Lake Issyk-Kul

Experience and Lessons Learned Brief

*Rasul Baetov**, Cholpon-Ata, Kyrgyz Republic, koabu@yahoo.com

* Corresponding author

Lake Issyk-Kul (also referred to simply as Issyk-Kul), located in the Kyrgyz Republic (commonly referred to as Kyrgyzstan), is the world's second-largest high-altitude lake and a major biological and economic resource of the country. Among lakes lying 1,200 meters or more above sea level, Issyk-Kul is second only to Lake Titicaca in overall area. Slightly salty, the lake never freezes, which contributes to its importance as a stopover for migratory birds. Over the past few decades, the level of the lake has dropped some 2.5 m as the result of water diversions. In the face of several serious threats to the lake, the Government of the Kyrgyz Republic has created the Issyk-Kul Biosphere Reserve, run by a Directorate General.

1. Physical Geography of the Issyk-Kul Basin

The Lake Issyk-Kul basin is one of the Kyrgyz Republic's most important natural areas, occupying 22,080 km², or about half of the area of Issyk-Kul oblast (province), which covers 43,144 km². The oblast of Issyk-Kul lies between latitudes 41°08' and 42°59' N and longitudes 75°38' and 80°18' E.

The Lake Issyk-Kul basin (Figure 1) lies within the geographic area known as the Northern Tien-Shan, "the heaven's mountains", and encompasses the unique topography of the basin of Lake Issyk-Kul, a closed lake framed by the Kungei-Alatau mountain chain to the north and the Teskei-Alatau mountain chain to the south. The watershed also includes the high-mountain syrts (the Kyrgyz word syrt in this context can be translated as "outside" or "external", meaning that these far-off pasturelands lie beyond the territory immediately surrounding Issyk-Kul) and the desertland and steppes of the Central Tien-Shan, a land of perennial freezes, high peaks and extensive glaciation zones, whose waters also feed the Aral and Tarim basins. Within the Issyk-Kul basin itself are 834 glaciers of various sizes ranging from less than 0.1 km² to 11 km². These glaciers cover 650.4 km², or about 3% of the overall basin area. The Issyk-Kul oblast contains 3,297 glaciers, the overall area of which is 4,304 km²; this constitutes roughly 40% of the total number of glaciers, and half of the total glaciated area in the Kyrgyz Republic. Glaciers play many roles in the ecology of the basin, but their primary value lies in their function as collectors of clean freshwater and sources of flow into local rivers.

Issyk-Kul is a tectonic lake, approximately 25 million years old, formed by faults, folds and warps in the earth's surface. As a great part of this surface sank and was flooded, surrounding areas rose 3,000 to 3,500 m above what is now lake level to form the Teskei Alatau and Kungei Alatau ranges to the north and south. On the east, the basin is bounded by the isolated peaks of Alabel and Chaarzhoon (2,722 m); to the west by Karakuu and Kyzylompol. The ring of mountains surrounding the lake is broken on the west by a narrow gorge, the Buum, through which flows the River Chu. The Chu flows within a mere four km of the lake and is linked to it by the Kutemalda

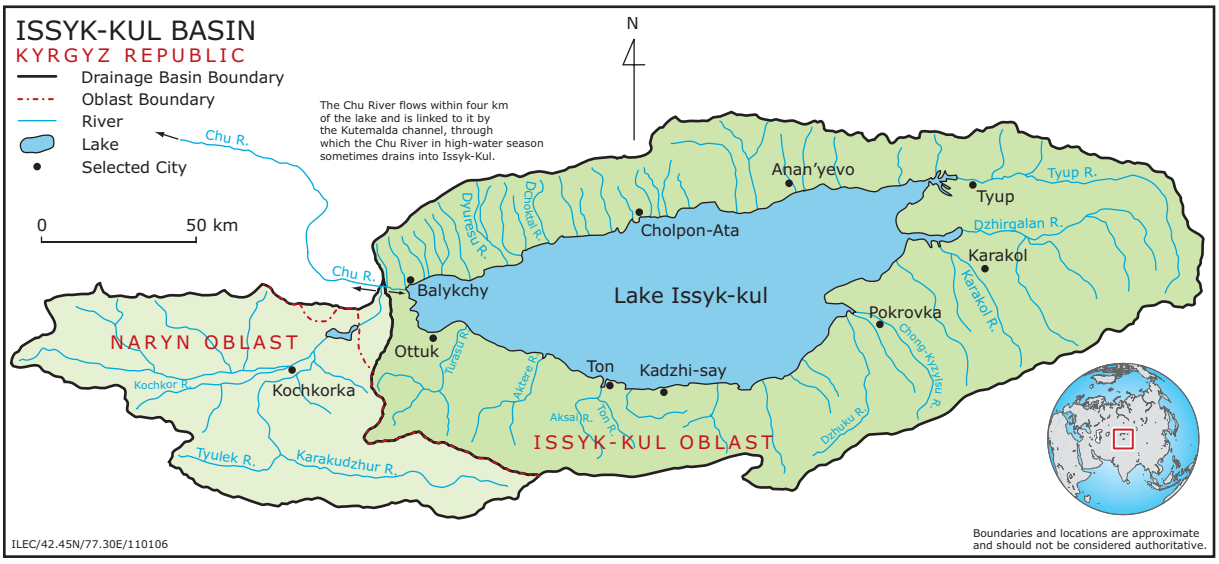

Figure 1. The Lake Issyk-Kul Basin.

channel, through which the river in high-water season sometimes drains into Issyk-Kul.

Lake Issyk-Kul is 180 km long and 60 km wide at its widest point. Its average depth is 280 m, its maximum depth is 668 m, and its overall area is 6,236 km^2. Approximately 38% of the lake is less than 100 m deep; this is the area most densely inhabited by organic life. The overall water volume of the lake is 1,738 km^3, and its overall circumference is 688 km. Water level varies according to season. In spring and summer the water level rises by 21-22 cm due to abundant inflow from snowpack and glacier melt. In the autumn and winter, the water level falls accordingly.

Given the relatively small coves and mild indentations along its shoreline, the singular climate of the basin, the great depth and the unique hydrology of the lake itself, Issyk-Kul is an oligotrophic lake. It produces phytoplankton at a rate of less than 488 mg/m^3, zooplankton at a rate of 910 mg/m^3, and zoobentos at a rate of 10 g/m^2.

Issyk-Kul is a closed lake; hence its waters are somewhat saline. The salinity, however, is not high—a mere 5.968 g/L, five-and-a-half times lower than that of the ocean. Its mineral content is chloride/sulfate/sodium/magnesium-based. The low overall mineral content testifies to the fact that, in geological terms, Issyk-Kul has only relatively recently become a closed lake.

The waters of Issyk-Kul are rich in oxygen, as a result of aeration and movement of lake waters. These waters are clear and transparent due to the paucity of organic life and to the overall salinity, which has in turn contributed to the coagulation of tinted organisms. The transparency of Lake Issyk-Kul waters approaches that of seawater or ocean water, and in the open part of the lake Secchi disk readings are up to 30-35 m. Transparency and bright sunlight combine to create a range of shades in the lake, from sky blue to darkest indigo.

The high-mountain pastures to the south of Teskei Alatau and the slopes of the mountain ranges that descend into foothills around Lake Issyk-Kul make up the lake's drainage basin. Within the basin, 118 rivers and streams flow toward the lake, but only 49 of them actually drain into it. The river system reflects the distribution of rainfall in the basin. In the west, where precipitation is light, the river system is poorly developed, and the relative water volume is light. In the east, where precipitation is heavier, the hydro-network is denser and the rivers are fuller. The greatest volume of flow comes through rivers on the basin's eastern side. The volume of rivers on the western side of the basin is significantly smaller.

2. Threats to the Sustainable Use of the Lake

Issyk-Kul is the joy, the pain and the hope of the Kyrgyz people. In centuries past, people lived in harmony with the lake, husbanding its resources, passing their love for the lake from generation to generation. They did not try to subject it to their will, as they do now. As a result, nature has begun to punish them more often. Destruction of bedrock, erosion of soil, earthquakes, floods—these are only a few of the disasters before which humans stand helpless. The consequences of environmental damage have long ago crossed national borders; climate change has clearly shown that whatever happens in one of Earth's hemispheres directly affects the other one.

Intensive exploitation of the Issyk-Kul region has without doubt had a great influence on the unique natural qualities of this lake. Irreversible processes with long-term consequences have been set in motion. There is already concrete information on the extinction of several species, and on the destruction of landscape, including unique thickets of buckthorn, barberry, and ephedra. The state of lake waters continues to worsen; this represents a threat to the lake both as a recreation area and as home to a variety of natural systems. There are a host of problems around use of natural resources, and any solutions to these problems must take into account the unique environmental concerns of the lake basin itself, as well as the unique character of human life around the lake.

In the agricultural sector, for example, one of the most crucial current issues is erosion of cropland. This problem has arisen as a consequence of hillside plowing, improper watering and rotation of crops, poorly planned irrigation networks, and poor layout of fields in general. Unfortunately, there has also been overuse of timber and brushland resources, as well as the deterioration of plant cover and soils in natural pastures near villages—all due to overgrazing and generally poor grazing and herding practices.

2.1 Mining

The introduction of manufacturing has caused a number of problems in the region including: disruption of soils, terrain, and water tables by widespread mining operations; pollution from untreated agricultural runoff; pollution from illegal dumping or storing of toxic chemicals currently in use at the Kumtor gold mine. One of the worst regional environmental disasters in recent history occurred on 20 May 1998, when a truck hauling toxic chemicals crashed just upstream from the mouth of the Barkuum River, which empties into Lake Issyk-Kul. As a result, 1,762 kg of sodium cyanide, a chemical used in the processing of gold ore at Kumtor, were dumped into basin waters.

Despite the devastating accident, the Kumtor Operating Company provides an example of good environmental management in Issyk-Kul oblast. The company has banned grazing and hunting on outlying lands under its use; this has led to regrowth of plant cover in syrts and an increase in wildlife populations. Measures undertaken to improve wastewater treatment have helped maintain the natural chemical balance of the waters in the Kumtor and Taragai Rivers, and preserve biological communities.

2.2 Wastewater Treatment

Lack of both adequate infrastructure and financial means to support public utilities (let alone any resort or tourism industry) has made it impossible to improve wastewater treatment plants. This in turn has led to further pollution and unwise use of lake waters.

2.3 Hunting and Biodiversity

Poaching and unregulated hunting and trapping have reduced wildlife numbers, with particular impact on disappearing populations such as the lynx, the vulture, and any number of indigenous fish in the lake.

Biological diversity in the Lake Issyk-Kul basin can be preserved and sustained only if the entire region is developed in an environmentally sound way. First and foremost stands the question of preservation of rare and endemic species, among them the lynx (*Felis unsia*), the Tien-Shan mountain sheep (*Ovis common*), the Siberian deer (*Servus elaphus*), various hawks such as saker falcon (*Falco cherrug*) and *F. Schizothoraz*, fishes (*Leuciscus*, *Dyptichus*, *Erebia*), insects (*Netocia*, *Calosoma*), bumblebees (*Bombus*) and honeybees (*Xylocora*).

2.4 Recreation and Spas

Lake Issyk-Kul represents an enormous natural and cultural heritage. It has a long history as a recreation site and a spa. Its waters are strikingly clean and clear, and are said to possess healing powers. Thus the lake and the surrounding basin attract a tremendous number of vacationers, especially in the summertime. Yet poor infrastructure and lack of services at popular vacation sites put the lake under tremendous stress. This stress falls primarily on the northern shore and the slopes of Kungei Alatau, where forests and sub-alpine meadows are home to rare and protected species.

2.5 Conservation

At times, the strategy and tactics of environmental and biodiversity protection run counter to the interests of the local population. The basin is a densely settled region, home to a large industrial complex, to farms, fisheries, and recreational areas—all of which combine to make environmental protection a difficult process. The situation has become even more complicated in light of the socioeconomic crisis of recent years, because any efforts to preserve unique species and to maintain biodiversity are linked to social and economic development that must be environmentally oriented. Once again, this is because preservation of rare species and biological diversity overall must be linked with an environmentally oriented socio-economic policy. As it continues to develop, the local hunting and trapping economy must guarantee a balance between overall numbers of game animals and preservation of their ecological niche.

2.6 Reform-policy Priorities

Priorities for sustainable development of biodiversity include the creation of nurseries and hatcheries for rare and endemic species, and the protection of natural breeding, spawning and feeding grounds. This is especially important for the biota of the lake; since the biota lives in a closed-lake environment, it is more vulnerable to human pressure than are the dryland plant and animal communities that surround it. Thus, it is crucial that measures be taken and laws be passed to regulate commercial, industrial, agricultural and recreational use of both the shore zone and the lake waters, the watchword being "let us not squander renewable natural resources, let us use of non-renewable natural resources rationally."

Substantial attention must be paid to environmental management, to environmental protection, to prevention of emergencies, and to control of emergencies when they cannot be prevented. This will aid in preserving Lake Issyk-Kul, the natural system that lies at the heart of the basin.

2.7 Glacial Retreat

The first and most important task in the Issyk-Kul Biosphere Reserve is the collection of data and the creation of a data base on the current state of plant and animal communities, individual species, populations and numbers, to identify areas where biodiversity is most concentrated.

Kungei Alatau and Teskei Alatau, the mountain ranges that frame Lake Issyk-Kul, peak at 4,711 and 5,216 m respectively. They have been one of the factors in the development of the glaciers that provide a regular supplemental flow of water into the lake during the summer months.

Glaciation research conducted in 1995 has shown that in the last fifteen years, seven of the 22 glaciers included in the study have retreated by 90 m or more; six others have retreated by 60 to 69 m, and the remaining nine have retreated by 25 to 59 m. The rate of retreat has varied considerably from year to year, determined largely by fluctuations in temperature and precipitation. For example, a typical Issyk-Kul *cirque* glacier (a glacier that resides in basins or amphitheaters near ridge crests—most cirque glaciers have a characteristic circular shape, with their width as wide or wider than their length) retreats upward by roughly 2.5 and 1.3 m per year. Yet while the front edges of glaciers in the area have uniformly crept back to higher and higher elevations, a more objective indicator of their current condition is data on their mass balance, calculated over many years' time. Particularly indicative are data gained from long-term observation of Karbatkak, a typical *cirque* glacier, which originates at the sources of the Chonkyzylsuu River and flows down the northern slope of the central Teskei Alatau. Between 1957 and 1997, ice loss exceeded snowmass gain by 17.96 m. In other words, during the last 41 years, the upper surface of the glacier has dropped by 18 m. If we consider that at the beginning of the study, the central portion of the ice sheet was 49 m thick, we must acknowledge that such thinning

represents an even greater threat to the existence of the glacier than does any reduction in its overall length.

There are a number of reasons for the degradation of glaciation in Issyk-Kul, but the increase in surface pollution and climate change are the two most significant ones. Both contribute to more intense melting and therefore degrade the mass balance of the glacier. The average yearly temperature in the glaciation zone has risen by 0.2°C; summers are warmer by 0.6°C, evidenced not only by higher melting rates, but also by a longer ablation period. This continued warming trend will accelerate glacial collapse and, most important of all, lead to a change in the water volume of those rivers the glaciers help to feed. According to current calculations, by 2005 the overall glaciation area on the northern slopes of the Teskei Alatau will have shrunk by 32%. On the south-facing slopes of the Kungei Alatau range it will have shrunk by 76.6% (Dikikh 2000).

Analysis of many years of hydro-meteorological data indicates that over the coming five to ten years, glaciers on the southern slopes of the Kungei Alatau will be able to sustain the current water volume in rivers in spite of shrinking glaciers and increasing surface evaporation. After that, however, the flow will begin to diminish markedly. On the other hand, water volume of the rivers on the south shore of the lake, whose sources are in well-developed areas of glaciation, will not only remain stable but will continue to increase until 2020 or 2030. This conclusion was reached by calculating flow formed under the following conditions: reduction in the size of the glaciated area, more intensive melting, and increase in the area of ablation due to a higher snow line.

The yearly volume of surface runoff is calculated to be 3.72 km^3. An important part of this comes from the glacial waters that compensate for losses in the water budget of Lake Issyk-Kul, where water level continues to drop. In the last forty years weather posts stationed around the lake have noted an overall 189 cm drop in lake level. Without glacial runoff, this figure would have been much greater (Dikikh 2000).

Such a drop will only increase human stresses on the lake. Indirect evidence for degradation in water quality already exists. For example, comparisons with data obtained by V.P. Matveev show that the color of the water has changed over time. Hydrobiologists from the Issyk-Kul biological station have noted an increase in numbers of phytoplankton and microorganisms. The decline in lake level brings with it a reduction in the volume of biogenic elements entering the lake from littoral silts, and thus an increase of the biological productivity of the lake.

With the drop in water level also comes a certain increase in salinity. V.P. Matveev's data show that in 1932 the salinity of Issyk-Kul measured 5.82 g/L. By 1984 salinity had increased to 5.9 g/L. Over this period, the water level dropped by 2.5 m and overall volume by 16 km^3. Thus, further drop in the level of Issyk-Kul could lead to change in the entire ecosystem.

2.8 Agriculture

The plant world of the Issyk-Kul oblast is rich and diverse; equally diverse are its uses. This plant world deserves universal protection, in that it is beneficial to human health, improves the local climate, curbs erosion, and regulates river flow.

One of the most basic functions of plant cover is agricultural, which serves as a natural source of feed, such as from grazing lands and hayfields. Pasturelands are that part of the plant world that provide the food base for animal husbandry in the Kyrgyz Republic. The quality and quantity of livestock production depends on the state of these grazing lands. Any problems with pastureland (their overall state, species makeup, productivity, capacity, etc.) affect many other areas as well: beekeeping, hunting and trapping, not to speak of national parks, preserves and game reserves, since the food base for wildlife grazing in the foothills of these mountain ranges depends first and foremost on the state of the plant communities on which they feed.

Within a biosphere reserve such as Issyk-Kul, any use of natural resources that might lead to destruction of ecological balance (i.e. noncompliance with rules of pasture stress/capacity, overgrazing, trampling, etc.) is utterly unacceptable.

Overall natural pastureland area in Issyk-Kul oblast totals 1.4 million ha: of these, 0.4 million ha are spring and autumn pasturing grounds; 0.6 million ha are summer pastures; and 0.4 million ha are winter pastures.

At present, 12% of the total pastureland in the Issyk-Kul oblast is degraded in some way: invaded by inedible grasses or other inedible plant cover, eroded, trampled, etc. Moreover, 25% of the total area is overrun by various types of thistles and thornbushes, primarily caragana; this too is a consequence of neglect and improper use.

Over centuries, grazing practices have evolved around the mountainous terrain and the corresponding differences in start of vegetation at various elevations. In early spring, livestock is pastured close to settled areas, in the foothills and low lying mountain valleys; then, as grass cover appears at higher elevations, herds are driven upland to the central highland belt, and eventually into the high sub-alpine and alpine meadows. In the fall, livestock is moved back down through the central highland zones, the foothills and the flats.

Currently, with the disappearance of collective farms and state farms and the emergence of a great number of small private farms, grazing practices have changed. Virtually all livestock owned by small proprietors is now grazed year round near villages, on what were once exclusively spring and fall pastures. Farmers have neither the transportation nor the financial means to drive their animals upland to outlying pastures. Such disproportionate use of grazing lands leads to further degradation of lands near villages. This environmental

dilemma is typical for the entire length of Issyk-Kul's densely populated shoreline.

In consideration of the increasingly negative human impact on the environment, and in the effort to conserve natural resources, on 1 March 1999 the Kyrgyz Republic enacted the latest in a series of environmental laws, including one entitled "On monitoring of agricultural lands in the Kyrgyz Republic". This particular act is directed at timely identification of environmental change in commercially used lands, and also at assessment, prevention and elimination of negative processes.

Monitoring of agricultural lands is a key component in the monitoring of the natural environment overall; this includes monitoring of soils and natural pastures. In order to identify precisely which pastures are deteriorating and therefore in need of improvement, and in order to make recommendations on rational use and protection of grazing lands, it is crucial that grass cover be kept under constant observation. Given recent laws on land reform, which require that rent be paid for land use, it is particularly important to have credible information about the current state of grazing lands, about their productivity, and about any changes in the grass cover brought about by human influence.

In order to resolve problems of land use throughout the Issyk-Kul Biosphere Reserve, then we must be systematic in the monitoring of both cultivated and natural pastures. Since 1997, under the aegis of a project entitled "Developing sheep husbandry in the Kyrgyz Republic", geobotanists from the Kyrgyzgiprozem Institute have been conducting research in high-elevation zones. Their goal is to assess the current status of these high pastures, and then to design a set of measures aimed at preservation, defense, improvement, and rational use. Monitoring of pastures, recommendations based on this monitoring, and rental of these pasturelands to individuals will make it possible to educate livestock farmers in wise use of pastureland, in part by the application of rewards and sanctions.

Of particular importance is the issue of livestock grazing in mixed forest and woodland. The fate of Kyrgyz forests depends on how pasturelands within forested areas are used. Given the enormous role of mixed woodland and grassland pasture in the Kyrgyz rural economy, it is crucial that special systems are developed for their rational use. These should be based on optimal grazing loads and timelines for various types of pastures depending on the productivity and capacity of each.

In order to prevent negative impacts, it is also very important to identify those areas of pastureland that should be taken out of use altogether: steep slopes, avalanche prone areas, and lands presenting some threat to villages. Without such monitoring of pasturelands, an environmentally-oriented farm economy that both uses and conserves the natural riches of the Issyk-Kul basin is impossible.

2.9 Water Diversion

Given the long and consistent decline in lake level, the question of supplementing lake waters has been posed more than once. Since there are no natural prospects for improving the water balance of the lake, it is inevitable that the question will be posed again. There is no other choice but to do so.

An early project proposed by M.N. Bolshakov and B G. Shpak (1960) involved diverting some part of the waters of the upper Karkyr River into the lake, and later M.N. Bolshakov reaffirmed that this proposal might make it possible to ameliorate the water-balance crisis (1969). Engineering organizations in Kazakhstan were highly critical of this project, however, because the Karkyr River lies within the Lake Balkhash Basin, another area in dire need of water resources. On the other hand, scientists assert that diverting some part of the waters of the Karkyr would not present a significant threat to Lake Balkhash.

Other projects for easing the water-balance crisis in Lake Issyk-Kul have also been proposed. The first of these involves diversion of run-off that now drains into the Arabelsuu River from high mountain syrts above. Aside from the immediate expediency of such diversion, the proposal also allows for the creation of a reservoir in the Arabelsuu syrts. Such a reservoir might serve to change the microclimate of these high pastures and also to preserve already-existing glaciers in the area which contain centuries' worth of water resources in solid form.

The problem of improving the lake's water regime, given its unfavorable natural tendencies, is one of the most important issues arising from competing economic uses of the lake and its basin. Its importance is due to the connection between the natural tendency for the lake level to decline with the resulting decline in water quality caused by a rise in the general mineral content. Again, this is not the only problem, but it is one that requires careful and in-depth analysis of how to use the natural resources of the lake in a way that is most beneficial to the local economy in the long term. Herein lays a crucial and very complicated human issue.

In years past—let alone in decades past—very few people were concerned with studying resource use around the lake or with planning for the lake basin economy in the long term. This attitude was rooted in false assumptions about the "endless possibilities" of Issyk-Kul and its basin. No one considered the possibility that many of these resources might soon be exhausted.

Supplementary feeding of Lake Issyk-Kul over and above its natural water resources was necessary to maintain development of irrigation in the basin with inevitably diminishing reserves of natural waters, and also to maintain, at the very least, the current water balance and water level of the lake.

2.10 Introduction of Fish

Within the basin proper, Lake Issyk-Kul occupies a particular and unique place: it is home to a diverse group of endemic species that are also highly valued commercial fish. It is also home to introduced species from the Ponto-Caspian-Aral group and from the Indian and boreal groups. At the same time the lake hosts a number of high-mountain Asian fish species, eight of which are endemic.

In the past, the largest component of the fish population in the lake was the Issyk-Kul chebachok (*Leuciscus bergi*). At that time the chebachok was considered a common fish of no particular value, and the chebachok population was thought to be "inexhaustible". In light of this, there have been attempts to qualitatively transform the Issyk-Kul fish stocks.

The first attempts at acclimatization of non-native species were launched in 1930. On recommendation of Academician L.S. Berg, the Sevan trout (*Salmo ischchan gegarkuni*) was released into Lake Issyk-Kul. Then, in January 1936, 800,000 Sevan trout eggs were incubated and hatched in the Aksai River, after which the fry were released into the mouth of the river Ton. Comparison of data on growth rates for both fry and adult fish, plus comparisons by A. Konurbaev and A. Zhadin of the scientific literature describing the composition and density of animal life in the rivers draining into Lake Issyk-Kul and Lake Sevan have shown that habitat in Issyk-Kul was comparable to that in Lake Sevan. This leads us to acknowledge that Issyk-Kul was an appropriate setting for acclimatization of the Sevan trout. But despite attempts over more than seventy years to introduce this trout into Lake Issyk-Kul, and despite thirty years of cultivation, the Sevan trout has yet to reproduce in sufficient numbers to become self-sustaining. According to researchers Konurbaev and Zhadin, the reasons for this failure include: fewer opportunities for natural reproduction of the species; withdrawal of water for irrigation, which has led to the drying and silting-up of spawning grounds; death of the fry themselves as they are poured out with the river water to irrigate fields; inefficient fish-farming operations; poaching and theft, plus a multitude of other factors.

In the early 1950s, other non-native species uncharacteristic of the fish population of the lake began to be introduced. Between 1956 and 1958 the lake was stocked with bream (*Abramis brama orientalis*) and pikeperch (*Stizostedion lucioperca*), both of which migrated to the eastern part of the lake, where they found the most hospitable habitat. Also introduced were khramul and carp; with them apparently came other species as well, including tench (*Tinca tinca*) and crucian carp (*Carassius carassius*).

In the early 1970s, efforts to reconstruct fish stocks in Issyk-Kul took a new direction. The plan was to turn the lake into a reservoir for trout and whitefish, and to gradually reduce the numbers of chebachok to a bare minimum. To this end, the Sevan whitefish (*Coregonus lavaretus*), the pelyad (*C. peled*), and the Baikal omul (*C. autumnalis migratorius*) were introduced into Issyk-Kul. There were also proposals to replace the Issyk-Kul chebachok with the ryapushka, a more nutritious food fish. However, in light of the decision to save the chebachok and in light of new data on its consumption of zooplankton, further efforts were limited to importation of whitefish. As of the late 1970s, the Baikal omul was still observed in the lake, while at present there is no evidence of pelyad at all. The whitefish, however, has established itself as a major component of fish life in the lake.

These colonization efforts have led to a number of substantial changes in the composition of lake fauna. The number of native species has diminished, and some, including the naked osman (*Dyptichus dybowskii*), are on the verge of disappearing entirely.

At present, the following fish species are now present in Issyk-Kul: Sevan trout (*Salmo ischchan gegarkuni*), rainbow trout (*S. gairdneri*), whitefish (*Coregonus lavaretus*), omul (*C. autumnalis migratorius*), bream (*Abramis brama orientalis*), tench (*Tinca tinca*), giebel carp (*Carassius auratus gibelio*), striped gudgeon (Alburnoides taeniatus), Amur chebachok (*Pseduorasbora parva*), pikeperch (*Stizostedion lucioperca*), and sleeper (*Hypseleotris cinctus*).

There have also been anecdotal reports of catfish caught in the lake, and of a school of grass carp was sighted in the Tyupsky Bay 20 years ago.

Before any attempts at colonization of non-native species, the following fish were present in the lake: Issyk-Kul chebak (*Leuciscus schmidti*), Issyk-Kul chebachok (*L. bergi*), naked osman (*Dyptichus dybowskii*), Issyk-Kul marinka (*Schizothorax pseudaksaiensis isskkuli*), wild carp (*Cyprinus carpio*), Issyk-Kul gudgeon (*Gobio gobio latus*), Issyk-Kul minnow (*Phoxinus isskkulensis*), Issyk-Kul loach or "usan" (*Nemacheilus strauchi ulacholicus*), and gray loach (*N. dorsalis*).

Despite the unfavorable effects of human impact, Issyk-Kul dace is at present the most abundant fish species in the lake. Savvaitova and Petr (1999) provide further information on fisheries of Lake Issyk-Kul.

2.11 Biodiversity

There are even more terrestrial species than fish species endemic to the basin. Thirty-nine of these are on the endangered list.

Lake Issyk-Kul never freezes over, and it thus plays a special role in the preservation of biodiversity. The lake is a haven for waterfowl and shore birds during the fall and winter. Anywhere from 50,000 to 80,000 birds belonging to 30 to 35 species winter over on the lake. The lake is important for many other bird species as well, who use it as a stopover and feeding ground during seasonal migration. This is why, in 1975, Lake Issyk-Kul was included in the list of "Wetlands of International Importance" (Ramsar Convention). However,

with the collapse of the Soviet Union, the Soviet-era law sanctioning participation became null and void; this in turn led to the adoption of a new law by the newly independent Kyrgyz Republic, making the Kyrgyz Republic an official signatory of the Ramsar Convention, and thus Lake Issyk-Kul a nominee for designation as a Ramsar site. That designation became official in March 2003.

In August 2002, a regional seminar on preservation of high-altitude lakes, glaciers and other bodies of water was held in Urumchi, People's Republic of China. Twenty high-altitude lakes and glaciers were listed as potential Ramsar sites of either biological or cultural significance. Unfortunately, at present, there is no real data about the status of many of these sites, even as the growth of tourism in the region has brought more and more visitors to them every year.

2.12 Radioactive Contamination

Radioactive contamination of the lake has potential to be a significant problem. Uranium-carbon deposits may be contaminating the lake and the President of the Kyrgyz Republic, Askar Akayev, highlighted the need to speed up the reclamation of the Kadzhi-Say dump on the southern shore of Lake Issyk-Kul (BBC News 2004). Previously, Kyrgyz newspapers reported a warning from the Emergencies and Civil Defence Ministry that if no action was taken, heavy rains could wash radioactive particles into the Issyk-Kul basin, but the problem remains unsolved. A project to reduce this threat has reportedly attracted foreign funding. Russia is said to have given US$160,000, and a further US$400,000 has been made available by the USA. Now Russian Atomic Energy Minister Aleksandr Rumyantsev has presented an US$8.8 million project to reclaim areas around former uranium mines. The structures built to contain the waste are in great need of renovation and under constant threat from mudflows, avalanches and flood waters, as well as people combing them for saleable waste and scrap metal (BBC News 2004). It is worth mentioning that Lake Issyk-Kul is characterized by increased natural uranium content. Within the project "Assessment and prognosis of environmental changes in Lake Issyk-Kul" (Program of the European Commission "Copernicus-2", 2001-2003) the water assays were sampled from different depths near the banks of the lake and from low-debit sources draining the dumping grounds of the uranium-carbon deposit. The results obtained demonstrated that the ecological status of the Lake Issyk-Kul is not damaged at present and wastewaters from the uranium-carbon mine do not make a decisive contribution into the natural radioactive background (Palesski et al. 2003) but the threat persists.

3. The Issyk-Kul Biosphere Reserve

One of the most important steps taken in government environmental policy in general and in the preservation of Lake Issyk-Kul in particular is the creation of a specially protected area, the Issyk-Kul Biosphere Reserve (Figure 2).

In response to UNESCO's call to preserve the unique natural environment of the northeastern part of the Tien-Shan, which includes Lake Issyk-Kul, and in order to give aid to nations with transitional economies, the Federal Republic of Germany has provided technical aid to the Kyrgyz Republic in the latter's efforts to create of a bio-reserve within Issyk-Kul oblast. A draft plan on the creation of a biosphere reserve was completed in September 1998, and in May 1999, a new law entitled "On Biosphere Reserves in the Kyrgyz Republic" was adopted. This was followed by a government directive entitled "On Ratification of the Statute on the Issyk-Kul Biosphere Reserve" (1 January 2000). This last document regulates the activity of

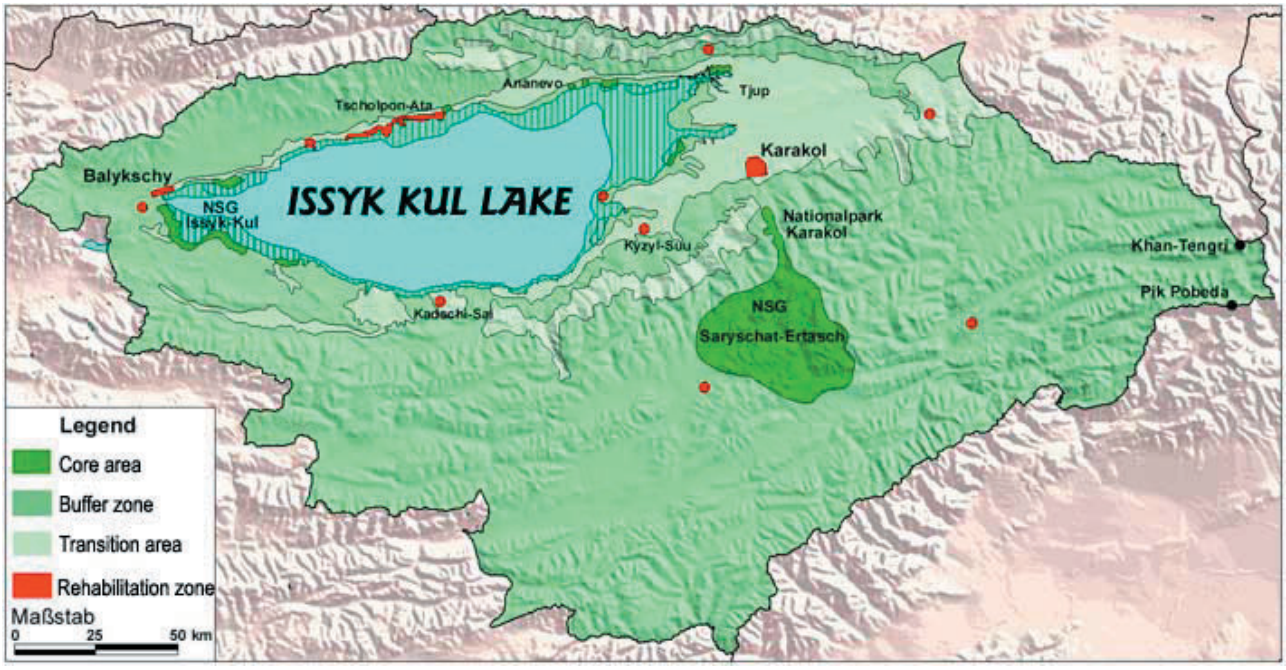

Figure 2. The Issyk-Kul Biosphere Reserve (Source: http://www.unesco.org/mab/br/focus/2002Oct/Issyk.htm).

the General Directorate of the Issyk-Kul Biosphere Reserve, which is charged with implementation of the idea and intent of biosphere reserves in general. In September 2001, by decision of the coordinating committee of the UNESCO Man and Biosphere Programme (MAB), the Issyk-Kul Biosphere Reserve became No. 411 on the list of World Wide Network of biosphere reserves.

The goal of creating such a reserve is twofold: conservation of natural areas, and support for long-term economic and social development that will help restore natural resources.

One of the Directorate's major objectives is protection of rare plant and animal species and other valuable natural complexes from the random and uncontrolled use that has followed the fall of the Soviet Union. Other tasks include monitoring of the environment, conducting scientific research, promoting long-term use of natural resources consistent with environmental demands, working diligently to raise environmental awareness and create a sense of stewardship of nature by explanation and example—goals impossible to achieve simply by banning or limiting use of resources. To that end, it has been crucial to delineate separate zones with separate preservation and use plans.

Table 1. Zoning Criteria for the Issyk-Kul Biosphere Reserve.

Sites	Description	Content
Core Zone		
Glaciers	Primary source of water retreat/shrinkage Monitoring of changes in ecosystems, scientific research, other activities that do not disturb natural processes	Stringent protections for entire natural complex
High mountain areas (niveal zone)	Snow leopard habitat (3,000-4,000 m asl) Mountain goat habitat (largest concentration here)	
Lakes	Habitat for rare waterfowl, fish Primary source of water resources	
Forests and brushlands (outlying)	Limited supply Wildlife habitat	
Existing reserves, preserves and national parks	Charged with environmental protection Legal guarantees in place	
Buffer Zone		
Natural and historic sites	Scientific research sites	Usually surrounds or borders core zone
Development of ecotourism	Traditional uses with extensive forms of economic activity, including regulated use of agricultural land, controller tourism, various forms of scientific research	
High-mountain summer pasture	Infrequent Winter wildlife habitat	
Forests and brushlands (near settled areas)	Use crucial to local economy	
Natural sites near settled areas	Environmental education sites Scientific research Ecotourism	
Transitional Zone		
Agricultural lands, including summer and economic winter pastures	Primary source of agricultural products for local consumption	Environmentally-oriented activity
Settled areas (towns, villages)	Population centers Economic centers	
Certain sections along shores of major lakes	Fisheries/fish farms Development of ecotourism	
Restoration Zone		
Abandoned mines	Damaged ecosystems	Areas have suffered environmental damage and require restoration
Other damaged sites	Subject to improvement	

The primary goal must be the protection of natural complexes from poachers, whose numbers may grow as economic instability in the country persists. Also important is regulation of industries that currently pollute. In this connection, yet another task of the biosphere reserve must be to defend natural complexes from future harm by industries that threaten the environment.

The most important individual components in the environment of the reserve were assessed for their natural and socioeconomic significance and also for their sustainability in the face of various types of stress, including anthropogenic stress. Results of this assessment served as the basis for division of the biosphere reserve into a number of zones, as summarized in Table 1. In accordance with UNESCO requirements, four zones were delineated: a core zone; a buffer zone; a transitional zone; and finally a restoration zone. Goals for protection and development differ from zone to zone, as do standards for use. However, environmental problems in all four zones are closely intertwined with economic activity, and, correspondingly, recommendations on improvement of the given areas are intertwined with prospects for economic development.

In order to conduct large-scale, long-term planning, plus a number of experiments including small-scale environmental projects in a number of regions in the reserve, three experimental sites were chosen as typical of the region's natural and socio-economic makeup. The goal was threefold: to develop "green" industry and tourism; to educate the local populace; and to then apply lessons learned to other areas. All these small projects were experiments of the biosphere reserve and the model sites were intended to serve as examples/models for implementation throughout the reserve.

Government agencies charged with oversight of environmental issues in Issyk-Kul oblast are given in Table 2.

Within Issyk-Kul oblast, there are eight specially protected natural areas, as listed in Table 3. There are two national preserves (*gosudarstvennye zapovedniki*), five game reserves (*zakazniki*) and one national park. These areas were created to protect and study the genetics of wildlife and plant life in the region, to study and protect ecological systems and landscapes both typical and unique to the region, to develop a scientific foundation for environmental protection efforts, and to ensure that natural processes within the region continue unhindered. They are institutions whose purposes include both conservation and research.

3.1 Problems Facing the Issyk-Kul Biosphere Reserve

The Issyk-Kul National Preserve (*Issykkulskii gosudarstvennyi zapovednik*) constitutes a mere 0.05% of the overall territory of the region. The preserve lies in close proximity to towns and villages, livestock operations, and other heavily used sites, which makes it difficult for the preserve to carry out the tasks laid upon it. Lack of financial support in general and poor working conditions in particular make it hard for the preserve to function in any normal way.

Many resolutions aimed at protecting the lake and improving the work of the preserve have been passed, but in general these have been poorly implemented, or not implemented at all. As the situation now stands, increasing tourism in the region will inevitably lead to conflict between tour agencies and the preserve. To prevent this, the boundaries of the preserve must be clearly delineated, and accommodations for tourists and tour agencies must be made in other, non-protected areas around the lake.

The Sarychat-Ertash National Preserve lies high in the mountains, at altitudes of 3,000 m asl and more, and is relatively far from population centers. Thus it is better protected against human impact. Farmers bringing herds to

Table 2. Government Agencies Overseeing Environmental Issues in Issyk-Kul Oblast.

Agency	Purpose/Function	Subordinate to
General Directorate of Issyk-Kul Biosphere	Charges fees for entry to biosphere reserve; fees go toward environmental activities Conducts scientific research, environmental education Oversees ranger service Oversees preserves and game reserves	National Forestry Service, Kyrgyz Republic
Government Supervisory Service	Supervision of wildlife, plant life of oblast	National Forestry Service
Issyk-Kul Hunting Authority	Supervises hunting Monitors and controls wolf population	National Forestry Service
Karakol National Park	Supervises/regulates timber use	National Forestry Service
Issyk-Kul Environmental Protection Authority	Supervises water/land/air use in the biosphere reserve In accordance with a law enacted by the Issyk-Kul Oblast Kenesh, levies fees for commercial use of airways or waterways within the Issyk-Kul biosphere reserve	Ministry of the Environment and Emergency Management

summer pasture and very occasional tourists (hikers, trekkers) are the only visitors to the area. Neither group presents a serious hindrance to environmental efforts.

However, there is one substantial threat to the preserve, and that is Kumtor, a gold-mining operation located roughly 20 km from the preserve's western border.

At present, agencies charged with environmental protection are poorly organized, and their work is for the most part limited to inspection. Virtually no scientific research is being done.

3.2 Tourism

Each and every tourist organization in the Kyrgyz Republic includes Lake Issyk-Kul and the Issyk-Kul basin in its itinerary. But at present, tourist pressure on these sites has not yet reached the level of former days, when the Kyrgyz Republic was still part of the Soviet Union.

Nonetheless, the increasing number of tourists and the promotion of mass tourism will undoubtedly affect the overall ecosystem of the region. Not only well-known sites such as Khan Tengri and Pobeda Peak, but other peaks as well, may suffer significantly if climbers and hikers pour into the Tien-Shan, in large part because the rare and endangered species which inhabit the area require a wide range. Until recently, there was no better place for them than the heights of the Central Tien-Shan, Kungei and Teskei Alatau, and the Interior Tien-Shan. If tourist pressure forces these animals to migrate to other areas, then other components of local ecosystems will also be set in motion.

The northern shore of Lake Issyk-Kul is particularly problematic in that it has become increasingly popular as an unregulated camping site where local residents sell services to visitors. The temporary canteens and food stands they set up do not meet health and sanitation standards. The lack of water treatment facilities in populated areas also poses a threat to the lake.

One possible solution is for the Issyk-Kul Biosphere Reserve to set up its own tourist routes; these might be developed jointly with tour agencies and climbing organizations. Developing ecotourism seems to be one advantageous way to foster both environmental protection and commercial tourism. This would help support environmental efforts and also provide jobs for the local population.

Table 3. Specially Protected Areas within the Issyk-Kul Biosphere Reserve.

Name	Area (hectares)	Year founded	Purpose	Flora and fauna
Issyk-Kul National Preserve	18,998	1948	Protection of winter habitat, nesting grounds, stopover for waterfowl and shore birds	Whooper swan, mute swan, flamingo, white heron, gray heron, white-tailed duck, Eurasian spoonbill
Sarychat-Ertash National Preserve	135,400	1995	Protection of ecosystems, rare and endangered species	Arkhar, Marco Polo sheep, snow leopard, Pallas's cat, golden eagle, mountain turkey, saker falcon, Lammergeier (bearded vulture)
Karakol National Park	38,256	1997	Preservation of ecosystems unique to Karakol Gorge	Pine, fir, larch, birch, roe deer, ibex snow leopard, bear, Siberian deer, lynx, golden eagle, kumai, saker falcon, Lammergeier
Tyup Game Reserve	19,085	1978	Protection of roe deer, Siberian deer, wild boar	Roe deer, Siberian deer, wild boar, ibex, Marco Polo sheep, Pallas's cat, marten, bear, lynx, black grouse, mountain turkey, Lammergeier
Zheti-Oguz Game Reserve	31,300	1958	Preservation of alpine ecosystems, wild game, rare species	Snow leopard, bear, lynx, Siberian deer, roe deer, ibex, wild boar, marten, ermine
Chonzhargylchak Game Reserve	13,092	1980	Preservation of ecosystems, wild game, rare species	Bear, ibex, wild boar, roe deer, Marco Polo sheep
Kensuu Game Reserve	6,878	1989	Preservation and increase of Siberian and roe deer population, wild boar population, lynx population	Wild boar, roe deer, Siberian deer, ibex, golden eagle, black vulture, grouse
Aksuu Game Reserve	32,014	1958	Preservation of game animals and of alpine forest ecosystems	Bear, marten, lynx, Siberian deer, wild boar, roe deer, black vulture, black grouse, sparrowhawk

4. Conclusion

The Kyrgyz people are nomadic by tradition, and thus are well aware of the need to protect and husband natural resources—their life has always been closely connected to the land. Yet over the last century, resources have not been used wisely and significant damage has been done. The current situation is in large part due to the fact that decisions on social and economic issues were made without any consideration of environmental risks or eventual impact, and without any public participation.

At present there is serious cause for alarm. Human impact on all biological communities is increasingly heavy, primarily as a result of socioeconomic problems. This impact takes a variety of forms, including poaching, widespread illegal cutting of brush and timber, illegal harvesting of medicinal plants, and capture and sale of rare and endangered species.

Much of this is due to a low level of environmental education, to ignorance of the laws and regulations governing use of natural resources, and to lack of information in general. Until now, there has been no access to information at all, nor has there been an opportunity for the public to take part in decision-making on environmental issues.

The General Directorate of the Issyk-Kul Biosphere Reserve is charged, among other things, with environmental education, and is currently taking a number of steps to educate the local populace on the state of the local environment, on the importance of wise use of natural resources, and on the objectives of the Biosphere Reserve. It is conducting workshops, publishing materials and recommendations on environmentally-oriented local and farm economy. It publishes and distributes "Ak-Kuu", a free quarterly newsletter with a circulation of 4,000. The directorate receives support for this from a German agency, the Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ).

In 2001, an Office of Environmental Information Management (EIM) was created within the Directorate. This new office's primary goal is to gather, systematize, analyze and publish environmental data. If the EIM works properly, both the local population and guests in the area (users) can find the information they need quickly and easily, and thus make the right decision.

So the first steps toward environmental education have been taken successfully. These should not stop at simply informing and educating. The public must be engaged in conservation and preservation of the natural and cultural riches of the Issyk-Kul basin.

5. Acknowledgements

The author gratefully acknowledges the original translation of this paper from Russian to English by Jane Ann Miller, the editorial support of David Read Barker of LakeNet and Richard Kujawa of Saint Michael's College, and insightful comments and supplemental information on an earlier draft by Robert Jellison and others at the International Society for Salt Lake Research.

6. References and Further Reading

Asykulov, T. 2002. *The socio-economics and natural environment of eastern Kyrgyzstan and development issues of Biosphere reserve Isykkul*. Graysvald.

BBC News. 02 Feb 2004.

Dikikh, A.O. 2000. "Glaciations in the Issyk-Kul basin: Its role as a flow source." In *Nature and People of Kyrgyzstan*. Special edition, Bishkek.

Jeenbaeva, R.I. 2000. "The Issyk-Kul Biosphere Reserve: Outcomes and hopes." In *Nature and People of Kyrgyzstan*. Special edition, Bishkek.

Konurbaev, A.O. and A.B. Jadin. 1997. "Changes in fish life in Lake Issyk-Kul: The Impact of Human Activity." *Echo Nauki* 4: 111-114.

Konurbaev, A.O. 1998. "Transgressions and regressions of Isykkul Lake." *News of National Academy of Science of Kyrgyz Republic* 2(3).

Osmonov, A.O. 2000. "Surface waters of Issyk-Kul Oblast." In *Nature and People of Kyrgyzstan*. Special edition, Bishkek.

Palesski S.V., I.V. Nikolaeva, A.I. Saprykin and V.M. Gavshin. 2003. "Assessment of contamination of the Issyk-Kul valley natural waters with uranium mine wastes." *Journal De Physique IV*. 107: 1013-1015

Savvaitova K.F. and T. Petr. 1999. "Fish and fisheries in Lake Issyk-Kul (Tien Shan), River Chu and Pamir lakes." In T. Petr (ed.). *Fish and fisheries at higher altitudes: Asia*. FAO Fisheries Technical Paper. No. 385. FAO: Rome.

Shnitnikov, A.V. 1979. *Lake Issyk-Kul: Nature, conservation and perspectives of lake use*. Academy of Science of Kirghiz SSR, Kirghiz Society of Geography: Ilim, Bishkek.

Sotnikova, S.A. 2000. "Monitoring of vegetation use in the Isykkul area." In *Nature and People of Kyrgyzstan*. Special edition, Bishkek.

Toktosunov, K.U. 2000. "Biosphere territory and prospects for development of the Issyk-Kul Oblast." In *Nature and People of Kyrgyzstan*. Special edition, Bishkek.

Toropova, V.I. and L.A. Kustareva. 2000. "Conservation and wildlife sustainable development in the Biosphere Reserve Isykkul." In *Nature and People of Kyrgyzstan*. Special edition, Bishkek.

Disclaimer

The findings, interpretations and conclusions expressed in this report are the views of the author and do not necessarily represent the views of The World Bank and its Board of Directors, or the countries they represent, nor do they necessarily represent the view of the organization, agency or government to which the author is associated. Also, the colors, boundaries, denominations, and classifications in this report do not imply, on the part of The World Bank and its Board of Directors, or the countries they represent, and the organization, agency or government to which the author is associated, any judgment on the legal or other status of any territory, or any endorsement or acceptance of any boundary.