Annex 10.1 BIODIVERSITY DIAGNOSIS

10.1.1 Main results of the diagnosis of aquatic biodiversity in the Moulouya basin. Prof. Mohamed Melhaoui.

Diagnosis results

In spite of conservation efforts, the aquatic ecosystems of the Moulouya have suffered serious degradation, which is still progressing rapidly. The severe, natural and very frequent droughts during the last two decades have aggravated this situation considerably. The rate of water use is constantly increasing, while water reserves are declining significantly. Besides the frequent drying-out of habitats throughout the river basin, we underline the increased salinity of the lower Moulouya coastal wetlands.

Following the example of other sectoral studies that have pointed out the seriousness of the losses to aquatic and sub-aquatic biodiversity, the IUCN/ABHM project shows that the deterioration of vegetation in aquatic areas has unfortunately exceeded the threshold of reversibility at a large number of sites. This deterioration is all the more serious as vegetation shelters a very diverse fauna, which obviously also undergoes heavy losses.

The lower Moulouya wetlands have witnessed massive and rapid destruction in recent years, which has led to the loss of some habitats and plant groupings. The impacts on the vegetation of these ecosystems are of various origins, but are predominantly due to agriculture, hydraulic infrastructure developments and urbanization, as well as hydrological disturbances linked to natural drought and climate change. Data on aquatic biodiversity and all the underlying changes that affect it should be taken into consideration in the next version of the general plan for integrated water resources management (PDAIRE) for the Moulouya river basin. They include, in particular:

- Dam building, which is considered to be a major factor of in the destruction of natural watercourse habitats and their plant cover: it acts by reducing water flow or even drying up the river bed downstream of the dam and by sending sediment downstream, which results in losses in biodiversity (the current construction of the Tamalout dam is a case in point); it is also a limiting factor for shad, eels and other migratory fishes;
- Erosion and deforestation (which are closely linked), since they eventually lead to a process of desertification, which has a negative impact on the watercourse, especially through the silting-up of dams and reduction of their storage capacity;
- Agriculture, a major activity around most wetlands: it spreads into wetland habitats and is a source of plant populations that colonize them. Agriculture also damages aquatic vegetation by pumping out ground and surface waters, thereby lowering water levels and reducing the length of submersion (as in the Chrarba marshes, towards the mouth of the Moulouya), and by diverting surface waters, which affects aquatic biodiversity.
- Overgrazing and cutting of riparian vegetation, which are among the main anthropogenic reasons for the loss of plant groups and habitats. Overgrazing threatens marshland vegetation, especially wet grassland and reedbeds, which are transformed into bare ground or agricultural fields. Trampling of lake margins, due to tourist activities, speeds up the deterioration of vegetation and the destruction of natural habitats.
- The impact of mining sites, with the potential for water pollution in the upper Moulouya, notably in Zaida, Mibladen and Aouli, and in the region of Touissit in the lower Moulouya;
- The effects of various forms of pollution: urban, industrial (small-scale oil mills) and agricultural (fertilizers, pesticides and plant protection products) as well as the polluting load discharged into the Moulouya river by the sewers and drains of adjacent settlements, all a real threat to aquatic biodiversity;
The problem of conflicts over customary water rights, notably between the upper reaches and the downstream part of the Moulouya basin, infringements of the Water Act (No 10-95), illegal sand extraction and dam water release: these are further threats to aquatic biodiversity;

The lack of awareness about aquatic biodiversity and preservation of water resources among the communities along the Moulouya.

In addition to the threats linked to human activities, the impact of climate change and associated risks, notably hydrological risks such as flooding and the deposition of waters’ sediment load during floods, which is very harmful to biodiversity;

The effects of natural drought in this arid region is currently believed to have contributed to a sharp deterioration in the Moulouya’s aquatic biodiversity, especially as Morocco has experienced severe droughts in the last two decades, while water needs have increased; these droughts also cause additional problems of high variation in the water levels in reservoirs (marling);

For all these reasons, aquatic biodiversity data need to be integrated in development programmes for the Moulouya river basin in order to improve management practices and protect threatened species.

Water pollution in the Moulouya basin. Photo © ABHM

Solid waste in the Moulouya river basin. The treatment centre for solid waste is in Missour. Photo © M. Melhaouï

Awareness raising

To integrate data on aquatic biodiversity into the planning of Moulouya water resources management and to emphasise the importance of aquatic biodiversity, the IUCN/ABHM project
carried out an original and effective awareness-raising campaign known as the Moulouya Caravan for the Preservation of Biodiversity, which was conducted in eight provinces of the Moulouya basin. This awareness campaign, which was widely reported in the media, enabled communities in the area to discover more about the biodiversity of the Moulouya from its source to its mouth. The main objective was to achieve widespread awareness and to disseminate the results of the aquatic biodiversity diagnosis among the various local actors in the Moulouya basin. It sought to make young people and residents of the Moulouya area understand their personal and civic responsibility to protect and preserve the Moulouya's water resources and aquatic biodiversity. The Moulouya Caravan was a joint project involving IUCN–Med in Málaga, the ABHM and its partners, the University of Oujda, local NGOs, the services of the Environment Department for Eastern Morocco, the Academies of the Ministry of Education and environmental associations in Moulouya river basin.

The Moulouya Caravan also took place in the context of two major events:

- The proposal to set up a National Charter for the Environment and Sustainable Development in Morocco;
- The celebration of the United Nations International Year of Biodiversity in 2010.

The Caravan is a mobile exhibition of the Moulouya river basin from the mouth of the river to its source in the Middle Atlas, covering 8 provinces:

Lower Moulouya: Oujda, Berkane, Nador, Taourirt, Guercif and Jerada

Middle Moulouya: Missour

Upper Moulouya: Midelt

The Moulouya Caravan was equipped with posters, fliers, stickers, brochures, CD-ROMs, educational booklets about fish, molluscs, aquatic plants and dragonflies, sample displays, and talks on the importance of aquatic biodiversity and the vital resource that is water, which lies at the root of the individual and collective needs of the Moulouya population and is now limited in quantity, degraded in quality and increasingly expensive.
Stakeholder involvement in the IUCN/ABHM Moulouya Project

- Dissemination of biodiversity data and public consultation

The active participation of stakeholders in the preservation of aquatic biodiversity was a decisive factor for the success of the project. This participation was increased by the involvement of the project of different parties and their support for the sustainable benefits brought by the project. The efficiency and effectiveness of the project will therefore be all the more ensured in the future. The local organization of partners and their cooperation in seminars or information workshops was undoubtedly decisive in the success of the project, which has to be guided by the needs and priorities identified by the ABHM’s main partners.

- Local NGOs play a fundamental role in the protection of the environment in general and biodiversity in particular. During the IUCN/ABHM Moulouya project, they expressed great interest in raising awareness among the area’s residents of the need to protect the Moulouya, which remains a symbol of biodiversity in the Mediterranean. Their grouping under the banners of the North Eco-Platform in the lower Moulouya area and of RALM (Network of Associations of Missour) in the upper Moulouya is a good sign that they are pooling their efforts.

- ORMVAM (the Moulouya regional office for agricultural enhancement) manages irrigation channels. In the lower Moulouya, macrophytes are often considered by ORMVAM agents to clog irrigation channels, slowing water flow and changing local flow patterns, or even temporarily raising water levels. To limit their development, macrophytes are cut mechanically or ripped out manually. These practices are not very efficient. The problem requires some objective thought. While Chinese carp have been used successfully to combat eutrophication in reservoirs, it has not been so in the Moulouya irrigation channels, where the results of trials in the lower Moulouya irrigation area in 1999 were not spectacular.

- The Environment Department service for the Eastern Region has been involved in this project since its start, as it is part of the Environment Strategy of the National Action Plan. The Moroccan Government has signed several protocols and international conventions, including the International Convention on Biological Diversity (CBD) in 1995 and the Ramsar Convention (protection of wetlands) in 1980 by the Water and Forestry Authority. There are 24 Ramsar sites in Morocco, 4 of them in the MRB. There is also a national legal framework, an institutional framework and agencies devoted to biodiversity.

- The biodiversity field survey led by local university researchers and their collaborators resulted in an updated database which can be regarded as a reference for the MRB and added value for secondary and university education and research. The majority of Mohamed I university researchers sit on ABHM scientific committees.

4- Evaluations of the current project by policy makers

The results of this project can be regarded not only as added value for the management of the fauna and flora in the Moulouya river basin, but also as additional knowledge of the country’s ecological heritage and biodiversity to be fed into the Clearing House Mechanism on Biodiversity of Morocco (website: http://ma.chm-cbd.net/).

The success of this project and its efficient management encouraged policy makers—the ABHM board of directors and the Eastern Morocco Development Agency (ADO), which is a member of
IUCN–Med—to think about continuing this project and, in the future, formulating other priority projects for the preservation of biodiversity in the Moulouya’s aquatic ecosystems.

- **Capacity building and training**

Now, for the first time, a river basin in Morocco has a database and takes aquatic biodiversity into consideration in its management programme. For this purpose, the ABHM has set up a scientific council and has programmed biodiversity among its areas of interest.

Aquatic biodiversity management currently takes the form of an open debate with all stakeholders. Recommendations for the Aquatic Biodiversity Management Plan result from a process of cooperation between different actors to define a common plan containing directions, operational objectives and actions to which actors and users of the site would be committed. It is supposed to be a real working tool for administrators and must ensure that the efforts undertaken in the Moulouya basin are sustainable, especially through the involvement of local actors.

Moreover, the Moroccan Ministry of the Environment has made the knowledge and preservation of environmental resources in the Mediterranean region of Morocco a top priority. It is working towards the creation of a regional environmental observatory. The results of this project in the Moulouya basin will be incorporated in this future agency.

5- **Main aquatic biodiversity results obtained and management recommendations**

The following are the main results obtained from the biodiversity assessment carried out in this project. Based on these results, a set of information material has been developed and a series of recommendations has been drawn up for dissemination among both local people and stakeholders:

5.1 **Aquatic plants**

The present situation of aquatic vegetation is so alarming that it requires emergency protection measures; in particular, the discharge of industrial and mining effluent must be stopped, overgrazing reduced and the cutting of wetland vegetation controlled along the Moulouya and its tributaries. Greater efforts are needed to raise awareness in local communities about the ecological value of aquatic plants, to encourage studies and monitoring of the status of rare or threatened flora (Figure 6), and to limit discharges of domestic waste into the Moulouya.

Potamogeton natans, *an aquatic plant recorded in the Moulouya basin*. Photo © M. Melhaoui

In view of the threats to the lower Moulouya, where wetlands are important, necessary
preventive measures include controlling development and urbanization projects, which destroy habitats and vegetation, and controlling the transformation of wet habitats into agricultural land. Raising communities' awareness of the importance of wetlands and their use is essential. A monitoring program seems to be necessary in order to better achieve the goals of wetland conservation in the Moulouya basin, and a management programme should also be set up to ensure effective coordination between institutions concerned with aquatic biodiversity. Conservation measures should be implemented especially for buttercups, *Elodea, Myriophyllum* and *Ceratophyllum* by protecting watercourses and localities where these species are observed.

Figure 6 Distribution map of threatened aquatic plants in the Moulouya river basin (Melhaoui and Sbai, 2009)

5.2 Freshwater molluscs

The inventory of mollusc species is of key importance for the Moulouya not only in terms of biodiversity knowledge but also due to their role in the filtration of pollution. It also contributes to the survey of Gastropoda as intermediate hosts of some water-borne diseases especially the various human and animal forms of bilharzia. Species such as *Bulinus truncatus*, *Lymnaea truncatula*, and *Planorbis metidjensis* have to be regularly surveyed and monitored (Figure 7).

Unio durieui (Deshayes, 1847), an ngered species according to the IUCN Mediterranean Red List, is present in the Moulouya basin. Photo © M. Melhaoui

Numerous mollusc species play a key role in ecosystems and provide various services. Species such as the Melanidae and *Physa acuta*, which are Mediterranean species of stagnant waters
and very slow-flowing watercourses, have important ecological functions (as decomposers of organic matter, for instance) and may be considered indicator species for organic matter proliferation.

The species of *Unio* and *Margaritifera*, which show slow development and long life expectancy, are filterers and accumulate many toxins such as heavy metals and pesticides. At high levels these toxins can kill them or impair their development and reproduction. Endocrinial disorders may also be a factor in the decline of the two species, as demonstrated with other molluscs. However, their conservation consists in controlling pollution and keeping them in shellfish farming experiments.

After the construction of the Mechraa Hammadi dam, the Office of Agricultural Enhancement (ORMVAM) carried out a number of hydro-agricultural developments in the lower Moulouya, greatly increasing the number of sites favourable to the settlement of molluscs and to the spread of parasitic diseases among people and livestock. This should naturally mobilize the Ministry of Health in collaboration with malacology researchers to set up a mollusc shelter survey programme in line with a national strategy to control shellfish that transmit parasitic diseases, especially *Bulinus truncatus*.

The creation of dammed reservoirs (absence of watercourse), hydroelectric power stations (change of flow) and agricultural practices (eutrophication of watercourses, pollution by pesticides, increase in turbidity due to soil erosion), have almost led to the disappearance of several shellfish sites at various locations in the lower Moulouya.

At the ecological level, freshwater molluscs are the basic diet of many aquatic vertebrates; (fish, amphibians, reptiles, birds and mammals). However, they are subject to the impacts of climate, especially irregular rainfall, flooding and the decrease in the piezometric level of underground waters linked to climatic and anthropogenic factors: For example, *Margaritana margaritifera marocana*, an endemic freshwater species in Morocco, is actually endangered in the lower Moulouya (Figure 8). Warmer summers, which make the upper reaches of the river dry up more quickly, is an additional risk factor for the malacofauna. The non-permanent movement of water in irrigation channels can also be fatal for molluscs.

Figure 7  Distribution map of molluscs that act as intermediate hosts of parasitic diseases in the Moulouya river basin (Melhaoui and Sbai, 2009)
5.3 Freshwater crabs

The diagnosis showed that the native freshwater crab species is endangered in the Moulouya basin due to problems of stream diversion, as in the case of Oued Zegzel, pollution, as in the case of Oued Zebra (effluent from Sucrafor in Zaio), or severe floods carting mud, as in the case of Oued Za. During the 2009 inventory in the Moulouya river basin, we updated the distribution map of this species and set up a database of locations where it is found so that its occurrence can be taken into account during development work (Figure 9). To improve the management of the Moulouya freshwater crab, we recommend:

- An ecological study of this species in locations targeted by the inventory conducted during this project.

- A genetic study of these populations would be of interest to check whether they all belong to the same species, and it would be an opportunity to find out if there are any endemic subspecies in the Moulouya.

This research confirms the scientific importance of the Moroccan population of freshwater crabs, as well as the high risk of extinction it is facing. It is an opportunity to renew the call to policy makers to take immediate concrete measures, with the support of local nature conservation associations and researchers from Mohamed I University in Oujda, for the protection of this animal, which depends completely on fresh water and has an extraordinary adaptive ability to survive in extremely arid locations. We therefore recommend protection for locations, with permanent, flowing, freshwater streams that harbour freshwater crabs, to be declared as natural reserves.
The freshwater crab *Potamon fluviatilis* = *Potamon edule* is an endangered species in the Moulouya basin. Photo © M. Melhaoui

Moreover, we have to be alert to the risk of invasion by the alien freshwater crab *Ericeira sinensis*, known as the Chinese crab, in northern Morocco. This crab exists in southern Spain and has a body 10–15 cm in diameter; it is recognizable by its hairy legs, the dark, blotchy, olive brown colouring of its carapace and the pale tips of its legs. This species, originating from China and Korea, was first spotted in Europe in 1912 in northern Germany. It probably arrived in Europe in a larval stage in ships’ ballast water. Today, it is present in most large European rivers. However, its nocturnal behaviour and cavernicolous character mean that it is poorly known. Because of the damage it can cause to river banks by digging its tunnels, this species is considered to be undesirable in Europe.

**Figure 9** Distribution map of the native freshwater crab in the Moulouya river basin (Melhaoui and Sbai, 2009)

### 5.4 Dragonflies and damselflies

New survey work shows that the Moulouya river basin shelters a rich fauna of dragonflies and damselflies (42 species, about 70% of the total Moroccan fauna of Odonata). Thirteen Moroccan endemic species, 1 endangered species and 9 species classified as near threatened have been recorded there (Figures 10 and 11). Six species are new for the Eastern province, but others were not found and could be locally extinct due to the destruction, draining or pollution of watercourses and marshes.
The upper and middle course of the Moulouya river is characterized by a very poor Odonata fauna. That is due to the torrential floods and the constant shifting of sediments in that part of the river, which prevent the lasting establishment of suitable habitats for their larval development.

*Calopteryx exul*, an Endangered species on the IUCN Mediterranean Red List, occurs in the Moulouya basin.

Good water quality must be ensured throughout this river network in order to guarantee the permanence of these species there. This requires an improvement to urban sewerage systems. The considerable deterioration in the chemical and biological quality of the waters in the upper reaches of the Oued Za basin, due to development and waste from the town of Ain Beni Mathar, is obvious when the state of this watercourse in 1983–1985 is compared with its state in 2009. This must be addressed and corrected, as must the effluent from the water purification works in Guercif, on the Moulouya. The same applies upstream in the larger towns such as Outat -el-Haj and Missour.

*Figure 10* Distribution map of threatened dragonfly species
5.5 Freshwater fish

The waters of the upper Moulouya are classified as cold waters (suitable for cold-water fish species such as salmonids, e.g. trout) and lukewarm waters (suitable for fish other than salmonids, such as carp, pike, perch, pike-perch, black-bass, eel and shad). The size of the Moulouya river basin, its northward flow to the Mediterranean, the diversity of its relief and the complexity of the stream network, account for the diversity and endemism of its ichthyofauna, some species of which are endangered (Figure 13), and the diversity of introduced species.

The indigenous ichthyofauna in the Moulouya river basin is characterized by the predominance of Cyprinidae, which represent more than half of the native species in the Moulouya and its tributaries. The upper reaches of the basin are characterized by the occurrence of wild trout Salmo trutta var. macrostigma. The range of this species is limited by its water quality requirements (oxygen and temperature levels). The Moulouya estuary has a relatively important semi-marine fish fauna. The oxbow lakes of the estuary are also colonized by strictly marine species such as gilt-head bream, sole and sea bass, or semi-marine such as Mugil and Cyprinodon, and migratory species such as eels and shads, which are endangered.
Eels and elvers (glass eels) supported a significant fishery in the mouth of Moulouya until 2004. Shad (*Alosa*), formerly abundant in the lower Moulouya, is currently undergoing a worrying decline because of different forms of habitat deterioration and is now rarely caught, because dam building prevents it from migrating to the upper reaches in order to reproduce. A few spawning areas that are still accessible in the lower course of the Moulouya are therefore crucially important. Twenty years ago, this species was generating substantial incomes for fishermen in the lower Moulouya. Unfortunately, its decline is now such that its future survival is in serious doubt. This is due to mining pollution, industrial effluents and urban waste, which are discharged into the Moulouya without any treatment. We should also highlight the absence of fishways to bypass the dams on the Moulouya.

![Shad](image)

Shad, *Alosa alosa* (Linné, 1758) (*above*) and *Alosa fallax* (Lacépède, 1803) (*below*), two fish species listed as Regionally Extinct northern Africa Red List occurred in the Moulouya basin in the past but this will not spawn. Photo © M. Melhaoui

In the lower Moulouya, the shad is of considerable ecological interest in terms of fish biodiversity, since this species has survived for a long time despite the effects of various forms of pollution and the building of the Mechraa Hammadi dam, which was designed without a fishway. The shad is endangered in the Moulouya estuary and is included on the IUCN Red List. The reappearance of shad in the Moulouya estuary appears to be linked to the reduction of fishing pressure in this safe, protected area, the diversity of breeding areas along a 30km stretch of river, and a reduction in pollution from certain water engineering developments. Another important fact is that the extraction of sand and gravel (spawning habitat) for building work is carried out a long way upstream of the estuary, just downstream of the Mechraa Hammadi dam.

Currently, eel and shad fishing are banned in this area, which is now protected by the Waters and Forestry authority. Neither of these migratory species is subject to any management practice. However, elver fishing is an important source of income for local fishermen, who are adept at catching them and are just waiting for the authority to grant them permission to do so.

In the Beni Snassen mountains at 1210m above sea level, the Zegzel gorges drain a karstic...
system producing clear waters for much of the year. Here, a population of barbels (catfish) is threatened with extinction because of water diversion by farmers and water pollution linked to the habit of washing vehicles with detergents in the lower course of the Zegzel.

The expansion of the dam building policy gave rise to a third type of milieu in the intermediate zone, with barbels as the predominant species and some other introduced species such as carp, pike, black-bass and pike-perch. A census recorded 12 introduced species in the Moulouya, resulting from two phases of introduction:

- The first phase (from 1967), described as ‘the period of sports fishing’, was characterized by a proliferation of fishermen’s associations in Morocco, which lay at the origin of most of the introductions, for instance pike-perch, rudd, black-bass and pike. These ‘blind’ introductions were carried out by the authorities and fishermen’s associations without any prior scientific study.


Fish stocking operations have intensified since the 1980s above the Mohamed V and Mechraa Hammadi dams and in the new reservoirs. Since 2000 river diversions have been made regularly every year but without any prior study. No efforts are currently being made to improve fishing operations by encouraging the private sector or setting up fishermen’s associations.

Throughout the Moulouya river basin, administrators have to address several types of pressure limiting or causing a decline of fish and aquatic organisms in general. These pressures must be taken into consideration during development work.

Some constraints are natural and linked to the flood regime of the Moulouya and its major tributaries, which periodically cause a considerable modification of sediments, preventing the development and structuring of habitats favourable to fish larval development. Climate change can also account for the reduction in rainfall, resulting in reduced flows and the drying-up of some parts of the river, which can be considered intermittent or ephemeral following long periods of drought. Other factors are human-related and result from carelessness and the use of this environment without taking precautions. This category includes:
- Drying-up of rivers, which is partly due to the natural cycle of drought, but also results from the abstraction of groundwaters for consumption and agricultural purposes;

- Mechanical habitat destruction, resulting, for example, from operations to straighten or inappropriately channelize watercourses (e.g. the diversions of the Zegzel), or the extraction of sand and gravel directly from the main channel of oueds (e.g. the Oued Za in Taourirt); all this destroys the habitats of larvae;

- Poaching of fish, especially from unguarded reservoirs;

- Discharges of untreated or poorly treated domestic or industrial wastewaters, such that the building of effective purification and treatment stations is crucial, notably in all large towns, especially in the upper and middle Moulouya;

- Pollution from agricultural activities (excessive use of pesticides and chemical fertilizers);

- Bad habits such as washing vehicles in watercourses using detergents (which are toxic to fish), which must be banned everywhere;

- Dam construction (e.g. the Tamalout dam in the headwaters of the Oued Ansegmir, a salmonid watercourse in the upper Moulouya), which generates large amounts of fine sediments, making the waters muddy and opaque, and therefore unsuitable for the development of aquatic organisms, over long distances downstream;

- Reservoir water releases (a frequent occurrence at Mechraa Hammadi dam), which can bring about anoxic sediments and generate toxic sulphides harmful to aquatic organisms.

In view of the importance of fishery resources to both biodiversity and the economy, the Water and Forestry authority should set up a code of conduct for fish conservation and management in order to raise awareness regarding fish habitats around dams or along the Moulouya and its tributaries. Fish habitat is such a complex ecosystem that the slightest change in any part may have unforeseen negative effects. This concerns construction works in and beside watercourses, where both the authorities and residents have to protect these special places: if fish habitat is destroyed, fish then disappear as well as other forms of aquatic life. Activities and practices which may harm fish and their habitats include:

- Dredging;
- Diversion or channelization of watercourses;
- Destruction of aquatic and marginal vegetation;
- Water abstraction;
- Wastewater discharges;
- Dumping of solid waste;
- Bridge building;
- Shoreline stabilization and bank reinforcement, etc.

Many measures have to be taken to avoid harming the habitat during activities in or near water, especially environmental impact assessments (Law 12-03) before project implementation begins. Biologists and fishery engineers of the Waters and Forestry authority are the only ones authorized to determine the status of fish habitat and to decide if the body of water requires legal protection.

Moreover, the strong variation in the tidal waters of dams can result in low water levels and raises concerns for fish. The development of artificial spawning grounds in different sections of the river could be a favourable solution. The artificial spawnings are easy to move when low water levels occur and can be simply withdrawn when water returns to normal levels, avoiding
egg mortality. However, the whole fish management system needs to be reviewed at each dam, with a specific programme and the means to monitor stocking operations and the young fish nursery and especially to carry out studies on fish stocks. It will also be necessary to promote commercial sports fishing, and to fight poaching.

Although the role of aquatic plants in fish habitat is obvious, rocks and logs are also important elements. In lakes fed by very small streams, marginal rocks are often the only places where some species can spawn successfully. Rocks can also protect the shore. These are therefore elements that deserve to be protected. Woody debris provides important shelter for fish, especially in watercourses. Logs can also improve the habitat by gouging deep pits in watercourses, and can even change their course. If for any reason rocks or woody debris have to be removed from the water temporarily, they should be kept and then put back in the same area or a nearby area at the same depth.

Where the reproductive habits of local species are known, it is important to make sure that activities nearby or upstream do not disturb critical stages in the life cycles of the fish. In the Moulouya, for instance, Cyprinidae spawn during spring and early summer, while Salmonidae generally spawn from autumn until spring.

Aquatic organisms and especially fish depend for their growth and reproduction on the quality of the waters in which they live. In general, water quality is determined on the basis of quantitative and qualitative criteria, such as, presence, of certain nutrients in sufficient quantities, oxygen content, pH (potential hydrogen), temperature, and the presence of substances known for their toxicity (metals, pesticides, phenols, etc.). Quality standards for fish waters aim at protecting the fish ecosystems, and therefore at enabling many different species to live and reproduce in watercourses. Water Law 10-95 and the Fishing in Continental Waters Law (Dahir of 21 July 1923) form the legal framework defining quality standards for fish waters. It should be borne in mind that river fishing is managed by the Waters and Forestry authority. Fishing activities are currently banned in the Moulouya SIBE, which has been a protected reserve since 2000. This allows for good protection of migratory fish such as eels and shad.

Sand and gravel (spawning habitat for several species of fish) is extracted for building work on a large scale upstream of the Moulouya estuary. In the future, it will be desirable to restore and rehabilitate stretches with degraded gravel fish habitat and to maintain the stability and quality of running water systems. Moreover, it is imperative to guarantee the free movement of reproducing migratory fish in the Moulouya. Improvements to fishways and similar devices may allow shad to quickly re-colonize areas from which they have disappeared. The downstream migration of shad also needs to be facilitated with specific devices, and eels, eels and shad must be enabled to migrate to good quality areas in order to increase the recruitment rate of these species.

All these considerations must be taken into account in a fish management plan in order to better serve the authorities, fishermen and the local population of the Moulouya river basin.