FISH, FISHERIES, FISHERMEN

CHRISTIAN LÉVÊQUE
ORSTOM
213 rue La Fayette, 75480 Paris cedex 10, France

Abstract

The great longevity of ancient lakes (those more than 100,000 years old) may explain the existence of an intralacustrine speciation process that gave rise to species flocks. Many species flocks belonging to various fish families have been identified, and in some very old lakes, such as Lake Tanganyika, several species flocks exist in various fish families. Living resources of the ancient lakes have for a long time been exploited traditionally by indigenous populations. Over many generations, a close relationship between culture and aquatic environment has developed, including a large body of traditional knowledge about lake functioning and its resources. It also embodies a relationship that goes beyond the material to the spiritual well-being. Macrophytes are widely used for domestic purposes, to feed cattle, and to build fishing craft. Local fishermen have also developed a huge variety of fishing gear, made with local materials and adapted to the ecological behaviour of fish species. The different fishing methods and gear constitute a cultural heritage, the result of a co-evolution between local populations and their environment. Also, many local populations have developed traditional and informal rights, which have been in effect for a long time, pertaining to access to and exploitation of living resources. In many cases, local communities are more effective in regulating access to the fishery than government officials. The cultures of indigenous lacustrine populations also include various legends and myths related to the lake and the exploitation of its living resources. Examples taken mainly from Lake Titicaca (South America), Lake Biwa (Japan), and the Rift Valley Lakes (East Africa) are provided to illustrate different cultural and social aspects of the relationships between fishermen and their lacustrine environment.

1 Introduction

Aquatic organisms share a common history with the ecosystems in which they evolved. Their evolution and speciation are the result of long-term co-adaptations to changes in their biotic and abiotic environments. An exceptionally high faunal diversity, including some of the most spectacular species-flocks among fishes, is observed in ancient lakes (or "long-lived lakes" sensu Martens 1997). An aggregate of several species should be identified as a flock only if its members are endemic to the geographically circumscribed area under consideration and are each others' closest living relatives (Greenwood 1984). The longevity of ancient lakes may explain their unique endemic evolutionary radiations. The processes accounting for these radiations are a matter of debate among scientists, but there is more and more evidence that sympatric speciation may occur in isolated waterbodies (sympatric speciation occurs when reproductive isolation is developed within an unbroken geographic range,

H. Kawanabe, G.W. Coulter, and A.C. Roosevelt (eds.), Ancient Lakes: Their Cultural and Biological Diversity, 3-15.

despite continuous gene flow). These species-flocks are sometimes considered as an endangered world heritage to be preserved from destruction by human activities such as overfishing or introductions of exotic species (Coulter *et al.* 1986; Nagelkerke *et al.* 1995).

To some extent, cultural diversity is also the result of a co-evolution between societies and their environment: from the beginning, the interplay between cultural and natural processes has resulted in significant changes in both the biophysical environment and the life conditions of humans. This embodies a relationship that goes beyond the material to the spiritual well-being. For people of the Andes, for example, Lake Titicaca is a sacred place and the background of their legends. In the 16th and 17th centuries the lake was seen as a bottomless body of water that collected rain and river water and let it drain, by way of its interior, towards the sea. The lake was thus a large hole communicating with the enormous ocean on which Earth floated (Bouysse-Cassagne 1992). Several legends put Lake Titicaca, as well as Tiwanaku, at the origin of the creation (Titicaca reflects the name of the island where the god Wiracocha performed his second creation). The Aymara term that designates Titicaca's Lago Pequeno means "place of eternity". When humanity had been annihilated by the great flood, in the times of the darkness, the god Wiracocha created the stars. He commanded them to disappear beneath the earth and then made them rise up again through holes or hollows in the earth's crust that are mountains, caves, springs and lakes. The Incas used to venerate the stars in a temple on Titicaca Island - the present-day "Sun Island". Moon Island is another sacred place on the lake. In the Andean pantheist view, the birth of the sun and the moon are inextricably linked to these islands (Bouysse-Cassagne 1992). Similar legends have been reported for other ancient lakes, including Lake Biwa (Kada 1991). Indigenous cultures developed around lakes in relation with the utilisation of the lake's living resources, and ancient lakes offer good examples of rapidly disappearing native traditions for the use and management of natural resources.

2 The Diversity of the Fish Fauna in Ancient Lakes: A Biological Heritage

One of the most important features of ancient lakes is the existence of "species flocks". At present, different rich fish-species flocks have been identified in various ancient lakes, which are therefore exceptional natural sites for the study of speciation patterns.

In Africa, the most striking feature of the Great East African Lakes (Victoria, Tanganyika, and Malawi) is that each has its own highly endemic lacustrine fauna of cichlid fishes, which apparently evolved from riverine ancestral stocks. Cichlid speciation has also occurred, to a lesser extent, in other smaller lakes of the Rift Valley, such as Lakes Albert, Turkana, Edward and George, and Kivu. The non-cichlid fauna of the East African Lakes is highly endemic and reflects the fauna inhabiting their present and former drainage systems. The origin of Lake Victoria dates back to between 250,000 and 750,000 years ago. The lake harbours a species flock of more than 300 endemic haplochromine cichlids. The diverse cichlid fauna of Lake Malawi (3.6 to 5.5 Myears old) could be much more than 500 species (Ribbink 1988; Fryer 1996) and a species flock is also reported for the clariid catfish *Dinotopterus* (10 species). Evolution in Lake Tanganyika (14 to 20 Myears old) has led to the occurrence of species flocks within a few families: seven mastacembelid species, six species of *Chrysichthys* (Bagridae), seven species of *Synodontis* (Mochokidae), and four species of *Lates* (Centropomidae) (De Vos and Snoeks 1994). Only 200 endemic cichlids have been reported from Lake Tanganyika, but morphological and electrophoretic data both suggest that several lineages are much older than the lineages of Lakes Victoria and Malawi and can be traced back to at least seven distinct ancestral lineages (Nishida 1991; Sturmbauer and Meyer 1993). The remarkable diversity of the large barbs (genus *Barbus*) in Ethiopia's Lake

Tana constitutes another example of a potential species flock, which has been discovered only recently (Nagelkerke *et al.* 1995).

In South America, the native fish fauna of Lake Titicaca includes the genera *Trichomycterus* and *Orestias*, both endemic to the Andean Altiplano. Twenty-four *Orestias* species are presently recognised in Lake Titicaca (Lauzanne 1992).

In Asia, the cyprinid fauna of Lake Lanao on the Mindanao Plateau of the Philippines presents a widely acknowledged but controversial example of adaptive radiation. Adaptive radiation is a term used to describe diversification into different ecological niches by species derived from a common ancestor. According to Myers (1960), Lake Lanao's cyprinid fauna, a species complex of 18 endemic taxa, arose within the lake approximately 10,000 years ago.

In Russia, Lake Baikal (25-30 Myears old) comprises 56 species and subspecies of fish which belong to 14 families (Sideleva 1994). One of the important features is the presence of cottoid fish species flocks, comprising 29 species (11 genera) of totally endemic sculpins belonging to three families: Cottidae, Comephoridae, and Abyssocottidae. This is probably the most ancient lacustrine flock among living fishes.

3 Human Impact on Fish Species Flocks

For many authors, ancient lakes are natural laboratories where it is possible to study evolution at work. They are a natural world heritage that has to be preserved from extinction. This endemic fauna, however, is currently threatened by the introduction of exotic species, trawl fisheries, and habitat alteration. The recent, documented disappearance of over a hundred cichlid species from Lake Victoria has resulted in an international concern for the knowledge and preservation of this unique fish fauna.

3.1 SPECIES INTRODUCTION

The introduction of alien fish into inland waters has occurred all around the world (Welcomme 1988). The main goals of deliberate introductions by fishery officers were initially to improve sport fisheries and aquaculture, or to fill supposedly "vacant niches" and improve wild stocks in old or newly created impoundments. However, introductions of alien species have been considered the main causes of extinction of endemic species flocks in several ancient lakes:

3.1.1 *Lake Titicaca*

The rainbow trout *Salmo gairdneri* was introduced in a fish farm near Puno in 1941 or 1942. It was accused of seriously threatening the endemic *Orestias* fauna and of being responsible for the disappearance of species such as *O. cuvieri*, but this has never been proven (Loubens and Osorio 1992). *Basilichthys bonariensis*, locally known as the "pejerrey" is a member of the family Atherinidae, originating from estuarine and riverine habitats in Argentina, Uruguay, and southern Brazil. It was introduced in 1946 into Lake Poopó by an angling club and entered Lake Titicaca in 1955 or 1956. It is now the most important species in the fisheries (Loubens and Osorio 1992).

3.1.2 *Lake Lanao*

The introduction of the white goby (*Glossogobius giurus*) in the early 1960s resulted in the elimination of numerous species of endemic cyprinid fish (Kornfield and Carpenter 1984). Along with the eleotrid *Hypseleotris agilis,* introduced around 1975, the goby is now the dominant species in the lake. Many other exotic fish species have also been introduced, such as *Cyprinus carpio*, *Micropterus salmoides*, *Channa striata*, and *Anguilla celebensis* (Kornfield 1982).

3.1.3 *Lake Biwa*

The recent increases in numbers of the exotic bluegill *Lepomis macrochirus*, black-bass *Micropterus salmoides,* and *Channa maculata* have been mirrored by serious declines in the native species *Onchorhynchus rhodurus rhodurus* (an endemic), *Hemigrammocypris rasborella*, and *Hymenophysa curta* (Cohen 1994; Kawanabe 1996; Nakajima and Nakai 1994; Yuma *et al.* 1998).

3.1.4 *Lake Victoria*

Much has been said about the impact of the introduction of the Nile perch on the hundreds of endemic haplochromines (see for instance Witte *et al.* 1992b; Lévêque 1997). In the early 1980s the impact of the introduced *Lates* (Nile perch) upon the indigenous fish fauna was considered an ecological and conservation disaster (Coulter *et al.* 1986; Ligtvoet 1989). It was later recognised that predation by *Lates* may not be solely responsible for the depletion of haplochromine stocks, which had already been affected by fisheries well before the establishment of *Lates.* Unregulated fishing pressure and trawling techniques introduced in the Tanzanian part of the lake may have largely contributed to that decline (Ogutu-Ohwayo 1990). Witte *et al.* (1992a) provided quantitative data on experimental catches from 1979 to 1990 in the Mwanza Gulf that showed that the decline of haplochromines had already started prior to the Nile perch upsurge. Of the at least 123 species recorded at a series of sampling stations, more than 80 (ca. 70%) disappeared from the catches after 1986. But in deepwater and sub-littoral regions, haplochromine catches decreased to virtually zero after the Nile perch boom.

The Lake Victoria ecosystem is currently unstable, and changes in the flora and fauna can also be expected due to eutrophication. Whether or not these changes will affect positively or negatively the survival of the haplochromines is not known. Remnants of the cichlid fauna will probably survive in the littoral areas, but may be threatened there by fishing pressure with small-meshed nets (Witte *et al.* 1992b). There is little hope of restoring the original fish species diversity. Meanwhile, it appears that the introduction of *Lates* to Lake Victoria has provided a basis for a useful fishery and is not the only cause of decline among the haplochromines. The future of both remains uncertain. Last but not least, water hyacinth has now invaded Lake Victoria, and the remaining fish fauna is therefore more and more threatened.

3.2 FISHERIES PRACTICES

Among the major threats to the unique species flocks of ancient lakes are overfishing and the introduction of new fishing practices (Lévêque 1997). Indeed, the maximization of yield has the highest priority in developing countries with expanding populations and increasing food requirements.

Ribbink (1987) stressed the fragility of the cichlid communities endemic to the African Great Lakes. The structure of these communities can change dramatically within a few years when trawlers and other such fishing gear are used. For example, the commercial bottom trawl fishery started in Lake Malawi in 1968 and experimental surveys conducted from 1971 to 1974 showed a rapid decline in abundance of the larger species (individuals over 190 mm) from 79% of the catch in 1971 to 18% in 1974 at one sampling site in the Southeast arm of the lake. Cichlid species such as *Lethrinops stridei* and *L. macracanthus* declined drastically (Turner 1977). Over 20% of the species disappeared from the catch in the four years 1971-1974.

By the early 1990s the large benthic feeder *Lethrinops macracanthus* had disappeared, while *L. microdon*, formerly the mainstay of this fishery, has declined from 16% by weight of the 1971-72 catch to less than 2% in 1991-92 (Turner 1994). Demersal trawl surveys have also shown that fish communities in the most heavily fished areas in the south of Lake Malawi have been severely disrupted by trawlers; three large haplochromine species have been eliminated and a further eight show statistically significant declines (Turner 1994).

A number of authors have recorded the effects of overfishing in Lake Victoria, where some species have declined or virtually disappeared. The history of the fishery has been briefly reviewed by Barel *et al.* (1991), Witte *et al.* (1992), and Craig (1992). An endemic tilapia fishery was already established for *Oreochromis esculentus* and *O. variabilis* at the beginning of the century (Acere 1988), and in the following decades catches decreased and fish became smaller (Graham 1929). Nylon gill-nets and outboard motors were introduced in 1952. This improved technology and increased fishing efforts resulted in a severe drop in the catches of endemic tilapia (Fryer and Iles 1972). In the 1960s, the use of small-mesh nets (38 to 46 mm) and an increase in the use of beach seines resulted in a further reduction of the small fish: haplochromines and juveniles from other genera such as *Synodontis* spp. and *Schilbe intermedius* (Marten 1979). Meanwhile, light fishing for the cyprinid *Rastrineobola argentea* developed in both Kenyan and Tanzanian waters.

During the 1970s, Marten (1979) had already noticed that the inshore fishery of Lake Victoria showed symptoms of severe overfishing: "Despite the numerous species and general abundance of *Haplochromis*, inshore *Haplochromis* in the heavier fished areas of Lake Victoria already seem to be cropped at the limits of their potential." The problem was that the heavy fishing was associated with the use of small-mesh gill-nets and seines to catch small fish, a practice that endangered the catches of the larger species in the long term. Actually, since the three countries bordering the lake achieved their independence in 1961-63, no restriction on fishing gear has been in effect in Tanzania and Uganda, whereas nets below 13-cm mesh size were prohibited throughout the lake before independence. Much noise has been made about the consequences of the introduction of the Nile perch, a so-called "ecological disaster," but it is obvious that increased fishing pressure in the absence of regulation has also played a major role in the disappearance of the haplochromines in Lake Victoria.

According to Coulter *et al.* (1986), the collective experience on the African Great Lakes in recent years is that large-scale mechanised fishing is incompatible with the continued existence of the highly diverse cichlid communities. Cichlids appear especially vulnerable to unselective fishing because of their particular reproductive characteristics (low fecundity, parental care, low mobility, etc.). According to Turner (1977), it is not possible to maximise the yield of fish protein without causing a change in species composition and a decline in the number of endemic species. A number of suggestions have been made which could afford at least partial protection to sections of the cichlid communities. These include increasing the mesh size of nets and the replacement of mechanised fishing gear with labour-intensive methods. An alternative to large mechanised fisheries would be to increase the number of artisanal units, which should be preferable for the conservation of species (Coulter *et al.* 1986). But smaller units are more difficult to manage and involve different social and economic factors.

It has also been suggested that parks should be developed (Coulter *et al.* 1986) and that fishing should be rendered impossible in certain areas by placing obstructions on the bottom that would snarl trawl nets (Ribbink 1987). Lake Malawi National Park will very probably afford protection to widespread species, but no data are at present available to confirm this hypothesis. It is unknown yet whether these reserves can adequately preserve the integrity of populations. Preservation may only be possible for stenotopic populations (strictly confined to their specific habitat) whose distribution coincides with the park area. The size of the reserves, the intensity of fishing in nearby areas, and the possible influence of pollution or introduced alien species, should also be taken into account (Coulter *et al.* 1986).

Lake Tana is one of the few African lakes that has not yet been damaged by human activities. There are no introduced fish species or major sources of pollution. However, commercial fisheries have been developing in the southern part of the lake since 1986. Fishing grounds have extended significantly during the last few years and fishermen take their largest catches at or near the spawning grounds at the mouths of the large rivers, taking mostly large, ripe animals. Although the tendency to raise fishing pressure is understandable, the barb populations are expected to decrease rapidly if the fisheries target spawning migratory fishes, which are especially vulnerable to overfishing (Nagelkerke *et al.* 1995). Preventive measures must be initiated now, before an ecological crash occurs.

3.3 EUTROPHICATION

Habitat alteration is one of the major causes of the loss of diversity of inland waters. The eutrophication of Lake Victoria during the last 25 years is quite well documented (Hecky and Bugenyi 1992). Enhanced quantities of exogenous nutrients appear to have been entering this lake for many years, both through rivers and from aerosols (ash particulates), as a result of human activities in its watersheds. The eutrophication of Lake Victoria may result from the cumulative effects of increasing urbanisation around the lake, as well as the use of fertilizers and pesticides for agriculture or tse-tse fly control. The observed increase in algal biomass in this case might be attributed to an increase of nitrogen and sulphur, because phosphorus concentrations changed little from 1961 to 1988. This eutrophication could lead to increased oxygen demand in the lake's deep water and thus decrease the hypolimnetic volume habitable by fish during seasonal stratification. This phenomenon is partly responsible for the threat to, or disappearance of, cichlid species belonging to the haplochromine flock. Drastic reduction in the herbivorous haplochromine stocks from intense fishing activities and Nile perch predation may contribute to the phenomenon by lowering the consumption of plant material and therefore increasing oxygen demand through decomposition of this material.

A slow eutrophication of Lake Kivu has also been reported, manifested by lower average oxygen levels and higher nitrate levels. Population growth, deforestation, and erosion are likely to be the main causes of these changes.

4 Social and Cultural Aspects of Fishing Activities

Modern science by itself seems unable to halt and reverse the depletion of resources and the degradation of the environment. Resource management has not been designed for the sustainable use of resources, but for their efficient utilization, as if they were boundless. There is a need to develop a new resource management science that is better adapted to serve the needs of ecological sustainability. This could be achieved by including strategies derived from ethnographic traditions. The concept of "people's participation" in national resources management is being voiced and increasingly recognized in international fora. We have to consider the diversity of traditional resource management practices and systems if we want to achieve the task of reconstructing this new resource management science.

Over many generations, the culture of indigenous people (those that have been living in or occurring naturally in a particular area) has been influenced by the environment. Local peoples, depending on a number of historical, social, and ecological factors, amassed an extraordinary store of knowledge about the local natural resource base and natural ecosystem functioning and responses to various uses. Many societies have developed complex managêment patterns for biological resources, and this local knowledge may yield new ideas about the conservation and management of natural resources.

4.1 WATERCRAFT

All around the world, indigenous people show remarkable ingenuity in fashioning any material that is to hand into something that will do for a fishing boat. Around Lake Victoria, for example, people built papyrus canoes that resemble those of ancient Egypt. Each is composed of hundreds of papyrus stems fixed together with rope also made of papyrus. When papyrus is not available, leaves of palm trees may be used. On other lakes such as Lake Baringo (Kenya), the material consists of desiccated branches of the ambatch tree, which festoons the shores. In Lake Titicaca, boats are made of totora reeds (Cyperaceae).

4.2 FISHING METHODS AND FISHING GEAR

The huge diversity of fishing gear that has been developed over centuries should be considered as a technical and cultural heritage which is rapidly disappearing. With the introduction and spread of new fishing technologies, many traditional practices have become extinct. It is outside our scope to review here the numerous fishing methods and fishing gear that have been used in ancient lakes; however, a few examples taken from Lake Titicaca, Lake Biwa, and the East African lakes will illustrate the rich patrimonial knowledge in that field.

4.2.1 *Lake Titicaca*

There is archaeological evidence of the importance of fishing in Lake Titicaca as far back as 1300 B.C. In the early decades of this century, lakeshore peasants fished from rafts made of the local totora reed, and used many types of gear including drag-nets, dip nets, basket traps, and spears.

Fishing operations on Lake Titicaca involve small-scale operations with low capitalisation, simple gear, and small fishing craft. About half of the fishermen operate from reed boats or "balsas", propelled with a pole, a sculling oar, and a small sail, while the other half fish from wooden boats propelled with a pair of oars and a sail. Several small-sized species of *Orestias*, together with the young of other species and grouped under the name "hispi", were subject to intensive fishing in the open water areas in summer (mainly January) through the use of spherical fish traps ("kulancha") drawn by a balsa, or hand nets in the totora beds. This fishery was very important during the first half of the century, but the hispi disappeared as early as 1944-45, and in 1950 the fishery ceased to exist. The 1960s were a key period of transition from totora rafts to wooden boats, and multifilament nylon gill-nets have now become the predominant form of fishing gear (Orlove *et al.* 1992). There is still a traditional trawl fishery operating in Lago Pequeno, where pairs of boats pull a large trawl behind them, making a number of tows on each fishing trip (Vellard 1992a).

Nowadays, fishermen practice demersal gill-net fisheries for native species and pelagic gill-net fisheries for introduced species.

4.2.2 *Lake Biwa*

Various traditional fishing techniques have continued uninterrupted since ancient times (Kada 1984). That is the case for the "yana" which is a set gear, with or without traps, that crosses a river. The "eri" is also a set trap unique to Lake Biwa. The basic unit is anchor-shaped, and the size varies from several meters up to 2000 m. The simplest consist of one final trap, whereas complex ones may include more than 20 traps. Mastering eri construction demands long experience and is inherited by members of a single fishing community on the central eastern coast of the lake.

4.2.3 *East African Lakes*

Until the middle of this century, African inland fisheries were traditionally pursued with a variety of locally fabricated gear such as baskets, spears, seine nets, etc. Traditional fishing methods, ranging from simple harpoons to basket-work fishtraps, are typically selective for both size and species and are adapted to the diversity of fish capture possibilities under particular environmental conditions. Soon after the Second World War, the introduction of nylon ensured the nylon gill-net's pre-eminence in most African fisheries. Later, in the 1960s, mechanised fishing and trawling were developed in the East African Lakes. Commercial gear often has a by-catch of unwanted species which has contributed to the overexploitation of resources.

In East Africa, many of the diverse kinds of fish require special methods for their capture and there has been plenty of room for the fisherman's ingenuity. For example, at the beginning of the century, fishermen of Lake Albert shores used fishing methods that mimic the food-webs observed in the lake (Worthington and Worthington 1933). There is a tiny cichlid fish in Lake Albert, *Haplochromis albertianus*, which lives in the bottom ooze and feeds on detritus and dead plankton. This fish serves as food for the tiger-fish, which, in turn, is eaten by the Nile perch. Lake Albert fishermen make bundles of grass or brush-wood, weigh them down with stones, and lay them on the bottom at a depth of 10 to 15 m. The little *Haplochromis*, seeking shelter from the tiger-fish on the bare sandy bottoms, worm themselves into the bundles. Every morning, fishermen haul up the bundles and extract the little fish. A *Haplochromis* is then fixed to a little barbless hook and dangled still alive over the side of the canoe until a tiger-fish gulps it as it swims near the surface. The tiger-fish is then hauled in the canoe, affixed in its turn to a big, barbed hook and allowed to swim away at the end of a stout rope. The great Nile perch gulps the tiger-fish and finds itself impaled by the sharp hook.

In many places, fishermen take advantage of reeds to built fishing gear. The "ngogo" of the Jaluo (Lake Victoria) is an enormous apparatus designed for fishing near the shore. In some respects it resembles a beach seine, but the "net" consists of a vertical fence made of innumerable papyrus stalks lashed together by plaited papyrus rope. The fence is about 2.5 m deep and 200-300 m long, a big work which occupies many men for many days.

> *"This method of fishing is slow and laborious: five men stand on a raft to the stern of which is tied one end of the ngogo, and in the shallow water they punt round in an enormous semicircle trailing the net behind them. Then for an hour two groups of men sitting on the shore haul on the warps, and inch by inch the great fence is dragged towards the shore until all the fish are concentrated together. Next a line of a dozen or so massive non-return baskets is placed across the inner opening of the semicircle and more hauling on the fence drives the fish thus trapped into the baskets"* (Worthington and Worthington 1933:147).

An almost identical apparatus, made of papyrus rope with banana leaves attached at intervals, was used on Lake George.

Still on Lake Victoria, the "osageru" is another apparatus made of innumerable papyrus stems forming fences stuck into the mud near river-mouths to produce a complicated maze of many spiral curves. The fish, leaving or entering the river, become muddled by the maze of fences, follow round one of the spirals, and find themselves entrapped in a non-return basket which is neatly fixed at the centre of each.

In Lake Tanganyika, native fishermen (Bwari) know as many as 17 fishing methods, ranging from hooks and lines to seines and traps (Ankei 1989). There are two small endemic species of the herring family (Clupeidae), *Stolothrissa tanganyikae* and *Limnothrissa miodon*, called the Tanganyika "sardine", or "ndagala" (in Swahili). These pelagic fishes feed on zooplankters that migrate diurnally, being concentrated between 50 m and 120 m during the day, but at night, within 10 m of the surface. The sardines follow these movements. Fishermen have taken advantage of the powerful attraction of light. There was originally a brushwood fire on a platform in the bows of the canoe. Before 1937, torches 5 m long made of grasses were used. Attracted by light, the sardines swarm around the canoe and they are caught with very large, fine-meshed scoop-nets mounted on long poles called "lusenga" (Collart 1954). This light attraction has been known for centuries, and in olden times it was a unique scene to see the lights of hundreds of fishermen fishing ndagala at night. Large dug-out canoes were used (6-7 m long). This technique has been modernised by the introduction of kerosene vapour lamps since 1956, and large ring-nets are used. A similar fishing method exists also on Lake Kivu, where the cyprinid *Raiamas moorei* is attracted at night by lights and caught with very large scoop nets (Hulot 1956).

4.3 ACCESS TO FISH RESOURCES

Most inland fisheries are artisanal in nature, and their management is incredibly complex. Models based on fish population dynamics and fishing effort, which were developed for marine fisheries, do not work for inland fisheries. "Traditional management, sanctioned by local custom or religious belief, is still strong in many areas, and its replacement by modern methods necessitates widespread modifications of the whole socio-economic framework of the societies concerned." (Welcomme 1989). If community controls are eroded, and state controls are inefficient as a result of inadequate means to enforce them, the fishery resource is left without a framework to ensure that it is properly managed.

Most cultures emphasize community responsibility, and traditional community-based resource management systems have recently became of major interest to international organisations (UNESCO, FAO, IUCN). According to some authors, small scale fisheries are the key to long-term management success. Where local communities of fishermen can control access to fishing space and enforce regulations, exploitation rates can be better managed, and this is an essential condition for sustainable exploitation (Berkes and Kislalioglu 1991).

Lake Titicaca offers a good example of traditional resource management by local communities. Most Lake Titicaca fishermen are not specialised and engage in fishing as a secondary activity to agriculture. Local communities dispersed along lakeshore manage aquatic resources through a system of Territorial Use-Rights in Fishing (TURF). This refers to a well-defined portion of aquatic space, to which community members have certain exclusive though informal rights. These rights focus principally on two main types of resources: the beds of totora reeds, which in most cases consist of plots owned by individuals, and the fish. Access to the entire TURF is open to all the fishermen in a community, and community members are the only ones who have rights to fish within the TURF. There is some measure of surveillance of the TURFs and they are defended through a series of sanctions brought against outsiders who cross the boundaries (Leveil and Orlove 1990).

Each TURF is approximately rectangular in shape. One edge is made up of the portion of the lakeshore lying within the community. The offshore boundary, parallel to the lakeshore, separates the TURF from the waters of the lake that are open to all fishermen. This offshore boundary is located at different distances from shore and includes waters at different depths between it and the shore. The two edges, or lateral boundaries, run perpendicular to the shore line and are the extensions into the lake of the boundaries separating the lands of adjacent communities. On average, the total area of a TURF is 30 km^2, and it is used by an average of less than 20 fishermen. The presence of these territories could explain the absence of overexploitation of the Lake Titicaca fisheries because they contribute to limiting fishing effort to a level that allows satisfactory incomes for the fishermen and the stable maintenance of fish populations (Levieil and Orlove 1990).

The social organisation of the communities favours the defence of the TURFs, and they have defended their collectively-held territories for generations; policing a perimeter and expelling outsiders are well-developed practices for fields and grazing lands, and they are easily extended to totora beds and fishing grounds. However, by contrast, in the Peruvian part of the lake, the aquatic space and shoreline areas are under the exclusive control of the state, within the jurisdiction of the Ministry of Fisheries. Because these laws and regulations are weakly enforced by a distant and often careless administration, the TURF system continues to operate regardless of its informal status. In general, local communities are more effective in regulating access to the fishery than government officials.

Lake Biwa, the largest lake in Japan, has been perceived as a "sea" since ancient times and has been historically regarded for administrative purposes as a "little sea". The ways in which the lake's water space is divided among the surrounding villages and the tenurial institutions have been sustained over centuries and are similar to those existing along the Japanese coast (Kada 1984). The historical evolution of Lake Biwa fishery management provides a unique example of changes over time in water tenure tradition and resource conservation measures (Kada 1991). The logic by which limited access can be socially mediated has differed from one period to another, but here have always been at least some controls in place during each period. During the Ancient Period (8th-16th century), exclusive rights to the fishing grounds were first authorised by the emperor and then granted by powerful shrines. In return, the shrines received part of the catch. Buddhist ideas concerning the prohibition of killing live animals led to the designation of protected grounds near temples or shrines and to religious ceremonies involving a memorial service for dead animals. During the Feudal Period (1600-1867), religious authority gradually declined and regional-based communal management became the dominant controlling force. The use of new fishing methods was generally forbidden, and the use of traditional methods, such as the yana and eri, was strictly limited to privileged groups. After 1867, Japan entered into the modern era and adopted new technologies that affected the logic of resource management. While communal management remained important, since most of the privileged fishing rights had been in continuous use in each village community, scientific control was progressively established. In effect, all three factors (religious, communal, and scientific control measures) have existed through the years, varying only in degree.

4.4 THE USE OF OTHER AQUATIC LIVING RESOURCES: THE CASE OF LAKE TITICACA

Lake Titicaca shore-dwellers use aquatic macrophytes as food for their live stock and for themselves, as material for handicrafts, boatbuilding and roofing, and as fertiliser for agriculture. Each type of macrophyte serves a particular purpose (Levieil and Orlove 1992). *Elodea*, *Myriophyllum*, and *Potamogeton* are used mainly as livestock fodder. Totora verde (*Schoenoplectus tatora*, Cyperaceae) is also a good fodder for cattle, pigs, sheep, and horses due to its digestibility and protein content. When stalks are desiccated they are used for handicrafts and the construction of balsas (boats). In addition, people eat the rhizomes of totoras.

Lake Titicaca is also characterised by the existence of amphibian species flocks. The genus *Telmatobius* provides remarkable examples of what is apparently sympatric speciation in the lake basin. The range of forms extends from medium-sized, thick- and warty-skinned forms living in marshes, to smooth- and thin-skinned swimming forms living in weedy or torrential streams, and giant lake-dwelling forms, spending their life in several meters of water and rarely coming to the surface (Vellard 1992b). Amphibians play an important cultural role among the indigenous Aymara and Quechua populations and are never mistreated. The frogs are associated with fecundity rites (Vellard 1975). The large species (*Telmatobius* and *Bufo*) are used to prepare curative infusions in cases of anaemia, asthenia, tuberculosis, and female sterility. Swallowing a small living frog is the recommended remedy for fevers and exanthematic typhus. Conversely, when somebody injures a frog, he may get opthalmia. The large *Telmatobius culeus* is a sacred animal. In time of drought, the indians from Sun Island leave one or two of these frogs in a narrow jar placed on the top of a mountain. The frogs "cry", calling for the rain that soon arrives, makes the jar overflow, and lets them escape to find their way back to the lake. In prolonged drought, the ceremony takes on a community scale. A divine caste, the Yatiris, carry a female *T. culeus* to a sacred mountain, Khapia, to the south of the lake where there is another deep lake. After numerous ceremonies, and offerings at the water's edge, they make the female frog "cry". A male appears at the water surface and carries the female off. The rain will soon come (Vellard 1992b).

5 Conclusions

All certainly agree that ancient lakes are unique natural laboratories to study evolution at work. They are a world heritage to be preserved, both for their biological components and for the technocultures developed among their surrounding human societies for the use of living resources. Such a statement is easy to make at a scientific meeting; what about in the non-scientific world? What kind of practical issues or operational recommendations can we suggest to decision makers? Are they willing to understand scientists and to make use of scientific results? Moreover, who should be in charge of conservation? A key question: are local populations and national authorities ready to accept regulations? Who will pay for it? What control is necessary and who will be in charge of this control? Most of the above questions have not yet received relevant answers.

What we do know is that for hundreds of years people made use of their aquatic living resources and sustainably managed this natural heritage. Social constraints and limited access to living resources usually contributed to a wise use of these resources. However, increasing human population and the consequent need for more resources, as well as cultural changes, have resulted in the rapid disappearance of the traditional management knowledge.

The fate of biodiversity does not primarily rely on technical issues, but also on social and cultural ones. Humans are, overall, the main cause of the biodiversity crisis. How human societies will manage their natural resources and their environment is the key question for the future of biodiversity. Shall we be fully aware of the gravity of the problem in order to meet this challenge?

References

Acere, T. O. 1988. The controversy over Nile Perch, *Lates niloticus* in Lake Victoria, East Africa. *Naga* 11(4):3-5.

Ankei, Y. 1989. Fish knowledge of Songolo and Bwari. *African Study Monographs* 9 (supplementary issue): 1-88.

Barel, C. D. N., W. Ligvoet, T. Goldschmidt, F. Witte, and P. C. Goudswaard. 1991. The haplochromine cichlids in Lake Victoria: an assessment of biological and fisheries interests. In M. H. A. Keenleyside, ed., *Cichlid Fishes: Behaviour, ecology and evolution*, pp 258-279. London: Chapman & Hall.

Berkes, F. and M. Kislalioglu. 1991. Community-based management and sustainable development. In J. R. Durand, J. Lemoalle, and J. Weber, eds., *La Recherche Face à la Pêche Artisanale*, pp. 567-574. Paris: ORSTOM.

Bouysse-Cassagne, T. 1992. Past and present human populations. In C. Dejoux and A. Iltis, eds., *Lake Titicaca. A synthesis of limnological knowledge*, pp. 473-494. Dordrecht: Kluwer Academic Publishers.

Cohen, A. S. 1994. Extinction in ancient lakes: biodiversity crises and conservation 40 years after J. L. Brooks. *Archiv für Hydrobiologie. Beiheft. Ergebnisse der Limnologie* 44:451-479.

Collart, A. 1954. La pêche au Ndagala au lac Tanganyika. *Bulletin Agricole du Congo Belge* 45(3):3-49.

Coulter, G. W., B. R. Allanson, M. N. Bruton, P. H. Greenwood, R. C. Hart, P. B. N. Jackson, and A. J. Ribbink. 1986. Unique qualities and special problems of the African Great Lakes. *Environmental Biology of Fishes* 17:161-184.

Craig, J. F. 1992. Human-induced changes in the composition of fish communities in the African Great lakes. *Reviews in Fish Biology and Fisheries* 2:93-124.

De Vos L. and J. Snoeks. 1994. The non-cichlid fishes of the Lake Tanganyika basin. *Archiv für Hydrobiologie. Beiheft. Ergebnisse der Limnologie* 44:391-405.

Dominey, W. J. 1984. Effects of sexual selection and life history on speciation: species flocks in African cichlids and Hawaiian Drosophila. In A. A. Echelle and I. Kornfield, eds., *Evolution of Fish Species Flocks*, pp. 231-249. Orono, Maine: University of Maine at Orono Press.

Fryer G. and T. D. Iles. 1972. *The Cichlid Fishes of the Great Lakes of Africa: Their biology and evolution.* Edinburgh: Tropical Fish Hobbyist Publications Inc., London: Oliver & Boyd.

Fryer, G. 1996. Endemism, speciation, and adaptive radiation in great lakes. *Environmental Biology of Fishes* 45:109-131.

Graham, M. 1929. *The Victoria-Nyanza and its Fisheries. A Report on the Fishing Surveys of Lake Victoria.* London: Crown Agents for the Colonies.

Greenwood, P. H. 1984. What is a species flock? In A. A. Echelle and I. Kornfield, eds., *Evolution of Fish Species Flocks*, pp. 13-19. Orono, Maine: University of Maine at Orono Press.

Hecky, R. E. and F. W. B. Bugenyi. 1992. Hydrology and chemistry of the African Great Lakes and water quality issues: problems and solutions. *Internationale Vereinigung für Theoretische und Angewandte Limnologie. Mitteilungen* 23:45-54.

Hulot, A. 1956. Aperçu sur la question de la pêche industrielle aux lacs Kivu, Edouard et Albert. *Bulletin Agricole du Congo Belge*, 47(4):1-68.

Kada, Y. 1984. The evolution of joint fisheries rights and village community structure on Lake Biwa, Japan. *Senri Ethnological Studies* 17:137-158.

Kada, Y. 1991. Historical changes and continuity of the aquatic resource management logic: the case of Lake Biwa, Japan. *Resources Management and Optimisation* 8(3-4):179-195.

Kawanabe H. 1996. Asian Great Lakes, especially Lake Biwa. *Environmental Biology of Fishes* 47:219-234.

Kornfield, I. 1982. Report from Mindanao. *Copeia* 1982:493-495.

Kornfield, I. L. and K. E. Carpenter. 1984. Cyprinids of Lake Lanao, Philippines: taxonomic validity, evolutionary rates, and speciation scenarios. In A. A. Echelle and I. Kornfield, eds., *Evolution of Fish Species Flocks*, pp. 69-84. Orono, Maine: University of Maine at Orono Press.

Lauzanne, L. 1992. Native species. The *Orestias*. In C. Dejoux & A. Iltis, eds., *Lake Titicaca. A synthesis of limnological knowledge*, pp. 405-419. Dordrecht: Kluwer Academic Publishers.

Lévêque, C. 1997. *Biodiversity Dynamics and Conservation: The freshwater fish of tropical Africa.* Cambridge, U.K.: Cambridge University Press.

Levieil, D. P. and B.S. Orlove. 1990. Local control of aquatic resources: community and ecology in Lake Titicaca, Peru. *American Anthropologist*, 92(2):18-38.

Levieil, D. P. and B. S. Orlove. 1992. The socio-economic importance of macrophytes. In C. Dejoux and A. Iltis, eds., *Lake Titicaca. A synthesis of limnological knowledge*, pp. 505-510. Dordrecht: Kluwer Academic Publishers.

Loubens, G. and F. Osorio. 1992. Introduced species. 2 - *Basilichthys bonariensis* ("the pejerrey"). In C. Dejoux and A. Iltis, eds., *Lake Titicaca. A synthesis of limnological knowledge*, pp. 427-448. Dordrecht: Kluwer Academic Publishers.

Marten, G. G. 1979. The impact of fishing on the inshore fishery of Lake Victoria (East Africa). *Journal of the Fisheries Research Board of Canada*, 36:891-900.

Martens, K. 1997. Speciation in ancient lakes. *Trends in Ecology & Evolution* 12(5):177-182.

Myers, G. S. 1960. The endemic fish fauna of Lake Lanao and the evolution of higher taxonomic categories. *Evolution* 14 (3):323-333.

Nagelkerke, L. A. J., F. A. Sibbing, J. G. M. van den Boogaart, and E. H. R. R. Lammens. 1994. The barbs (*Barbus* spp.) of Lake Tana: a forgotten species flock? *Environmental Biology of Fishes* 35:1-22.

Nagelkerke, L. A. J., M. V. Mina, T. Wudneh, F. A. Sibbing, and J. W. M. Osse. 1995. In Lake Tana, a unique fish fauna needs protection. *Bioscience* 45(11):772-775.

Nakajima, T. and K. Nakai. 1994. Lake Biwa. *Archiv für Hydrobiologie. Beiheft. Ergebnisse der Limnologie* 44:43-54.

Nishida, M. 1991. Lake Tanganyika as evolutionary reservoir of old lineages of East African cichlid fishes: inferences from allozyme data. *Experientia* 47:974-979.

Ogutu-Ohwayo, R. 1990. The decline of the native fishes of lakes Victoria and Kyoga (East Africa) and the impact of introduced species, especially the Nile perch, *Lates niloticus*, and the Nile tilapia, *Oreochromis niloticus*. *Environmental Biology of Fishes* 27:81-96.

Orlove, B. S., D. P. Levieil, and H. P. Trevino. 1992. Social and economic aspects of the fisheries. In C. Dejoux and A. Iltis, eds., *Lake Titicaca. A synthesis of limnological knowledge*, pp. 500-504. Dordrecht: Kluwer Academic Publishers.

Ribbink, A. J. 1987. African lakes and their fishes: conservation scenarios and suggestions. *Environmental Biology of Fishes* 19:3-26.

Ribbink, A. J. 1988. Evolution and speciation of African cichlids. In C. Lévêque, M. N. Bruton, and G. W. Ssentongo, eds., *Biology and Ecology of African Freshwater Fishes*, pp. 35-51. Paris: ORSTOM.

Sideleva V. G.. 1994. Speciation of endemic Cottoidei in Lake Baikal. *Archiv für Hydrobiologie Beiheft. Ergebnisse der Limnologie* 44:441-450.

Sturmbauer, C. and A. Meyer. 1993. Mitochondrial phylogeny of the endemic mouthbrooding lineages of cichlid fishes from lake Tanganyika, East Africa. *Molecular Biology and Evolution* 10:751-768.

Turner, G. F. 1994. Fishing and the conservation of the endemic fishes of Lake Malawi. *Archiv für Hydrobiologie. Beiheft. Ergebnisse der Limnologie* 44:481-494.

Turner, J. L. 1977. Some effects of demersal trawling in Lake Malawi (Lake Nyasa) from 1968 to 1974. *Journal of Fish Biology* 10:262-271.

Vellard, J. 1975. Les batraciens dans la magie et la médecine des Aymaras. *L'homme et l'animal. Comptes Rendus du 1er Colloque d'Ethnozoologie*. pp. 227-230. Paris: Muséum National d'Histoire Naturelle, Laboratoire d'Ethnobotanique.

Vellard, J. 1992. Former lake fisheries and fish fauna of the lake. In C. Dejoux and A. Iltis, eds., *Lake Titicaca. A synthesis of limnological knowledge*. pp. 495-499. Dordrecht: Kluwer Academic Publishers.

Vellard, J. 1992. The Amphibia. In C. Dejoux and A. Iltis, eds., *Lake Titicaca. A synthesis of limnological knowledge*, pp. 449-457. Dordrecht: Kluwer Academic Publishers.

Welcomme, R. L. 1988. *International Introductions of Inland Aquatic Species*. Rome: FAO.

Welcomme R. L. 1989. Review of the present state of knowledge of fish stocks and fisheries of African rivers. *Canadian Special Publication of Fisheries and Aquatic Science* 106:515-532.

Witte, F., T. Goldschmidt, J. Wanink, M. van Oijen, K. Goudswaard, E. Witte-Maas, and N. Bouton. 1992b. The destruction of an endemic species flock: quantitative data on the decline of the haplochromine cichlids of Lake Victoria. *Environmental Biology of Fishes* 34:1-28.

Witte, F., T. Goldschmidt, P.C. Goudswaard, W. Ligtvoet, M. P. J. van Oijen, and J. H. Wanink. 1992a. Species extinction and concomitant ecological changes in Lake Victoria. *Netherlands Journal of Zoology* 42:214-232.

Worthington, S. and E. B. Worthington. 1933. *Inland Waters of Africa. The results of two expeditions to the great lakes of Kenya and Uganda, with accounts of their biology, native tribes and development*. London: MacMillan & Co.

Yuma M., K. Hosoya, and Y. Nagata. 1998. Distribution of the freshwater fishes of Japan: an historical overview. *Environmental Biology of Fishes* 52:97-124.

Lévêque Christian. (1999).

Fish, fisheries, fishermen.

In : Kawanabe H. (ed.), Coulter G.W. (ed.), Roosevelt A.C. (ed.) Ancient lakes : their cultural and biological diversity. Ghent : Kenobi Productions (BEL), 3-15.

ISBN 90-804341-2-4