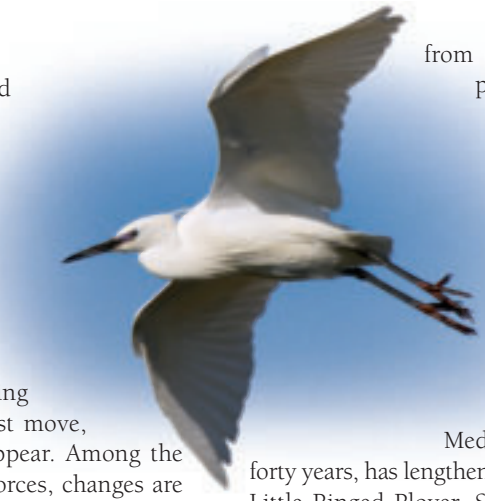
Figure 14.

Change over time of the Community Temperature Index (CTI) for Mediterranean waterbirds.



However, this migration may not be rapid enough. For example, the temperature increase recorded in France between 1987 and 2006 is equivalent to a northward climate shift of 273 km, whereas during the same period of time, on average the bird community only shifted 91 km (Devictor *et al.*, 2008). Species with a lower dispersal capacity, like amphibians, or which are unlikely to go from one hydrosystem to another (fish), face an even greater risk – especially when their distribution is limited. Finally, species

The Little Egret used to be especially a summer visitor on the northern shore of the Mediterranean, but today it can be seen there throughout the year and ranges all the way to Belgium and the British Isles (© T. Galewski).



from high altitude wetlands, such as peatlands and alpine lakes, appear to be extremely vulnerable, because these habitats are likely to become very rare in the Mediterranean region.

Species phenology is also changing in response to climate change. For example, the list of long-term migratory birds that have begun wintering in the Mediterranean region during the last forty years, has lengthened considerably: the Little Bittern, Little Ringed Plover, Sand Martin… In the past, these species would leave our region to spend the winter in sub-Saharan Africa, but today's more moderate temperatures have enabled a growing number of birds to stay in the same place during the winter. The importance of Mediterranean wetlands as wintering quarters could thus increase in the future, especially if the degradation of Sahelian aquatic ecosystems continues at its current pace. On the other hand, some species, for which the Mediterranean represents the southern boundary of their wintering area, have greatly decreased in numbers during the same period: the community of shorebirds that winter in French estuaries shifted north by about 20 km per year between 1977 and 2009 (Godet *et al.*, 2011).

What is the Community Temperature Index (CTI)?

The CTI, which was described by Devictor *et al.* (2008), evaluates whether or not the changes affecting biodiversity are directly linked to climate change. The value of the index at the scale of the community of vertebrates corresponds to the average values of the temperature index of each of the species concerned (Species Temperature Index - STI). The value of the index for a given species corresponds to the average temperature recorded in its distribution area. Therefore, species with a southern distribution area will have a higher STI than those with a northern distribution area. At the present time, STIs are only available for birds; however, the methodology could be extended to other taxonomic groups in the future.

If the data exist, the CTI is weighted in function of the relative abundance of each of the species in the community.

↑ *Overexploited and receiving less and less precipitation, which has become quite irregular, water resources are becoming increasingly scarce in the Mediterranean region, resulting in the drying out of wetlands (© Hellio & Van Ingen).*

Alarming prospects

Forward-looking analyses have shown that beyond an additional 2 to 5° C increase in temperatures from now until 2080, the Mediterranean basin will be impacted by lower precipitation and a higher frequency of extreme events, such as droughts and heavy rainfall episodes, a phenomenon that has already been observed locally. In North Africa, the torrential downpours that occur every 5 to 7 years carry enormous quantities of sediments, which further aggravates the destruction of the already fragile aquatic habitats (Garcia *et al.*, 2010). The species that are intolerant to a temporary lack of water (fish) are the most highly threatened by the consequences of climate change. The extinction of *Acanthobroma telavivensis* in the wild is an example of this. It used to be very abundant in rivers in the Mediterranean catchment basin of Israel, where it was endemic; however, this fish declined a great deal between 1950 and 1970 because of water extraction and pollution. The last occupied watercourse dried up in 1999, due to a lack of precipitation, which led to the complete disappearance of the remaining populations.

The other major physical consequence of climate change is the rising sea level. With an average rate of 1.7 mm per year during the 20th century (IPCC, 2007), by the end of the 21st century, the total increase could amount to 35 cm, and would be even more significant in the eastern Mediterranean. The following phenomena are expected: 1) an increase in flooding along low coastlines, particularly in deltas, lagoons, and foreshore areas; 2) more rapid erosion of the coast; and 3) increased salinity in the estuaries (Plan Bleu, 2009). The consequences for all of the species linked to coastal wetlands may prove to be catastrophic, in particular for many waterbirds (e.g., Greater flamingo) and sea turtles.

3.2.4 Hunting, fishing, and harvesting

The exploitation of species for food, medicinal, commercial, and recreational (for collectors) purposes affects all taxonomic groups. Nonetheless, few species of plants and invertebrates are seriously threatened by this pressure. Meanwhile, birds, mammals, and fish are likely to be exploited to a degree that directly threatens the survival of entire species or at the very least, their Mediterranean populations.

Hunting: less preponderant today than in the past

Hunting was a subsistence activity for a long time in the Mediterranean region, but with better economic development it became more of a leisure activity. No statistics are available at the Mediterranean level, but if we take account of the recent decrease in Europe, there are probably between 5 and 10 million hunters in the entire basin (Pinet, 1995). Even if they do not all hunt in wetlands, waterfowl hunting is one of the most common forms of hunting practiced. Undoubtedly the principal threat for waterbirds and large mammals until the beginning of the 20th century, hunting was responsible for the decline of a great number of species, sometimes pushing them to the edge of extinction. For example, the Great Egret, the feathers of which were used to make hats, and the Eurasian Beaver, which was hunted for its fur and oil. Beyond the resources they supplied, such as meat, feathers and fur, several species were hunted because they represented a real or legendary threat for the human means of subsistence. This is particularly true of piscivorous birds (cormorants, herons and pelicans), which had their colonies destroyed by fishers on a regular basis. The protected status given to most of these species, and the many regulations adopted enabled their populations to be re-established.

↗ *A Spotted Redshank that had its beak mutilated by lead shot during migration. Millions of birds are shot each year by Mediterranean hunters, which threatens the survival of certain species that are already quite fragile due to habitat loss (© S. Cavaillès & M. Sinoir).*

Hunting remains, nonetheless, a limiting factor for biodiversity in several Mediterranean countries (Albania, Bosnia and Herzegovina, Montenegro, Lebanon, Egypt, Cyprus, and Malta; MWO, 2012; Schneider-Jacoby & Spangenberg, 2010), where waterbird populations are in decline (section 2.2). The Lesser White-fronted Goose and the Red-breasted Goose, two endangered species at the global level, continue to be shot at illegally in their wintering quarters in Greece and Bulgaria. Meanwhile, the legal hunting practiced on other species is an additional risk factor, because it disturbs these geese and prevents them from accumulating the fat reserve needed for their return migration (Zöckler & Lysenko, 2000). Finally, hunting is responsible for collateral damage, such as lead poisoning, an illness that affects a great number of ducks that ingest lead shot, ammunition that is still widely used in wetlands in spite of the fact that it has been forbidden in several countries.

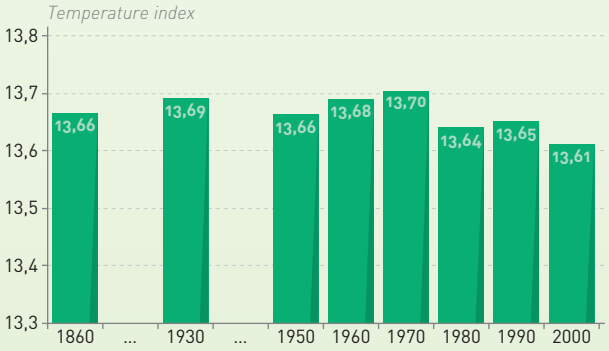
Box B

The impacts of climate change stronger in the winter than in the summer: an example from the Camargue

The diversity and number of birds have increased overall in the Camargue over the last 60 years (see box C). Global warming is a plausible hypothesis to explain the 20th century arrival of new breeding species (Barbraud *et al.*, 2004), such as the European Bee-eater and the Great Spotted Cuckoo. The increase in summer temperatures may have favored the reproduction of warm-dwelling species and helped to extend their breeding range northward. However, the temperature index of the Camargue breeding bird community (Fig. B1) does not confirm this hypothesis. In fact, the index hasslightly decreased since the 1980s. Major habitat conversion in the Camargue in the 1950-70s may explain this result. Indeed, changes in the landscape have resulted in the extinction of several species, often warm-dwelling, that are characteristic of Mediterranean open habitats (see Box C). In addition, several medio-European species who cope with a large range of temperatures settled in the delta (e.g. Wood Pigeon, Mute Swan), thus contributing to the decline in the index.

Figure B1.

Evolution of the temperature index of the breeding bird community in the Camargue since 1860.



Like the breeding community, the number of bird species recorded in the winter in the Camargue has largely increased in recent decades (Fig. B2.1). However, it seems that this time climate warming has played an important role. The temperature index of the wintering community has shown a marked increase over the 1990s and 2000s (Fig. B2.2). More warm-dwelling species have started to overwinter in the Camargue (e.g. Black-crowned Night Heron, Glossy Ibis). Such wintering behavior was not recorded before 1960. Recent observations suggest that new species, such as the Little Ringed Plover, Gull-billed Tern and Black-winged Stilt, will soon begin to overwinter on a regular basis. The cold snaps occasionally affecting the Camargue are known to have very serious consequences for birds. Prolonged freezing of water bodies are at the origin of population decline among the

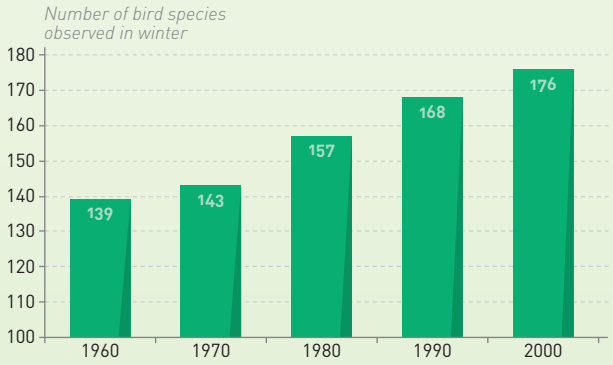
↑ *Black-crowned Night Heron (© T. Galewski)*

most warm-dwelling species (e.g. Greater Flamingo, Zitting Cisticola, Cetti's Warbler). Since the 1990s, these extreme climatic events are rarer and shorter, probably contributing to the increase of the temperature index.

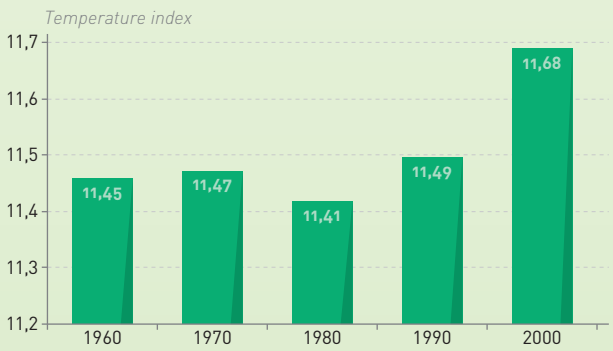
In conclusion, climate change has very likely influence on wintering birds in the Camargue. Conversely, the impact during the breeding season is not obvious, probably mitigated by changes in land use.

Figure B2.

(1) Changes in the number of bird species observed in winter in the Camargue per decade since 1960;



(2) Evolution of the temperature index of the community of birds wintering in the Camargue since 1960.



From subsistence fishing to sport fishing

Overfishing is not a prime factor of species decline in Mediterranean wetlands, contrary to what is a common problem in pelagic ecosystems. Nevertheless, some particularly highly-valued species, such as the Eel, Flounder and Nile Perch, continue to be caught excessively, which is incompatible with the sustainable exploitation of these fish populations. However, the number of commercial fisheries on the lakes and lagoons seems to be decreasing, and they have been partially replaced by fish farms. Although it is a source of other environmental problems (i.e., pollution), intensive fish farming has perhaps enabled the fishing pressure on certain species, such as the Gilthead Sea Bream, to be decreased (Abdul Malak *et al.*, 2011).

The sturgeon family provides us with a terrible illustration of the fact that this has not always been the case. Sturgeons are large fish, which live in the sea and estuaries, and travel upstream to spawn. Highly sought-after for their flesh and roe (the famous caviar), all of the species have experienced catastrophic population decline as a result of overfishing. For example, the Atlantic Sturgeon, which used to be abundant in all of the seas of Europe, including the Mediterranean, has experienced a drastic reduction in its distribution area. Today, the few individuals that travel up the Garonne River in France represent the final population of this species. Second, the establishment of a caviar factory on the banks of the Guadalquivir (Spain) in the 1930s wiped out the important population of Sturgeons that were living there in only 10 years (Maitland & Crivelli, 1996). Five other species of sturgeons can still be found in the Danube and travel upstream to Bulgaria and Serbia. Their populations are on the brink of extinction, but the legal and illegal exploitation of their populations continue, particularly in Romania. As for the Adriatic Sturgeon, the last wild individuals still found in the Po River (Italy) in the 2000s have probably disappeared today.

Whereas the commercial aspect of fishing in wetlands is declining today, it is an increasingly popular recreational activity, particularly in the best-endowed countries like France. The impacts of hook and angling as well as harpoon gun fishing have perhaps been underestimated and insufficiently explored. The latter has developed so rapidly in recent decades that today it represents a threat for several families of coastal fish. For example, this activity is directly involved in the decline of the Green Wrasse – a fish that lives in shallow coastal water – which is up to 80% along the French coast (Pollard & Choat, 2010).

↑ *Contrary to deep sea fishing, the fishing that takes place in Mediterranean wetlands is often small-scale and concerns the local market. As such, it does not represent a major threat for the species of fish caught (© Hellio-Van Ingen).*

3.2.5 Conversion of wetlands into farms and residential land

Half of wetlands have disappeared in just 100 years

Having begun in Ancient Greece, the drainage of wetlands intensified and became more widespread during Roman times, first in North Africa and Italy (Hollis, 1992), then throughout the rest of the Mediterranean basin. This destruction accelerated during the 20th century with an additional loss of wetlands estimated to be 50% (MWO, 2012). Turkey is perhaps the country that lost the most wetland area during the past century, but data are insufficient for Egypt and France, where vast expanses of natural wetlands were also drained. The same is true in the Maghreb, where extensive wetland areas were lost during the colonial period (1850-1930); however, the information available, such as the colonial archives and Constantine cadastre are too widely scattered to be transformed into concrete figures. The actual losses are probably greater than the estimates available, because small wetlands, such as ponds, are not generally counted. When data do exist, they show very great losses between 60 and 90% (MWO, 2012). The case of Hula Lake in Israel is one of the most famous and disastrous examples of wetlands drainage that took place between the 1950s and 1970s, and resulted in the extinction of two endemic fish (*Tristramella intermedia* and *Acanthobroma hulensis*). Lake Amik (350 km^2) in south-eastern Turkey and Lake Karla (160 km^2) in Greece are two other examples: both were home to exceptional concentrations of fish and birds (Skinner & Zalewski, 1995).

Agriculture and urbanisation: pressures that vary over time

Historically, wetlands were drained especially for health-related reasons. Epidemics of malaria were common throughout the Mediterranean region and the drying out of marshes was recommended until the end of the 19th century to fight against this plague. The discovery of quinine, then widespread spraying of DDT[12] in the infected regions put an end to these health-related drainage campaigns. Subsequently, and to meet the needs of a growing population, wetlands were destroyed essentially for agricultural purposes. With a globalised and more productive agricultural system, the total agricultural area has stabilised in the Mediterranean region since 1961, and has even decreased locally

12 : DDT: Dichlorodiphenyltrichloroethane is the first modern insecticide, which was widely used from the 1940s to the 1970s. Its highly toxic effects are said to be responsible for the population collapse of many species of birds of prey in Europe and North America during the same period of time.

(Mediterra, 2009). Nevertheless, as demographic growth is still very strong, it is now urbanisation that appears to be a very important threat for wetlands. Pressure is particularly strong on the coastal strip and in river valleys. The banks of the Nile and its delta are among the most densely populated and most urbanised areas in the Mediterranean region, with more than 1,000 inhabitants/km^2 (Fig. 10A). In addition to the increasing population, there is a new distribution of people and thus of how the land is occupied, with a strong rural exodus, which means that a growing proportion of the population is moving to the big cities, often located along the coast. Consequently, wild areas continue to be converted into urban and agricultural zones even around the principal wetlands. However, a study on several southern European countries has shown that nearly 1% of the surface area of wetlands with important bird areas (IBA) was transformed between 1990 and 2006 (MWO, 2012). This rate is probably higher in North Africa and the Middle East, where the population growth rate and rural flight are even more significant (Fig. 10B and 12).

The "small" wetlands and their species are under particularly high pressure

↑ *A wetland transformed into an agricultural zone, Bekaa valley, Lebanon (© L. Chazée – Tour du Valat).*

The preemption of land for agriculture, for residential, tourist, industrial constructions, and for infrastructure represents a major threat for amphibians, reptiles, plants, and aquatic insects. These groups are highly diversified in small and/or seasonally flooded wetlands, such as ponds, temporary marshes and wetland prairies. Rarely found in inventories, and not given adequate consideration due to the fact that they are not generally home to very 'typical' fauna, these habitats are not taken into account adequately in land-use plans or when protected areas are designated. The small size of these habitats, and the small number of species living there, make all of these ecosystems particularly vulnerable to disturbances. Some endemic species living in temporary ponds in the north-west plains of Morocco are in a critical state of conservation today, because these areas are increasingly used for growing crops and grazing, or simply destroyed to build infrastructure. For example, this is the case of the *Pelobates varaldii* frog and the *Callitriche mathezii* aquatic plant. Peatlands and high-altitude wetland prairies, as well as permanent ponds in wetter regions are also frequently threatened: the Yellow-bellied Toad from the Apennines, and *Armeria helodes* – a plant that is endemic to the Italian Alps, which has a world population of less than 50 – are likely to become extinct because their habitats are now being used for crop growing activities.

↑ *Temporary pond, Var, France (© F. Médail).*

The growing proportion of artificial wetlands

Paradoxically, agriculture, and to a lesser extent, the development of the urban fabric and infrastructure, have also resulted in the creation of millions of hectares of artificial wetlands. In addition to the dammed reservoirs and hillside storage reservoirs mentioned above (section 3.2.2), reservoirs, retention lagoons, drainage and irrigation canals, rice fields, salt pans and other oases account for nearly one-fourth of the total wetland surface area in Mediterranean countries today (MWO, 2012). However, these areas were partly reclaimed from natural wetlands. For example, whereas in 1860 more than 300 km^2 of the Ebre Delta in Spain were still covered by wild habitats, today two-thirds of this area has been converted into rice fields. Because they are too deep, water level fluctuates too fast, and no paludal vegetation can grow on their cement edges, most of the artificial bodies of water are not good habitats for the plant and animal communities. Nonetheless, some such bodies of water have become major conservation sites for species threatened with extinction. This is true of Lake Kerkini in Greece, an important site for the Dalmatian Pelican, and also some hillside reservoirs in northern Tunisia, which host significant numbers of Marbled Teal. Likewise, the habitats of an important part of the European population of Black-crowned Night Herons can be found in certain rice growing zones (in northern Italy). Meanwhile, the conservation of the Greater Flamingo is closely linked to salt farming activities in the Mediterranean region (Béchet *et al.*, 2011).

Nevertheless, the changes in biodiversity caused by replacing a natural wetland by an artificial one are similar for all taxonomic groups: most often common and generalist species replace rare and specialist species (section 2.2). The final result is an assemblage of species that is not very 'original', with conservation issues of little import, and spatially homogeneous. Mainly inhabited by common species, many of these artificial wetlands have lost their 'Mediterranean' features that made these areas so precious.

Box C

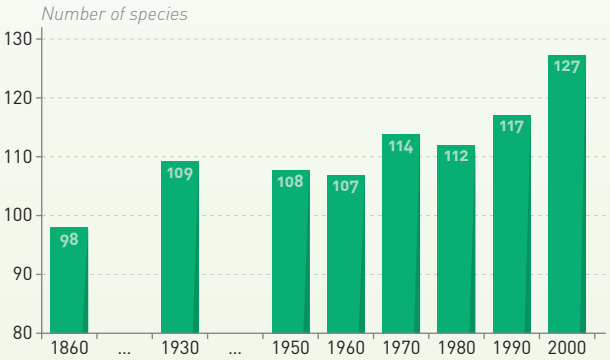
Are artificial wetlands a real boon for birds? an example from the Camargue

The high soil salinity and disastrous floods of the Rhone and the sea have long prevented the development of human activities in the delta, contributing to the conservation of landscapes and biodiversity. However, the building of dikes in the mid 19th century changed this dynamic along the river and the coast. The creation of a vast network of irrigation and drainage channels allowed people to have considerable autonomy in managing water for their activities, primarily agriculture. Vineyards, the dominant culture at the turn of the 19-20th centuries, required large amounts of water in the winter to fight against the Phylloxera pest. Beginning in 1940, vineyards were replaced by rice cultivation that reached a peak in the 1960s (32,500 hectares), then fluctuated before becoming again an important crop in the 1990s (around 20,000 ha). Rice production induced flooding of large areas in the summer, creating a water cycle contrary to the natural cycle in the Mediterranean region. Alongside the development of agriculture, salt production was intensified in the mid-19th century, leading to the conversion of large areas of brackish lagoons in salt pans until the early 1970s. Water levels are kept under control in salt production ponds. The presence of water in summer, at a time when natural shallow ponds are often dry, generate strong primary and secondary production. These developments, as well as the development of a tourist resort and an industrial center in the 1960s, were built at the expense of natural habitats.

These important changes have obviously affected the biological communities of the delta. Contrary to some beliefs, species diversity has not decreased (at least not among the best known taxonomic groups such as vertebrates). The number of breeding bird species has increased steadily since the mid 19th century (Fig. C1), a trend also recorded in mammals. Although several species have disappeared, other, more numerous species have settled in the Camargue. If the increased observation and the appearance of few allochthonous species can partly explain this increase in species diversity, the arrival of species previously absent is well documented (e.g. Cattle Egret, Grey Heron, Beech Marten). Several hypotheses have been proposed to explain this positive trend (Barbraud *et al.*, 2004), including the increase in summertime flooded areas required for rice and salt production.

Figure C1.

Change in number of known breeding bird species in the Rhône delta since 1860.

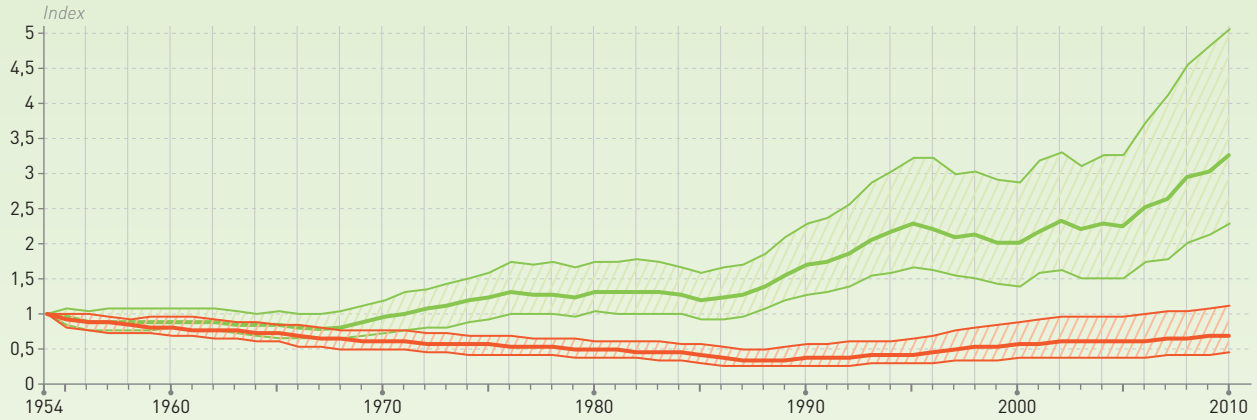


Under this assumption, we should observe an increase in waterbird numbers from the 1950-60s, when rice cultivation and salt production were at their peak. However, analysis of monitored data collected by various entities in the Camargue does not clearly validate this hypothesis. The numbers of waterbirds have actually increased in the delta in recent decades (more than 200% in 60 years), but this was mainly observed from the late 1980s (Fig. C2), long after the profound changes which occurred in the landscape of the Camargue.

↗ *Woodchat Shrike (© T. Galewski).*

Figure C2.

Living Planet Indices of waterbirds (green) and land birds (orange) in the Camargue. (The hatched area shows the confidence intervals).

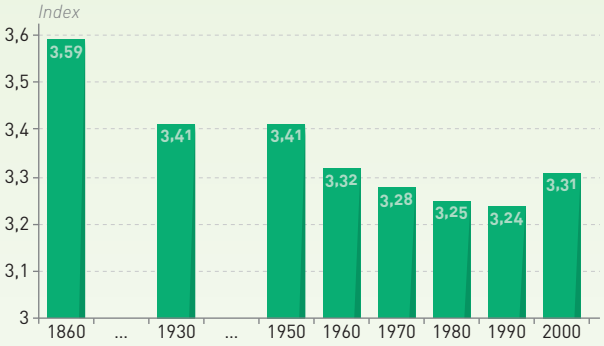


However, there was a 70% decrease in the index of landbirds between 1954 and 1987, contemporary of the major changes in the delta (Fig. C2). It is true that the extension of wetlands has mainly been at the expense of the temporary brackish marshes and grasslands (decreased by more than 50%, Tamisier & Isenmann, 2004) which are habitats of many land bird species. As a consequence of agricultural intensification, the network of hedges that bounded plots was also fragmented. Finally, the transition from predominantly sheep farming to cattle and horse breeding has led to a change in plant communities in traditionally grazed grasslands and brackish marshes.

Further evidence of the negative impact of the artificialization of the Camargue on bird communities is the decline in the proportion of specialist species. The specialization index of the breeding bird community in the Camargue (Fig. C3) decreased sharply between 1860 and 1930, which corresponds to the containment of the delta, and then again in the 1960s, at a time when large areas of natural habitats were converted to agricultural, industrial and touristic areas. Many species that have appeared or have increased since the late 19th century are, indeed, widely distributed in Europe and occupy a great diversity of habitats (e.g. Grey Heron, Great Cormorant, Jackdaw, Common Starling, Woodpigeon).

Figure C3.

Evolution of the specialization index of the breeding bird community in the Camargue since 1860.



In contrast, among the extinct or declining species, many are specialists of the open Mediterranean, such as the Southern Grey Shrike, Lesser Grey Shrike, Woodchat Shrike, Calandra Lark or Short-toed Lark.

Given this analysis, the link between wetlands and the conservation status of waterbirds in the Camargue is unclear. In order to explain the overall positive trend of species in the Rhone delta, additional factors such as species protection, the designation of protected areas and management of areas favorable for waterbirds, should be considered.

Artificial wetlands - such this sewage treatment plant - represent a growing proportion of Mediterranean wetlands. Some species adapt well to these new habitats, here Common Shelduck (Frontignan, France - © T. Galewski).

3.2.6 Invasive species that are causing problems

Less and less 'natural' species are taking over

A direct consequence of the globalised trading system and increased mobility, more and more species have been introduced, voluntarily or accidentally, in regions where they are not found naturally. These exotic species sometimes succeed in establishing themselves or even proliferating to such an extent that they become a threat to the indigenous species. In Mediterranean wetlands, it is the introduction of fish that has had the strongest repercussions on indigenous biodiversity. The proportion of species introduced in the community of fresh water fish is generally very significant and increasingly rapid: for example, 13 of the 45 species of fish in Lake Skadar (Montenegro), and 14 of the 19 species in Lake Trasimeno (Italy) (Maitland & Crivelli, 1996). The impacts linked to introducing great predators are the most spectacular, because they often lead to the extinction of the species upon which they prey. For instance, the Sander was responsible for the extinction of the bleak *Alburnus akilii*, which was endemic in the Turkish Lake Beyşehir, at the end of the 1990s (Crivelli, 2006). These introductions also create important problems for amphibians, particularly when the exotic fish are released in ponds where originally no fish was present. Invasive species can compete with local species, particularly for food resources. This is true of the Mosquitofish and the Stone Moroko, two of the most invasive fish in the region (and world). Of course, introduced species that cause problems are not only found among fish: the American Mink and water ferns (*Azolla filiculoides* and *Salvinia natans*) are some of the allochtonous species that have negative repercussions on aquatic biodiversity and are regularly criticised for that reason (Garcia *et al.*, 2010).

An introduced species may sometimes hybridise with an indigenous species that is genetically close, and in this way cause it to disappear. For example, most of the numerous trout species that are endemic to the Mediterranean hydrographic network are threatened today by the introduction of other species (generally the Brown Trout) with which they hybridise. The genetic diversity of species is sometimes threatened by the reproduction of wild individuals and individuals from the same species raised in captivity, then released in large numbers by a fishing or hunting association. This process entails a risk of genetic pollution, which may weaken the wild species after a few generations, because it becomes less well-adapted to its environment. Many fish and some waterbirds and mammals are concerned (e.g., Mallard, Champagnon *et al.*, 2009). Though they receive less media attention, there are also indigenous species that become invasive and create problems for other species. These changes may result from a modification in the original ecosystem subsequent to its eutrophication, for instance. In this case, generalist nitrophilic species, such as Sticky Fleabane, proliferate and gain the upper hand over specialist species, which are better-adapted to nutrient-poor wetlands.

3.2.7 Disturbances and human intrusions

The increasing human density on the coast and around wetlands, and more specifically the development of tourism and open air recreational activities, may disturb the fauna and flora there. The Mediterranean region is the principal destination in the world for international tourism: **in 2007, 275 million international tourists came to this area, which means 30% of the world total**. The Plan Bleu estimates that this number should reach 637 million tourists by 2025, with half of them visiting the coastal regions. Many species see their very existence directly threatened by the infrastructure development needed to open a new tourist site (trails and roads) and also by the visitors whose trampling degrade their habitats and may unintentionally kill some individuals (Garcia *et al.*, 2010), as well as by the disturbances resulting from all these activities.

The problem can become serious when the populations are numerically low in number and limited to small geographic zones. For example, *Bythinella markovi* and *B. turca* aquatic snails are critically endangered: the former because the Bulgarian cave to which it is endemic has been opened to visitors, and the second because the source in which it lives in Turkey is right in the middle of a village and is used for domestic purposes. The land snail *Tyrrhenaria ceratina* is another such example: it is the only living specimen of its kind, and is endemic to a tiny dune area located at the mouth of a river, in the immediate vicinity of Ajaccio, the largest city in Corsica. The risk of seeing entire populations of many immobile or slow-moving organisms disappear under the soles of too many eager visitors must therefore be taken seriously.

The development of beaches and the excessive number of summer visitors on the Mediterranean coast are depriving the Loggerhead Sea Turtle of most of its egg-laying sites (© F. Veyrunes).

While species that are bigger may not run the risk of being trampled to death, they may still be very sensitive to disturbances related to human presence, which they imagine to be a kind of threat. Birds that nest in colonies are particularly sensitive to this kind of threat, especially those nesting on beaches. The decline of the Little Tern and Kentish Plover may to a large extent be attributed to the impossibility of these species to find 'wild' beaches on which they can establish colonies and raise their chicks. The period during which these birds use these areas often coincides with the high tourist season (spring-summer). It is the same excessive number of tourists who visit the Mediterranean shores during the summer period that is making it difficult for the Mediterranean Monk Seal and the Loggerhead Sea Turtle to return there today.

> 4. WHY SHOULD WE CONSERVE BIODIVERSITY?

Species provide basic services without which humans could not exist. Only rich and complex assemblages of species make it possible to provide the 4 types of ecosystem services commonly identified: support services, such as soil formation, and the production of raw materials; regulatory services, such as water purification, and pollination; supply services, such as food and building materials; and, finally, non-material cultural services, such as well-being and leisure activities. Although these concepts have been progressively disseminated via scientific and conservation networks in recent decades, they are still not given adequate consideration by decision makers and those working in the field of development (MWO, 2012).

4.1 WILD SPECIES: A VITAL RESOURCE

On a daily basis, human beings use many plant and animal species that come from wetlands. For example, in North Africa, more than one-fourth of aquatic plants are used by local communities, which enable them to considerably improve their daily lives (Juffe-Bignoli *et al.*, *in prep*). These plants are used for their medicinal properties, are exploited by the pharmaceutical industry, which extracts their active molecules in order to make pharmaceutical drugs (see section 4.3) or other chemical products. They are also used by the local communities for human consumption (Watercress, *Cyperus esculentus*, *Iris pseudacorus*, and various mints) or to feed livestock (sedge, sorrel, rushes, mannagrasses, *Scirpus s.p.*), and are sought after for ornamental use, for making baskets, and to be used as building materials (rushes, reeds, and *Typha s.p.*). Among these species, more than one in five is becoming extinct today locally due to the loss and degradation of wetlands. For example, this is true for the Blue Lotus, an emblematic aquatic plant, which has been widely used in Egypt since the time of the Pharaohs, and is today at the point of disappearing in North Africa. Finally, we must recall that the trade of medicinal wild plants is significant, and that Morocco and Egypt are among the principal countries exporting them to the EU.

↑ *Cutting of the reed (© E. Duborper).*

Fishing remains, however, the most important activity in terms of economic returns. It is an age-old activity in the region, which has been practiced both for local subsistence and trade. Production figures amount to more than one million tons per year, approximately one-fourth of which is directly caught in wetlands (Maitland & Crivelli, 1996; Papaconstantinou & Farrugio, 2000). Most statistics only cover sea fisheries, which include coastal lagoons. These lagoons are exploited by an important number of fishers – several thousand in the Nile lagoons and delta alone – and represent therefore a major economic force. The fishing equipment and methods are generally based on traditional know-how.

↓ *Reedbeds (© H.Hôte).*

The most common species sought after are migrating fish, such as Sea Bass, Gilthead Sea Bream, Striped Mullet, Common Sole, and European Eel, which are caught in the autumn when they swim out of the lagoons. *Atherina s.p.* are also highly coveted locally where they are used for fish fries. Many fishers complement their sea fishing activities by gathering shellfish such as oysters, mussels, clams, which they find in natural banks. Fisheries located in continental wetlands receive less attention and only some rare estimates are available. One of the reasons is that the products obtained from this fishing are sold locally. However, it is an activity that is practiced in many lakes, such as Kinneret and Prespa Lakes, where most of the fish caught is endemic species.

Overfishing and the degradation of water quality have harmed fish stocks, resulting in a decrease in fishing activities in recent years. The case of the European Eel is exemplary in this respect. Today, glass eel recruitment only represents 1 to 5% of the numbers recorded before the 1980s! In just 25 years, what used to be an abundant fish that guaranteed the prosperity of many fisheries in the Mediterranean region, has become a critically endangered species.

↑ *Following a very rapid and partly unexplained decline of European Eel populations, the commercial fishing of this highly sought after species is likely to become impossible in the near future (© MRM).*

4.2 SPECIES AT THE HEART OF LEISURE ACTIVITIES

Wetlands were long plagued with a bad reputation. Considered in the past to be unhealthy places, infested with mosquitoes that were vectors of malaria, today, most of them are thought of as attractive sites. Bodies of water, and many other wild landscapes, have been increasingly recognised for the vital role they play in maintaining our moral and physical well-being. Likewise, many recreational activities have been developed in conjunction with wetlands and the species that live in them.

Sport fishing and recreational hunting

In most of the Mediterranean region, professional fishing and livestock farming enable inhabitants to no longer have to catch and kill wild animals to ensure their subsistence. In this context, fishing and hunting have become recreational activities. They are practiced as sports or traditions, which are controlled to a greater or lesser extent by regulations that vary considerably from one country to another (see section 5.2.). In France, hunting, which had been reserved for the nobility, became more of a popular pastime after the French Revolution, and it is still perceived to be an important right by those who practice it. With 1,343,000 people who had a hunting permit in 2009, France boasts the largest number of hunters in the region, but hunting is practiced intensively in almost all Mediterranean countries with very high pressure in Lebanon, Cyprus, and Malta (more than 50 hunters/km^2 in the latter country compared to an average of 2-3/km^2 for the entire region). Hunting is both a captivating and economically important activity. In the Camargue, several million euros are generated locally every year by the fees paid by hunters to use private hunting marshes (Tamisier & Dehorter, 1999).

A decrease in the populations of game species would obviously constitute a prejudice for this activity. Likewise, the dramatic decline in European Rabbit and Red-legged Partridge populations, stemming from the introduction of diseases and intensified agricultural practices, has deprived French hunters of their favourite game. As for the Black-tailed Godwit and Eurasian Curlew, the destruction of their nesting habitat (wetland prairies) has resulted in a moratorium on hunting them in France.

↑ *Angling is becoming increasingly popular, but it requires wetlands that are in good shape and in which fish are abundant (© L. Chazée).*

Angling is even more popular than hunting. It is practiced by 10% of the French population, and in some ways can be seen as a true sport. For example, fishing competitions are organised by fishing federations, in which the goal is to catch the biggest fish or to catch the greatest number of fish in a limited amount of time. Degraded water quality negatively impacts this activity, because the most highly-coveted species by fishers such as Salmonidae, in particular, are the most sensitive to this pollution. Finally, although this practice concerns more the Atlantic coast of Mediterranean countries, the fishing on foot practiced at low tide to gather shellfish, molluscs, and cephalopods in the foreshore, is another well-loved recreational activity that depends directly on the good state of conservation of the species collected.

Sustainable tourism

Wetlands often feature attractive landscapes and are teeming with animals that are quite visible, which makes them naturally good destinations for tourists. The expression 'sustainable tourism' includes all forms of alternative tourism that make the best long-term use of the natural, cultural, and social heritage resources available in an area, while at the same time minimising the negative impacts that may be generated. Sustainable tourism is therefore opposed to mass tourism, which is concentrated in the seaside resorts in the Mediterranean basin, and generally has negative repercussions on the environment. Here we will focus on eco-tourism, which places plant and animal species at the heart of the visit.

↗ *Ornithologists (© E. Didner).*

A growing number of tourists are travelling to wetlands today, so that they can observe charismatic species, which are often gregarious birds that are easy to see like flamingos, cranes, pelicans, swans, and geese. Ornithology is a recreational activity that has long been popular in Anglo-Saxon countries, and is now rapidly gaining ground in southern Europe. Mediterranean countries – with their medley of rare and endemic species – are now the favourite destinations of bird lovers from throughout the world. In this process, wetlands are becoming ideal places for environmental education, where different educational activities can be developed, particularly in visitor centres (Papayanis, 2008). Ecotourism is very different from mass tourism; nonetheless, it is a developing economic sector that creates jobs and generates significant revenues for local communities while at the same time allowing traditional rural activities to be maintained. For example, Lake Manyas in Turkey attracts many amateur ornithologists who might have spent 103 million dollars locally in a single year according to statistics (Gurluk & Rehber, 2008)! In return, ecotourism makes local authorities and communities more interested in their environment, transforming them into defenders of the local area and its biodiversity.

4.3 BIODIVERSITY AND HUMAN HEALTH

After a period of triumphant optimism, which came after the development of quinine, of antibiotic treatments, and the eradication of smallpox, recent decades have seen the emergence or re-emergence of pathogens that have been affecting human populations and domestic animals (Daszak *et al.*, 2000; Dobson & Foufopoulos, 2001). Studies are accumulating and showing that the loss of plant and animal biodiversity has direct consequences on public health, because they are vital for fighting infectious diseases (Chivian and Bernstein, 2008). A decrease in the diversity of communities can favour the transmission of pathogenic agents to humans, by diminishing the 'dilution' effect. Some pathologies are indeed transmitted between host species by a vector, which is a species that does not cause the disease itself but transmits the infection by transporting the pathogenic agents from one host to another. Among the species infected by the vector, some cannot transmit it themselves: these are called 'dead end' species for the pathogen. The number of 'dead-end' species increases with the diversity of communities, which diminishes how frequently the pathogen is transmitted to humans by 'dilution' of the vectors among a larger number of hosts (Gauthier-Clerc & Thomas, 2010). On the other hand, communities of diversified species reduce the risk that exotic species will be able to spread. For example, the presence in the Camargue of some forty species of mosquitoes reduces the risk of colonisation by non-indigenous mosquitoes, which are vectors of emergent diseases such as chikungunya, dengue, and the West Nile, due to the competition exerted against them by the indigenous species. The major mosquito eradication campaigns that are to be conducted in the region could change the situation, and favour the proliferation of mosquitoes that transmit these diseases (Poulin, 2011).

Many aquatic plants are used for their medicinal properties. They are very commonly used in developing countries where access to modern medical technology is not always easy (90 species are used in North Africa according to Juffe-Bignoli *et al.*, *in prep.*). Plants are generally used to fight minor diseases, but also to alleviate pain (headaches, wounds, stomach cramps), as a diuretic (*Mentha spp.*), astringent, purgative (*Rumex crispus*), tonic, sedative, cataplasm (*Persicaria senegalensis*), and against bronchitis, fever, and rheumatism (Wild Celery).

↑ *European pennyroyal is a plant that is typical of temporary ponds. It is widely used for its medicinal properties, notably to treat bronchitis, whooping cough, and biliary insufficiency, and as an antispasmodic tonic (© P. Grillas – Tour du Valat).*

> 5. HOW IS WETLAND BIODIVERSITY CONSERVED?

As we have seen, the biodiversity in Mediterranean wetlands faces many pressures that are not likely to decrease in the upcoming decades. In order to decrease the disastrous impact that an additional loss of biodiversity would have on humans and their activities, Mediterranean people and their political representatives must make more bold decisions in favour of their environment. In this part, we will discuss the strengths and weaknesses of some of the solutions that have already been implemented.

5.1 SCIENCE - POLICY INTERFACE: THE EFFORTS MUST BE CONTINUED

Monitoring operations help warn us in real time about the decline of a species or population. Their importance is therefore vital for starting research programmes that identify the causes of the decline as well as for taking the measures enabling these trends to be reversed. The situation seems to be very different from one country to another: thanks to the presence of NGOs and government agencies that are very active in terms of environmental protection, Spain and Israel have put in place many operations for monitoring biodiversity in their wetlands. On the contrary, due to a lack of infrastructure or a lack of financial means, monitoring operations are too rare to be able to establish an accurate state of biodiversity in several countries: Libya, Egypt, Jordan, Syria, Bosnia and Herzegovina, and to a lesser extent Algeria, Tunisia, Turkey, FYR of Macedonia, and Serbia (Fig. 15). Moreover, most of the monitoring activities are isolated operations that depend on short-term funding.

Today, waterbirds are the best known elements of biodiversity. Other species, habitats, ecosystem services, and socio - economics must be monitored in parallel to find sustainable solutions to species decline. Finally, even if monitoring operations do exist, the results must still be written up and conveyed to decision makers. Substantial efforts still need to be made in this domain in most Mediterranean countries (MWO, 2012). More research is also needed to be able to identify the indicators with which this transfer of information can be achieved. The indices developed for birds by Birdlife International, which have been adapted to the national scale in France and Spain, are good examples to follow.

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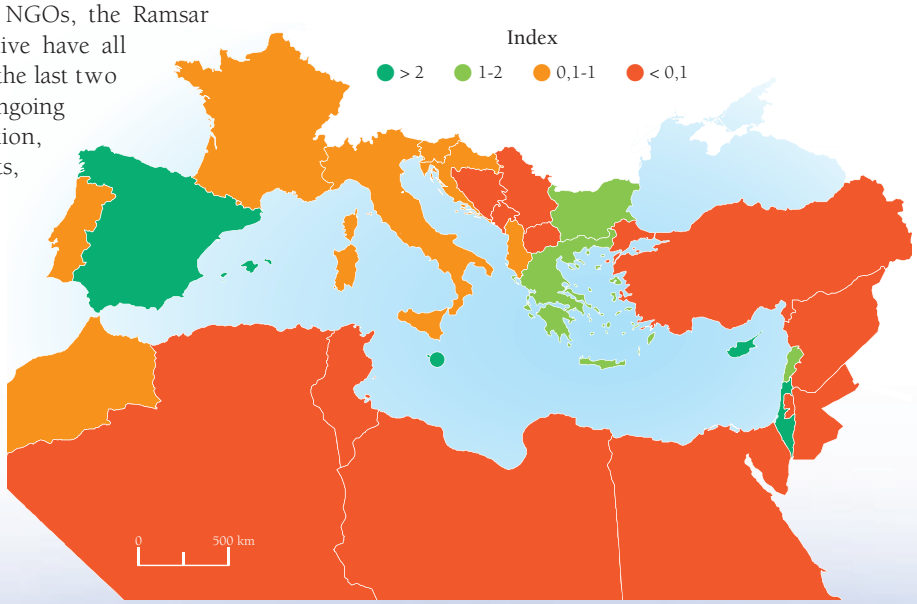
↗ *Biodiversity monitoring and more generally wetlands research must be encouraged, and their results must be better integrated into decision-making processes (© Tour du Valat).*

Based on the observation that wetlands have suffered from a lack of popularity, conservation stakeholders are doubling their efforts to target their communication at the general public. Making citizens and especially children more conscious of wetland issues seems to be vital if we are to bring about a profound change in attitude and behaviour toward nature. Associations, environmental NGOs, the Ramsar convention, and the MedWet initiative have all worked hard in this direction during the last two decades, in particular, through ongoing programmes disseminating information, organising meetings and special events, and going to schools to speak with children about these issues.

Figure 15.

Bird monitoring efforts in wetlands of different countries. The monitoring effort index is estimated as the ratio between the number of time series available in the MWO database and the total national wetland surface area.



↓ *Nature activities, a playful kind of environmental education (© Tour du Valat).*

↓ Northern Wheatear (© T. Galewski).

Box D

The importance of regularly and comprehensive bird monitoring in the Eastern Mediterranean

Generally speaking, biodiversity is not sufficiently monitored in the southern and eastern regions of the Mediterranean. However, the need is particularly urgent because these regions are major flyways in the world, were an increasing scarcity of wetlands threaten many species of waterbirds.

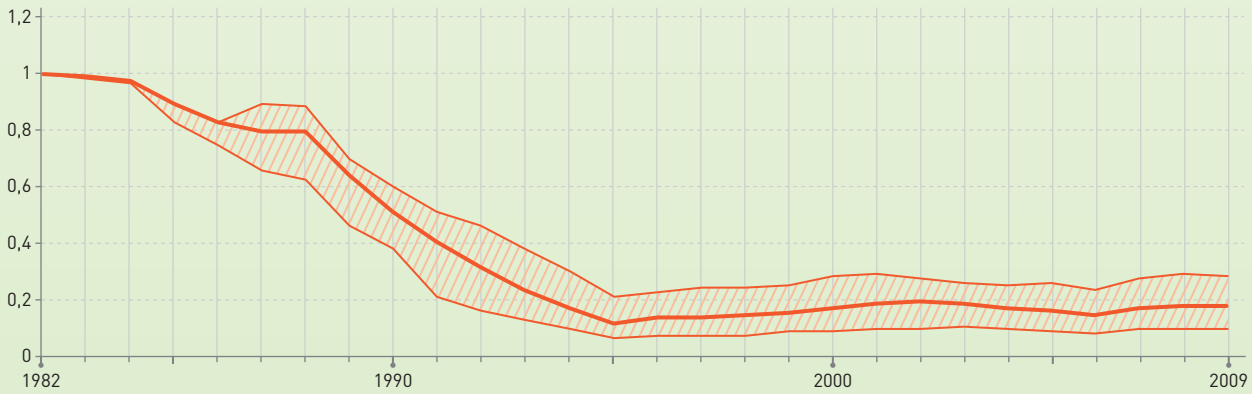
A Breeding Bird Atlas for the Gediz

Atlases of breeding birds are commonly produced in Europe and North America. They can drastically improve the knowledge of species distribution and numbers. Written at several year intervals, they allow for the recognition of species trends and identification of necessary conservation actions. Such initiatives require the mobilization of a large number of experienced birdwatchers and many hours spent in the field. Thus far, few atlases have been written for in the southern and eastern Mediterranean, where the network of birdwatchers is poorly developed and, when it exists, does not have sufficient resources.

The study conducted on the delta of Gediz by a team from the Izmir University is exemplary. In 2002, over 30,000 ha were divided into 305 one km squares. On each square, three 10 minute point counts were made during the springtime breeding period. In addition, habitats and threats present on each square were recorded. Reprinted in 2006, this monitoring has identified 117 species of birds nesting certainly or probably in the delta. The number of breeding species is much richer than previously thought before the atlas project. The location of nesting territories of the most sensitive species could be clarified and indicator species for each habitat identified. For instance, the Northern Wheatear is a good indicator of the presence of illegal dumps.

The data were not collected over a sufficiently long period (2002 and 2006) to detect a significant trend in the evolution of breeding bird populations. However, an analysis of threats to biodiversity in the Gediz Delta can already be made. Clearly, the loss of natural habitats by illegal dumping, urbanization, industrialization and drainage are very serious threats. Wetland habitats, such as wet grasslands, freshwater marshes, brackish marshes and mudflats, experience the most destruction or degradation: (Onmuş *et al.*, 2009). The south-eastern part of the delta that is directly connected to Izmir, Turkey's third largest city by population size is particularly under pressure. The expansion of the Collared Dove in the delta between 2002 and 2006 (present in 60 plots compared to 35 plots four years earlier) can be correlated with the rapid expansion of urban housing. Poaching and overgrazing are other serious threats to the birds of the Gediz. Before the initiation of the atlas, the number of species monitored

Figure D1.
Living Planet Index of breeding birds of the Gediz Delta.



was too low to draw general conclusions, but it is clear that several species have seriously declined during the 1980s and 1990s (Little Egret, Little Ringed Plover, Kentish Plover, Ruddy Shelduck; Fig. D1). Since then, the trend is stable or increasing due to measures to protect the colonies of some bird species including (ex: Greater Flamingo).

Aammiq marshes, an observatory for migrating birds in the Middle East

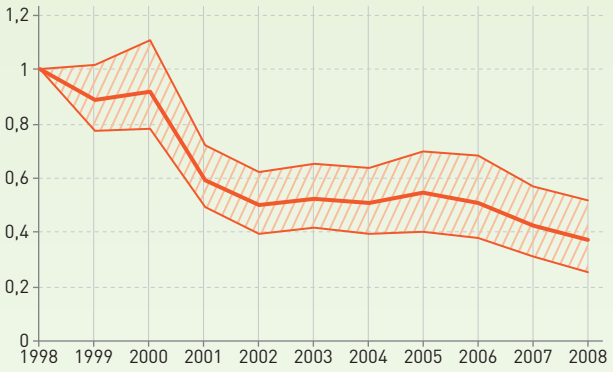
Lebanon, like other countries of the western Middle East, is located on one of the major flyways in the world. Very few wetlands remain today in the region. Aammiq, with Hula in Israel and Jabboul in Syria, represent the latest sites where migratory birds can find the resources needed to continue their journey.

Since the founding of A Rocha - Lebanon in 1996, breeding, wintering and migratory birds have been monitored. Breeding and wintering bird numbers are limited due to the small size of the site, but migratory birds are largely dominate the site.

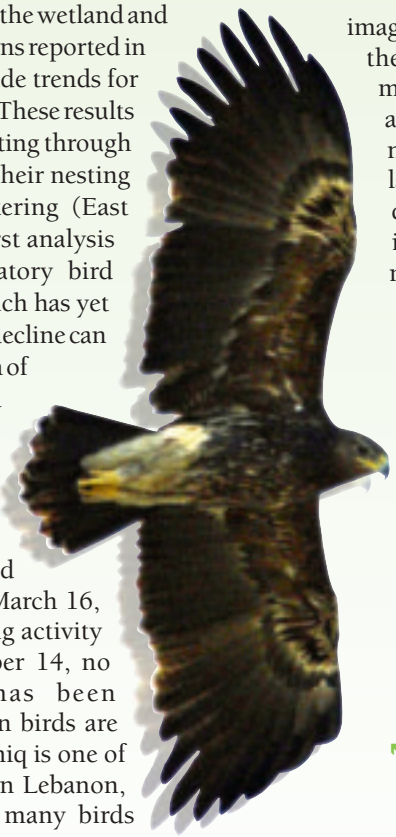
Specific studies on raptors and other soaring birds were undertaken and a ringing station has ringed thousands of birds since 2001. Furthermore, weekly counts were conducted in two distinct points of the wetland and fed a large database. The observations reported in this database will eventually provide trends for each species occurring in Aammiq. These results will be very valuable as birds migrating through Aammiq are rarely monitored on their nesting (Russia, Central Asia) and wintering (East Africa) grounds. Currently the first analysis suggests a net decline of migratory bird populations (Fig. D2), a trend which has yet to be confirmed. The causes of this decline can be explained by both a deterioration of breeding and wintering habitats and the adverse conditions faced by birds in Aammiq.

Figure D2.

Living Planet Index of birds in Aammiq.



Lebanon is home to over 500,000 hunters, 40% of which should not have a hunting license (World Bank, 1995). Despite the Act of March 16, 1993, which condemns all hunting activity between March 15 and September 14, no serious law enforcement has been established. More than 10 million birds are killed each year. Given that Aammiq is one of the favourite places for hunting in Lebanon, and also a major stop-over for many birds migrating through the Middle East, it is easy to imagine the dramatic impact that hunting has on the dynamics of many species. As Aammiq marshes are internationally renowned (they are Ramsar and UNESCO sites) and are in need of urgent protection, it is hoped that the last hundreds of hectares of wetlands will not disappear. However, it is urgent that hunting is controlled, or even banned, on the marshes and surrounding areas.

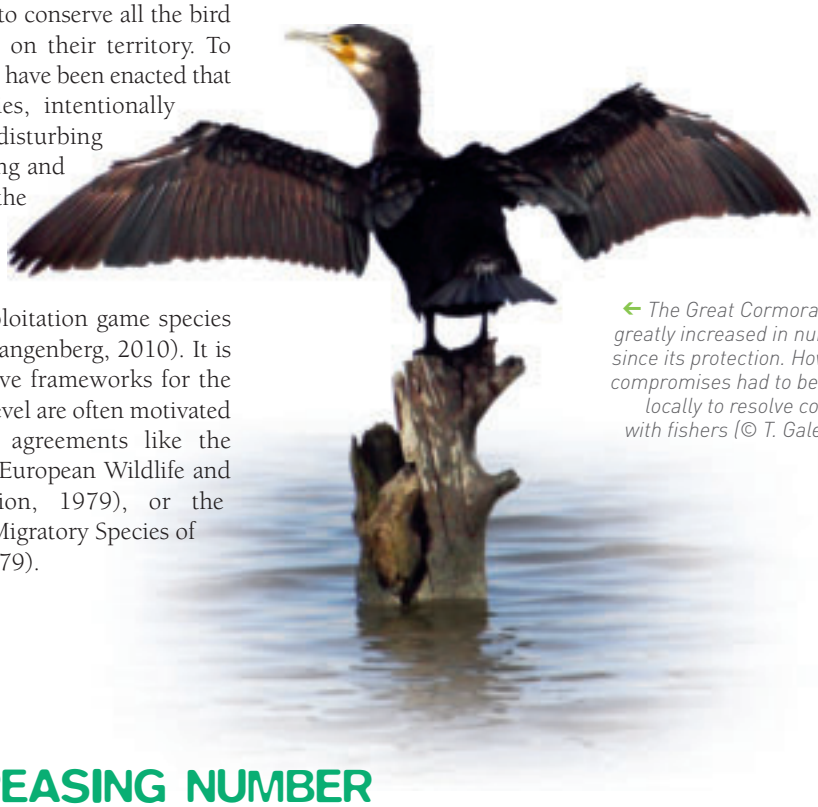


↖ *Greater Spotted Eagle (© T. Galewski)*

5.2 SPECIES PROTECTION LAWS INADEQUATELY ENFORCED

The causes of the decline in biodiversity have evolved since the 19th century. Whereas excessive hunting, the destruction of species that were said to be harmful, and the intensive gathering of plant species used to be responsible for the decline of many species, the principal threat today is the destruction and degradation of their habitats. The direct protection of species has undoubtedly played a major role in restoring many bird and mammal populations. This protection requires the enactment of laws that condemn the destruction of a species or at least ensure that it can be sustainably exploited by limiting the numbers taken (for example, by shortening the hunting season, setting a minimum catch size and quotas for fishing, or even restricting the gathering of plants and mushrooms). The enactment of the Birds Directive by the European Union (EU) in 1979 is one of the most exemplary and effective measures ever taken. It obliges member states to conserve all the bird species living naturally in the wild on their territory. To achieve this goal, regulatory measures have been enacted that forbid the killing of certain species, intentionally damaging their nests or eggs, and disturbing them, particularly during the breeding and dependency period. Meanwhile, the laws regulating hunting in the Balkan countries that are not members of the EU appear to be much more lax and incompatible with the wise exploitation game species populations (Schneider-Jacoby & Spangenberg, 2010). It is worth highlighting that the legislative frameworks for the protection of species at the country level are often motivated by commitments to international agreements like the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention, 1979), or the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, 1979).

In spite of changing mentalities and behaviour, the relationship between protected species and human activities can still be conflictual. Many examples illustrate this point with regard to Mediterranean wetlands. The spectacular rise in the Great Cormorant population in recent decades after their colonies were protected, has created conflicts in several regions between amateur and professional fishers, because these birds have been accused of catching too many fish. In this case, a certain amount of regulation of the cormorant population was permitted. The rapidly increasing numbers of Common Crane and Greater Flamingo have been causing problems locally with farmers who have land near wetlands. These birds tend to eat in the corn and rice fields. As the general public is strongly attached to cranes and flamingos, solutions were found to reduce the farmers' losses without harming these emblematic species.



← *The Great Cormorant has greatly increased in numbers since its protection. However, compromises had to be found locally to resolve conflicts with fishers (© T. Galewski).*

5.3 AN INCREASING NUMBER OF PROTECTED WETLANDS

A well-known mechanism for protecting wild habitats consists in having them designated as protected areas. Some countries have defined objectives in terms of the percentage of their national territory that must be protected, and the Convention on Biological Diversity (CBD) set a goal for 2020 of at least 17% of the land area and inland waters, and 10% of marine and coastal areas for the entire globe. Most countries are still greatly below this threshold, and less than 5% of the Mediterranean basin was protected in 2010 (CEPF, 2010). Nonetheless, the designation by the EU of sites in which biological diversity must be preserved (the Habitats Directive, 1992 and the Natura 2000 network) has enabled several thousand sites to be identified, which represent 28% of Mediterranean countries in Europe (MWO, 2012). Countries that are applying for EU membership are implementing the same process with, for example, 35% of the Croatian territory proposed as future Natura 2000 sites. Although at the present time few specific objectives have been set in terms of wetlands protection, a study conducted in 3 Mediterranean countries - Albania, Cyprus, and Serbia – highlighted the fact that 1/3 of the area of wetlands is protected nationally. Conservation efforts have been focused more on coastal wetlands than on inland or artificial wetlands.

Beyond the national levels of protection, there are also 'international quality labels', such as UNESCO world heritage sites, Biosphere reserves, and Ramsar sites. The Ramsar label is only for wetlands considered to be of international importance by the governments concerned. The development in the number of Ramsar sites provides a rather good image of how wetlands have been taken into account in the designation of protected areas. Since its ratification in 1971, the Ramsar convention has led to the designation of 344 sites in Mediterranean countries, for a total area of approximately 6 million hectares, or nearly 30% of the total wetlands area. This area tripled between 2000 and 2010, whereas there was only a 48% increase at the world-wide scale. The will to grant protected status to wetlands is therefore very obvious in the region and is shared by all countries. Albania, Greece, Algeria, Tunisia, and Morocco have listed more than half of their wetland areas as Ramsar sites. On the contrary, south-eastern Mediterranean countries – Libya, Egypt, Jordan, Israel, Palestinian Authority, and Syria – have only designated very few sites, representing less than 5% of their national wetlands area. Other countries, such as Italy and Turkey, which have substantial wetlands, also appear to be lagging behind in the Ramsar site designation process. In any case, we must remember that one-third of Ramsar sites do not benefit from any real protection status, as the almost complete disappearance of the Sultansazligi marshes in Turkey has shown us (Dadaser-Celik *et al.*, 2008).

Finally, the protection of a site only has a real impact if it is effective and accompanied by concrete conservation measures. Too often, when the institutional and financial capacities required to put in force the regulations are not mobilised, illegal fishing, hunting, and grazing activities can be observed in protected areas (MWO, 2012). A study conducted on the Ramsar sites in Mediterranean countries has shown that the presence of a national protection status does not influence waterbird population trends. On the other hand, sites at which a management plan is being implemented host waterbird populations that are increasing more than at sites where there is no management plan. It would therefore seem to be true that protection status alone does not suffice to bring about an improvement in the ecological state of a site, but must be accompanied by the application of management measures. Only 38% of the Ramsar sites at the Mediterranean level have put in place conservation management measures, and even less in North Africa.

5.4 THE ERA OF HABITAT RESTORATION AND SPECIES REINTRODUCTION

European directives and international agreements oblige countries to conserve species and their habitats, and also encourage them to re-establish the populations of certain priority species. Achieving these objectives increasingly requires the restoration of their habitats and the reintroduction of individuals in regions where they had disappeared. The results for the Emporda marsh in Spain and Hula valley in Israel are among the most spectacular and beneficial for biodiversity. Today, the habitats recreated there can host a highly diverse and exceptional quantity of waterbirds and other aquatic organisms. Wetlands restoration, which also satisfies the objectives in the EU Water Framework Directive (2000), has developed rapidly in Europe recently. The reintroduction of plant and animal species has also been practiced for some decades in the aim of extending the distribution areas of species that have become rare or to increase their numbers. The Eurasian beaver, Purple Swamphen, White-headed Duck, and White Stork are some of the wetland species that have benefited from these operations, and have been able to rebuild viable populations. However, reintroductions do not only concern well-known species. The Majorcan Midwife Toad, a small toad that is endemic to the Balearic Islands, had almost completely disappeared from the wild in 1980 due to predation by the Viperine water Snake and competition with Perez's Frog, two species introduced by humans. Since, at least 10 populations have been successfully reintroduced in wetlands showing positive characteristics for the species, which has helped to considerably decrease the risk of extinction.

↑ *The Purple Swamphen was successfully reintroduced in Spain, and since this reintroduction it has naturally spread to the south of France (© T. Galewski).*

Box E

The Dalmatian Pelican in Prespa: an umbrella species

The ecological situation in the Prespa lakes has deteriorated considerably from the 1960s, when agriculture and traditional farming gave way to an intensive, irrigated agriculture (especially beans). The lake level dropped, large areas of wet meadows were drained, and the remaining grasslands were gradually invaded by reeds due to a lack of management. These transformations and the nuisances caused on colonial birds by local people due to a lack of protection and awareness, led to local extinction of at least 12 bird species between 1967 and 1994 (Catsadorakis, 1997). The Spoonbill and Glossy Ibis are two examples. Many others, including herons, decreased dramatically.

The presence of a colony of Dalmatian pelicans, a rare and declining species throughout the world, on the Greek portion of Lake Mikri Prespa motivated an international research and conservation program focused on this species. Researchers observed an abnormally high mortality and low reproductive success (Crivelli, 1996; Crivelli et al. 1998). The Society for the Protection of Prespa (SPP), founded in 1991, has based its conservation actions on the results of this research. To improve the breeding conditions for pelicans, several decisions were made: limit the disturbance of colonies by hiring a guard, surround the colony by buoys to prevent intrusion by motor boats, educate the local population, and involve fishermen in looking after the pelican colony. An agreement was also made between the SPP and the Greek national electrical company to secure power lines located near the colony, which greatly reduced collisions. All these conservation measures have had a positive impact on the populations of Dalmatian pelicans, but also on several other species that nest in reedbed colonies, such as white pelicans, Great Cormorants, Pygmy Cormorants and several species of herons. The recovery of these species is responsible for the increase of the Living Planet Index since 1990 (Fig. E).

The second step was the restoration of wet meadows habitat, where many waterbirds forage. The Dalmatian Pelican once again became a flagship species, and was at the origin of a LIFE-Nature project, supported by European funds between 2002 and 2007. The aim was to promote the onsite conservation of this species by restoring wet meadows, which are very important habitats for many organisms, particularly for the reproduction of several fish species predated by pelicans and exploited by fishermen (e.g. Carp). The construction of a new lock enabled better management of lake water levels and ensured flooding of grasslands without damaging crops. Grazing of reedbeds was reinstated through the establishment of a herd of buffalo. These measures helped to increase the surface in wet meadows from 35 ha in 1992 to over 100 hectares today. In addition to maintaining a healthy population of pelicans on the lake, this project has improved the status of many other species of waterbirds. The return of the breeding Glossy Ibis illustrates it. Along with the attention given to pelicans, a long-term monitoring of Prespa fish species has been carried out since 1984 in collaboration with the Tour du Valat. The presence of several endemic fish species justifies such monitoring. Despite the dramatic 15 year increase in the number of fish-eating birds, this survey suggests that the large population of fish remained stable which gives hope for a sustainable future for fishermen and pelicans.

Dalmatian Pelican (© Hellio & Van Ingen). ↓

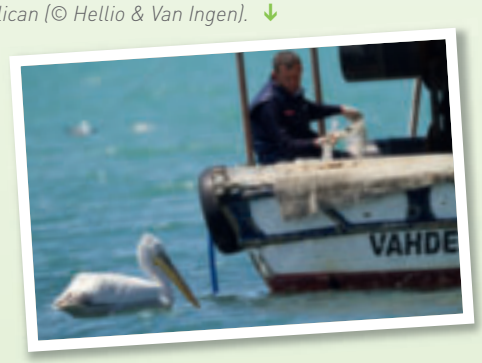
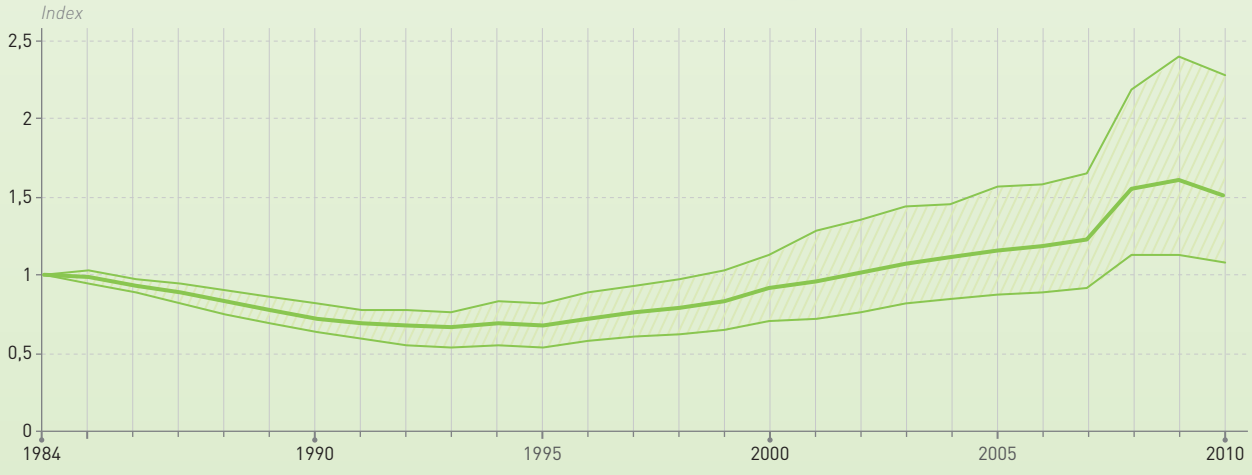


Figure E. *Living Planet Index of breeding birds in Prespa lakes (the hatched area shows the confidence intervals).*



> 6. KEY POINTS TO REMEMBER

6.1 MOST SPECIES HAVE A PREOCCUPYING CONSERVATION STATUS

- **Highly diversified biological communities** use Mediterranean wetlands, particularly in the northwest (France, Spain) and southeast (Egypt, Israel) parts of the basin. Endemism is very strong among certain groups, notably on Mediterranean islands, peninsulas, and mountains.
- **One-third of species linked to Mediterranean wetlands are threatened with extinction** according to the IUCN Red List. Spain, Greece, France, Croatia, Morocco, Turkey, Israel, and Italy host a significant part of these threatened species.
- **Bird populations have had an overall increase of 70% since 1970** in Mediterranean basin wetlands. The increase is strong in the western part, whereas a decline has been observed in the Balkans and Middle East. It is especially the generalist species, which are already common and widely distributed geographically, that have seen their numbers increase.
- **Fish, amphibian, reptile, and mammal populations have declined by 40% since 1970**. Their poor conservation status, as well as that of molluscs and aquatic plants, can be related to the overall decline in the status of watercourses and small wetlands (springs, temporary ponds, and peatlands), which often host the most fragile species. These declines are particularly preoccupying, because the rate of endemism is much higher in these groups than in birds. Their disappearance from the Mediterranean region would mean their total extinction.

↑ *Ocellated Lizard* (Timon lepidus) - *(© M.A. Marchand).*

6.2 SPECIES MUST FACE SIGNIFICANT AND MULTIPLE PRESSURES

✖ The destruction of wetlands will continue to affect biodiversity:

- In the most industrialised countries, the major **drainage operations for agriculture and urbanisation** have been replaced by small-scale but still insidious development projects in wild areas. If at the present time, large wetlands are generally only impacted on their outer rims, it is likely that the conversion of smaller wetlands is being continued at a brisk pace. In developing countries, where there is strong population growth, the drainage of wetlands remains a major concern.

✖ The degradation of wetlands is due to multiple mechanisms and causes:

- **Water pollution** is one of the principal threats facing aquatic organisms. They are indirectly affected by eutrophication, which modifies their habitat, and directly affected by contamination from toxic pollutants.
- **Water abstraction** is increasing to satisfy human needs, resulting in the drying out and salinisation of wetlands. Dam-building continues to increase rapidly, which prevents the migration of fish and impacts the functioning of watercourses and their estuaries.
- **Climate change** with the decrease of precipitations and the increase of temperatures are worsening the hydric deficit and increasing the risk that wetlands dry out. The risk of extinction is greater for endemic species and ones that require the presence of water. The rising sea level predicted for the upcoming decades is likely to affect littoral wetland species by modifying their habitats.

✖ Direct threats to species remain significant:

- Even if the impact of **hunting** on birds and mammals has been mitigated to a large extent by national regulations, the situation remains problematic in several countries in the Balkans and Middle East, Cyprus, and Malta.

Fishing – whether for commercial or recreational purposes – can worsen the decline of certain species that have an unfavourable conservation status.

- Besides its impact on the functioning of wetlands, **climate warming** has resulted in a northward shift in the distribution area of species, modifying communities and fragilising isolated populations and the least mobile species.
- **The introduction of exotic species** – particularly fish – has already led to the extinction of several endemic species in the Mediterranean basin. They can threaten indigenous species by competition, predation, and hybridisation.
- The development of **outdoor recreational activities** can create problems when they are not well designed, particularly in littoral wetlands. Species that are immobile or with limited mobility, such as plants, and molluscs are trampled on, while birds, seals, and turtles can no longer find deserted beaches required for their reproduction.

6.3 SPECIES PROVIDE US WITH MANY SERVICES

- A significant **source of revenues** for local communities, fish which are found in coastal waters, lagoons and big lakes, are the basis of commercial fishing activities. The poor conservation status of many of the exploited species and degraded water quality threaten the future of fisheries.

  Aquatic plants perform many functions and are also a base product in many economic sectors: fodder for livestock, building materials (reeds and rush), and pharmaceuticals (many medicinal plants).

- **As the basis of many recreational and traditional activities**, wetlands and their species contribute to our moral well-being while **supporting** our local economy. Ecotourism, ornithology, wildfowl hunting, angling, and the gathering of shellfish and plants for food are just some of the very popular activities done by people in Mediterranean wetlands.
- **Human health** is directly dependent on the good status of biodiversity. Diversified assemblages of species reduce the risk of transmitting diseases to human beings and domestic animals. Many wild aquatic plants are the basis of traditional medicine, and are used today in modern medicine.

6.4 SOLUTIONS ARE IMPLEMENTED TO FIGHT SPECIES DECLINE

- Progress has been made in **raising the awareness of citizens and decision makers** about the importance of conserving wetlands and their biodiversity. The results are visible for emblematic species, such as flamingos and pelicans; however, much remains to be done to improve the conditions of less spectacular and/or ordinary species.

  Biodiversity monitoring and research results are poorly integrated into socio - economic components of the territory, and must play a role in raising the awareness of decision makers and informing them so as to encourage them to make decisions that are favourable to wetlands. However, monitoring results remain insufficient in many countries, and generally only concern a few groups like waterbirds.

- **To prevent the degradation of wetlands**, a growing number of sites enjoy national and/or international protection, even if the total surface area still remains below the objectives set in international conventions. Nonetheless, protection often remains theoretical, and is not backed by the concrete implementation of management plans and conservation actions.

  The construction of wastewater treatment plants, the ban on certain toxic molecules, and improved waste management have enabled water quality to be improved locally; however, the trends are still heterogeneous between different countries. The number of toxic molecules spewed out by factories and found in the water supply is growing rapidly with a lack of knowledge about their effects.

- **To re-establish biodiversity**, many species have been given legal protection or measures have been adopted to limit their exploitation. The re-establishment of many waterbird and large mammal populations demonstrates that these actions have been effective.

  Several species reintroduction projects, in sites where they had disappeared, and wetlands restoration projects, in formerly drained areas have been conducted around the Mediterranean. The results are sometimes spectacular, and give hope that there will be an improvement in the conservation status of many species if these initiatives are more widely implemented.

PART
- VII -

7. RECOMMENDATIONS

The disappearance and degradation of Mediterranean wetlands have caused an unprecedented decline in biodiversity. In order to stop the destruction of these habitats so indispensable to very many species, and to envisage their restoration, potential actions were formulated and discussed in the MWO's first technical report "Mediterranean wetlands outlook" (MWO, 2012).

In the more specific framework of improving the conservation status of wetland species, the following actions are urgently required:

- Tackle the **underlying causes of degradation** by means of improved governance in the field of environmental conservation, developing better environmental policies, and applying the protection laws already in force.
- Broaden and intensify the application of **water quality monitoring** in response to the recommendations of the conventions and legislation in force. This monitoring also needs to cover new types of pollutants (e.g. microimpurities).
- **Economise water resources** and preserve their quality, particularly by adopting less intensive and water-greedy agricultural practices. In addition, instream flows need to be maintained so that rivers, and the wetlands into which they flow, function correctly.
- Ensure that species can migrate to cooler areas and thus escape the effects of climate warming by developing **climate change corridors** bypassing the human infrastructures that fragment the landscape.
- Accelerate the process of **protected area designation** to incorporate areas recognised by the scientific community as being important for biodiversity (IBAs, IPAs, KBAs [13]). Protection efforts need to be directed towards wetlands rich in endangered species: water courses, temporary marshes, damp grasslands and peat bogs, including those with very small surface areas.
- The placing of wetlands under protection needs to be combined with **sustainable management** and the implementation of conservation programmes. Conservation stakeholders need to play an active part in land-use planning, at both na-tional and local level, in order to be able also to work for unprotected wetlands.
- Develop and improve **monitoring and research** concerning the biodiversity of wetlands in order to fill the knowledge gaps preventing better management and conservation of sites.

In order to reduce direct pressures on wetland species we recommend the following actions:

- Reinforce **species protection laws** and mobilise the financial and human resources required for their application.

↓ *Prespa lake, Albania (© L. Chazée – Tour du Valat).*

13 : IBA: Important Bird Area, IPA: Important Plant Area, KBA: Key Biodiversity Area.

• Identify the most damaging **invasive species** and priority wetlands where action plans need to be set up. Raise awareness among hunting and fishing clubs and the general public concerning the dangers provoked by the introduction of exotic species into natural habitats.

• Manage tourism around coastal wetlands so as to limit the **disturbance** caused to the most sensitive species (bird colonies, sea turtles, etc.).

• Assess the **ecological services** provided by the biodiversity of wetlands, the livelihoods to which they can contribute, and thus raise the awareness of local populations and decision-makers concerning methods for sustainably exploiting them.

Contribution of the MWO's "Sites" assessment

The assessments carried out concerning the biodiversity of five wetlands confirm the MWO's conclusions for the whole Mediterranean region. Despite the ecological, social, economic and cultural differences between the five sites, the pressures impacting species are often very similar. The intensification of agricultural practices and the disappearance of traditional activities are general phenomena affecting most of the Mediterranean, including developing countries. They lead to a freshwater deficit and the destruction of natural wetlands and surrounding habitats. This results in an impoverishment of biological communities and/or the replacement of rare heritage species by common, less specialised species. Another adverse factor observed on all the sites except Ichkeul was intentional disturbance of the animal species that frequent the wetlands. Illegal hunting is a major problem at Aammiq, and has caused the extinction or reduction of several species at Prespa. Many wetland bird species are gregarious and disturbance of their colonies, whether intentional or not, has serious repercussions on their population dynamics. When simple but effective protection measures are set up, as in Prespa, the results can be spectacular.

This sample of sites demonstrated that scientific research is essential, in particular for guiding the conservation actions carried out by NGOs or public institutions. The Ichkeul and Prespa studies show that the involvement of local populations and decision-makers is imperative for ensuring the success of conservation actions. Currently new driving forces, such as climate change or the economic and political upheavals taking place, require vigilance and the adaptation of management methods to ensure the sustainability of these systems.

The image obtained is undoubtedly incomplete because only birds were studied in detail and birds are not necessarily as sensitive as other groups to certain pressures (such as pollution). An assessment including monitoring carried out on other taxonomic groups would certainly provide complementary information; assuming such monitoring exists…. Even with regard to birds, the data gathered often remain insufficient for detailed local analysis. Some of the monitoring is too recent - Gediz, Aammiq – or concerns too few species - Prespa, Ichkeul – to enable thorough interpretation of the indicator values obtained. In this respect the Camargue appears as an exceptional site because of its long-standing monitoring programmes that have gradually been extended to cover most bird groups using the Delta. However, such situations remain extremely unusual in the Mediterranean region.

The site assessment approach was revealed to be fully complementary with the MWO's regional approach. While enabling the MWO to access data that are difficult to obtain from the large-scale databases of its partners (Wetlands International and BirdLife) or from the scientific literature, the sites provide case studies for testing and effectively completing the pan-Mediterranean analysis. Reciprocally, the MWO can assist the development of local work by providing a common conceptual framework, international coverage of the results, vertical complementarity of monitoring at site, national and international level, and technical, financial and institutional support. The study thus suggests that the partnerships between the MWO and local observatories should be continued and consolidated, and that the network should be extended throughout the Mediterranean basin to ensure better consideration of wetlands at both international and local level.

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↑ *Gediz delta, Turkey (© Hellio & Van Ingen)*

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