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East European Programme

Lake Baikal: on the brink?

IUCN East European Programme

Lake Baikal: on the brink?

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Preface

Lake Baikal lies almost in the centre of the Asian land mass, surrounded by forest, steppe and mountains, and is renowned for its beauty. This lake, the world's seventh largest in surface area, is even better known for its scientific interest and, unfortunately, its environmental problems.

Scientifically, it is regarded not only as unique but as the most interesting of all lakes on the planet. It is the oldest, deepest, largest in volume (one-tenth of the earth's unfrozen freshwater) and richest in biomass and number of recorded species, of which more than 1,000 are endemic. The list could be continued. Baikal has indeed been likened to an enormous living laboratory.

Perestroika has now allowed for international scientific cooperation on a significant scale through the new Baikal International Centre for Ecological Research (BICER) being organised by the Limnological Institute of the Siberian Branch of the USSR Academy of Sciences, and many foreign scientists are now taking part in research and expeditions.

For many Russians and certainly for the indigenous Buryat people around the lake, Baikal, the 'Pearl of Siberia', has a strong emotional, spiritual and almost anthropomorphic pull so that, until eclipsed in the Soviet media by Chernobyl and the Aral Sea, it was the USSR's environmental *cause célèbre*. For, unfortunately, the environmental problems which have long beset this unique ecosystem have not yet been solved, despite nearly 30 years of struggle. It remains the focus of passionate support and now formalised local grass-roots activity.

Baikal's best known problems are the two factories at Baikalsk and Selenginsk with their adverse effect on both air and the lake's water. But there are many other problems. They include the timber industry's deforestation and transport of logs, the use of pesticides and fertilizers by agriculture, the sewage and industrial wastes entering the lake by its biggest tributary (the Selenga) and a new town (Severobaikalsk) at the north of Baikal now polluting the lake's air and water, as well as atmospheric pollution from a chain of industrial towns to the west.

One reason why the problems persist is that, although there have been several top-level resolutions in Moscow to solve them, there has been little real compulsion to do so - and it has usually been against the interests of the ministries involved, concerned to fulfil their planned targets. Now, however, a law is under discussion which may at last give teeth to the environmental lobby (Kazannik, 1991).

Fortunately, Baikal's ecosystem has been affected in relatively small areas, but several Soviet scientists and others are now warning that the damage will soon be irreversible, and it would be well to note their urgency. Many Soviet citizens concerned about the lake's future believe that its best protection lies in its listing by Unesco as a World Heritage Site, but this may take some time. However, the procedure for nomination is at least now beginning.

The popular will is there to save Baikal. What is necessary now besides an enforceable law is the political and economic will plus increased environmental education at a local level. Given that, as well as sustained - and informed - pressure at local, national and international level, this 'wonder of the planet' may yet be saved for all posterity.

John Massey Stewart

April 1991

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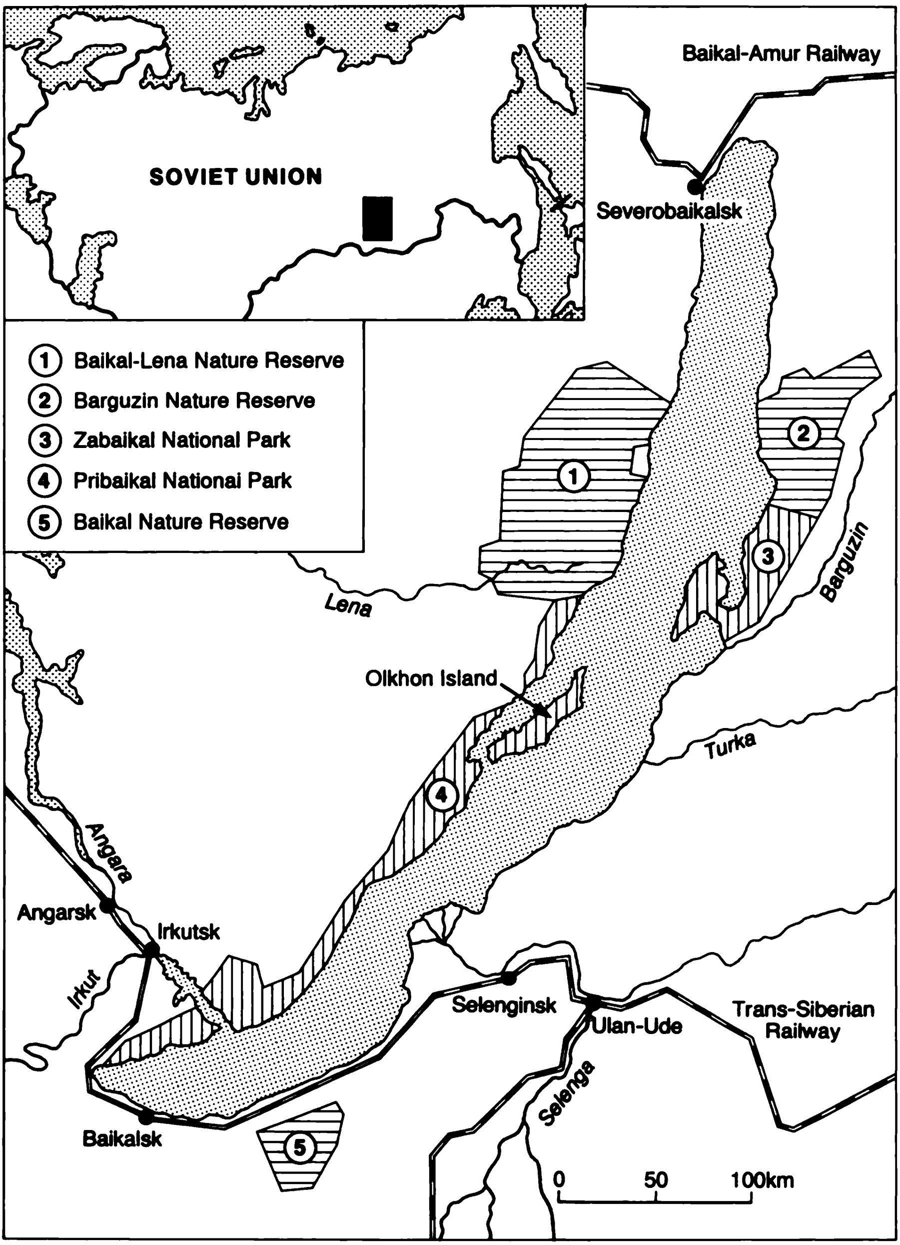

Map 1. Lake Baikal

Physical, Biogeographical and Cultural Value

Lake Baikal, at the heart of the continent of Asia, has had many superlatives attached to its name and is without any doubt one of the natural wonders of the world. The lake and its basin have a wealth of relict and endemic species of plants and animals and in terms of species diversity Baikal has no equal. Comparable freshwater bodies include the Caspian Sea, Lake Tanganyika and Lake Ohrid which, in certain features of their biota, resemble Baikal. Of some 1,550 animal and 1,085 plant species and subspecies found here, two-thirds are endemic to the lake (Galazy, 1980), including the Baikal seal *Phoca sibirica*.

Baikal is the world's largest freshwater lake in terms of volume, containing more than 23,000km^3 of water, equivalent to 20% of the earth's non-frozen freshwater or more than 80% of the Soviet Union's surface freshwater (Galazy, 1980). It is also the world's deepest lake, with a maximum depth of 1,637m. It is the seventh largest lake on earth in terms of surface area, covering 31,500km^2, being 636km long and up to 48km wide. The lake is by far the oldest in the world, containing in places more than 6,000m of sediment built up over approximately 25 million years (WWF, 1990). Despite increasing pollution over the last few decades, Baikal remains the world's purest freshwater lake of its size (Maddox, 1989).

Baikal's catchment area covers 600,000km^2, part of which is in Mongolia. Over 330 rivers and streams enter the lake, with the Angara as the only outflow (United Nations, 1987). The Selenga contributes more than 50% of the total inflow and the Barguzin and Upper Angara provide another 10% (WWF, 1990). The ratio of the inflow to outflow is close to unity. It is estimated that the annual inflow constitutes about 0.26% of the total volume of the lake and that water turnover is on average once every 400 years. This, combined with temperatures which do not exceed 3.4°C below depths of 200-300m and rarely rise above 14-15°C at the surface, means that self-purification is a slow process. The endemic crustacean *Epishura baicalensis* plays a particularly important role in maintaining the purity of Baikal's waters, forming 90% of the biomass of zooplankton, but is very sensitive to pollution (Galazy, 1980). During one year, zooplankton can filter over 450 million m^3 of water, more than 7.5 times the total inflow of water from all Baikal's tributaries (Galazy, 1984).

Baikal is oligotrophic if production is computed per unit volume, but if calculated on an area basis it is mesotrophic to eutrophic. This apparent paradox is a consequence of the high transparency (up to 30-40m) which causes high productivity in the active water layer but much lower nutrient production at greater depths where about half of the total water volume is contained. Pollution would increase nutrient levels and affect the subtle ecological balance (Galazy, 1980). However, water circulation caused by the melting of the winter ice cover, which is up to three metres thick and lasts for up to five or six months, keeps

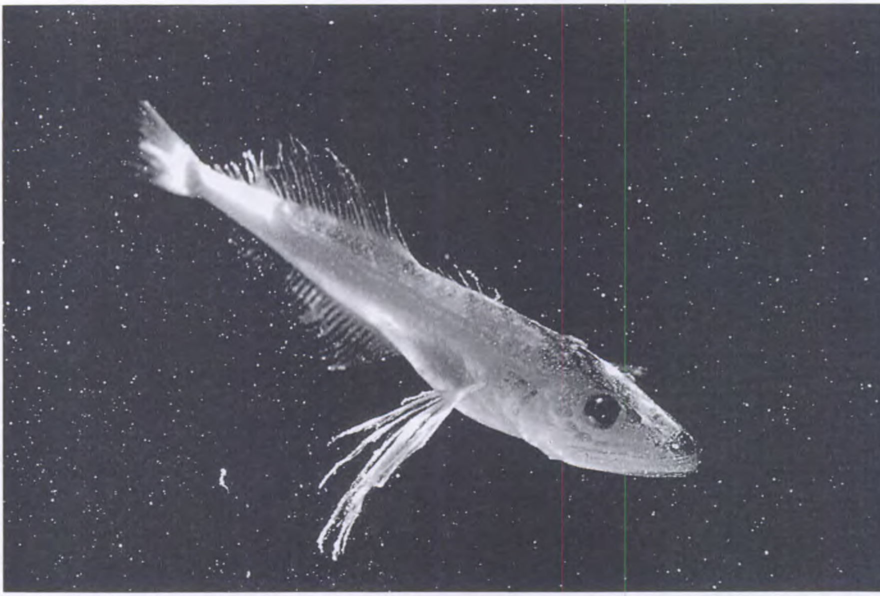

**Plate 1. Lake Baikal endemic: golomyanka *Commephorus* sp.
(Photo: Limnological Institute, Irkutsk)**

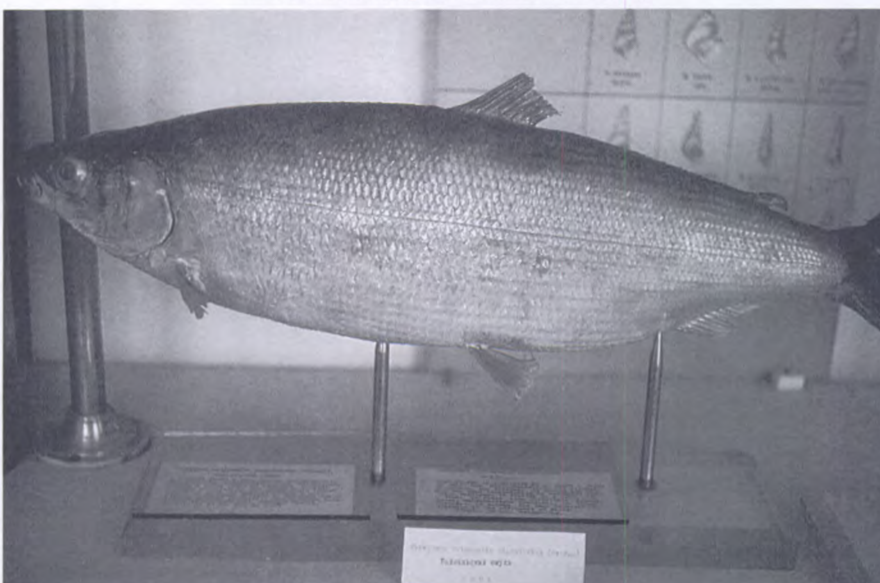

**Plate 2. Lake Baikal endemic: omul *Coregonus autumnalis migratorius*
(Photo: J. Massey Stewart)**

the water oxygenated to great depths; no lake has so many organisms at such great depths as in Baikal (Maddox, 1989).

Baikal means "rich lake", on account of its rich fish life of 52 species belonging to 12 families, including the commercially valuable omul (white fish) *Coregonus autumnalis migratorius* and the now uncommon sturgeon. Curious endemic species such as the golomyanka *Commephorus baicalensis* and *C. dybowskii*, which bear live young, inhabit the lake. The lake has a rich culture and has for centuries been thought by the Buryats, the local indigenous people, to be a home for supernatural forces or beings, partly due to the strange physical and meteorological phenomena which sometimes occur (WWF, 1990). In more modern times Baikal has become a figurehead symbol for Russian nature, and songs and poems have been written about it. Its protection has been an issue in Siberian, indeed Soviet environmental politics since the mid 1960s. Nearly one million tourists visit each year, enjoying the unspoilt scenery, fishing, hunting, water recreation and visiting the hot mineral springs, some of which were opened up for tourists in the 1950s (Vorob'yev, 1989; Vorob'yev and Martynov, 1989).

Baikal is not only a unique natural phenomenon but also a natural reservoir which plays an important part in the economy of Eastern Siberia. Ten years ago G. I. Galazy, then director of the Siberian Department of the USSR Academy of Sciences' Limnological Institute, predicted that in the foreseeable future Baikal might represent the only source of pure water remaining in the Angara-Yenisey territorial industrial complex and region (Galazy, 1980).

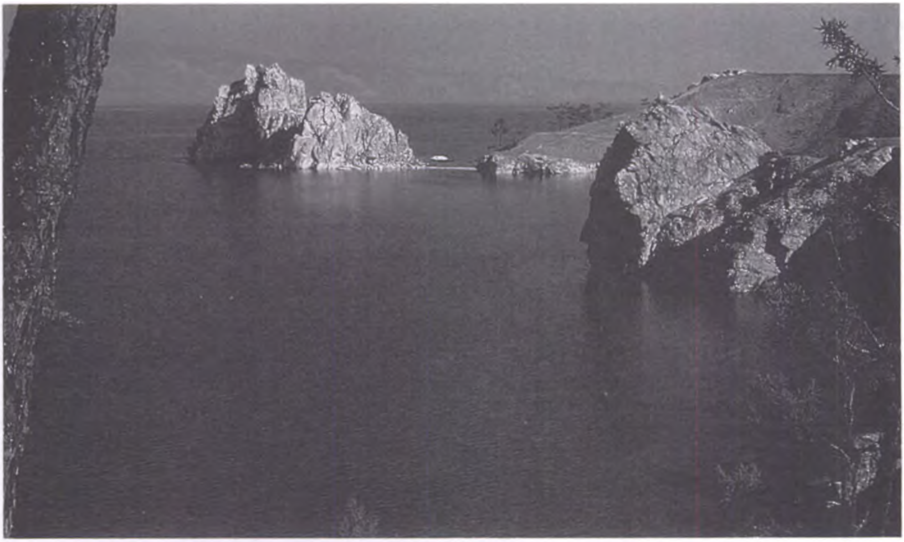

Plate 3. Cape Burkhan on Olkhon Island, a sacred site for Buryat people (Photo: J. Massey Stewart)

Pollution

The environment of Siberia is extremely sensitive to disturbance, partly due to its low biological productivity caused by the low temperatures. At present, pollution problems are mainly confined to the southern end of Baikal where most of the industry is located, but the danger of disrupting the entire sensitive ecosystem is very real and the situation is worsening. Although levels of air and water pollution in the basin have not yet reached the stage of causing irreversible damage, if pollution continues at present rates irreparable damage will be inevitable (Vorob'yev, 1989).

Studies over many years by the Institute of Limnology of the lake's chemical balance show that each year 7.32 million tons of mineral compounds and 0.6 million tons of organic material enter Baikal. The Angara takes 5.6 million tons of mineral compounds and 0.15 tons of organic material out of the lake, so that it annually retains 1.72 million tons of mineral compounds and 0.45 million tons of organic material. Only the great volume of the lake has so far ensured that the progressive overall change in mineralisation is slow.

The main source of pollutants entering Lake Baikal is the Baikalsk Pulp and Paper Combine (BPPC). The other main sources of pollution are: the wastes from the Selenga Pulp and Cardboard Combine (SPCC) and factories located in the Selenga River basin, in particular those in and around Ulan-Ude; organic and mineral matter resulting from logging operations established on the inflow rivers; waste oil products contained in both the water from tributaries and released directly by ships cruising the lake or at pumping and filling centres; sediment loading; increased turbidity; thermal pollution; water level fluctuations; atmospheric dust emissions from factories and vehicles; and agricultural pollutants (Galazy, 1980; Unesco, 1990). The Baikalsk plant continues to raft logs over the entire length of the lake and to pollute air and water with emissions or discharges. Heavy metals are detected in discharges of the SPCC (Unesco, 1990).

The Baikal Pulp and Paper Combine

The Baikal Pulp and Paper Combine (BPPC), built at Baikalsk on the southern shore of the lake in 1966, discharges without purification more than 240,000m^3 per day of processed waste and almost 150,000m^3 of theoretically clean waste water into the lake. Over the past 15 years of operation it has put 1.5 billion m^3 of industrial waste and more than 800,000 tons of mineral salts into the lake (Galazy, 1991). The combine operates facilities that could treat 98 million m^3 of waste water per year in 1986 and has also commissioned a recycling water supply system with a total throughflow of over 220 million m^3 per year (United Nations, 1987). However, even though effluents pass through an intricate treatment system, waste from the BPPC contains residual pollutants (i.e. over 18,000 tons of chlorides per annum)

Plate 4. Baikalsk Pulp and Paper Combine
(Photo: J. Massey Stewart)

Plate 5. Selenga Pulp and Cardboard Combine
(Photo: J. Massey Stewart)

which threaten the delicate Baikal ecosystem (Galazy, 1980). Neutralising the daily waste produced by the BPPC requires 2.4 billion m^3 of Baikal water. In 23 years or so of operation it has been estimated that 15,000km^3 of water have passed through the plant, more than half the total volume of water in the lake, which is therefore no longer in its natural condition (Galazy, 1988). Following the introduction of water tariffs, it has been possible to calculate the cost of the damage to water quality in the lake. On this basis the plant takes two days to exceed the value of its annual production and the true annual cost of damage to water quality is 150 to 200 times greater than its profit (Galazy, 1991).

The BPPC also releases large quantities of pollutants into the atmosphere, many of which precipitate in the Baikal basin and affect the lake indirectly (Soviet Weekly, 6 August 1988). The daily release of harmful substances totals more than 100 tons, including more than 19 tons of aerosols, as much as 3.5 tons of sulphur dioxide and other substances (Galazy, 1991). Up to 4 tons of solid material per km^2 from the BPPC's discharges alone falls on the neighbouring territory each year, covering an area of 2,000km^2, practically the whole of the southern basin of the lake (Galazy, 1980) and extending for 160km to the northeast and more than 40-50km to the west. Tree tops have been affected in an area of almost 600km^2 and the entire forest is drying up in an area of 160km^2 (Galazy, 1991).

The CPSU (Communist Party of the Soviet Union) Central Committee and Council of Ministers had preliminary plans to build a pipeline diverting waste from Baikal until a new mill was completed in 1993 at Ust Ilimsk on the Angara River, 700km north of Irkutsk (Galazy, 1980). The BPPC plant would then be used to house a furniture production line (United Nations, 1987). However, after much discussion and rejection of various options, a decision has yet to be made on the future of the Baikalsk mill on which a local population of 30,000 depends for its livelihood (Massey Stewart, *in litt.*, 1990). Only 15 million of the 3 billion roubles allocated for the Ust Ilimsk plant had been used and work had not progressed past clearing the site by 1989, so that the Baikalsk mill will obviously continue to operate for some time (Filipchenko, 1989). One improvement has been that a harmful yeast production facility associated with the BPPC was closed in January 1987 as part of a number of comprehensive measures to protect the lake (Tass, 25 January 1987).

Selenga Pulp and Cardboard Combine

Baikal's ecosystem is also greatly affected by waste from the Selenga Pulp and Cardboard Combine (SPCC), built 50km upstream of the Selenga delta, which started operation in 1974. This waste includes nearly 12,000 tons of minerals, 3,400 tons of organic and 135 tons of other wastes per year (about 60,000m^3 per day). This, together with that from Ulan-Ude's industry and domestic sewage is, after inadequate treatment, discharged into the Selenga River (Galazy, 1991). Partially treated effluent from about 50 factories in Ulan-Ude reaches Baikal and contributes 27% of the partially treated waste water discharged into the lake

(United Nations, 1987). Studies have shown that the Selenga River, rising in Mongolia and providing half of Baikal's water, has seen a doubling in the amounts of oil products since observations began, while sulphates, chlorides, phenols and organosulphuric compounds are also present. Some 98.4% of eggs laid in the main fish spawning grounds south of Ulan Ude are now killed by contamination and the remainder are not able to produce healthy offspring (Galazy, 1991). Pollution from the Selenga has been found to reach up to 130km northeast of the river mouth and to the opposite shore (Galazy, 1991). More than 1,500km^2 of the surface area of the lake is affected by the polluted waters of the Selenga River. A treatment plant is planned to be installed at Ulan-Ude by 1993 which will be capable of treating over 67 million m^3 of effluent per annum (United Nations, 1987). A closed water system is scheduled to be in operation at SPCC by 1991 but this is still uncertain. The SPCC also emits 441,000 tons of aerosols and other pollutants to the atmosphere each year.

Irkutsk-Cheremkhovo Industrial Region

Air pollution from this region of heavy industry, a minimum of 43km from Baikal's western shore, often reaches the lake due to the prevailing westerly winds. In 1985 industries of the Irkutsk region emitted 1.2 million tons of air pollution (Massey Stewart, 1990b). Problems persist because pollution control measures in most industrial enterprises are not fully effective, with only about 80% of pollutants removed from emissions in the Irkutsk region (United Nations, 1987). Improvements are planned, particularly to the emissions from coal-fired power stations which are the worst offenders. There are also plans to develop gas reserves in Irkutsk Oblast (region) (Vorob'yev, 1989). From Angarsk and Irkutsk alone, 770,000 tons of air pollutants are released into the atmosphere each year and have killed 40,000ha of forest and acutely affected a further 250,000ha; in the Barguzin Nature Reserve about half the trees are affected (Altekruse, 1989).

Other sources and effects of industrial pollution

A report in January 1989 (Soviet television, 10 January) stated that waste from half of the local industries is inadequately treated and 25 purification plants continue to release raw sewage into Baikal's tributaries. Apart from the pulp and paper combines, thermal power plants, chemical and petrochemical works are largely responsible (United Nations, 1987).

The influence of industrial waste has been found over several hundred square kilometres of Baikal, within which local concentrations of lignin, hydrogen sulphide products and non-sulphate sulphur cover more than 20km^2 of the bottom. Fibrous and other heavy suspended and colloidal substances drift along the underwater slopes of the lake to depths of up to 250m. Colonies of Rotifera, an indication of water pollution, have also been found (Komarov, 1980). Half of the enterprises which still release waste into Baikal do not purify them sufficiently (Moscow television, 6 January 1989).

Numbers of dead zooplankton observed have increased. In 1970-71 dead *Epishura* were found in areas where waste is discharged at levels 50 times those in unpolluted areas. *Epishura*, an important first link in the food chain, constitutes 90% of the total biomass of zooplankton in the lake and is an important biological filter (Komarov, 1980). Undiluted industrial waste inhibits the development of plankton and assimilation of carbon, while waste diluted 10-fold or more has a stimulating action, producing an eutrophication effect (Galazy, 1984).

Anatomical and cytophysiological investigations and studies of the morphology of fish blood (bychki, golomyanka, grayling and omul embryos) and that of warm-blooded animals have shown profound degenerative changes of the leukaemia type and increased mutagenesis in the somatic sexual cells of these animals even when industrial wastes have been diluted 50 times (Galazy, 1980). Industrial waste diluted by a factor of 100 or even 10,000 can still have detrimental effects, including the disruption of the olfactory system of the omul which causes stress symptoms in this fish (Galazy, 1984). Pollutants in general have affected overall fish catches, the annual total in 1985 being 3,800 tons, of which about half were omul (United Nations, 1987).

Plate 6. Forests on the west coast of Baikal, near Peschanaya Bay (Photo: J. Massey Stewart)

Between 1957 and 1990 the percentage of the north Baikal omul infected by parasites grew from 15-17% to 60-70%, "without doubt caused by increasing pollution" (Baikal-Watch, p. 14). And 30-40% of this omul population is now infected by *Diphyllobothrium dendrificum*, a dangerous parasite for humans which has now been discovered among inhabitants of the north Baikal region.

Domestic waste

Sewage from Ulan-Ude and other settlements is often discharged into the Selenga river without adequate treatment. In 1988, Ulan-Ude's sewage contributed 500 of the 700 tons of nitrates entering the lake (Massey Stewart, 1990b). Destruction of anthropogenous organic matter which arrives in Baikal proceeds very slowly in the low temperatures; less than 30-40% of the organic matter discharged into the lake decomposes within a year. The mineral component also decomposes slowly, if at all. Stabilisation of the constantly growing pollution zone is impossible (Galazy, 1980).

Forestry

An estimated 50,000ha of forest has to be felled each year to meet the needs of BPPC and SPCC (WWF, 1990). Hundreds of square kilometres of taiga have already been cleared to meet the needs of the paper mills (Komarov, 1980) and in some areas timber quotas have already been filled for the next 100 years (Galazy, 1991). Clearing the naturally sparse forest cover has several detrimental effects on the lake. The coniferous taiga vegetation acts as a filter to pollutants carried by precipitation, intercepting or neutralising them, and this effect is lost in cleared areas. It also protects the soil from erosion, particularly on steep slopes which are common in the area. Exposed soil is washed into streams and rivers and eventually reaches the lake, upsetting the natural balance and affecting the water's extreme clearness. After logging, the rate of soil erosion increases by 100-200 times (Komarov, 1980) and more than 3 million tons of soil are carried annually into the lake by rivers. About one-third of all arable land and one-fifth of all other areas lacking forest cover, where no natural regeneration has occurred, are subject to erosion (Galazy, 1984). Mudflows frequently accompany the spring and summer downpours around the southern extremity of the lake (as in 1934, 1960, and 1971) and, since 1915, serious mudflows have occurred about once every seven years just west of the lake. Throughout the region, bridges and roads are destroyed by flowing masses of mud and rock. In 1970 a flow eradicated a portion of the Trans-Siberian Railway in the vicinity of Slyudyanka and Baikalsk. The greatest potential for flow is in the vicinity of the Stanovoi Mountains through which the Baikal-Amur Mainline railway now passes (Mote, 1986). In addition, indiscriminate felling has considerably decreased the Selenga's flow (*Nature*, 11 August 1988).

Apart from commercial felling, tree loss is caused by fires which are common in the resinous coniferous forest and is made worse by the growing number of tourists, uncontrolled camping and slow implementation of fire control measures. Natural regeneration in the area is extremely slow, given the low temperatures, short growing season and naturally low density of the forest (Galazy, 1984).

Problems have been caused in the past by timber rafting. Each year, 2 million m^3 of timber were rafted across Baikal (Galazy, 1980). About 10% of logs were estimated to become waterlogged and sink, and other organic material is lost from the rafts. It is calculated that up to 70,000 tons of organic material is added to the lake in this way, using up valuable oxygen in the water during decay and affecting the quality of $60km^3$ of lake water. Rafts were also sometimes broken up during storms. However, in May 1987 a resolution was passed to stop all log transport by rafting on Baikal from 1 January 1988 and to cease log rafting completely within the basin by 1995 (Vorob'yev, 1989; WWF, 1990). In practice, ships will not completely replace the towed rafts of logs on Baikal itself until nearer 1995 (Massey Stewart, 1990b).

The CPSU Central Committee stated in 1987 that measures must be taken to protect and make rational use of the forest resources and that felling should only be carried out in accordance with approved rational harvesting quotas. Clear felling in the Baikal shoreline area was terminated as from 1 January 1988 and forestry enterprises engaging in the prevention of forest fires and in reafforestation have been organised (Soviet television, 28 July 1988). Felling on slopes in the basin steeper than 15° has also been prohibited (WWF, 1990). However, there are problems with implementation of policies. The Russian Republic's Deputy Minister of Forestry was given a strict reprimand in 1987 for lax supervision of the observance of regulations regarding forest use in the Baikal basin, for failing to improve forest conditions by afforestation and allowing extensive fire destruction. Two other ministers were also reprimanded for irresponsibility in 1987 and told that they would be held accountable if they did not take measures to improve the situation. However, according to one report, the forested area in both Irkutsk and Chita Oblasts and the Buryat ASSR increased slightly between 1973 and 1983 (United Nations, 1987).

Agriculture

Agricultural runoff containing various pesticides and fertilizers reaches streams and rivers and adds to the load from other pollutants (Galazy, 1980). The discharge of chlorides and sulphates by agriculture into the lake has increased over time (Galazy, 1984). Almost 700 agricultural operations coming under the State Agro-Industrial Committee, formerly the Ministry of Agriculture, have contaminated tributaries of the lake with caustic organic chemicals and oil (*Izvestiya*, 26 April 1989). Pesticides are a particularly serious threat to life in the lake, and nine out of ten fish species sampled for monitoring purposes contained traces of DDT, PCBs and hexachlorocyclo-hexane; all banned, but still produced in the Soviet Union (Massey Stewart, 1990b). In Buryatia, 314,000ha of agricultural land are affected by wind erosion and 276,100ha by water erosion (Galazy, 1991).

Shipping

Passenger vessels contribute to the petrochemical pollution load of the lake, although transport of oil products across Baikal ended on 29 October 1988, according to reports. In addition, quays where soil and water pollution occurred were closed and the large loading complex at the south of the lake was to be redesigned for other cargo (Moscow Home Service, 29 October 1988). A specialised vessel for cleansing Baikal's waters of various pollutants was to work in areas adjacent to ports and temporary anchorages and also along cargo and passenger routes (Moscow Home Service, 27 September 1988).

Additional Problems

Water control schemes

Changes in the hydrological regime during the 1960s, in addition to pollution from industry and forestry, have resulted in the depletion of fish reserves. The main cause has been the construction of the Irkutsk hydroelectric power station and dam (completed in 1959) downstream of the lake. This caused the lake's water level to rise by 1.2m, resulting in a loss of shallow feeding and spawning grounds, cooler water temperatures near the shore and lower growth rates of micro-organisms. Fish catches initially fell considerably with the completion of the Irkutsk dam from 91 million kg in 1942 to only 20 million kg in 1965 (WWF, 1990).

Fish stocks management

Soviet television reported in January 1989 that some of the fish populations in Baikal can now only be maintained by artificial reproduction. Eight to ten per cent of the Baikal omul population is now maintained artificially and individuals grow more slowly; 20 years ago, omul reached 500g in four years; now this takes five to six years. Numbers have increased, partly as the result of a breeding programme, but size and recruitment remain low. Between 50% and 97% of eggs die on spawning grounds below Ulan-Ude which are still too polluted, despite the substantial dilution of wastes by the Selenga river. As it has become so scarce, commercial fishing of this species is now restricted by quota (Galazy, 1980). The rise in the water level of Baikal has also contributed to the extermination of Lahontan cutthroat trout, important contributing factors having been overfishing and stocking the lake with non-native game fish (*Tahoe Daily Tribune*, 15 June 1990).

Seal virus

The nerpa or Baikal seal *Phoca sibirica* is one of the very few freshwater species of seal in the world (Spinks, 1988). A local newspaper '*Vozdushny Transport*' reported in 1988 that local inhabitants had observed an outbreak of extremely weak seals on the shores of the Selenga estuary and found the bodies of seals along many parts of the shoreline (Tass, 8 September 1988). By October 1988, about 5,000 of the total 80,000-90,000 Baikal seals had died due to a distemper-like virus (totally different, however, from the North Sea seal virus which, it has been suggested, started at Baikal; Visser *et al.*, 1990). The main outbreak of the disease was in 1987 and the beginning of 1988, but the virus circulated in the population. The number of seal (pup) deformities rose in the spring of 1990 and included deformities previously not seen; the Limnological Institute has been studying the literature to establish if the virus could have had this effect. One Western scientist, however, suggests that the cause is more likely to have been chemical pollution. Seals, at the top of the Baikal food chain, consume toxic substances that have accumulated in the fish that they eat, and the scale of the epidemic in Baikal suggests that pollution may have decreased their resistance to the virus (Massey Stewart, 1990b).

Urban and industrial development

Human development on the shores of Baikal is threatening the lake's integrity as well as increasing pollution problems. Previously, most industrial development was concentrated at the southern end, near the lake's outlet, which helped confine pollution to the south. Now the new Baikal-Amur Mainline (BAM) railway (which runs from Baikal almost to the Pacific, north of the Trans-Siberian railway) touches the northern end of Baikal, encouraging development and the construction of a new town, Severobaikalsk. In 1989, 26 of the new town's boiler houses had no scrubbers to remove emissions of sulphur dioxide and other pollutants, which accumulated in the atmosphere, resulting in acid rain. There are, however, still plans to increase the population of the town to 140,000 and add two new engineering works (Massey Stewart, 1990b). Development in the area has been taking place without research or careful planning (Soviet television, 28 July 1988). According to Baikal Watch (p. 14), the northern part of the lake is being polluted by domestic waste water, by the transport of coal and fuel in barges, by people washing their cars and changing their engine oil on the ice in winter, etc., quite apart from air pollution (Unesco, 1990). Further unplanned construction is continuing along the shoreline of the lake in Irkutsk Oblast and the Buryat Autonomous Soviet Socialist Republic. Restoration work to clear up felled timber and industrial dumps on the shores of Baikal is not being properly organised (*Pravda*, 29 July 1988). About a quarter of the 97 existing waste purification plants in the Buryat ASSR dump sewage in depressions in the ground, which eventually seeps into Baikal (Moscow television, 6 January 1989).

The development region associated with the BAM covers over 3.5 million km^2, and gravel extraction along rivers and streams for construction purposes has turned them into gullies filled with muddy water. This, combined with oil pollution, has drastically reduced fish populations. Where mountain forest has been cleared for the railway, very little has regenerated, the thin soil layer being easily eroded after clearance in an area which has particularly unstable slopes (Komarov, 1980).

Tourism and hunting

There is little accommodation around the lake apart from one Intourist hotel and a few small tourist bases. However, about one million people visit Baikal each year and 700,000 of these camp, mostly on the more accessible eastern shore. Tourists are responsible for litter and other damage to camp sites and trails as well as up to hundreds of forest fires annually. Despite these problems and that of sewage disposal, there are plans to build one of the largest recreational, health and tourist centres in the Soviet Union on the lake's shores (Massey Stewart, 1990b). Disturbance from the uncontrolled use of motor boats and hunting has led to the extermination of some animal species, including nesting cormorants around Maloe More, roe on Olkhon Island in 1965 and the last Manchurian wapiti in 1966 (IUCN EEP, 1989). The unrestricted use of tens of thousands of private motor boats causes as much petroleum pollution as that caused by cargo ships (Galazy, 1991).

Plate 7. Divers photographing endemic sponges (Photo: Limnological Institute)

Policies

The original reason for locating the Baikalsk pulp mill on Baikal's shore was to take advantage of the extremely pure, clear water, as the mill was to manufacture special cord for aircraft tyres, a function which was later cancelled (WWF, 1990). A resolution in 1960 stated that the two mills could only operate if their effluents were harmless. As early as 1961, however, Grigorii Galazy, then director of the Limnological Institute, warned that the Baikalsk and Selenginsk plants would destroy the delicate ecological balance of the lake, but he was ignored (Massey Stewart, 1990b).

In 1966 a special commission to examine the plans for development around Baikal was set up by the Presidium of the Academy of Sciences in Moscow. Continued concern about pollution led to the expansion of purification facilities and the setting up of a special committee to monitor water quality. In 1969 the CPSU Central Committee and the USSR Council of Ministers adopted a special resolution on measures for the preservation and rational utilisation of natural complexes in the Baikal basin and three years later (on 16 June 1971) the Central Committee and the USSR Council of Ministers jointly adopted a resolution on additional measures for ensuring the rational utilisation and preservation of natural resources in the Baikal basin. These decrees resulted in various measures, including the clearance of sunken timber from rivers, construction of new ships and roads to provide alternatives to rafting logs and the setting up of fish hatcheries (WWF, 1990).

In 1976 a second commission reported on the state of the Baikal basin. It echoed the fears of the first and recommended the shut-down and re-equipping of the pulp and paper combines for environmentally safe production. In 1977 a third decree was issued by the Central Committee and the Council of Ministers, demanding stricter protection of the lake. This laid out, for the first time, an overall approach to both environmental and economic problems and led to the beginning of improvements to the situation (Massey Stewart, 1990b). However, pollution continued, and tourism was also identified as causing problems (WWF, 1990).

In 1986 a third government commission was set up to work out optimal and effective protection measures. In April 1987 the Politburo of the CPSU Central Committee discussed ways in which laws protecting Baikal had been violated and decided on a set of scientific, economic and technical measures to improve radically the ecological situation of the Baikal region. Then, in May 1987, the Central Committee of the CPSU and the Council of Ministers passed a resolution on "Measures to ensure the protection and rational use of the natural resources of the Baikal area in 1987-1995". This included: cessation of logging in the immediate area and of rafting; regulation of shipping; conversion of all factories and housing within a 45km zone around the lake to electric heating, with towns such as Irkutsk, Angarsk and Cheremkhovo being converted to natural gas; the establishment of a National

Park covering almost half a million square kilometres around Baikal and the development of tourist facilities; and changes in the two pulp mills, including a waste diversion pipeline away from Baikal into the Irkut River and the conversion of BPPC to furniture production, see section on BPPC above (WWF, 1990). Also included was the improved monitoring of waste water quality and more stringent pollution standards. Measures were also put forward to improve the efficiency of existing nature conservation facilities.

A conference took place at the CPSU Central Committee on 28 July 1988 to examine progress in the fulfilment of the resolution (adopted on 13 April 1987) on measures to ensure the protection and rational use of natural resources of the Baikal basin in 1987-95. It was noted that, on the whole, nature protection measures scheduled for 1987 had been implemented and treatment facilities and gas purification equipment had been introduced at a number of enterprises in the Baikal area (Soviet television, 28 July 1988). In 1981-85, discharges of partially treated waste water were reduced but it proved impossible to stop them entirely (United Nations, 1987). The plans mentioned above to divert the BPPC's treated effluent into the Irkut River were cancelled. Although the consequences of resolutions in 1969, 1971 and 1977 of the CPSU Central Committee and USSR Council of Ministers have reduced the negative impacts of pollution, the measures adopted are still far from adequate (Vorob'yev, 1989).

Problems with implementation

The implementation of the proposed measures to protect the Baikal basin has not been without criticism. Despite a campaign of more than 20 years to save the lake, recent mobilisation of public opinion and increased support in government circles, there has been a general failure to implement policies and the situation in general has deteriorated. Many ministries and government bodies are behind schedule in installing anti-pollution devices. Examples include the administrators of the Kultuk plant who have been criticized for faulty installation of an expensive waste-burning furnace, so waste is still dumped and washed by rain into the lake. Increased pollution protection measures had not worked at the Slyudyanka plant since 1982 (*Izvestiya*, 7 October 1987). The main construction administration of the Buryat republic was reported to have prevented the commissioning of anti-pollution installations at Ulan-Ude (*Izvestiya*, 7 October 1987).

The special Interdepartmental Monitoring Commission is failing to deal with backsliding organisations and funds; equipment allotted to pollution control is also being used ineffectively, according to Yegor Ligachev, then a member of the Politburo (Maddox, 1989). Even if fines for pollution are implemented, the benefits from the greater production possible if pollution is continued may outweigh the penalties (Vorob'yev, 1989). There is also a general feeling that the greatest tasks are being tackled lethargically (Soviet television, 28 July 1988). Problems associated with the implementation of policies designed to protect the lake, however, are recognised by the Central Committee, and ministers and departments failing to implement the resolution adopted have been reprimanded (Moscow Home Service, 15 May 1987). Little afforestation has occurred around Baikal, but during the 12th five-year plan it is hoped that forest regeneration will be expanded considerably and include far more extensive fire prevention measures (Vorob'yev, 1989). The reduction of pollution by waste water is behind schedule: 22 of the 34 undertakings to be completed by 1988 are still not complete (*Izvestiya*, 1989).

Zoning and protection plans for the whole basin

A water protection zone for Baikal has been established to include almost all the entire Buryat ASSR, three *rayons* (areas) of Chita Oblast, the Slydyanka and Olkhon *rayons* in Irkutsk Oblast and a part of Irkutsk *rayon* belonging to the lake's catchment area. Within this zone, problems will be tackled in an integrated way (rather than by separate ministries) and all economic activities strictly controlled. New construction and expansion of existing industrial enterprises is prohibited or, exceptionally, can be approved by a special resolution of the RSFSR (Russian Republic's) Council of Ministers (Vorob'yev, 1989). In April 1989, a Comprehensive Territorial Environment Protection Plan (TerKSOP) for the Baikal basin came into effect (Massey Stewart, 1990b). This was devised by the State Urban Planning Institute (Gosstroy RSFSR), with the aid of the Academy of Sciences of the USSR, to plan sustainable development of the area. It includes three zones: first, a shoreline protection belt encircling the lake and including several nature reserves; here development will be most tightly controlled and no commercial tree felling permitted. The second zone includes the valleys of the main tributaries to the lake, where industry and forestry can operate according to strict regulation. The third zone comprises the rest of the basin, where development is being focussed on light industries and those producing little pollution (Vorob'yev, 1989).

Another document, setting out the "norms of permissible influences in the Baikal basin ecosystem" is being formulated by the Siberian Section of the Academy of Sciences of the USSR. It includes lists of environmentally hazardous substances and permitted emission limits, regulations on the catching of fish and seals and limits on other forms of activity (Vorob'yev, 1989).

Protected areas within the Basin

The area has three state nature reserves (*zapovedniki*), Baikal, Barguzin and Baikal-Lena, which together cover about one million hectares, although three-quarters of Baikal-Lena is outside Baikal's catchment (site information sheets for Baikal and Barguzin are given in the Appendix). There is also a national park in two sections: Pribaikal (on the western shore) and Zabaikal (on the eastern side). There are also over 30 partial preserves (*zakazniki*) in the Baikal basin but these generally cover a small area, as do the 160 or so natural monuments (*natsional'nye pamyatniki*).

The establishment of a national park was proposed in the 1960s by a number of organisations, but the inclusion of the whole basin was inadvisable because of the presence of several industrial and urban centres, as well as the large area involved. The compromise was the Comprehensive Territorial Environment Protection Plan (see previous section) which included the establishment of a unified Baikal National Park. The Pribaikal National Park was set up in 1986 along half the western shore of the lake, including Olkhon Island, and abuts the Baikal-Lena Reserve. It includes 100km of shoreline, 600 species of flowering plant and at least 39 mammal species. An extension has been proposed to widen the current area. However, this national park does not include any of the area of the lake itself and only two of the nature reserves (Barguzin and Baikal-Lena) include a small strip of water, 3km wide, along the lake's edge (Vorob'yev and Martynov, 1989).

Local concern and pressure groups

Since the 1960s Baikal has been a focal point of environmental concern and environmental protection efforts. Many locals support the opinion that the lake must be saved (*Izvestiya*, 7 October 1987). As early as 1966, the year that the Baikalsk plant opened, over 30 scientists declared in a letter to the press that the government should take steps to save Baikal (Massey Stewart, 1990b).

Concern continued over the years both at local and national level, with the media and intelligentsia, particularly the scientific community, campaigning for Baikal's conservation. In 1987 a plan was approved to divert the waste from BPCC by pipeline away from the lake into the Irkut River, a tributary of the Angara. This would also have significantly reduced much hostility to the BPCC, allowing the plant to continue operation. However, the 200 million rouble project would have destroyed forest and a particularly popular resort area and threatened to endanger the water supply of Irkutsk (Moscow Home Service, 11 November 1987). It therefore met with opposition from a large group of Siberian scientists (including Valentina Galkina, deputy director of the Baikal Ecological Museum), writers and cultural figures (such as Valentin Rasputin, Siberia's best-known novelist, and Alexander Batalin, a campaigning local journalist) as well as local people (Massey Stewart pers. comm., 1991).

In June of the same year the grass roots Baikal Movement was formed (the first of Baikal's green groups). Demonstrations were organised and, despite the risk of dismissal, imprisonment and intimidation from the authorities, over 100,000 people signed a petition to the Central Committee in Moscow demanding that the pipeline plan be dropped. It was, indeed, abandoned (Cornwell, 1988).

In April 1989 the independent Baikal Fund was created, founder members including the Central Council of the All-Russian Nature Conservation Society and the Siberian Department of the USSR Academy of Sciences. It has now raised 600,000 roubles for the protection of Baikal. The Baikal Fund has been perhaps the most important pressure group in the area, but there are several smaller ones including Baikal Eco-world, which organised an international conference in Buryatia in autumn 1990 (Massey Stewart, 1990b).

A prominent member of the Baikal Fund, Valentin Rasputin, declared in October 1989 that pollution in Baikal had increased by 60% over the previous 18 months. As he had recently been chosen as a member of Mikhail Gorbachov's presidential council, he also spoke at length to him about the problems of Baikal. As a result, a presidential commission was sent to Baikal in December 1989. However, reports say that factory chimneys ceased to smoke during the official visit, crystal clear discharge water from the pulp mills was produced and a false impression of standards generally given (Massey Stewart, 1990b).

Although the Baikal Fund functions in Buryatia, most pressure group activity has occurred in and around Irkutsk, west of the lake. However, in September 1990, the First International Ecological Conference 'Man and his Habitat around Baikal' took place in the Buryat capital, Ulan Ude, (east of Baikal) in view, it stated, of the urgency of the problems confronting the lake. Believing that Baikal's ecosystem "is in great peril of irreversible changes with unpredictable consequences", the conference resolved *inter alia* that Baikal's ecological problems must be settled both through international cooperation and cooperation between the Russian Republic, Buryatia, Tuva (autonomous republic to the west) and Mongolia, where the Selenga's pollution problems begin.

This cooperation should be organised through a future international centre for the ecological protection of the Baikal region. The centre's interim president will be Sergei Gerasimovich Shapkhaev, a Buryat himself, People's Deputy of the USSR and chairman of Baikal EcoWorld. In addition, he is one of the prime movers for a new law to protect the Baikal basin which is now under discussion.

International Cooperation

World Heritage List

A consensus of opinion exists among many Soviet scientists and Baikal activists that Baikal's ecological future can best be assured by acceptance as a World Heritage Site on Unesco's World Heritage List. A Unesco fact-finding mission visited the area in May 1990 and agreed unanimously that Lake Baikal to a great extent fulfilled the four major criteria of "outstanding universal value" for inclusion on the list. However, it noted present and possible future threats to the lake, citing as the most serious of the latter the introduction of alien species, including pathogens, as well as chemical pollution.

The mission felt that certain criteria should be met as a prerequisite for nomination, in particular: the inclusion of the Baikal basin as a World Heritage Area (WHA); the subdivision of this WHA into a core zone with most rigid protection and a buffer zone; the establishment and administration of an administrative framework which should provide legislation, planning, management, research, funding, etc. The mission also noted that a significant portion of the Selenga river watershed lies in Mongolia, a country which is not party to the World Heritage Convention, and advised against attempts at an inter-governmental agreement which might delay proceedings.

The mission believed that the Lake Baikal WHA should enable the optimisation of the protection of this unique ecosystem and allow coordinated and interdisciplinary scientific research with strong international cooperation. Important components of this research programme could be coordinated by and conducted within Unesco's MAB (Man and the Biosphere) Programme.

For planning and managing the WHA, the mission suggested a coordinating Baikal Commission to be located in Irkutsk, consisting of the representatives of Irkutsk Oblast, Buryatia and the major local authorities.

However, Baikal's present environmental problems will delay its nomination as a WHA until the major ones are solved, and with the necessary evaluations and procedures required, formal Unesco acceptance is unlikely for several years. Nonetheless, the prospect greatly strengthens the hand of those fighting for the future of this remarkable and unique ecosystem (Unesco, 1990).

Water resource management

The Selenga River rises in Mongolia and the presence of an international boundary within the catchment area of Baikal is a potential problem. Felling of the forest had also occurred on the Mongolian side of the border. However, in July 1988, the Mongolian government convened the first ever Soviet-Mongolian environmental round table to discuss the protection of Baikal (*Nature*, 11 July 1988).

The Limnological Institute and BICER

A permanent research station was set up in 1918 near the Angara outflow and developed into the Limnological Institute, a unit of the Siberian Branch of the Soviet Academy of Sciences. An outline of the Institute's research plan to increase the effectiveness and quality of its research was approved by the Presidium (executive council) of the Soviet Academy (Moscow Home Service, 19 May 1987). It has now moved from Baikal to Irkutsk, to new buildings, as part of a scheme dreamt up by Mikhail Grachev, the Institute's energetic new director. Grachev aims to attract funding and scientists from outside the Soviet Union for the establishment and running of a research centre which is projected for Listvyanka on the edge of the lake (Maddox, 1989). This Baikal International Centre for Ecological Research (BICER) is to have an international board of directors and will open up research in a way which would have been inconceivable ten years ago. Plans include a large new laboratory and aquaria, a new port, accommodation for 1,000 staff and international computer and telecommunications links. The Siberian Department of the Academy has already given 5 million roubles (about £5 million) and promised to match foreign contributions with roubles.

In December 1989 the Royal Society of London signed an agreement for scientific collaboration on the lake. In summer 1990, scientists from eight countries, including the USA, West Germany and China, took part in expeditions on or around the lake (Massey Stewart pers. comm., 1991). Among them were three scientists from the Centre for Research in Aquatic Biology, Queen Mary and Westfield College, London, who undertook two projects on water characteristics and planktonic plants. Several countries are participating in the Baikal drilling project, which means to sample the deep layer of sediments in the lake (Massey Stewart, 1990a).

The Tahoe-Baikal Institute

In May 1988, cooperation between the USSR and USA led to the creation of the Tahoe-Baikal Institute, whose purpose is to bring together young people from many countries to study and discuss world problems, including environmental issues, and experience the wilderness areas in the vicinity of these two lakes. Work was begun in September 1990 to prepare a site between Listvyanka and Bolshoe Goloustnoe on the shores of Baikal (Direct Connection, 1990).

BaikalWatch

Another new group is BaikalWatch, operating from Earth Island Institute and the Centre of US-USSR Initiatives, both in San Francisco. In August 1990 it produced the report and recommendations of a Soviet-American environmental delegation (ten working groups of Soviet and American specialists) which it had helped send to the north of Baikal. A resolution of the Council of Ministers of the USSR stated that the delegation's results affirmed "there is shoreline pollution going on, as well as air and water, which soon may cause irreversible catastrophic consequences" and that it was "a political, economic and technical mistake to have decided to build BAM in the northern region of Lake Baikal".

The delegation's many recommendations include: monitoring of Baikal's water to discover the most polluted areas; the lake to be proposed as a Ramsar site and the whole watershed and buffer areas to be a biosphere reserve under the Man and Biosphere programme; new national park areas and a series of strictly protected wildlife sanctuaries; a visitors' interpretative centre and the development of both ecological education and eco-tourism; and restrictions on forestry and agriculture. They also note the absence of any central information centre or routine monitoring programme (BaikalWatch, undated).

Plate 8. Retrieving sediment trap on Limnological Institute's *Vereshchagin* (Photo: J. Massey Stewart)

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Appendix

Lake Baikal Region Biosphere Reserve: Barguzin Zapovednik Unit

IUCN Management Category: I (Strict Nature Reserve)
IX (Biosphere Reserve)

Biogeographical Province: 2.04.03/2.44.14 (East Siberian Taiga and Lake Baikal)

Geographical Location: The reserve covers 100km of the north-eastern shore of Lake Baikal and extends 45-80km inland to the western slope of the Barguzin range. The northern boundary is the watershed between the Yezovka and Kaban'ya rivers and the southern boundary the watershed of the Shumilikha and Gromotukha rivers. The reserve is contiguous with the Zabaikal National Park along its southern boundary (Vorob'yev and Martynov, 1989). It is about 360km north-north-east of Ulan-Ude, RSFSR. Approximately 54°20'N, 109°45'E.

Date and History of Establishment: Established by Tsarist authorities in 1916 and verified by Act No. 513 of the Council for Peoples' Economy on 4 January 1926. Declared a biosphere reserve in 1986, twinned with Baikal State Reserve 400km to the south-west.

Area: Total area of 358,600ha with a core zone consisting of 263,176ha, comprising the nature reserve itself. Lake Baikal Region Biosphere Reserve has a total area of 559,100ha, and includes both the Baikal and Barguzin state reserves.

Land Tenure: State

Altitude: 400-3,000m

Physical Features: The reserve includes a 100km long and 3km wide stretch of Lake Baikal along the shore and extends inland to the summit ridge of the Barguzin range. The mountainous section is almost inaccessible, being very deeply dissected with numerous glacial cirques and lakes which are the sources of mountain torrents.

Climate: The climate is severe, with 210 days below freezing point and a mean January temperature of -26°C, although average winter temperature is -20.8°C and average annual temperature is 4.6°C. The lake in this area is frozen for up to five months of the year. Precipitation is on average 470mm annually. The climate in the west of the reserve is moderated by the influence of the lake, with cooler summers and milder winters, the water temperature seldom exceeding 12°C. The many hot springs (40-78°C) present in the reserve are noteworthy.

Vegetation: Terraces near the shore have larch *Larix dahurica* and *Rhododendron dahuricum*, grading into the more fertile mixed fir-Korean pine *Pinus koraiensis* taiga and larch forests of *Pinus sibirica* and *Larix sibirica*, with some spruce *Picea obovata*, the monotypic willow *Chosenia macrolepsis*, with an understorey of honeysuckle *Lonicera periclymenum*, rowan *Sorbus aucuparia* and currants *Ribes rubrum* and *R. nigrum*. At higher altitudes there is pure fir *Abies sibirica* and 'cedar' *Pinus sibirica* forest, followed by thickets of dwarf pine *Pinus pumila* and finally, at the highest levels, *Kobresia*-dominated tundra, peaty meadows with sedges *Carex* spp., *Betula ermanii* on stoney talus and lichen *Cladonia* and *Cetraria*-covered rocks and cliffs. The hot springs support relict species from warmer climates such as violets *Viola* spp. In total, 600 species of vascular plants have been recorded.

Fauna: This is characteristic of the taiga with 39 species of mammal recorded, including pika *Ochotona hyperborea*, Siberian chipmunk *Eutamias sibiricus*, marmot *Marmota baibacina*, flying squirrel *Pteromys volans*, fox *Vulpes vulpes*, brown bear *Ursus arctos*, stoats and weasels *Mustela altaia*, *M. erminea*, *M. nivalis* and *M. sibirica*, otter *Lutra lutra*, large numbers of the most valuable sable subspecies *Martes zibellina princeps*, wolverine *Gulo gulo*, the endemic Baikal seal *Phoca sibirica*, a local race of musk deer *Moschus moschiferus*, Siberian red deer *Cervus elaphus sibiricus*, elk *Alces alces* and reindeer *Rangifer tarandus*. The avifauna includes 243 bird species, among them white-tailed eagle *Haliaeetus albicilla* and capercaillie *Tetrao urogallus*. The lake contains some 50 species of fish including endemic deep water species.

Cultural Heritage: No information

Local Human Population: No information

Visitors and Visitor Facilities: No information

Scientific Research and Facilities: Research has been conducted since 1957 and coordinated by the Academy of Sciences. In addition to a research station, a monitoring station was set up in 1983 together with control plots, ecological profiles and transects for the monitoring of climate, vegetation, animal populations and their harvesting. Some lecturing is also carried out.

Conservation Value: The reserve was specifically established for the conservation of the Barguzin sub-species of the sable *Martes zibellina princeps*.

Conservation Management: No information

Management Constraints: Risk of forest fires, especially near the western boundary.

Staff: Eighty-nine including 18 administrative, control and reserve management personnel, two Ph.D. and five university-trained scientists.

Budget: No information

Local Addresses: Chief of Reserve, 671715 Davshe, Severo-Baikal district, Buryat ASSR

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Date: November 1984, revised August 1986

Lake Baikal Region Biosphere Reserve: Baikal Zapovednik Unit

IUCN Management Category: I (Strict Nature Reserve)
IX (Biosphere Reserve)

Biogeographical Province: 2.04.03 (East Siberian Taiga)

Geographical Location: On the watershed between the Mishikha and Vydrinnaya rivers, in Buryat ASSR, and including the eastern part of the Khamar-Daban mountains, 170km west-south-west of Ulan-Ude and 100km across the lake from Irkutsk, RSFSR. Approximately 51°50'N, 105°05'E.

Date and History of Establishment: The reserve was established by order of the Council of Ministers of the RSFSR in 1969 (26 October N. 571). Declared a biosphere reserve in 1986. Twinned with Barguzin State Reserve.

Area: Total area of 200,500ha with a core area of 165,724ha comprising the nature reserve itself. Lake Baikal Region Biosphere Reserve has a total area of 559,100ha, and includes both Baikal and Barguzin state reserves.

Land Tenure: State

Altitude: 650-2,323m

Physical Features: The reserve comprises 117,214ha of forest and 1,552ha of water bodies. The south of the reserve is cut off from the northern part by the flat-topped Khamar-Daban range running on an east-west axis, which slopes precipitously down to Lake Baikal from its highest point (2,323m) at Sokhor Mountain. The north-facing slopes are cooler, wetter and snow-covered in the winter, while the southern slopes are drier and continental in character. Soils are of a mountain tundra type, varied locally by wet podzolic soils and chestnut meadow soils. The northern slopes have cirques and deep valleys with lateral ridges which extend to and into the lake shore forming rocky promontories in the lake.

Climate: Mean temperatures range from -20°C in January to 16°C in July, remaining below freezing point for 180-210 days per year, with snowfalls up to 1m deep. Annual precipitation ranges from 300 to 400mm.

Vegetation: Well-marked altitudinal zonation occurs. *Sphagnum* bogs and forests of poplar *Populus* and the monotypic willow-like *Chosenia macrolepsis* occupy low-lying areas, while the river valleys contain bird cherry *Prunus padus*, rowan *Sorbus aucuparia* and alder *Alnus glutinosa*. The northern slopes of the mountains have taiga of korean pine *Pinus koraiensis*, spruce *Picea* and 'cedar' *Pinus sibirica*, with fir *Abies sibirica* dominant in places, whilst the southern slopes are covered in mixed larch *Larix sibirica* and pine *Pinus* sp. forest which gives way to steppe vegetation on the foothills. At higher altitudes there is cedar elfin woodland and mountain tundra shrubs such as *Rhododendron parvifolium*. The high altitude meadows support thickets of dwarf Siberian pine *Pinus pumila* and birch *Betula middendorfii*. In total, 800 species of vascular plants have been recorded.

Fauna: Records exist for 37 mammal species and 260 species of bird. Mammals include brown bear *Ursus arctos*, sable *Martes zibellina*, mountain weasel *Mustela altaica*, steppe polecat *M. eversmanii* and Kolinsky weasel *M. sibirica*, wolverine *Gulo gulo*, lynx *Felis lynx*, wild pig *Sus scrofa*, musk deer *Moschus moschiferus*, roe deer *Capreolus capreolus*, elk *Alces alces* and reindeer *Rangifer tarandus*. Birds include swan goose *Anser cygnoides*, crested honey buzzard *Pernis ptilorhyncus*, black kite *Milvus migrans*, hawk owl *Sunia ulula*, rock ptarmigan *Lagopus mutus*, hazel grouse *Tetrastes bonasia*, capercaillie *Tetrao urogallus* and great bustard *Otis tarda*.

Cultural Heritage: No information

Local Population: There are no human settlements.

Visitors and Visitor Facilities: No information

Scientific Research and Facilities: Studies of ecosystem changes of the terraces bordering southern Baikal and of the Khamar-Daban range have been made, and monitoring of climate, vegetation, animal populations and their harvesting is carried out, as well as training and lecturing activities. Specific research is conducted on the conservation, reproduction and management of sable. Research activity is coordinated by the Academy of Sciences. Facilities include a research station, field station, experimental plots, climatic station and overnight accommodation for scientists. Access is by railway to the Tankhoi station.

Conservation Value: No information

Conservation Management: The local population does not participate in the management decisions governing the reserve. The core zone of strictly protected areas covers 165,700ha where all economic activity is prohibited and access is restricted. Within the buffer zone of

34,800ha, economic activity compatible with the preservation of the landscape is allowed. The core zone contains species of economic importance such as sable and Engleman spruce. An area of 487ha is set aside for laboratories and administrative purposes.

Management Constraints: There is a danger of fires. The presence of a railway line and highway along the northern boundary has an unknown effect on the natural ecosystem.

Staff: The total staff is 79, including 42 employed in administration, control and resource management of which 8 are university trained. There are 37 rangers.

Budget: No information

Local Addresses: Chief of Reserve 671120, Tankhoi, Kabansky district, Buryat ASSR

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