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REVIEW PAPER

Is Biodiversity Friendly Fisheries Management Possible on Issyk-Kul Lake in the Kyrgyz Republic?

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Abstract This paper aims to identify challenges, and threats, and further explore opportunities for a new Biodiversity Friendly Fisheries Management Regime on the Issyk-Kul Lake in the Kyrgyz Republic. This lake is the second largest high-altitude lake in the world providing recreational and small-scale fishing activities as well as cage culture of introduced species. The populations of several indigenous species are seriously threatened, because many of the introduced species are potential predators. We examine the root causes for overfishing and relationships of alien and endemic fish species in Issyk-Kul Lake and give possible policy options that can help remediate or mitigate the biodiversity degradation. This analysis focuses on necessary legal modifications, institutional cooperation, the protection of selected endemic fish species, control of the alien species, the sustainable extension services and management of fish ponds. Fisheries co-management is one option to explore shared stewardship and empowering user groups on the lake. A comprehensive fisheries management plan is also needed, in addition to immediate action and further studies on the following wider aspects: water management/irrigation issues, water-quality assessment near cage cultures, socio-cultural issues, resource inventory, and assessing fish biology and the lake ecosystem.

Keywords Fisheries management · Co-management · Biodiversity · Alien and endemic fish species · Issyk-Kul Lake · Kyrgyz Republic

INTRODUCTION

Many species of fish have been wiped out by man, either through deliberate action or otherwise, and by a series of events where damage was done but the cause was not found until too late. There is generally little awareness of the interactions between aliens and endemic species, and poor strategies exist for controlling or eradicating introduced alien species over the past few decades. These examples can be found in many inland lakes, especially the Great Lakes of North America (Great Lakes Information Network 2003).

The most famous environmental problem is alien species in Lake Victoria, where introduction of the Nile Perch *Lates niloticus* and Nile Tilapia *Oreochromis niloticus* is believed to have caused the extinction of the natural fauna of the lake. Approximately 150 different species of *Haplochromis* chiclids have become extinct and native tilapia *Oreochromis esculentus* is only found in small swampy ponds adjacent to Lake Victoria. Loss of half of the cichlid species has been termed as the greatest vertebrate mass extinction in recorded history (Ball 2004; Chege 1995).

In the case of Issyk-Kul Lake (Figs. 1 and 2), Sevan Trout *Salmo ischchan* was introduced in order to start commercial trout fishery in 1930. At first, predation was not a problem given the abundance of fish in the lake at the time. The widespread prevalence of Issyk-Kul Dace *Leuciscus bergi* also encouraged fishery biologists to advocate the introduction of other non-native species. Pike-perch *Sander lucioperca* and Oriental Bream *Abramis brama*

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orientalis were introduced into Issyk-Kul in 1954–1956, followed by Grass Carp *Ctenopharyngodon idella* and Tench *Tinca tinca* amongst others. In the early 1970s the decision was taken to transform the lake into a trout-whitefish water body at the expense of the local Issyk-Kul Dace population—and the Common Whitefish *Coregonus lavaretus* and the Arctic Cisco *Coregonus autumnalis* were introduced from Lakes Sevan and Baikal, respectively. All these introduced alien species had a dramatic impact on both lake landings and the species composition of landings in the latter Soviet period (Baetov 2003). There are currently 28 different fish species living in the lake, 11 of those are indigenous to the Central Asia region; and seven full species (and one subspecies) are endemic to the Lake Issyk-Kul.

Although the people of the Kyrgyz Republic are very proud of the lake, they are generally unaware of the existence of their native (endemic) fish species found nowhere else in the world, and the threats to which these species are today exposed in the lake. Such lack of awareness extends into government technical and administrative (and especially policy-making) bodies whose advice and decisions can create, or increase, potential or real threats to the existence of these same fish species within the lake ecosystem.

Biodiversity friendly fisheries management (as synonym to ecosystem based management) is based on FAO's Code of Conduct for Responsible Fisheries (FAO 1995), which provides a necessary framework for national and international efforts in ensuring sustainable exploitation, in harmony with the environment. It is also important for the sustainable management of the living aquatic resources, and the environment, that irresponsible aquaculture practices be eliminated.

Raising public awareness and the political will to sustain biological diversity over time will require more than just fishery science. There is also need for shared management such as co-management approaches, advocacy, and greater legal and ethical commitments to conservation practices. In order to help achieve the objectives of biodiversity friendly fisheries management at the Issyk-Kul Lake, a priority list of 10 main issues are presented in this paper.

BACKGROUND INFORMATION ON CONSERVATION IN KYRGYZSTAN

A good basis for implementing environmental policy-related projects has been under several legislations. The most important legal instrument notes: "Natural resources and their components are the national property of the Kyrgyz Republic and one of the main factors in its sustainable economic and social development" (UNDP 2007a, p. 5). Numerous normative acts and regulations have been approved and the process of integrating international norms into the national legislation is continuing. Kyrgyz Republic actively participates in international, regional and bilateral cooperation, being a member of 11 international Conventions and three Protocols in the field of environmental protection. The Kyrgyz Government has proved its commitment to the sustainable development ideas of the Special Session of the UN General Assembly Rio +5 in 1997, the Millennium Summit in 2000 and World Summit on Sustainable Development in 2002, and is actively implementing the United Nations Millennium Development Goals and Agenda 21. Kyrgyz Republic, along with other Central Asian countries, set up the Partnership for the Implementation of the Central Asian Initiative on Sustainable Development in 2003, and will preside over the Sub-regional Inter-Governmental Committee on Sustainable Development (UNDP 2007a).

Conservation activities in Issyk-Kul have been going on for around 60 years. In 1948 the lake became a controlled area for hunting (zakaznik), but its shores were not protected. Ten years later a small staff started to assist in the protection of the lake. One of their tasks was to nominate areas that needed special management or protection. From 1970, fishing was restricted—no fishing near waterfowl concentrations in winter—mainly in the shallow bays of the lake. Earlier agricultural activities took place right up to the borders of the lake, but nowadays the main agricultural activities have stopped in the immediate surroundings of the shore. This is very positive for the development of flora and fauna. Recreational concentrations have been established all around the lakeside, especially in the north. The tourism boom in the Issyk-Kul area has significantly increased the anthropogenic pressure on the lake ecosystem.

When the Soviet Union signed the RAMSAR Convention in 1976 things improved and 15,000 ha of water and 5,000 ha of bordering land were protected. In 1998 the whole area became a Biosphere Reserve and by 2000 over 4 million ha were protected as a biosphere reserve.

In 1991 the newly formed Kyrgyz Republic did not recognize the Soviet Union's signature of the RAMSAR Convention and from 2002 till 2007 Kyrgyz Republic was represented in the secretariat of RAMSAR convention by the Russian Federation. So only in 2007 the Republic (re)signed the Convention itself.

In September 2001, UNESCO officially recognized the Issyk-Kul region (oblast) as a possible World Heritage

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area, but it is still not included in the global World Heritage list. One of the main aims of the UNESCO World Heritage area and biosphere reserve is the protection of biodiversity.

Declaration of the lake as a Biosphere Reserve did not prevent many indigenous species to disappear. A declaration is therefore not enough; effective management that relies on local stewardship may help conserve and promote the idea of a Biosphere Reserve.

It is also far too easy to blame the illegal fishing that some species became extinct and that fewer fish are caught. More important problems are the absence of any fisheries management and no controlled protection of fish resources. Conservation strategies for many indigenous species are lacking.

This is the main reason for the implementation of the UNDP/GEF Project No. 00058610 (PIMS No. 3217): "Strengthening policy and regulatory framework for mainstreaming biodiversity into fishery sector". Since 2008, the activities of this project have been of critical importance in fostering cross-sectoral and multi-stakeholder support for regaining control over illegal fisheries and non-authorized introductions of alien fish species (Alamanov and Mikkola 2009; UNDP 2008b).

ISSYK-KUL LAKE LIMNOLOGY AND BIODIVERSITY

The lake basin is surrounded by mountains of the Kungei Ala Too and Terskei Ala Too, which have their peaks at 4,711 and 5,216 m, respectively. The lake is a special treasure, at an altitude of about 1,609 m above sea level, 178 km long, up to 60 km wide and with a shoreline of 668 km (Baetov 2003). The average depth of the lake is 278 m and the deepest point is as much as 702 m (Alamanov and Mikkola 2009). The water does not freeze due to regular upwelling and light salinity. In October 2008, salinity was measured from three different sites and it varied from 5 to 8‰. In March–April 2009 the salinity was a little less, varying in six sites from 4.5 to 7.0‰ and in July 2009 again from 5 to 8‰. After heavy rains in November 2009 the salinity was as low as 2‰, but in February 2010 again 6‰ (Mikkola, H., unpublished results). In winter, water remains at 5–6°C and only the shallow water in the northeastern part of the lake (near Tup) sometimes freezes.

Over 80 rivers bring their water into the lake but not one river flows out of it. Only two of the incoming rivers are permanent (Tup and Jergalan Rivers). It looks as though the river Chui never "found" its way to the lake as the river bends respectfully just before the lake to the west, disappearing into the desert of Kazakhstan.

In the fifteenth century the water level of the lake was more than 10 m higher than it is today, and the falling continues still. The total drainage basin of the lake is 22,000 km^2 of which the lake takes over 6,000 km^2.

Issyk-Kul is a typical oligotrophic lake, which can be characterized by high transparency, great depth and low productivity.

The flora of the Issyk-Kul Biosphere Reserve comprises around 1,500 species of plants within which there are some 30 species of very important wild medicinal plants. The fauna includes a wide variety of mammals (54 species), birds (267 species) and 28 species of fish, of which only 11 are indigenous and seven full species and one subspecies are endemic to the lake (see Appendix 1 in the Supplementary material). In the native fish fauna of the lake there were no predators. The populations of many endemic species are seriously threatened because eight out of 16 alien species are potential predators. Introduction of five additional species failed as shown in Appendix 2 in the Supplementary material.

Out of the alien fish species introduced, Pike-perch and Oriental Bream have established well into the lake, while Rainbow Trout *Onchorhynchus mykiss*, Sevan Trout and Common Whitefish will need human support to maintain their populations. Rainbow, Sevan Trout and Pike-perch are said to endanger endemic species with their predation, and Bream grazes on the developing eggs of Issyk-Kul and Schmidt's Dace *Leuciscus schmidti* (Konurbaev et al. 2005). Two dace species, Issyk-Kul Marinka *Schizothorax pseudoaksaiensis issykkuli* and Naked Osman *Gymnodiptychus dybowski*, are those endemic species which are most seriously endangered. Issyk-Kul Marinka (Fig. 3) has almost disappeared from the lake and only one Naked Osman (Fig. 4) was seen during the study in the lake (Mikkola 2009a, 2010).

ISSYK-KUL LAKE FISHERIES

It has been stated that, in the case of Issyk-Kul Lake, there is no history of fishing before the end of the 19th century. The lake was set to be a holy place for the Kyrgyz people. In ancient times (some 3,000 and more years ago) people did not even swim or bath in the lake (Imanaliev 2004). And this might have been like that even in the more recent past. Rock paintings (Petroglyphs) from this time, which can be found all around the lake, never show fishing, only sceneries on hunting wild animals.

Fishing started, according to statistics, after 1870 but commercial fishing is believed to have started on the lake in the 1890s. At first it was relatively disorganized and concentrated mainly on five species of fish: Schmidt's Dace locally known as Chebak, Issyk-Kul Dace locally Chebachok, Common or Sazan Carp, Issyk-Kul Marinka

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Fig. 1 The Kyrgyz Republic

Fig. 2 Issyk-Kul Lake is so large that the opposite shoreline is often not visible. Photo: A. Alamanov

and Naked Osman. Chebachok was the dominant species and accounted for around 90% of the overall catch (Petr and Mitrofanov 1998).

Records suggest that annual catches by the end of the century from the lake varied anywhere from 17.4 to 104.8 tonnes p.a. (Konurbaev et al. 2005).

A fish processing factory opened in Grigorievka in 1931. Harvesting was concentrated during the April–July spawning period when the species gathered in the lake shallows and catches climbed to 1,000 tonnes—90 to 95% of which were Issyk-Kul Dace—within the space of a decade. However, for the Soviets dace was essentially a low value/trash fish and, following the recommendation of L.S. Berg a leading Soviet fisheries academic at the time, 755,000 eggs of the Lake Sevan Trout were procured and discharged into Issyk-Kul in order to develop a commercial trout fishery in 1930 (Konurbaev and Timirkhanov 2003).

A further 800,000 eggs were released into the lake in 1936. Adaptation was successful—fecundity increased five-fold, growth rate four to six-fold and, moreover, the Issyk-Kul trout matured earlier than its Lake Sevan counterpart—specimens reaching sizes of up to 89 cm and

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Fig. 3 Issyk-Kul Marinka *Schizothorax pseudoaksaiensis issykkuli*—one recently captured female. Photo: A. Alamanov

Fig. 4 Naked Osman *Gymnodiptychus dybowski*—the only one seen alive during the study. Photo: A. Alamanov

17 kg. However, trout reproduction was severely constrained by the limited number of suitable spawning rivers. As a consequence, the state established hatcheries on the Ton (1964) and Karakol (1969) rivers and at Grigorievka—with the brief to capture spawning fish, extract the eggs, raise the fry-fingerlings produced, and then restock the lake (Thorpe et al. 2009).

The widespread prevalence of Issyk-Kul Dace also encouraged Soviets to advocate the introduction of other non-native species (Konurbaev and Timirkhanov 2003).

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Table 1 Dynamics of yearly fish catch in tonnes in the Issyk-Kul Lake (Alpiev 2009; Niyazov 2007)

Years	1965–1967	1968–1970	1971–1973	1974–1976	1977–1979	1980–1984	1985–1989	1990–1995	2003
Total fish catch	1335	1090	1129	914	591	334	174	278	10
Predatory fish catch	20	42	148	163	111	76	35	40	1.5
% share of predatory fish from total fish catch	1.5	3.9	13.1	17.8	18.8	22.8	20.1	14.4	15.0

Pike-perch and Oriental Bream were introduced into Issyk-Kul in 1954–1956, followed by Grass Carp and Tench amongst others. In the early 1970s the decision was taken to transform the lake into a trout-whitefish water body at the expense of the local Issyk-Kul Dace population—and the Common Whitefish and the Baikal Omul were introduced from Lakes Sevan and Baikal, respectively. All these introduced alien species had a dramatic impact on both lake landings and the species composition of landings in the latter Soviet period (Table 1).

It is clear that successful naturalization of Pike-perch and a rapid increase in its quantity caused a notable decrease in total fishing in Issyk-Kul. Increasing the quantity of Pike-perch and Sevan Trout created a misbalance in the ratio between predatory versus prey fish to the advantage of predatory fish, which caused the decrease of total fish productivity in the lake (Fig. 5). So it is easy to ascertain, that all efforts directed to increase fish productivity of the lake by introduction of alien species, have not been successful or justified. On the contrary, the alien species have changed the situation for the worse, i.e. fish productivity of the lake has decreased several times, and many endemic species are under the threat of total disappearance.

THEORETICAL PRODUCTION CAPACITY OF THE LAKE

From morphometric indicators of the lake (Zabirov and Korotaev 1978) the major productive zone of the lake (0–50 m depth) covers nearly 27.9% of the total surface area (which is 6,236 km^2). Thus, in maximum yearly materialized fishing with a volume of 1,400 tonnes equates to 2.2 kg/ha fish catch in a year. There would have been an opportunity to avoid issues relating to biodiversity and invasive species if the leading ichthyologists understood better what an ultra-oligotrophic lake Issyk-Kul is.

The average biomass of zoobenthos in the gulfs with open zones is 93.6 kg/ha (Pavlova 1964). In the transition from one feeding level to another, the lost feed coefficient against the productivity is approximately ten times. Thus, the benthos eating fish productivity of Issyk-Kul is approximately 9 kg of fish per hectare. Taking into the account that half of the feed will be used by small not tradeable fish, the productivity which can be used for human consumption is approximately 4.5 kg/ha. Again taking into account that humans can withdraw no more than 50% of fish species from the general fish reserves, fishing makes up 2.0–2.5 kg/ha (Thorpe et al. 2009). Thereby, fishing in Issyk-Kul expected from the feed base coincided with fishing results which were achieved in optimum years, i.e. 1,200–1,400 tonnes (see Table 1).

DATA AND METHODS

As we had no boat, research equipment and laboratory at the lake, we had to base our management study in fisher's intuitive knowledge and experience. Basic data were gathered between May 2008 and February 2010 from fishers through personal interviews. The authors did an extensive literature search of all fish species living in the lake, also by consulting FishBase (2009), FishCatalog (2008), and Red Data Book of Kyrgyz Republic (Davletkeldiev 2006).

With the National Fisheries Expert Akylbek Rispaev, the UNDP/GEF project had an authorized opportunity to undertake a number of test fishing trips, during which the authors gained a lot of new first-hand information of the present fish stocks in the lake despite the moratorium.

During 2008–2009, the UNDP/GEF project also had a team of lawyers (Nookatbek Idrisov and B. Koichumanov) and fishery biologists (Mukhtar Alpiev and Edil Niyazov) to undertake an overview of legislative and scientific bases of conservation of endemic fish species of the Issyk-Kul Lake.

It was quite difficult to find reliable statistics about fishing in the lake and its socio-economic significance. During the last 15 years little or no research has been carried out in this area. Most of the data, sometimes anecdotal, provides a baseline for future work and highlights the need for data gathering. The personal interviews focus on fish species landed, impacts of fishing activities, processing, management effectiveness and options to explore.

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Fig. 5 Large (over 7 kg) Rainbow Trout *Onchorhynchus mykiss* captured near the fish cages—when over 35–40 cm this species becomes a very serious predator of small endemic fish species (cf. Svärdson et al. 1968). Photo: A. Alamanov

RESULTS AND ANALYSIS

Effectiveness of Presidential Moratorium

Due to several reasons in recent years (overfishing, pressure of predatory fishes, mass poaching, not enough financing of hatcheries and fish inspections, etc.) the fishery sector in Issyk-Kul is in a catastrophic situation. As a result the President of the Kyrgyz Republic has declared a Moratorium for Artisanal and Commercial Fish catching in Issyk-Kul and Son-Kul lakes for a period of 5 years (2008–2013). But the moratorium can become an effective measure of restoration of fish recourses in the lake only if the mechanism of implementation and realization is developed as well. Otherwise the moratorium will not work. So, for example, in 1986 a total ban was declared for catching Issyk-Kul Naked Osman, but it has not led to positive results, and now this species is extremely rare (Mikkola 2010).

It is well known that a fishing ban alone rarely saves already threatened fish species or stocks (Konurbaev et al. 2005; Konurbaev and Timirkhanov 2003).

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People Depending on the Fish Resources

The Issyk-Kul province with its 428,500 habitants is the second least densely populated region of the Kyrgyz Republic. Most of the population lives in the towns and villages near the shore of Lake Issyk-Kul and is involved in livestock rearing, agriculture, tourism services and fishing. The contribution of fishing to annual average income of district families is from 5 to 10% and only for some groups up to 30%. Places having good access to fish resources are Grigorievka, Teplokluchenko and Maman in Issyk-Kul province, where some 3–5% of the working population is involved in fishing (UNDP 2008a).

Currently three categories of people are involved in fishing activities: fishermen, fish processors and sellers. Gender and demographic breakdown is the following: fishers are mostly young and middle-aged men (100%), whilst fish processors and sellers are mainly women and sometimes children—both males and females. During the tourist season (summer) all household members, including children, sell fish. Such labor division among men and women is a result of historical development and people think that fishing is only men's work. At the same time women can combine fish processing with other home work that is appropriate for women. This same division of labor can be found almost anywhere in the world, although modern technology has allowed some women to start fishing on their own or together with relatives in some countries like in Canada, Finland and the United States.

The monthly income of fishermen is not more than 40 USD and that of women processing the fish 54 USD, i.e. women get higher income from the fish (UNDP 2007b). However, the head of the household, a male, has a significant role in deciding how to allocate family assets, including income from fish.

Type of Fishers and Fishing Activities

Issyk-Kul fishermen can be divided into two big groups: *hereditary* and *new* fishermen (Ilibezova et al. 2005). *Hereditary fishermen* are those, who have been occupied in fishery for a long time: 8–9 and more years and whose fathers and grandfathers have been occupied in fishery, too. This group's members are professionals—*to walk on the water*, i.e. to fish not only for acquisition of income, but for one's private satisfaction, love for fishing and desire to preserve fish and the lake for their children and grandchildren. This group expresses anxiety with regards to existing problems in the fish sector of a region more than others and was the most emotional in course of discussion of the issues on violation of fish protection legislation.

Today people fish barbarically. We are *hereditary* fishermen; with a heavy heart, we observe how poachers fish. During Soviet times there was a limit for each fishermen and fishing nets were allowed to catch adult fish. Today nobody controls the nets and their mesh size (Sarieva et al. 2008). Relatively cheap monofilament nets with a very small mesh size have flooded the markets, causing this problem.

New fishermen began fishing recently, often less than 5 years ago and their fathers and grandfathers have not been occupied in fishery. Till recent time agriculture was the main occupation of this group: tillage, cattle-breeding and work in collective farms and state farms. This group doesn't know enough about fish reproduction technology and are not worried about fish fauna preservation.

Significant parts of fishermen from both groups have no official permission for fishing at present due to the moratorium, and from a legislative point of view they are all poachers (Ilibezova et al. 2005). Interviews with some 'poachers' in the Karakol area on April 5–6, 2009 revealed that they did not believe that the fishermen themselves could participate in the fisheries management for the time being. The reasoning was that all fishermen have individualistic views that all management meetings would last too long and afterwards people would just go home and do what they like on the lake. 'Poachers' felt that it is better that the Government controls, but it should be clear to the fishermen, who controls, and what, and preferably there are not too many controllers. 'Poachers' found it very common and extremely funny that they are witnessing State Agency Inspectors arresting the Fisheries Department (FD) Inspectors and vice versa, both allegedly participating in the illegal fishing operations at the lake side-by-side with the 'poachers'.

There are now 54 inspectors on the State Agency payroll at the Issyk-Kul Lake. In addition the Agency has 18 hired inspectors. FD has five inspectors for the entire lake. Unfortunately the salary of all of these inspectors is very low (70–85 USD/month), so the working morale is low with poor incentives and vulnerable to corruption. The whole State inspection service has only one boat with an engine in Karakol, so the effective control does not exist. Inspectors have no communication means, only private cellular phones for use of which no compensation is given. Some fuel money and a small maintenance fee is provided if an inspector is using his own car.

Issyk-Kul fishers are not occupied in fish processing. They deliver fresh fish to the people occupied in processing or to the second-hand dealers. Normally fishers sell fish to women. Women process the fish, smoke, dry and sell them. When comparing incomes received from fish, we saw above that women's income is higher than men's (UNDP 2007b).

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People Occupied in Processing and Selling of Fish

Discussions and meetings with people occupied in processing/selling of fish provide a premise that this type of activity is absolutely new for the population since independence. Practically all people occupied in processing stated that their parents had never been occupied with fish processing with the purpose of acquisition of income. Generally, in the past they processed fish for own consumption. Only an insignificant portion was sold, and that just in the tourist season. The majority of people occupied in processing has organized some small family-type businesses at home. Taking seasons into consideration, people occupied in processing regulate the volume of production, enlarging/reducing it, as required. Accordingly, the number of distributors selling fish on the beach is changing. People occupied in processing and sellers informed us that many of them purchase a patent for the right of trade (Ilibezova et al. 2005).

In the course of discussion with representatives of all three groups we were informed that fishery is not the only source of existence. However, for a majority of them it is the only source providing for *daily living money*. It was mentioned that since early spring tillage and cattle-breeding require significant capital investments in seeds, combustive-lubricating materials, forage, etc. At the same time said expenses would be covered earliest in the period of cropping. Thus, income from fish allows having cash for the families on a daily basis including cash for implementation of other types of activities (Ilibezova et al. 2005).

Management and Policy Options

There are 10 main issues on which this paper focuses and concludes as its main recommendations.

Legal Modifications will be Needed

Legislation is one of the ways to set up appropriate institutional structures and legal frameworks in resource management.

Kyrgyzstan is currently not a party to any international agreement that deals specifically with fisheries, but the country has signed a number of agreements that are concerned with biodiversity in the broader sense and also involve the aquatic environment. The Fishery law and policy exists (Government of Kyrgyz Republic 1997), but it does not adequately address all aquaculture matters typically considered in such legislation worldwide. It is widely considered necessary that the current legislation needs to be updated to bring it into line with the Biodiversity Friendly Fishery Management Regime (BDFMR) and other international standards, like the FAO Code of Conduct for Responsible Fisheries (FAO 1995).

It is known that the agreements under which two major companies were allowed to use the lake for the Rainbow Trout cage farming were made only at the local level with the district administration (Sarieva et al. 2008) without any Environmental Impact Assessments (EIA). Local authorities and even the Issyk-Kul Biosphere Reserve/Territory Administration (IKBRA) can comment on any cage culture applications, especially if paid to do so, but there are no rules on how they can do so, or who should do it and on what basis. If the local authorities and the Issyk-Kul Biosphere Reserve Administration are given a bigger role in making these types of decisions (as is common practice in many countries), it is important that the UNDP/GEF project will organize a training seminar in EIA as there is no local knowledge to undertake such activities without training.

The law concerning the Ecological and Economic System of Issyk-Kul clearly bans 'biological pollution', including the use of alien water living organisms (like fish and plants) in aquaculture in the lake (13 August 2004, No. 115). There are currently about eight cage farms and 26 cages in the lake. Many of them do not have all the official documents required for such operation.

The Government could ask the FAO Legal Department to help in formulating the necessary fishery law amendments in order to bring it into line with the BDFMR, FAO Code of Conduct for Responsible Fisheries (FAO 1995) and other international standards.

Institutional Cooperation

At present, agencies charged with environmental protection, fisheries, and aquaculture development are not highly coordinated, and their work is for the most part limited to inspection. Control is seen by all as the main source of power, i.e. money. Virtually no monitoring or scientific research is being done and no authority or institution has any experience in EIA.

There is a real need for a more integrated and consistent approach to fisheries management at the legislative and policy level. New legal rules or policy modifications are necessary in the Institutional Cooperation.

Presently some 16 authorities/institutions are, in some form or other, participating or insisting on participating in control of fisheries in Kyrgyz Republic. The recommendation is that the division of labor in the future fisheries management and inspection is made crystal clear by centralizing the control and by separating the functions of the main players as follows.

First, the State Agency for Environmental Protection and Forestry (SAEPF) would be solely responsible for effective and impartial control/inspection of the fishers and

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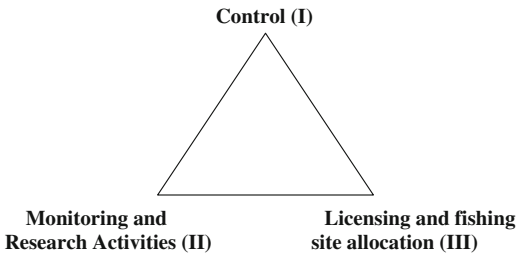

Fig. 6 Separation of the functions of the main players in fisheries management and inspection on the Issyk-Kul Lake. I = State Agency for Environmental Protection and Forestry; II = Academy of Science, Fisheries Department and Issyk-Kul Biosphere Reserve/Territory Administration; III = Fisheries Department (Alamanov and Mikkola 2009)

fish farmers at the Issyk-Kul Lake (see Fig. 6). It would also be responsible for the quality of the operational control undertaken by the regional inspectors. Its Regional structures and staff may need to be empowered and further trained in order to fulfill these tasks at the highest professional level. The UNDP/GEF Project could possibly assist the inspection service by making a manual for the inspectors and by providing more boats with outboard engines to facilitate the movements of the inspectors on the lake. Inspectors currently have no equipment for communication or personal security. There is an opportunity for the UNDP/GEF Project to contribute in resolving these problems as well. International cooperation, especially with the FAO Trust Fund Project GCP/KYR/003/FIN, is recommended.

A manual of inspection should be given to all inspectors together with a strong training package and practical work supervision. FD and IKBRA could be involved in this training and supervision, but they should not have any direct control role in the future, as they both have a more important role in the monitoring and research.

At the moment even the local administration (village heads, governors and vice governors) have taken their role in the control. This is somehow understandable as the Governor initiated the moratorium, and also feels responsible for the inspection. Although the law gives him this power, it is recommended that control is centralized at least during the moratorium in SAEPF. New Resolution #161 from April 22, 2008, gives all control rights and responsibilities to the FD, but also says that to reveal and prevent the violations of fisheries rules and regulations on conservation of fisheries resources, the FD should carry fishery protection raids (unannounced investigations) jointly with law-enforcement and conservation authorities.

If and when the moratorium ends and the legal artificial and commercial fishing should start, the village level fisheries management committees should be in place to make sure that the local fishermen are involved in the sustainable use and conservation of the resources. These committees have to be formed with the strong help and participation of the local authorities.

Also, the Fisheries Department and IKBRA will together be responsible for monitoring, but in that activity very clear division of labor is needed between these two institutions (see Fig. 6). FD's main interest is the activities of the fishers and fish farmers. IKBRAs role is in the protection of biodiversity. Both institutions should also assume full responsibility for the artificial and/or pond reproduction of all existing endemic fish species, with the help of the UNDP/GEF project and with the private sector, if possible and necessary.

Together with the Academy of Sciences, FD and IKBRA should set the fishing limits based on research (see Fig. 6). SAEPF should not be involved in the monitoring and research activities if they alone have control functions.

The Academy of Science, IKBRA and FD (in applied research and fisheries statistics) would have the research role including the EIA. These three parties should have a concrete long-term plan as to how they cooperate and what type of annual funding each one has to run the Cholpon-Ata Biological Station. There should also be a clear order of command in undertaking the EIAs at the lake and in sharing the costs and profits from the EIAs. Also, a protocol is needed in the use of the monitoring and research results.

Finally, the Fisheries Department could do the licensing and the fishing site allocation (renting) for the commercial fishing entities, as they have the best technical knowledge in that issue. In order to separate the control from licensing, they should cease to have any role in the control of fishing (Fig. 6).

Management Fund It is recommended to create a management fund for the commercial fishing in Issyk-Kul Lake. FD, SAEPF and the Academy of Science would share this fund management in equal terms and they would define the annual food fish sale fee. They would also together decide the distribution of quotas for the commercial fishing entities. Money received from the fees would be divided between the participating organizations/agencies as follows: SAEPF 30%, FD 30%, Academy of Science 20%, local administration budget 10%, and state administration budget 10%.

Protection of Selected Endemic Fish Species in the Lake Issyk-Kul

Priorities for sustainable development of biodiversity include the creation of nurseries and hatcheries for rare and endemic species, and protection of natural breeding, spawning and feeding grounds.

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Establishment and Enforcement of Closed Areas and Seasons One way to protect the endemic species is the establishment and enforcement of closed areas and seasons. Establishment of set-aside areas, a total of 65,000 ha, is within the project objectives (UNDP 2008b). This action can be completed, with the closed seasons, to achieve even better recovery of the endangered endemics, like Schmidt's and Issyk-Kul Dace, Naked Osman and Issyk-Kul Marinka.

In addition to the establishment of closed areas and seasons for protecting the spawning of endemic species, the creation and maintenance of wide transparency and public awareness of set rules and regulations of the fishery management of Lake Issyk-Kul is also very important, which is the precondition of the involvement and guarantee of the support of local communities.

Artificial Propagation of Issyk-Kul Marinka and Naked Osman Fisheries experts need to complete a systematic survey in order to map the possible whereabouts of the Naked Osman and Issyk-Kul Marinka. About 5,000 Naked Osman were transferred in 1960 from Issyk-Kul to Son-Kul Lake and they are believed to be well established in that lake (Konurbaev and Timirkhanov 2003). Therefore, if not enough Naked Osman are available in Issyk-Kul, it is important to get Naked Osman from Son-Kul Lake and propagate them for the Issyk-Kul Lake. Thus far the UNDP/GEF project has captured only one live Naked Osman from the Issyk-Kul Lake in June 2009 (Mikkola 2009a). Because the captured Naked Osman brooders and their eggs are sensitive to transport stress, field hatcheries will be needed.

Issyk-Kul Marinka brood fishes may still be found in some of the ponds and reservoirs near the lake. The project should organize fishing in these waters, where people have reported its presence. Leaseholders of the ponds/reservoirs most probably have suitable nets to capture the fish alive (Rispaev and Woynárovich 2008). If not, two seine nets should be purchased by the project. These seine nets, 20 and 30 m respectively, with suitable depth, could be joined temporarily when fishing of a larger water body is needed.

It is also necessary to have means to transport live fish (brood fish of Issyk-Kul Marinka). Purchase of a quantity of strong transparent plastic bags of 15–20 l and one oxygen cylinder with a pressure reducer meter would be important.

Artificial fish stocking cannot rely only on the private sector with industrial hatchery operations. The FD and Academy of Science, together with the state-owned Ton Hatchery and the two mobile hatchery units of the UNDP/GEF project, could start a programme for artificial reproduction of the most vulnerable endemic species to be introduced back to the lake after hatching and a short rearing period. Details have to be worked out with Kyrgyz fisheries experts having experience in the rearing of Marinka and Naked Osman.

Fig. 7 Construction of the artificial nests has now started in Kyrgyz Republic. Photo: Azat Alamanov

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Control of Selected Alien Fish Species in Lake Issyk-Kul

Introduction of predatory fish species into Lake Issyk-Kul is the key issue for the protection and management of indigenous fish biodiversity. These introduced predators pose a considerable management challenge in a huge lake like the Issyk-Kul. The main predators have become widespread, like the Rainbow Trouts, Sevan Trout and Pike-perch, and this make them difficult to control or eradicate.

There is a fishing moratorium on the lake at the moment, so there is not much knowledge on the actual structure of the fish populations in the lake. Only illegal fishermen have daily information on their catches. 'Poachers' interviewed on the fifth and sixth of April 2009 in the Karakol area knew well that at first the Bream and Pike-perch were the worst enemies of the endemics, but now Rainbow Trout (Fig. 5) is a new predator, because it is believed to be very predacious as it readily comes near the shoreline even into shallow waters while Pike-perch often remains in the deeper waters.

Effective Harvesting or "Sanitary Fishing" of Large Alien Predators Well-designed sampling fishing as started by the UNDP/GEF project in March–April 2009 combined with the intention of catching brood fishes of endemic species could fill the existing information gap. "Sanitary fishing" could also provide information on what sort of changes are taking place in the fish fauna of the lake. Hence the design and application of further management measurements would become possible.

A group of traditional fishermen together with the fishery inspectors from different parts of the lake would be licensed to catch with 40–65 mm nets large Pike-perch, Whitefish, Bream and Rainbow and Sevan Trout in order to control the size of these introduced species. This would lower the predatory pressure against the endemics and other small species.

Number of nets and fishermen/inspectors should be worked out with the local fisheries experts. The present feeling of the experts is that the "sanitary fishing" is only justified as a scientific experiment and not as commercial fishing.

Introduced/Alien Fish Versus Endemics The best solution would have been to prevent the introduction of exotic fish species, but once introduced, eradication might not be feasible. The potential ecological and social ramifications of eradication projects make them controversial; however, these programs provide unique opportunities for experimental ecological studies. Deciding whether to attempt eradication is not simple and alternative approaches might be preferable in some situations.

Table 2 Alternative strategies to deal with the endemics versus alien fish species (Alamanov and Mikkola 2009)

Endemics	Introduced alien species
Artificial reproduction	No more artificial reproduction
Restocking	No more restocking
Protection of the spawning grounds	Using artificial nests to get the eggs
Reduction of alien fish predatory pressure	Effective catching before and during the spawning
Fishing method controls to protect the endemics	Removal of large alien fish with 'sanitary fishing'

It is proposed that in the case of Lake Issyk-Kul all strategy options will be used as listed in Table 2.

A Pike-perch harvesting strategy should be exactly opposite in the Issyk-Kul Lake to the sustainable stock protection strategy in Finland. Pike-perch matures sexually in 4 years and the size is then some 40 cm, so in the Issyk-Kul all Pike-perch bigger than 40 cm should be effectively harvested with 40–65 mm nets during the spawning time in May–June each year. In Finland less than 38 cm fish have to be put back into the lake and in May–June there is a moratorium in Pike-perch fishing.

Captured mature Pike-perch could also be milked and the hatched eggs used for fish farming purposes in suitable ponds.

Sevan Trout also depends on artificial hatching, so stopping all new restocking into the lake should rapidly lower the trout population and leave more room for the endemics. Also, a more effective and acceptable way of reducing their populations in the lake and at the same time the predatory pressure towards the endemics would also be reduced (see Table 2).

Selective fishing of Pike-perch and Bream should be organized on their spawning grounds during their propagation season. It should be investigated how best we could reduce the numbers of alien Eleotris *Micropercops cinctus* and Stone Moroko *Pseudoraspora parva*. However, these actions should be completed only after taking into consideration all relevant facts and aspects. Bream, Eleotris and Stone Moroko are important preys of Pike-perch, so the disproportional reduction in the population of any one of them could cause further damage to the endemic species (cf. Rispaev and Woynárovich 2008).

The interruption of the production cycle of Pike-perch and Bream through artificial nests could be a more productive option of reducing their populations (Fig. 7). In order to learn the technique, in setting and collecting artificial nests, two study tours have been organized to Hungary for concerned officers and project staff.

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Sustainable Management of Fish Ponds in the Issyk-Kul Province

In order to reduce the fishing pressure on Issyk-Kul, fish farming activities should be restarted in the ponds and reservoirs around the lake. The role of integrated fish farming in poverty reduction is great, because it increases employment, self-employment and income generating opportunities. Fish farming integrated with irrigation and animal husbandry could be one of the most feasible livelihood options for many households around the lake. Moreover, as soon as the large scale artificial propagation of endemic fish species would start, a wider section of the poorer people around the lake could be involved directly as fry and fingerling producers of Issyk-Kul Marinka and Naked Osman.

In order to compensate for the lost fish production of the lake, a pond aquaculture will be encouraged with all available means, including four species not yet cultivated in the Kyrgyz Republic, but present in the country. In Europe, Whitefish and Pike-perch are now commonly farmed in ponds and they fetch a much higher price in the markets than Salmon *Salmo salar* or Rainbow Trout. This same development may happen also in the Kyrgyz Republic, especially if the present cage culture operations will saturate the markets with Rainbow Trout.

It has been confirmed that there is a huge potential for sustainable fish farming activities at Lake Issyk-Kul (Rispaev and Woynárovich 2008). There are a lot of ideal sites, which are suitable for constructing fishponds or small household water reservoirs. Some of the poorer families with clear ambitions and professional support from specialists have already started the construction of ponds and production of fish.

These identified water bodies have a total area of about 785 ha, and the estimated production potential of these water bodies is between 190 and 600 tonnes/year (Rispaev and Woynárovich 2008).

This means that fish farming could produce 40–125% of the average of the annual catches registered on the lake between 1965 and 2003.

It is recommended that the owners and leaseholders complete some additional investments at their fishponds and small water reservoirs in order to ensure environment friendly fish farming. In no circumstances should the ponds have connection with the lake, and even during the floods ponds should not drain to the lake.

Sustainable Integrated Fish Culture Extension Services in the Issyk-Kul Province

It is also recommended to support the establishment of professional private and public extension services combined with reliable fish seed supply, which will be the sustainable solution for both the near and distant futures. These extension services completed with "pass porting" the ponds/reservoirs and monitoring their water qualities, especially their effluents, will ensure pollution free fish culture activities around Issyk-Kul Lake. Extension services can be supported through GEF Small Grant Facilities.

Biodiversity Fee for Cage Farms, and Monitoring of the Activity

By allowing lake-based cage culture of Rainbow Trout, which in the 1980s obviously failed fully to establish itself in the lake after their escaping from Tonsky fish ponds, the authorities are allowing an inevitable and unwanted new introduction of that fish to the lake.

Rainbow Trout is now very common in the lake, mainly in cages, at a minimum of 300 tonnes per year, but also in the lake itself, because escaped specimens move around and damage freely the endemic fish fauna of the lake.

The existing eight cage farms and their 26 cages (as in April, 2009) are bound to cause pollution (in the form of chemicals and medicaments used for the treatment and prevention of diseases and pathogenic bacteria and parasites) and eutrophication of the basin in which they are located as the excess feed sinks to the bottom of the lake through the net cages. Extra nitrogen and phosphorus will add to the primary production of algae and lower oxygen levels. Sinking unused feed and also fecal secretions (faeces and urine) of fish will cause the formation of H_2S gases which will eventually harm the cage farmer himself, and later also the other users/fauna of the lake.

One approach suggested would be to move away all Rainbow Trout cages from Lake Issyk-Kul. The law from 13 August 2004, no. 115 on EES of Issyk-Kul, would support fully such an action.

However, as it may be difficult to convince any of the eight entrepreneurs who have already massively invested in the cages (Sarieva et al. 2008), to remove their farms from the lake, a reasonable environmental compensation/biodiversity fee should be levied for all those remaining in the lake. Basis for the fee would have to be according to production levels, but collection of the production data has to improve first. It is a well known fact that currently the cage culture producers are often grossly underestimating their production figures. Even the FD admits that private fish farms always give them false data; the official production figure has been 22.6 tonnes in 2008, even though the UNDP/GEF project estimated a minimum 300 tonnes.

A tentative biodiversity fee could be 2% of sales value (now some 14 USD per kilo) of Rainbow Trout produced. Present 'real' production of about 300 tonnes would bring over 85,000 USD per year for protection of the endemics.

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Monitoring of the Cage Farming Activity The IKBRA should organize and pay for the monitoring of the cage culture, especially the impact on water quality and if possible the quantity of fish escapes. To control and oversee this activity a special commission is to be formed containing representatives from the State Agency of the Environment (including the UNDP/GEF Project), FD (including the FAO Trust Fund Project), NGO and an owner representative of the cage farming entities. It would be easier to insist removal of the cages from the lake, if the caused pollution and fish escapes are well proven with the monitoring results, which the committee has approved. In the United Kingdom, Rainbow Trout stockings will be banned completely in 2015 (Dr. Paul Hickley, personal communication). A similar time limit should also be worked out for Kyrgyz Republic's cage farms.

Relevance of Fishery Statistics

Reliable statistics are vital for any fishery management decisions. The last 10 years of fishing statistics do not reflect the true state of the sector, and there are some doubts about the previous statistics as well (Konurbaev and Timirkhanov 2003). We have no real knowledge of the occurrence and numbers of many alien species (to be controlled, like Rainbow Trout, Pike-perch, Grass and Silver Carp *Hypophtalmichtys molitrix*, Oriental Bream, Eleotris and Stone Moroko) or endemic species (to be protected, like Issyk-Kul Dace, Schmidt's Dace, Issyk-Kul Marinka, Naked Osman etc.). FD should collect and publish annually the fish export and import data and calculate the fish consumption per capita.

Maybe FAO could undertake a TCP project to improve the fishery data collection, if they get an official request from the Government, especially as it would also benefit the large FAO Trust Fund Project (GCP/KYR/003/FIN).

Fisheries Management Plan

As a follow-up to the BDFMR there is a need to work out a fisheries management plan for the Issyk-Kul Lake. The FAO (1997) definition of a management plan is as follows: A fisheries management plan is a formal or informal arrangement between a fishery management authority and interested parties which identifies the partners in the fishery and their respective roles, details the agreed objectives for the fishery and specifies the management rules and regulations which apply to it and provides other details about the fishery which are relevant to the task of the management authority.

A fisheries management plan describes: Who, where and what is this about? What do we want to achieve? How will we achieve it? How will we know if we are achieving it or not?

In close cooperation with the UNDP/GEF Project the FAO Project GCP/KYR/003/FIN (FAO 2008) could prepare a comprehensive fisheries management plan for Kyrgyz Republic water bodies, starting from the Lake Issyk-Kul.

Fisheries Co-Management is an Option

Co-management is the sharing of responsibility and authority among the government and the community to manage resources. It is a participatory and flexible management strategy that provides and maintains a forum, or structure, for action on participation. It includes rule making, leadership, negotiation, dialogue, decision-making, and conflict management as well as knowledge generation and sharing, learning, and development process among resource users, government and other stakeholders. It is dynamic and adaptive partnership, using capacities and interests of fishers and communities, complemented by the state's abilities to provide enabling legislation, enforcement and other assistance.

Co-management is searching for better management approaches as the conventional/centralized fisheries management systems have in the case of Issyk-Kul failed to conserve endemic fish stocks, protect vital habitat and to support the residents of communities that depend on them. Fisheries managers increasingly recognize that a fishery cannot be managed effectively without the cooperation and participation of fishers and other stakeholders to make laws and regulations work.

Any new development initiatives must be consultative and participatory in order to be more consistent with local cultural values. Customs provide an important element for the development of locally based resource management systems. Consequently, allocation and sustainable management of natural resources is a key issue for the local population, whose daily life is directly dependent on the availability of these resources, goods and services.

Similarly it is recommended that customary local institutions should be included in the process when future conservation and management initiatives are planned. In that respect nothing has yet been done in the Issyk-Kul Lake, as shown in Appendix 3 in the Supplementary material.

To test the participatory management approach in Kyrgyz Republic, the FAO Trust Fund Project (FAO 2008) aims to introduce one or two local fisheries co-management committee(s) to cover at least some of the most important fishing villages of the lake. In these committees, fishermen, fish processors, fish sellers, local village authorities, and representatives of Issyk-Kul Biosphere Reserve

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Administration, FD, SAEPF and the Academy of Science will sit together to agree on rules as to how best to utilize and protect the fish resources of that part of the lake (which committee members are covering) and what kind of equipment will be allowed to fish what, when and where. It remains to be seen if this participatory control arrangement decreases the illegal fishing ('poaching') and increases sustainable fishery and thus facilitates the survival of the remaining endemic species in the lake. There are some good examples of the participatory and co-management success in the other parts of the world (Khan et al. 2006; Njie and Mikkola 2001; Wilson et al. 2003). Even a limited moratorium can work and be respected if it originates from real needs to protect resources which also the fishermen see as crucial and important (f.i. Njie and Mikkola 2002).

Lake Could be Reserved only for the Recreational Fishery

And last but not least we would like to put forward a totally different proposal (Alpiev 2009) to protect the biodiversity. The numerous problems of Issyk-Kul could also be solved by changing of the status of Issyk-Kul Lake from a lake which is meant for industrial fishery to a lake which is reserved for artisanal and recreational fishery. Already in 2004 complex research of the Issyk-Kul area (Konurbaev 2004) showed that the fishery sector was never a priority on the country level or region level; for example, only 1.2–1.5% of the total economy was covered by the fishery sector. And now, when total productivity of the lake is going down, the income from the fishing in the lake has even less importance. First, this proposal to change the status of the lake would mean that fishing by any type of nets would be completely excluded. Fishing with nets would be considered malicious poaching and should be strictly punished. Only recreational fishing would be permitted—allowing only hook and line angling, and reel and lure fishing.

Such recreational fishing will basically target large predatory species—Rainbow and Sevan Trout and Pike-perch that, certainly, in due course will shift proportions of predator and prey fish species. Recreational fishing of large fish will also promote Issyk-Kul as more attractive for tourists.

Fishing only with line and hooks, and reel and lures, is favorable also because during spawning most of the fish species will not eat, and catching of fish in that time is not easy. That should improve the chances of the fish to finish spawning.

Income from selling licenses for recreational fishing will be collected into a special fund operated at SAEPF or at the Fishery Department of the Ministry of Agriculture. The money collected from fishing licenses could be used for the following activities:

- Protection of fish resources in Issyk-Kul Lake
- Scientific monitoring and research
- Artificial propagation of endemic fish species
- Part of the funds should be spent for 'sanitary fishing' which will help control the quantity of alien species

If this suggestion will be realized, it can solve the two main problems of decreasing fish productivity in the Issyk-Kul Lake: poaching and control of the quantity of Pike-perch and Rainbow Trout. The number of Sevan Trout is easy to regulate, as it mostly depends on the stocking rate of fingerlings into the lake and these are reproduced artificially in the hatcheries.

No economical benefits should be accepted as an excuse for the cage farmers to oppose the biodiversity conservation.

The recreational fishing will surely attract additional tourists and that will reflect positively in the well being of the area, and to some extent in the whole country's economy.

DISCUSSION AND CONCLUSIONS

Although fishers are convinced that the predators, especially Rainbow Trout, are the most destructive to biodiversity, the truth may not be that simple. Very intensive irrigation development has taken place in Kyrgyzstan over the last 30 years and heavy abstraction led to reduced water levels on the Issyk-Kul Lake and drying of many of the incoming streams that the endemic fish species previously used for feeding or spawning (Alpiev 2006; Mikkola 2009b).

Sometimes, over-fishing of certain species can actually be a good thing. Since introduced species, like Rainbow and Sevan Trout as well as Pike-perch are such a popular food fish, they could be severely over fished. This could lead to population reduction, and several populations of endemic fish species should soon show signs of increasing numbers. So why not let the local fishing communities capture large introduced fish species as much as they can rather than restricting them through moratorium.

There are 10 main issues on which this presentation focuses and concludes as its recommendations. These are the necessary legal modifications, reorganized institutional cooperation (in control, monitoring, research and licensing), the protection of selected endemic fish species, control of the alien species, the sustainable management of fishponds, and the creation of sustainable integrated fish culture extension services in the Issyk-Kul region. Alternatively, the cage farms should be removed from the lake and/or a reasonable environmental compensation/biodiversity fee should be levied, and a proper monitoring of the cage farming activity should be installed by the authorities.

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There should be involvement of stakeholders (fishers in co-management), with change of attitude from government-driven to community-driven management and ownership of the process. Biodiversity friendly fisheries management is not possible without a comprehensive fisheries management plan. Finally, we discussed an option to stop all commercial fishing at the lake and reserve it only for the recreational fisheries. Immediate further studies/actions are required on the following wider aspects: water management, water-quality assessment near the cage culture activities, socio-cultural issues, resource inventory, fish biology and ecology of the lake ecosystem.

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REFERENCES

Alamanov, A., and H. Mikkola, eds. 2009. *Workshop report on Lake Issyk-Kul biodiversity friendly fisheries management regime proposal and fisheries co-management*. Ecocentre, Cholpon-Ata, Kyrgyzstan, 10–12 September 2009. GCP/KYR/003/FIN FAO Field Document 1/2009, 92 pp.

Alpiev, M. 2009. New approach to conservation of biodiversity in ichtyofauna of Lake Issyk-Kul, 108–113 pp. In *Structure of the biodiversity friendly fisheries management regime within the Lake Issyk-Kul, Kyrgyzstan. UNDP/GEF Project: Strengthening policy and regulatory framework for mainstreaming biodiversity into fishery sector*, eds. A. Alamanov and H. Mikkola. Cholpon-Ata, 113 pp.

Alpiev, M.N. 2006. Internal water ecosystems. In *Third National Report on Saving of Biodiversity in the Kyrgyz Republic*. Bishkek (in Russian).

Baetov, R. 2003. *Management of the Issyk-Kul basin*. Mimeo 28/08/2003, 22 pp.

Ball, D. 2004. Lake Victoria: The problems and options, 1–2. http://aquarticles.com/articles/management/Ball_2Victoria.html. Accessed 21 Oct 2010.

Chege, N. 1995. Lake Victoria: A sick giant. People & the Planet, 1–4. http://cichlid-forum.com/articles/lake_victoria_sick.php. Accessed 21 Nov 2010.

Davletkeldiev, A.A. ed. 2006. *Red Data Book of Kyrgyz Republic*. State Agency on Environment Protection and Forestry under the Government of Kyrgyz Republic, Institute for Biology and Pedology of National Academy of Sciences of Kyrgyz Republic, Ecological Movement "Aleine", 2nd edition. Bishkek, 544 pp (In Russian).

FAO. 1995. *Code of Conduct for Responsible Fisheries*. Food and Agriculture Organization of the United Nations, Rome, 41 pp.

FAO. 1997. *Definition of a Management Plan*. Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org. Accessed 21 Nov 2010.

FAO. 2008. *Support to Fishery and Aquaculture Management in Kyrgyz Republic*. FAO Trust Fund Project GCP/KYR/003/FIN, FAO, Rome, Italy, 80 pp.

FishBase. 2009. http://fishbase.org/Summary/speciesSummary.php. Accessed 22 Feb 2009.

FishCatalog. 2008. http://research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp Accessed 12 Aug 2008.

Government of the Kyrgyz Republic. 1997. *Fishery Law of the Kyrgyz Republic #39, 25 June 1997*. Bishkek (in Russian).

Great Lakes Information Network. 2003. Invasive species in the Great Lakes Region, 1–8. http://great-lakes.net/envt/flora-fauna/invasive/invasive.htlm. Accessed 28 Nov 2010.

Ilibezova, E., L. Ilibezova, and E. Selezneva. 2005. *Research of Households and Communities under the Project on Preservation of Ichtyofauna of the Lake of Issyk-Kul Basin*. Public Opinion Research Center El-Pikir, Bishkek, 28 pp.

Imanaliev, K. 2004. *Kyrgyzstan (The Word about Homeland)*. BBK, Bishkek, 248 pp.

Khan, A.S., H. Mikkola, and R. Brummett. 2006. Fisheries co-management in Africa (La gestion commune des pêcheries en Afrique). *Revue Congolaise des Transports et des Affaires Maritimes* 3(5): 65–82.

Konurbaev, A.O., and S.R. Timirkhanov. 2003. *Looking at fishes in Kyrgyzia—Central Asia*. Daru Ltd, Bishkek, 120 pp.

Konurbaev, A.O. 2004. *Fish farm as a value sector. Collection of scientific basis of complex development of Issyk-Kul oblast of the Kyrgyz Republic*. Bishkek, 284 pp (in Russian).

Konurbaev, A.O., L.A. Kustareva, M.N. Alpiev, D.T. Kabatev, and E.S. Konurbaev. 2005. *Conditions of Issyk Kul Lake Ichtiofauna, fishery and its management*. Mimeo, Bishkek, 24 pp.

Mikkola, H. 2009a. GCP/KYR/003/FIN "Support to fishery and aquaculture management in the Kyrgyz Republic". *FAN FAO Aquaculture Newsletter* 43: 6–7.

Mikkola, H. 2009b. Kyrgyzstan-protecting fisheries. *Meat Trade News Daily*, 27/10/2009.

Mikkola, H. 2010. Introductions causing serious problems to endemic fish. *Suomen Luonto* 69(4): 15–16 (In Finnish).

Niyazov, B. 2007. *Condition of fish farming in the Kyrgyz Republic in 2006*. Paper presented at the National Workshop on Fisheries and Aquaculture in the Kyrgyz Republic: Status and prospects to increase the contribution of the sector to food security, EU/FAO/Government of Kyrgyzstan, Bishkek, 12 Sept 2007.

Njie, M., and H. Mikkola. 2001. A fisheries co-management case study from The Gambia. *Naga, The ICLARM Quarterly* 24(3–4): 40–49.

Njie, M., and H. Mikkola. 2002. Management and development of the Gambia River fisheries. A case for the co-management of inland fisheries resources, pp. 228–239. In *Africa's inland fisheries: The management challenge*, ed. K. Geheb and M-T. Sarch. Fountain Publishers, Kampala, Uganda, 280 pp.

Pavlova, M.V. 1964. *Zoobenthos of Issyk-Kul Lake bays and their use by fishes*. Printing Ilim, Frunze, 95 pp (in Russian).

Petr, T., and V.P. Mitrofanov. 1998. The impact on fish stocks of river regulation in Central Asia and Kazakhstan. *Lakes and Reservoirs: Research and Management* 3: 143–164.

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www.kva.se/en

Rispaev, A., and A. Woynárovich. 2008. *Practical recommendations on protection of endemic and control of alien fish species in the Lake Issyk-Kul and sustainable management of fish farms in Issyk-Kul Oblast*. UNDP/GEF-Project, Bishkek, 124 pp.

Sarieva, M., M. Alpiev, R. Van Anrooy, J. Jørgensen, A. Thorpe, and A. Mena Millar. 2008. *Capture fisheries and aquaculture in the Kyrgyz Republic: Current status and planning*. FAO Fisheries Circular No. 1030 (SEC/FIMF/FIEP/C 1030 En), 107 pp.

Svärdson, G., N-A. Nilsson, H. Dahlström, and P. Tuunainen. 1968. *Fish, management of fishing waters and fish farming).* Kirjayhtymä, Helsinki, 302 pp (In Finnish).

Thorpe, A., R. Van Anrooy, B.N. Niyazov, M.K. Sarieva, J. Valbo-Jørgensen, and A. Mena Millar. 2009. The collapse of the fisheries sector in Kyrgyzstan: an analysis of its roots and its prospects for revival. *Communist and Post-Communist Studies* 42: 141–163.

UNDP. 2007a. *Kyrgyzstan. Environment and Natural Resources for Sustainable Development*. State Agency on Environment Protection and Forestry under the Government of the Kyrgyz Republic and United Nations Development Programme in the Kyrgyz Republic. Bishkek, 85 pp.

UNDP. 2007b. *Access of men and women to the natural resources of Kyrgyzstan*. United Nations Development Programme in the Kyrgyz Republic and State Agency on Environment Protection and Forestry under the Government of the Kyrgyz Republic. Survey B, Bishkek, 40 pp.

UNDP. 2008a. *Poverty alleviation through sustainable development of local communities*. United Nations Development Programme in the Kyrgyz Republic. Bishkek, 194 pp.

UNDP, 2008b. *Strengthening policy and regulatory framework for mainstreaming biodiversity into fishery sector*. PIMS 3212, Bishkek, 31 pp.

Wilson, D., J. Nielsen, and P. Degnbol, eds. 2003. *The fisheries co-management experience: Accomplishment, challenges and prospects*. London: Kluwer.

Zabirov, R.D., and V. N. Korotaev. 1978. Characteristics and morphometry of the lake. In *Ozero Issyk-Kul*, 3–48. Printing Ilim, Frunze (in Russian).

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