6. SUMMARY AND RECOMMENDATIONS FOR FUTURE MONITORING, RESEARCH AND MANAGEMENT ACTION

6.1 Introduction

The Lake Tanganyika Biodiversity Project was conceived largely as an environmental protection project, but has, in its design and operation, responded to the move towards adoption of integrated conservation and development (ICAD) programmes. The East African Great Lakes provide a critical test for the realities of implementing the new ICAD programmes currently being adopted by national governments, international agencies, NGOs and resource user communities in response to the UN Conference on Environment and Development (Rio de Janeiro 1992). The post-Rio conservation agenda is guided by international environmental agreements, principally the Convention on Biological Diversity (CBD). The CBD promotes a utilitarian approach to conservation – through sustainable use and equitable sharing of benefits derived from exploitation of that biodiversity. Thus, our summary and recommendations are framed within this paradigm. We recognise that there is a moral imperative to ensure that biodiversity conservation does not take place at the expense of rights to social and economic development in the region.

At the same time as the adoption of ICAD approaches to environmental management, the international development agenda has shifted from support for national economic growth, towards poverty-targeting or 'pro-poor' growth (Allen and Thomas, 2000). In natural-resource management projects, this development strategy is being pursued through adoption of the 'sustainable livelihoods approach' (Scoones 1998, Carney 1998). This approach, while seeking to understand the extent and causes of poverty, dependence and vulnerability, focuses primarily on strategies used by the poor and vulnerable to survive and prosper in difficult circumstances. In other words, the approach uses an analysis of people's assets, abilities and strengths to identify possible routes out of poverty (Ellis 2000). One of the key components of the 'asset pentagon' available to the poor is 'natural capital' or 'natural endowment' - the renewable natural resources available to and managed by individuals, households, communities and nations. These may include soil fertility, water, agrobiodiversity, fuelwood, fisheries and other 'goods and services' provided by the natural environment. Sustainable use of natural capital, including biodiversity, is therefore a key component of current approaches to poverty eradication (e.g. Tisdell 1999). This is particularly relevant for the inhabitants of the riparian countries of Lake Tanganyika.

The theoretical basis for integrated environment and development programmes is that there need not be a conflict between conservation and development (in the form of poverty eradication). Indeed, for development to be sustainable, the two must be reconciled: maintaining 'natural capital' is integral to sustainable development, and only through development will the poor have the resources and ability to exercise choice in not having to degrade the environment in order to survive. While the notion that it is the poor who are the enemies of the environment is disputed (Broad 1994; Chambers, 1994), these ideas underpin utilitarian perspectives on biodiversity conservation and current approaches to poverty eradication through support for sustainable livelihoods. Perhaps nowhere else on earth is the challenge to integrated conservation and development approaches so great as around the shores of the African Great Lakes, where some of the world's poorest people survive by exploiting some of the World's most biodiverse environments. The assumptions that underpin ICAD approaches are that people in Lake Tanganyika can benefit from biodiversity conservation. This key assumption has not been subjected to any critical scrutiny by the project, and later in this chapter we attempt to redress this important oversight.

At present, discussions on integrating conservation and development in Lake Tanganyika take place against a background of key uncertainties in the information base for management. Projects by FAO/FINNIDA and the current GEF project have made enormous progress in addressing key, broad issues for management: institutional development, legal frameworks, management objectives and priorities for fisheries and biodiversity conservation. They have also, through original research and synthesis of existing information, greatly contributed to this knowledge base. The Strategic Action Programmes resulting from this project has proposed priorities for further action, including intervention and funding by external agencies. Despite this progress, several key information gaps remain, most of them at the interface between technical special studies and socio-economic analysis. While we recognise that management action should not have to wait for perfect information, our contention is that several key areas of existing knowledge (such as the link between conservation and development) have not been addressed by the LTBP project, and that these key areas could determine the whole approach to future management in the lake basin.

In this look to the future, we draw partly on our own and others' inputs into the SAP, to highlight information and management needs. As this is a technical document, rather than a management document, we focus particularly on areas of interest to those whose work has a technical remit. Thus, we concentrate on the research and monitoring needed to support the management recommendations we make. We hope this will assist with the technical basis for proposals seeking funding to implement the SAP. We divide our overview into three areas broadly representing monitoring needs, future research priorities and management approaches, but recognise that these three contain many cross-linkages, with choice of management direction determining research priorities and so on.

6.2 Monitoring

Two types of monitoring of the environment have been recognised: performance and ecological (see Abbot and Gujit, 1998). *Performance monitoring* is used to assess the effectiveness of management interventions, such as community initiatives, district plans, government laws and policies, and donor projects etc. In contrast, *ecological monitoring* assesses changes in the biophysical environment such as quality and extent of reed beds, fish species richness or community structure. Emphasis is often on the latter, however, both are essential to monitor success of conservation and management programmes.

By providing information on changes and trends, on what works or how activities might be improved, monitoring underpins the activities of decision makers and planners. To be effective, monitoring programmes must deliver relevant information at the right time in a format that is appropriate to the end user. Note that this "end user" is rarely involved in data collection and may not have even had a role in analysing the information or been part of the programme design. Awareness of these constraints and given the limited technical remit of BIOSS, recommendations for biodiversity monitoring were necessarily very technical in nature. We developed appropriate criteria for site selection, agreed locations in consulation with other special studies and provided a standardised methodology for collection of biological data collection (see SOP for details).

Monitoring programmes should aim to assess both the symptoms and the causes of change. Thus, a monitoring programme that detects degradation in, say, habitat quality is not useful unless the cause of that change can be elucidated. Scientific monitoring programmes tend to be focused on the proximate causes of change (e.g. turbidity, impact of fishing, water quality). In order for the monitoring programmes outlined in the SOP to be successful even at this function, the riparian institutions will have to achieve a level of integration of pollution, sediments and biodiversity work that the special studies failed to accomplish during the LTBP project. Trained teams are in place and technical methodologies have been established and, in some cases, recorded in sampling protocols that aim to standardise monitoring techniques across the lake (e.g. the BIOSS SOP). Thus, the prognosis for sustained monitoring are good, but the momentum generated by the project needs to be acted upon quickly if it not to be lost.

Technical monitoring programmes of the type designed by BIOSS can serve an important 'alarm' function. An alarm is only useful, however, if someone is able to respond to it. Monitoring programmes need to also address the root causes of change – including human population change and migration, the pattern of land tenure and land use, and the location and impact of coastal and lake-basin development – and think in terms of addressing or mitigating these pressures on biodiversity.

A monitoring programme is also only useful if it continues beyond its conception! Many monitoring studies are designed to be comprehensive and rigorous, but their rigour is never tested because the programmes are not sustained, or too many resources are spent on data collection and insufficient remain for proper long-term data storage and analysis and, most importantly, to maintain capacity to act on the information produced (Darwall and Allison, in press). A quote from Roberts (1991) summarises the folly of many monitoring programmes:

> *…much field recording "tells us only that lots of people are keeping lots of records: often for no good reason, using dubious methods, and producing vast quanitities of un-analysed and often unanalysable data"*

Such programmes are a drain on institutional resources and are of no practical use. Modest ambition, coupled with realistic assessment of institutional capacity are a prerequisite for the design of sustainable environmental monitoring programmes. Many development projects still fail to allocate sufficient resources to post-project analysis, sustainability and process issues, in their concern to meet shorter-term project success indicators specified in logical frameworks.

Assessing whether management interventions to conserve biodiversity are successful can be problematic. Most measures rely on biological indicators of success, such as increases in diversity indices or species richness, the abundance of selected 'indicator' taxa (Noss, 1990; Spellerberg, 1991). These may not be evident for some years, even if the project has successfully addressed threats to diversity. They also require considerable technical and financial resources to implement them. Of potential interest to project evaluation teams are monitoring and evaluation tools recently developed specifically for integrated conservation and development projects, based on analysis of the degree to which a project has successfully reduced identified threats to biodiversity (Margoluis and Salafsky, 1998; Salafsky and Margoluis, 1999). This supports our assertion that monitoring the root causes of biodiversity loss is as important as trying to assess the magnitude of the loss.

6.3 Research

6.3.1. Expanding survey activities

Considerable work remains in documenting the biodiversity of Lake Tanganyika. Much of the Tanganyika coastline has not been adequately surveyed. Some of the biggest gaps in knowledge include: the Congolese coastline south of Baraka to the Zambian border, the Tanzanian coastline between Ujiji and Mahale Mountains National Park and south of Mahale to the Zambian border. These areas combined constitute well over 50% of the Lake's perimeter. Studies show that as new areas in Tanganyika are investigated new species are found, even among the relatively well-known groups (West *et al*. 1999; L. DeVos, pers. comm.; J. Snoeks; pers. Comm., K. Martens, pers. comm.).

At the same time these explorations are undertaken, it is critical that the base of taxonomic expertise is increased, especially within the region. Some groups, like sponges, decapods, insects and the many worms and worm-like groups, have not been recently, and in some cases have never been, properly described and monographed using modern techniques and classification ideologies. Even for relatively well-known groups (fish, molluscs and ostracodes), taxonomic expertise is concentrated in the Northern Hemisphere. Producing basic identification materials for all groups and ensuring taxonomic training for regional scientists is a critical step in documenting Tanganyika's biodiversity and engaging regional scientists to take a proactive role in understanding and managing it. Some institutions and funding agencies have already recognized this urgent need to increase taxonomic training, especially in developing countries (e.g. the US National Science Foundation's Partnerships for Enhancing Expertise in Taxonomy program).

6.3.2 Developing methods of assessing aquatic ecosystem health

Biotic indices have been used as a relatively quick and easy way of assessing the health of aquatic ecosystems. Essentially the invertebrate fauna is surveyed and the proportions of certain taxa, for which the oxygen requirements and environmental tolerances are well understood, are manipulated into an index, which reflects the relative health of the ecosystem. The technique requires considerable research input prior to application (e.g. see Kerans and Karr, 1994). This technique has been used widely in European and North American streams, where the taxonomy of aquatic invertebrates is well understood (reviews by Fore et al. 1996 and Wright et al. 1998)). Much taxonomic and ecological work remains before this technique would be viable for assessing the state of East African waters, though there are clearly enormous benefits of having such a method of assessing ecosystem health for natural resource managers. Such techniques are only recently being developed elsewhere in Africa (Roux et al 1993; Crosa et al, 1998).

6.3.3 Assessing biodiversity values

The definition of biodiversity as variation (genetic, taxonomic, ecological) implies that the more variation (e.g. species richness) the more valuable a system is in conservation terms. This would be the case only if all species (or other units of biodiversity) had the same value. In practice, this is not the case. Humans place differential values on biodiversity, depending on whether it has ‘use values’ as well as ‘intrinsic value’.

There are three types of economic value that can be associated with biodiversity: **direct use**, **indirect use**, and **non-use** values (e.g. Barbier et al, 1994). Within these categories are several sub-divisions.

Direct use values refer to economic benefits that accrue directly as a result of the continued existence of a genotype, species, community, or ecosystem. Direct uses may be *consumptive* (the organism is harvested or removed from its environment, as in fisheries or the aquarium trade) or *non-consumptive* (economic benefits generated without harvesting, such as revenue from eco-tourism).

Indirect use values are the economic benefits that arise indirectly from the continued existence of biodiversity. In Lake Tanganyika, the diversity of organisms may be involved in maintaining crucial ecosystem functions, such as a relatively stable and productive environment for fisheries production (but see later for a critique of this assumption). The interactions between primary production and consumption by higher trophic levels may also play a role in maintaining water quality. The disruption of the role of diverse fish communities in nutrient cycling in Lake Victoria has been proposed as one side-effect of the introduction of Nile Perch, that caused the rapid decline of the hapolochromine fish fauna (see Kaufman, 1992 for review). Another example of indirect use values, and their loss, is the increase in Bilharzia in Lake Malawi purported to be linked to reduction in populations of mollusc-eating fishes that were thought to control the intermediate snail hosts of the disease (Turner et al, 1995). This has costs to human health and even to the tourist industry. The indirect value of the snail-eating fish can be estimated through the cost to human communities of poor health, and to the provision of increased health services in the riparian countries, and any decline in lakeshore tourism.

Biodiversity has value beyond mere utility, and environmental economists have tried to estimate these **non-use** values too. **Existence values** are calculated by economists on the basis of what people are willing to pay to ensure that, for example, a particular cichlid species continues to survive. **Intrinsic values** recognise the rights of all living things to share the planet. **Bequest values** recognises that our environment has value to future generations, and that species or ecosystems that are of little or no use to us may find uses to future generations. In calculating such values, it must be borne in mind that they are highly subjective and culturally determined.

Traditionally, resource values have been calculated on the basis of direct use values only. Environmental economists argue that this is why modern societies under-value the environment, and degrade it to convert ‘natural capital’ into ‘financial capital’ (Costanza et al., 1997). They argue that if environmental/biodiversity values can be ‘captured’ or estimated, then the true costs of alternative land, water or resource uses can be calculated. This provides the basis for an analysis of trade-offs between preservation and consumptive use, or to assess the real value of extinctions, in terms of loss, not only of direct use values (the old approach) but also of non-use and indirect use values. With these environmental valuation techniques has come the realisation that when we lose a species, we may lose a lot more than we anticipated. Putting a value on bequest, existence and other such concepts is rather difficult in practice, but does serve to bring such values to the attention of policy makers.

This utilitarian approach to environment is becoming much utilised in global environmental management – the use of tradable carbon permits to manage carbon dioxide emissions in combating global warming, and the principle of 'polluter pays' are two examples.

In the case of Lake Tanganyika, use values are of most concern regionally, while non-use values are more important internationally (Table 6.1). An understanding of the differential values of different biodiversity will help to determine priority approaches. This is already recognised implicitly in the SAP process, but needs to be made explicit to justify decisions. For example, the species flock of endemic leeches of Lake Tanganyika have some intrinsic value, possible bequest value, but little or no use and existence value, while *Lates stappersii* has a high direct use value, but as a single, common species it has modest existence and intrinsic value.

Recognition of these differences would help to choose between funding a taxonomic and ecological study on the leeches, or a fishery management initiative. The fact that the values of *Lates* accrue locally, while the value of the leeches accrues internationally, will also provide the SAP with guidance of where funding support can be expected.

The key points to reinforce are:
- Species richness alone is not a reliable guide to biodiversity value. Areas of low richness (e.g. the pelagic zone of Lake Tanganyika) can have very high use values.
- Costs and benefits of biodiversity conservation accrue differently to different groups of people (e.g. local resource users, international scientists). An understanding of the distribution of costs and values will help define and direct conservation action, and identify stakeholders' potential roles in conservation activity to safeguard their own interests.

Table 6.1 provides an overview of the economic values of biodiversity, and illustrates these concepts with reference to Lake Tanganyika's biodiversity. Consideration of economic values of biodiversity, hypothesised relationships between biodiversity and ecosystem function, and the objectives of the CBD, leads to BIOSS suggesting the following guiding rationale for biodiversity conservation in Lake Tanganyika:

1. The purpose of biodiversity conservation in Lake Tanganyika is to maintain the lake's unique, diverse, ecosystems, and their constituent taxonomic and genetic diversity. This will be achieved through efforts to maintain habitat quality and ecosystem integrity, and through regulation of the exploitation of the fish species.
2. Biodiversity conservation in Lake Tanganyika should aim to emphasise the conservation of ecosystem function. The most important ecosystem function, regionally, is the production of fish. Internationally, the function of major interest is the set of conditions that have allowed rapid evolutionary radiation in several taxonomic lineages, making the lake an important scientific resource, and of exceptional species richness.
3. Biodiversity conservation in Lake Tanganyika should also aim to promote the sustainable use of biodiversity, principally through fisheries management, but also through tourism and other non-consumptive uses.
4. Any economic benefits derived from biodiversity conservation in Lake Tanganyika need to be shared equitably within the lake region.

We deliberately avoid the aim of conserving 'each and every species'. This is both very difficult to achieve, and would be almost impossible to monitor or assess. In the long term, it is also a less meaningful goal than conserving the conditions under which the remarkable evolutionary radiations, that make the lake a biodiversity 'hotspot' of international importance, took place.

Table 6.1 Biodiversity values and stakeholders: some examples from Lake Tanganyika

Values	Biodiversity Resource	Uses and Users
Direct Use		
Consumptive	Food fish	fishers, processors, market traders, transport companies, rural and urban consumers throughout region.
	Sport fish	Recreational fishers, tourism development
	Ornamental fish	Aquarium fish exporters, local employees, riparian governments (export revenue), aquarium dealers, aquarists in Europe, North America.
	Fish genetic diversity	Aquaculture development – global
Non-consumptive	Eco-tourism: coastal habitats, 'Charismatic species': cichlids, other fish and vertebrates, molluscs, crabs.	Ecotourists, diving tourism and associated development including employment and foreign exchange revenue.
Indirect Uses		
Ecosystem services	All species – particularly phytoplankton, 'keystone' species (e.g. shrimps, clupeids, top predators)	Environmental modulation - role in maintaining lake function, e.g. position of thermocline: trophic cascade effects Ecosystem productivity and stability, to benefit all those dependent on direct uses (above).
Knowledge	All species - especially diverse endemic lineages (cichlids, molluscs and Ostracods).	Scientific research on evolutionary processes that ultimately benefits all human society.
Aesthetic	Habitats, charismatic or flagship species	Anyone who derives satisfaction from looking at the lake's biodiversity or habitats
Non Use Values		
Existence	Charismatic species usually	Conservation-minded individuals
Intrinsic	All biodiversity	All humanity
Bequest	All biodiversity	Future generations

There are currently no studies of biodiversity values on Lake Tanganyika, or any other African Great Lake. Such work should be a priority to inform further development of coastal aquatic parks and other conservation measures and is crucial to inform on-going debates on the relevance and value of parks for conservation and development in low-income countries (Wells, 1992; McClanaham, 1999; Salafsky and Wollenberg, 2000).

Such valuation studies should include:

- Assessment of direct and indirect benefits from fishing and aquatic parks to the local economy.
- A contingent valuation (CV) survey to evaluate willingness to pay for preserving current levels of resource use.

- Stakeholder focus groups to examine the opinions of different social groups on fishing and the aquatic parks.

Both direct and indirect use values need to be analysed. The biodiversity of Lake Tanganyika provides direct use value from goods such as fish, which are consumed or removed from the lake by the aquarium trade. Through tourism and scientific research activities, biodiversity also supports non-extractive industries. These direct uses have an economic value, which is to some extent revealed through household consumption, market expenditures and sales. Lake Tanganyika's aquatic resources and biodiversity support a range of ecological services. Although these services have no market price, their economic benefits can be quantified through looking at the costs of losing them.

6.3.4 Identifying conservation-development linkages

If biodiversity conservation and development are to be reconciled, and if, as it is proposed in previous conservation-related proposals for Lake Tanganyika (Cohen, 1991; Coulter, 1999), people will benefit from biodiversity conservation, then it is imperative to explore carefully the links between biodiversity and the benefits derived from biodiversity. There has been a tendency to assume such linkages rather than to critically analyse them.

The techniques of livelihoods analysis, which build on experience gained in the application of participatory rural appraisal techniques and formal questionnaire surveys, are only recently being implemented (Scoones 1998; Ellis 2000). The first studies of the formal application of rural livelihoods analysis to the management of small-scale fisheries are only now beginning to emerge (Sarch and Allison 2000; Allison and Ellis, *in press*). We know of no applications of such analysis to the utilisation and conservation of aquatic biodiversity. Livelihoods analysis can identify the role of local stakeholders much more precisely than has hitherto been possible (Meadows and Zwick, 2000). Livelihoods analysis and stakeholder identification can be linked to valuation of biodiversity in order to make rational decisions on the promotion of integrated conservation and development strategies. A recent analysis of linkages between biodiversity conservation and livelihoods (Salafsky and Wollenberg, 2000) provides a possible methodological framework for assessing the feasibility of an integrated conservation and development approach on Lake Tanganyika.

Linkages between livelihoods and biodiversity can be direct and indirect, as illustrated in Table 6.1. The key assumption in the case of the proposed indirect linkage between biodiversity conservation and the maintenance of ecosystem services is that biodiversity is integral to the optimal maintenance of such services. This assumption is founded in the literature relating enhanced ecosystem functions (e.g. productivity, resilience, stability, nutrient cycling efficiency etc) to maintenance of high diversity (reviewed by McCann, 2000). The hypothesised links between diversity and ecosystem function are illustrated in Figure 6.1.

Much of this evidence comes from model ecosystems and controlled experiments, most of which have been criticised for problems with experimental design. The most recent review on the subject opines that the hypotheses presented in Figure 6.1 which are held to apply in any discussion of the link between biodiversity conservation and the maintenance of critical ecosystem services, persist despite "enthusiasm outweigh[ing] supporting scientific evidence" (Schwartz et al 2000). One critical weakness in any discussion of the link between livelihoods and biodiversity is therefore that the link between biodiversity and the maintenance of ecosystem services is unsubstantiated. This point does not seem to have been addressed in the literature advocating integrated conservation and development.

Although indirect values such as ecosystem services are often invoked as a reason why people should conserve biodiversity, it is even more common to propose that people can derive more direct benefits from conserving biodiversity than from allowing its over-use. The notion that human welfare is maintained and enhanced by biodiversity conservation is the fundamental premise for the recent interest in extractive reserves and promotion allowing people access to biological resources as a means of protecting them. It is a premise that rests on the extent to which people depend on the biodiversity for their livelihoods. The general models for conservation and development outlined by Salafsky and Wollenberg

(2000) provide a useful starting point for analysis of potential for integrated conservation and development.

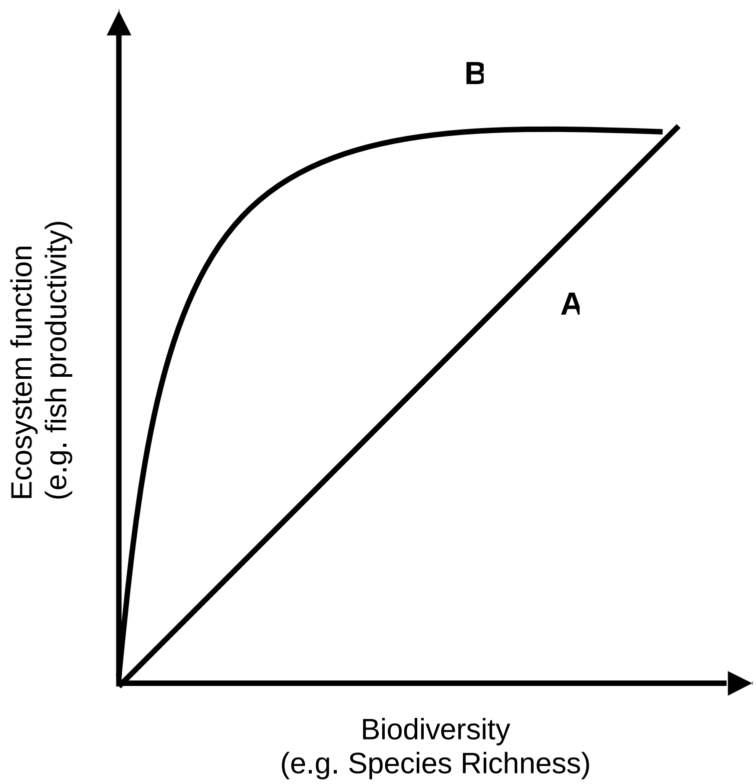


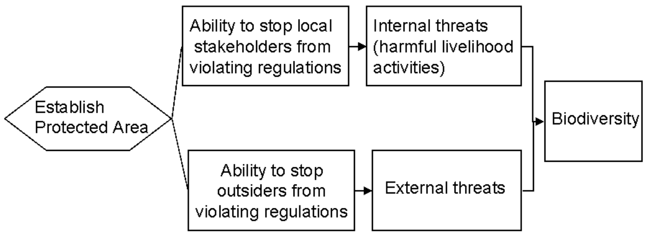
Figure 6.1 Conceptual models of biodiversity-ecosystem function linkages proposed in the literature (after Schwartz et al, 2000)

From the figure, Model A represents thinking where every species has a role in supporting ecosystem function and the loss of a single species affects ecosystem function. Model B accepts that some species play little or no part in regulating ecosystem function (the redundancy model) and some species can be lost without loss of ecosystem function.

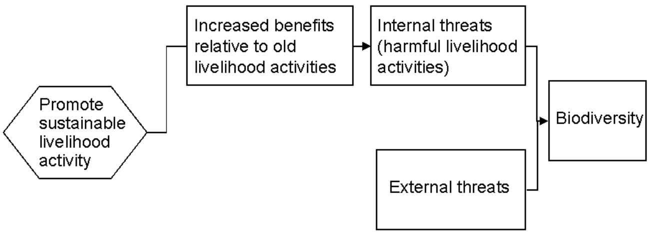
In the following analysis, we take what is known about biodiversity-livelihoods linkages in the Lake Tanganyika basin, and analyse the potential for direct linkage, indirect linkage and non-linked conservation and development approaches. We recognise that this analysis is limited by the type of data available at present. We have already highlighted the lack of data on the economic value of biodiversity, and have alluded to the limited amount of information on what elements of biodiversity people actually use (no livelihoods analysis surveys). Nevertheless, the information from Socio-economics, Sedimentation, Biodiversity and Fishing Practices special studies allow the main linkages to be identified conceptually, which should allow us to offer some advice on the most realistic way forward for biodiversity conservation in Lake Tanganyika.

Figure 6.2 illustrates three models representing general approaches to conservation projects and programmes. All three models aim to use some form of project interventions (the hexagon on the left of the model to maintain the state of biodiversity (the box on the right).

1. No Linkage: State-run protected area strategy



2. Indirect linkage: Economic substitution strategy



3. Direct Linkage: Linked Incentives Strategy

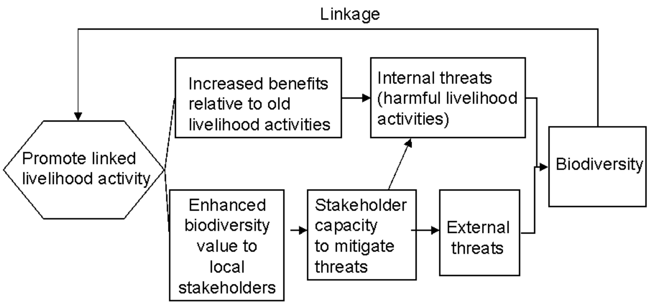


Figure 6.2 Models of three conservation strategies. Hexagons indicate possible intervention strategies, while rectangles indicate conditions at the site of the intervention (from Salafsky and Wollenberg, 2000)

Biodiversity can be thought of as having three main attributes: the species (or other taxonomic unit) present, the area of habitat present and the degree to which the habitat is able to maintain its ecological functions. This target condition is affected by one or more human-caused direct threats, subdivided into internal threats that are caused by the stakeholders living at the project site, and external threats caused by outsiders. Examples of direct threats in Lake Tanganyika include over harvesting of fish or water pollution by factories in Bujumbura. Behind these direct threats are causal factors that are less often visible, but may be significant drivers of the threats. These many include local livelihood needs, government development policies or local road and transportation development (Salafsky and Wollenberg, 2000). In the case of Lake Tanganyika, the security situation around the Northern and Western lake probably means that people are unwilling to make long-term investments in land and the maintenance of soil fertility, as tenure is uncertain. This is likely to result in few measures being taken to conserve soils, and therefore in increased sedimentation and land degradation.

Conservation projects[16] can use a mixture of different strategies or interventions to combat threats at a given site. The three conservation paradigms illustrated in Figure 6.2 correspond to three such strategies: direct protection, economic substitution and linked incentives.

Model 1: Direct protection is the current model for conservation in Lake Tanganyika. People are excluded from areas set aside for biodiversity conservation, and they benefit little from conservation activities (Meadows and Zwick, 2000). The 'fines and fences' approach used by national parks, and indeed the notion that people must be kept apart from nature in order to conserve it has been much attacked in recent decades (see Chapter 5 for discussion). While such approaches may be effective in meeting conservation objectives, given adequate resources for enforcement (Margules and Pressey, 2000), they do not address the needs of people living around, or displaced by such conservation enclaves. In the protected area model, livelihood activities appear as an internal threat to conservation, and the response to that threat is to implement a protected area. Much of the thinking behind the LTBP project's early conceptualisation was driven by this model, and it remains the best established approach to conservation in the region, despite its current failure in Rusizi and the pressures on parks elsewhere. Given the levels of poverty and livelihood insecurity experienced by many in the lake catchment, there is also a moral imperative to prioritise development and seek compatibility between development and conservation. The protected area strategy remains an anachronism given this imperative and serious analysis of alternatives is urgently required.

Model 2: In the economic substitution model, the project's strategy is to attempt to implement livelihood activities such as the development of rural industries that provide an alternative to livelihood options seen to threaten biodiversity, such as farming on steep lakeshore hillsides, or fishing with beach seines. This approach is being attempted by a DANIDA funded Coastal Zone Environmental Management programme in Malawi. Identifying and promoting such alternative livelihood activities is incorporated as a main objective of the socio-economics component of LTBP (Meadows and Zwick, 2000) but alternatives have proven difficult to identify. These authors were, however, able to suggest a range of development interventions to assist in modifying existing livelihood activities to add value to harvested natural resources and reduce environmentally damaging activities (Box 2 in Meadows and Zwick, 2000). Economic substitution models have suffered from unclear linkages between conservation and economic incentives, and from the 'honey pot' effect, where development activities near parks attract people into the area, thereby placing greater strain on the natural resource base (Salafsky and Wollenberg, 2000). Providing income-generating alternatives to local people that are not linked to incentives for biodiversity conservation also fails to mitigate against external threats. Anyone not benefiting from alternative livelihood activities provides a potential threat to the environment. In the Lake Tanganyika basin, this could include the many people displaced by civil conflict.

[16] A project is here broadly defined as "any actions undertaken by any group of people interested in achieving certain defined goals and objectives" (Aalafsky and Wollenberg, 2000).

Model 3: The linked incentives model attempts to 'close the loop' by linking biodiversity and the livelihood intervention. The linkage is the driving force behind a sequence of activities leading to conservation. Livelihood activities that counter internal threats should enhance the value of the biodiversity to the local people, thus prompting them to take actions to mitigate both the internal and external threats to the biodiversity. In other words they both benefit financially or in terms of livelihood security and are empowered by the conservation project. In Lake Tanganyika, the development of eco-tourism, sport fishing and the aquarium trade are often cited as examples of ways in which biodiversity conservation can be linked to enhanced livelihood opportunities. We believe such thinking to be unrealistic (see Chapter 5 for discussion and analysis) but also point out that no analysis of costs and benefits of conservation has ever been undertaken (see previous section).

We have already pointed out that linkages between biodiversity and indirect benefits to local livelihoods in the form of ecosystem services are unsupported by evidence (see Figure 6.1 and associated text). We would also contend that there are limited linkages between the most biodiverse areas and livelihood activities in Lake Tanganyika. Lindley (2000) has pointed out that the links between threats to inshore fish diversity and fishing are indirect. Most fishing activity targets the species-poor pelagic ecosystem, and a theoretical threat exists whereby collapse of the offshore pelagic fishery through over fishing could lead to increased exploitation of inshore areas by people desperate to obtain nutrition and income. At present, much of the inshore fish fauna is relatively lightly fished by a wide variety of small-scale gears. Thus, the degree of dependence of livelihoods on diversity is low, and the biodiversity-livelihood linkage is weak. Weak biodiversity-livelihood linkages are not a good prerequisite for integrated conservation and development programmes that seek to sustain both livelihoods and diversity by enhancing the value of such linkages (Salafsky and Wollenberg, 2000). Neither is there a link between livelihood sustainability of people involved in farming and the lake's biodiversity. Loss of littoral zone diversity through increased sedimentation will have little impact on livelihoods of farmers in the catchment. Thus, there are no ways to link incentives to biodiversity conservation with improved livelihoods. This suggests that integrated conservation and development programmes (Model 3) are not feasible

Our main conclusions are thus:

- Linkages between biodiversity and livelihoods in Lake Tanganyika are weak and indirect at best.
- Linkages between biodiversity and ecosystem function (and therefore provision of ecosystem services) are unproven but also likely to be weak
- Financial benefits from alternative livelihoods associated with conservation activities are likely to be very limited

And therefore:

- Integrated conservation and development programmes that are self-sustaining are not currently feasible in the Lake Tanganyika basin. Funding for conservation activities will have to come from external sources if conservation is not to impose costs on those living around the lake.

External funding could come from either governments or international agencies. Analysis of lessons learnt from biodiversity conservation projects in Africa (Hart et al, 1998) suggests that the commitment of many African national governments to biodiversity conservation programmes is weak. Such programmes are seen as the external imposition of an international environmental agenda and governments can even be hostile to programmes promoted and managed by external agents that are perceived to favour "animals and trees over people". Hart et al (1998) conclude that biodiversity conservation programmes are unlikely to be sustainable unless they are integrated into country development strategies, or financed indefinitely by the international community.

We leave it to others to assess whether ownership of the SAP, legal convention and Lake Basin Management Authority is sufficient (and carries sufficient political weight) to compete for resources within country development strategies, or whether continued international finance will be required to support the international interest in Lake Tanganyika's biodiversity. The main conclusion of the Socio-economic special study is that:

> "the biodiversity of the lake will only be managed sustainably and conserved through programmes of poverty alleviation, livelihood diversification, and social and economic development in lakeshore communities, within a context of security and institutional reform"
>
> (Zwick and Meadows, 2000, p40).

These authors admit, however, the difficulties of achieving this. We agree with their interpretation and would reiterate our suggestion that funding for such activities should not come from the local people who need the resources but not the diversity. It should come from those who value the biodiversity but don't need the resources i.e. - the 'global community'. This implies continued international funding of conservation programmes, and detailed attention to ways of transferring financial resources for conservation in support of the type of poverty alleviation programmes identified by Zwick and Meadows (2000). Such a conclusion is not unique, and there have recently been other voices raised to question the prevailing orthodoxy of development through conservation. Godoy et al (2000) argue that local forest dwellers in Central America should be paid for non-local values of rainforests as an incentive to resist deforestation. We argue that the lake dwellers of Central Africa require the same consideration in order to preserve the non-local values of Lake Tanganyika.

6.3.5 Inshore-offshore trophic and fishery linkages

The importance of inshore-offshore trophic links has long been considered, in the particular context of interdependency of Lake Tanganyika's fisheries (Coulter, 1991; Lindley, 2000). The interdependency has, however, never been formally studied, even qualitatively. Identifying the main inshore-offshore linkages could provide a more rigorous basis on which to base both current management decision-making, and future research in this neglected field of study in African Great Lakes.

Of particular relevance is identification of the role of inshore ecosytems as spawning and nursery grounds for commercial fish. It is well documented (see Coulter, 1991 for review) that three of the commercial perch species (namely *Lates mariae*, *L. microlepis* and *L. augustifrons*) have a juvenile inshore phase lasting up to one year[17]. The key habitats for these species are the reed beds composed of *Ceratophyllum*, *Vallisneria* and *Patamogeton* and, to a lesser degree, the roots of emergent vegetation (*Phragmites*) and even among rocks (Thompson et al, 1977). *L. microlepis* appear to use macrophyte beds as nursery areas, and may spend up to a year (25-180 mm TL) in these habitats, young *L. microleps* live inshore after leaving weed cover, recruiting to the pelagic zone on reaching maturity at around 500 mm TL (age 3-4 yrs).

Field and laboratory studies into the habitat preferences of juveniles of two *Lates* species are reported in Kondo and Abe (1985). Both species are found to settle on grass beds, with *L. angustifrons* preferring the short grasses composed of Vallisneria sp.; while *L. mariae* prefers the taller grass beds composed of *Potamogeton schweinfurthii*. Nocturnally active, both species fed mainly on shrimp, moving onto fish as they grow. Shrimps are abundant in the shallows (<6m), with 12 of the 13-recorded endemic species being found in weedy habitats (Kimbadi, 1989). These 12 species belong to the *Atyidae, while* the 13th species is from the Palaemodindae family (Kimbadi, 1993).

These biological results are important foundation for understanding the linkages between inshore and offshore habitats. While more detailed research is required, we highlight the need to locate these sites of littoral vegetation, assess the pressures on them and identify suitable management actions.

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17 In contrast *L. stappersi* juveniles remain in the pelagic zone

The biological interactions within multi-species fisheries are formally recognised in Article II of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), signed in 1980. This convention has been viewed as pioneering the way towards what is now widely known an 'ecosystems approach' to natural resource management. CCAMLR's interpretation of 'ecosystem' is firmly rooted in a biological understanding of the fishery, i.e. the trophic implications of targeting different species in the Southern Ocean surrounding the Antarctic. More recent adoption of the ecosystems approach by the CBD (as its primary framework for action) and others such as The World Bank and IUCN, explicitly acknowledge the environmental, socio-economic and cultural components of 'ecosystem' and thus recognise the broader context of managing natural resources, particulary those with significant biodiversity. A significant initative in ocean research and management is the idea of a 'large marine ecosystem' - of which 50 have been identified in the world (see www.edc.uri.edu/lme/default.htm). The GEF (under its international waters and biodiversity programmes) are supporting The Gulf of Guinea Large Marine Ecosystem Project[18].

Independantly, but in line with this trend in managing biodiverse resources, approaches to fisheries management are moving from traditional top-down sectoral control of catch and effort towards a more livelihood-based form of management that is integrated, adaptive, environmentally and locally appropriate. Many of the principles of the ecosystems approach, as defined in CBD documentation (see www.biodiv.org, particularly the working papers of SBSTTA[19]) replicate or are complementary to concepts governing coastal zone management (Clarke, 1992). Indeed CZM could be seen to provide a more rigorous implementation framework to some of the more theoretical concepts defined under the ecosystem approach. See the BIOSS recommended management response (Section 6.4.2) to management of the biodiverse littoral zone and the importance of sustaining the pelagic fishery.

6.4 Management

In our consideration of management of biodiversity, the results from BIOSS now need to be integrated with the outcomes of the other threat-based special studies of the project. For this purpose we provide a short précis of key results from sediments, fishing practices and pollution, but refer readers to the relevant technical documents of these studies.

6.4.1 Threats

Coastal development, particularly the loss of terrestrial vegetation leading to increased siltation, presents a great threat to littoral biodiversity. At present, over much of the lakeshore, this effect is relatively localised around fishing villages and major towns. It is more widespread in the more densely populated areas around the north basin and along the Tanzanian coast. Only major catchment deforestation in erosion prone catchments could provide a wider threat to diversity. The sediments special study addressed the extent to which catchment-wide deforestation presents an immediate threat to biodiversity. Increased sedimentation and other human impacts along the coast of the lake may have altered community structure and reduced biodiversity in adjacent sub-littoral areas. It is not known if any species extinctions have taken place as a result of these activities. It is more likely that local variants may have been lost, and that the distribution of some species has been reduced or fragmented (Patterson, 2000).

Fishing activities provide a potential threat to biodiversity conservation. There are questions regarding the sustainability of exploitation of pelagic fish, particularly the larger Centropomids (*Lates* sp.). Sustainable exploitation issues are within the scope of the Lake Tanganyika Research project (LTR) and are presented as a Fisheries Management Plan for Lake Tanganyika. It is unlikely that these species are threatened by extinction, or significant loss of intra-specific genetic diversity. In recognition of the diversity of littoral zone and to complement the intense research attention on pelagic fisheries, FPSS focused on the incredible range of fishing practices deployed in the littoral zone. Over 50 different practices were described reflecting the diversity of fish and habitat type (Lindley, 2000).

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18 See: www.africaonline.co.ci/AfricaOnline/societes/goglme/goglme.html

19 Subsidiary body on Scientific, Technical and Technological Advice (SBSTTA)

There is little use of habitat-destructive fishing gear in the lake (e.g. bottom trawls, explosives). Thus, fishing activities only impact directly on fish communities. It is possible, of course, that impacts on fish assemblages have knock-on effects on the rest of the ecosystem, but not enough is known about ecosystem dynamics to assess this at present.

Beach seines have already been banned from Tanzania, due to their perceived negative impacts on biodiversity and sustainability of exploitation. There is little evidence of impact, but such evidence is difficult to obtain, so the ban has been implemented under an environmentalist interpretation of the precautionary principle. Experience from the ban of beach seines from the Kenyan shores of Lake Victoria illustrates the role these gears play in a riparian community (Wilson et al, 1999). While beach seines are expensive gears and tend to be owned by prominent people, they require the co-operation of others to pull the net. This provides an important opportunity for men in families who do not have fishing gears to take part in the fishery and access high quality protein. In addition, operation of beach seines is one of the few ways that women actively fish: the value of bringing fresh fish home to their children should not be underestimated.

In Lake Tanganyika, it appears that the ban is not enforced completely, reflecting the very real logistic and practical constraints to monitoring and enforcement of such fisheries legislation in the lake. Sandy shore fish communities are also impacted by other gears, such as gillnets, which target the larger species. There are also a variety of small-scale gears in use on a subsistence basis, whose collective impact on sub-littoral fish community diversity may be significant.

Rocky-shore fish species will be relatively unexpected by fishing activity. Net fishing, except with relatively small gillnets, is not possible where the underwater topography is rocky and complex. Line-fishing and trap fishing are practiced, targeted at a few of the larger species (catfish, murmured, *Lates* sp. Boulengerochromis). All these species are widely distributed, and these activities are unlikely to impact significantly on biodiversity (although once again, ecosystem effects of reducing the abundance of larger, predatory fish is not known). Optimal sustainable use issues are another matter, best considered by fishery management agencies, such as those involved in the LTR project.

A key recommendation from FPSS was that the important role that the pelagic fishery played in the livelihoods of lakeside communities. Many small-scale fishermen target pelagic fish, but have been largely invisible to research focusing on more intensive fishing methods. However this livelihood link is of critical importance to Lake Tanganyika's biodiversity – if the pelagic fishery is not managed appropriately and fails to support these fleets of small-scale fishermen, they will retreat towards the coast putting pressure on the biodiverse littoral zone.

Organic pollution and other contamination from industrial, mining and domestic sources all have potentially serious consequences for biodiversity, again, particularly in the coastal areas. Sheltered bays with limited circulation are most immediately threatened by eutrophication and even quite small, localised sources of pollution. Kigoma harbour and adjacent Bay provide examples of impacted coastal waters. Of the areas adjacent to terrestrial protected areas, only the waters off Rusizi are potentially threatened by river-borne pollution sources. The waters off Gombe, Mahale and Nsumbu are a long way from current major pollutant sources, and are likely to be fairly pristine (Bailey Watts et al, 2000).

6.4.2 Recommended management response

Taking these insights from other special studies regarding the nature of the threats to biodiversity alongside results from BIOSS presented in the previous chapters, lead us to the conclusion that the SAP must have a regionally integrated strategy to deal with localised threats in the littoral zone. Focusing solely on transboundary issues (i.e. the initial impetus for this project) would miss critically important threats, and does not provide guidance for lakeshore development – only for threat mitigation. We feel that by adopting the principles of coastal zone management (CZM[20]), riparian countries can achieve threat mitigation within the context of sustainable development.

A CZM plan for Lake Tanganyika would zone areas according to their conservation importance, degree of threat, and requirements for human development. This system of zoning would set out the type of coastal development permitted in different areas, thus concentrating effort and resources on ensuring such development does not threaten littoral biodiversity. The planning process would aim to minimise conflicts between identified coastal zone uses, and to locate developments according to an agreed plan, rather than the present unplanned approach to lakeshore development (e.g. construction of roads, harbours, settlements etc.). This would also provide a mechanism to mitigate effects of past unplanned development which have an adverse impact on water quality, biodiversity and fisheries resources.

Note that this BIOSS recommendation does not ignore the existence of transboundary threats - appropriate management of the pelagic fishery, as prioritised by FPSS, is a good example of a threat requiring international cooperation. Nor does it ignore the potential for transboundary threats to develop in the future. Rather, BIOSS sees CZM as complimentary, not contradictory, to effective management of transboundary issues. We are not alone in arguing for a CZM approach to the management of large lakes. Such an approach is explicitly recommended in the FAO Code of Conduct For Responsible Fisheries (Article 10: FAO, 1995), and a coastal zone management approach guides an on-going DANIDA project on environmental management in the Lakeshore Districts in Malawi. Legal frameworks for CZM are already in place, with recent importance of CZM in the region highlighted in the 1993 Arusha Resolution on Integrated Coastal Zone Management in Eastern Africa (Shah et al., 1997).

CZM provides a framework which should achieve a co-ordinated approach to addressing threats across the region, ultimately prevent localised threats becoming transboundary in nature, facilitate sharing lessons/experience amongst the four riparian countries and so enhance the regional cooperation necessary for transboundary issues. TANGIS, the geographical information system developed within LTBP, would be a critical information management tool to development and implementation of this strategy.

The core principle of sustainable development requires that the wider strategy of littoral-zone conservation takes into account human-development needs. By adopting a coastal zone management strategy, the regional body set up under the SAP and the Convention, can target resources where they are most needed. Thus avoiding the potentially ineffective strategy of spreading resources widely to maintain a whole-basin, whole-lake approach.

A coastal zone management approach will provide appropriate levels of protection to specific habitats. The original project document specified only two options – national parks, or unprotected areas. In practice, an integrated strategy that specified permissible coastal development on a zoned basis could be a more relevant and cost-effective strategy for biodiversity conservation and threat mitigation and prevention in Lake Tanganyika.

A key implication for the adoption of CZM is the need for appropriate institutional support. As is common in most countries in the world, riparian government responsibility is currently allocated on sectoral grounds. CZM requires that some form of co-ordinating body that draws together fisheries, agriculture, planning, community development, infrastructure, local government etc. so that future development is well planned and managed. Mitigating the effects of past poor development is another key role for such a body.

In an ideal situation, CZM would be government policy and appropriate mechanisms established to facilitate localized planning and management actions. However, co-operation can occur at many levels: for example parks, fisheries, agriculture, tourism, community development could come together and address issues over the aquatic boundary of a national park; or the various departments in a lakeside administration (village, sub-county or district)

[20] Note that the BIOSS contribution to the SAP provides a briefing on CZM, to which readers are referred. See also Scialabba (1998)

could plan future developments jointly. Current trends in the management of common-pool resources[21], such as Lake Tanganyika are for bottom-up approaches. Any implementation of CZM in Lake Tanganyika should draw from these experiences. In fact, FPSS noted in its advice to the SAP that community initiatives along the Zambian coast offered a good basis on which to develop appropriate management plans for fisheries (Cowan and Lindley, 2000): CZM could provide stakeholders with an appropriate framework to begin this work. Experience of implementing CZM in Ireland has been found to be more sustainable if introduced at a small-scale, building on local initiatives (Power et al, 2000). This approach in Ireland also helped address some of the uncertainty about coastal processes and a lack of baseline data: circumstances familiar to stakeholders on Lake Tanganyika.

As with most resource management issues the role of central government is important but complex. National level ministries can provide the necessary framework and support for co-ordinated management at the lake. However, the great distances between the capitals and the lake are a real constraint to the degree to which central government can take a hands-on approach to managing the lake. We believe the flexibility of CZM presents riparian governments and communities with a mechanism to begin making wise management choices for their shores of Lake Tanganyika, in advance of a regionally based management plan.

6.5 Concluding summary

The highest biodiversity, in terms of number of species, is situated in the sub-littoral zone (down to 40 m). We find that a high percentage of this biodiversity is ubiquitous in its distribution, but that there are a limited number of taxa with spatially restricted distributions. 73% of described lacustrine fish (90% of species recorded in BIOSS surveys) were found in waters adjacent to existing national parks. A conservation strategy based primarily on maintaining and extending the functions of the existing terrestrial parks is therefore recommended

This report provides the first detailed analysis of biodiversity assessment surveys for large areas of the lake, based on replicated survey designs. The analysis is limited largely to fish, due to difficulties in surveying other groups. Survey protocols for molluscs have been developed and could now be used to supplement comparative surveys based on fish. Surveys of biota have been guided and stratified by surveys of habitat that have highlighted the need to consider habitats as a fundamental unit of conservation. This extensive dataset has been rigorously analysed to assist the design of future surveys.

The current threats to diversity in the littoral zone are most immediate from localized environmental degradation (deforestation in small and medium-sized catchments, effluent from coastal towns and villages), situated almost exclusively in the coastal zone. Therefore Lake Tanganyika needs a management approach that co-ordinates planning and management of all activities based on the land and the water. By explicitly recognizing the ecological, physical and social links between the two resources, and the need to balance development and conservation, CZM provides managers with a formal structure and a set of well-established management principles to follow.

LTBP had a strong technical focus, providing essential baseline information for the first management plan for the lake. The basis for scientific monitoring and underpinning of management has been established under LTBP, but the wider skills in communication, joint planning, co-operation between different ministries/disciplines and management are still required. Throughout our report, we have stressed the need to consider process issues as well as deliver technical outputs. If the international community still values this unique lake, we would recommend ongoing support that concentrates more on building the institutional capacity needed to ensure sustainable development of this biodiverse resource. We would also recommend a critical analysis of the costs and benefits of such conservation and explicit and development of management approaches that will assist in ensuring that benefits of conservation flow to those who live around the lake, while the costs are borne by all who value it.

[21] Common-pool resources denotes resources that are neither public, nor private

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