Adaptive co-management of harvest reserves in Indonesian rivers

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ABSTRACT

Protected areas are used in many different ways in Indonesia, and for a range of purposes. In inland waters, spatially managed areas include large national parks primarily aimed at nature conservation, and 'harvest reserves' intended to boost fish stocks to improve fishing. Some harvest reserves are established and managed by government departments, while others are implemented by fishing communities. Some are closed all year, while others allow some types of fishing in some seasons - floodplain river fish stocks must be particularly protected over the dry season, to ensure that enough brood fish survive to spawn at the start of the next flood. The benefits of these different types of reserves (either to fish stocks or to village fishers) are not well known, but new reserves are still currently being actively promoted by Indonesian agencies.

A DFID-funded research project is currently investigating appropriate selection criteria and co-management guidelines for harvest reserves in Indonesian floodplain rivers. This paper describes the alternative ways in which reserve benefits may be investigated to ensure their most effective use. Studies of 'edge-effects' around reserves and 'with-without' comparisons between reserved and non-reserved areas are difficult in river systems due to the strong spatial variations in habitat. 'Before-after' studies following the implementation of new reserves are also difficult to interpret due to the strong environmental variations in flood strengths and resource productivity between years. The benefits of harvest reserves may be best detected by studies which compare indices of benefits before and after the reserve is introduced relative to the changes in the same years in nearby non-reserved control sites, assumed purely due to the environment. This paper shows how fishing communities and fisheries departments (or other regional management agencies) may jointly determine the most effective local approaches for harvest reserve by an 'adaptive co-management' approach.

KEY WORDS: Adaptive co-management, harvest reserves, rivers

INTRODUCTION

Reserves, refuges, closed areas, marine protected areas and the like are becoming increasingly popular throughout the world (Roberts and Polunin, 1991; Dugan and Davis, 1993; Shackell and Willison, 1995). For fishery managers, such area-based approaches provide a visible, easily understandable and relatively enforceable means of controlling fishing effort. They avoid the bycatch problems associated with single-species approaches, and the technical difficulties of multi-species ones. However, though closed areas do have clear advantages, their actual impacts are still not well understood for many types of fishery.

This paper looks at the use of 'harvest reserves' as management tools intended to benefit floodplain river fisheries in Indonesia. Harvest reserves are now being implemented by the Indonesian Provincial Fisheries Services as a positive precautionary measure, though without clear knowledge of their benefits. The paper describes the difficulties of assessing the benefits of existing reserves using short term studies. An alternative *adaptive co-management* approach is also described by which the long-term impacts of new reserves (or any other management tool) may be better assessed, using the basic principles of controlled experiments. For floodplain river fisheries, this approach would require the active participation of both regional fisheries management agencies and local fishing communities. Full details on the recommended approaches are given in Hoggarth *et al*, in press (b).

These studies were made under a United Kingdom DFID-funded research project entitled 'Selection criteria and co-management guidelines for harvest reserves in tropical river fisheries', known in short as the 'River Fishery Reserves' project. The project is investigating the basic factors which influence the success of reserves in artisanal river fisheries: such knowledge should at least ensure that reasonably promising reserve locations are selected in future. The management of such reserves may then be optimised in subsequent years, using the recommended adaptive co-management approach. To set the scene for this summary paper, the characteristics of floodplain river fisheries are first described, under their three resource components: environment, fish, and fishing.

CHARACTERISTICS OF FLOODPLAIN RIVER FISHERIES

All fisheries are based on an interaction between the environment, the fish which live in that environment, and the fishers who catch the fish. The complexity of each of these factors is at a maximum for floodplain fisheries, as described in the following sections.

The floodplain river environment

Floodplain river systems are highly variable, both spatially or geographically and over time. Their habitats may include flooded grasslands, flooded forests, small and large river channels, and permanent and temporary lakes and pools. Each of these habitats is used by different fish species for their essential life processes, such as spawning and feeding. The mixture of habitats varies significantly between localities and determines which types of management measures are likely to be of use. Seasonal variations occur both within the year, and between different years. For floodplain fish, the annual cycle divides the year into periods of high productivity during the flood season, and relative inactivity and hardship during the dry season. The variability in the size and duration of the seasons affects the productivity of the floodplain and the effectiveness and profitability of the fishery.

In addition to this natural variability, the demands for irrigation water, power generation and flood control mean that floodplains are increasingly being modified on both a local and a catchment-wide scale (Dudgeon, 1992). Any of the various competing activities may affect the natural functioning of floodplain systems, and their potential for fish production. Fisheries interests must thus be well represented in fora responsible for integrated catchment management. Both the quantity and quality of flood water must be maintained for high fish productivity, the diversity of floodplain habitats must be maintained for high fish biodiversity, and river channels must be maintained to enable the migrations of fish to their spawning grounds. These environmental characteristics of floodplain rivers necessitate a locally-specific and flexible approach to management, supported by a clear recognition of catchment developments and influences.

Floodplain river fish

Floodplains are inhabited by many different types of fish, including strongly migratory 'whitefish' and more locally-resident 'blackfish' able to tolerate the low oxygen conditions of the dry season. As with any fishery, whitefish and blackfish must be managed in spatial units appropriate to their distribution patterns: most whitefish will require a catchment focus, while blackfish may be managed more by villages for their own local benefits. The spatial relationships between waterbodies and the communities near to them will determine who may be able to manage blackfish effectively in each locality.

The level of fishing activity on floodplain fish stocks mainly affects the *species* of fish caught, rather than the total weight of the catch. The most valuable fish species usually decline with heavy fishing, leaving the small, fast-growing fish species which breed rapidly with each new flood. Though total catch weights may remain high in a heavily exploited floodplain fishery, their values usually decline. Managers must thus choose whether to allow heavy fishing for very little profit (e.g. where the objective is to generate employment or provide nutrition to poor people), or to restrain the amount and type of fishing to improve the types of fish caught and the profitability of the fishery.

Floodplain river fishing and its management

The high habitat and species diversity of floodplains is reflected in the complexity of their fisheries. Many different types of fishing gears are used, from simple hooks and traps up to much more elaborate, expensive and effective structures. 'Hoovering gears', such as fish drives, dewatering, poison and electric fishing all attempt to catch any remaining fish stranded in dry season waterbodies. In the most vulnerable waterbodies, these gears may need restricting to ensure the survival of blackfish preparing to spawn with the new flood. Barrier gears must also be particularly managed to ensure the access of whitefish to their spawning grounds.

Floodplain fishing communities often comprise a complex network of 'stakeholders', with leaseholders, middle-men and fishers at various levels of authority and dependency. Access rights for fishing are leased at auction in many of the most valuable places, usually for a one-year period. Bidding at such auctions may be free to all, or restricted to community members. In other localities, fishing places for gears such as barrier traps are allocated by lotteries for just fifteen days at a time. Such alternative mechanisms influence the distribution of fishery benefits between community members, the degree of control held over the fishers and the likely difficulties of managing tools such as reserves. Where they exist, however, such management networks may be valuable starting points for improving control of the fishery.

HARVEST RESERVES FOR RIVER FISHERIES

Types of protected area

IUCN (1994) define six different categories of protected area, including nature reserves, national parks, natural monuments and so on. Such protected area categories are essentially designed to maintain biological diversity, while also recognising a range of other resource requirements or uses. These types of protected areas are used in river systems, and may include whole floodplain regions, with their diverse composition of habitats (eg Dudley, 1996; McDowall, 1984).

In contrast, Carr and Reed (1993) defined a 'harvest refuge', quite specifically as a 'location of restricted harvesting of targeted species for the purposes of replenishing exploited populations through larval recruitment'. This definition recognises the importance of *fishery* benefits over the biodiversity of underlying resources. The definition however, emphasises that fishery benefits would be delivered by a larval dispersal mechanism (as

appropriate for sedentary species) rather than by the emigration of adults, also recognised in other types of reserve (Polacheck, 1990; Roberts and Polunin, 1991; Alcala and Russ, 1990).

In the River Fishery Reserves project, a 'harvest reserve' was flexibly defined as a *spatially-recognisable* area of water, managed with *any specified set of technical regulations*, intended to sustain or increase the *potential fish yield* available from *existing, natural fish stocks*, for the *benefit of fishers*. Before this definition was adopted, reserves were understood by many of the project team to refer only to areas *totally closed* to exploitation for the purpose of nature conservation. The adopted project definition thus allowed increased flexibility in the types of protected areas definable as harvest reserves, and emphasised the importance of giving benefits to fishers, by any natural biological mechanism. The definition also recognised that poor fishers may give higher priority to the contribution that the fishery makes to their livelihoods, than to biodiversity *per se*.

Harvest reserves in Indonesian river fisheries

The River Fishery Reserves project investigated 22 existing harvest reserves, identified in three Indonesian provinces with major floodplain river fisheries. Both reserves and other management practices were used quite differently in the three provinces. In West Kalimantan, community-managed reserves were used in at least three fishing villages in the Kapuas lake district, for the purpose of maintaining local fish stocks. These reserves appeared to be effectively managed by strong, traditional institutions, with restrictions placed only on the most dangerous gears or in the most vulnerable dry season. Interviews suggested that local fish stocks in the villages with reserves comprised more large, valuable fish species, than in some other villages without reserves.

In contrast, in both Jambi and South Sumatra provinces, harvest reserves were more often imposed 'top-down' by the *Dinas Perikanan* Provincial Fisheries Services. The regulations for these reserves usually prevented *all* fishing activities for the whole year, and were enforced by hired guards. Both Jambi and South Sumatra provinces have plans for developing several more riverine harvest reserves in the near future. While the West Kalimantan community reserves were intended to give benefits to fishermen within the village, the *Dinas Perikanan* reserves were intended to distribute their benefits more widely among the villages of the whole catchment. Some of the reserves, however, were located in fairly isolated lakes, and appeared poorly designed for the purpose of generating catchment-wide benefits.

From the results, a harvest reserve categorisation system was developed, by which the 22 reserves were classified under the following headings:

- **Catchment position** (upland or floodplain);
- **Habitat type** (river section or lake);
- **Management regulations** (various levels of partial restrictions on certain gears or seasons, or full, year-round closures);
- **Management agency** (established / managed mainly by government for catchment benefits, or by communities for their own local benefits).

It is clear that harvest reserves may be used in various ways. The ecological characteristics of reserves (their catchment position and habitat type) may be expected to affect their impacts on different fish species. Reserves in floodplain lakes may protect blackfish, while those in more upland river reaches may protect the spawning grounds of whitefish. The degree of closure implied by different management regulations may affect the level of protection offered, but may also affect the potential catch from the resource. A fully-closed reserve located in a village's largest water body may give generous protection to local fish but leave few chances to catch them. The roles of government officials and local communities in establishing and managing reserves are also likely to determine the effectiveness of enforcement. Reserves which are traditionally used by villages may have less illegal fishing than those newly established by government, especially if important traditional fishing grounds are withdrawn from the fishery, against the will of the community. With such variability in management approaches and technical details, it is clear that the assessment of 'reserve benefits' must take account of a wide range of locally specific, multi-disciplinary factors.

ASSESSMENT OF HARVEST RESERVE BENEFITS

This section considers how the impacts of harvest reserves may be assessed, both in terms of where the impacts should be measured, and what they should be measured *against*. The problems of three simple types of assessments are described, and it is argued that properly controlled studies are required.

Benefits within reserves, or benefits from reserves?

Where protected areas are established to conserve fish species, habitats or ecosystems, their benefits should be measured *within* the reserve boundaries. In contrast, the benefits of harvest reserves should be measured in terms of the socio-economic benefits received by fishers *from* the reserve. Such benefits may be measured in the catches outside fully closed reserves, or in the combined catches from both the fished and the reserved areas, where some exploitation is allowed inside the reserve.

The impacts of fully closed reserves on their *protected* (inside) fish stocks have been reviewed for coastal areas by both Roberts and Polunin (1991) and Dugan and Davis (1993). Reserves have been observed to have fish

abundances 2-25 times higher than those outside, and with individual fish sizes 12-200% larger than those outside. Reproductive output may clearly be expected to increase in such situations, but this has proven difficult to demonstrate in field situations. Watson et al (1997) found that fish catches *outside* reserves may be improved, but only where illegal fishing is adequately controlled. Such studies emphasise the need to take stakeholders, and inter-disciplinary factors into account in reserve design and management.

'With-without' studies of existing harvest reserves

During 1998 and 1999, the River Fishery Reserve project is investigating both the status of fish stocks inside different categories of harvest reserves, and the socio-economic benefits and their distribution between stakeholders within their associated fisheries. From the 22 reserves initially examined, 7 were selected for further studies in three main categories: (1) community managed, partially closed, lake reserves, (2) government managed, fully closed, lake reserves and (3) research institute managed, fully closed, riverine reserves. Four non-reserved 'control' sites were also selected for comparison with the reserves, two in category (2), and one each in the other two. The choice of study sites was restricted by the existence of the different combinations of reserve categories, while the 'control' sites were restricted by the lack of nearby water bodies with similar ecological characteristics.

It is intended that these comparisons will provide insights into the factors which affect the success or failure of reserves, both with regard to their protected fish stocks and their socio-economic benefits. It is also clear, however, that these 'with-without' comparisons will not produce accurate estimates of the true impacts of the reserves. While the use of a categorisation system has ensured that a range of different reserve types are studied, it oversimplifies the real factors affecting the state of the resources at each site. The productivity of a given local fishery depends not only the presence or absence of a reserve, but also on a wide range of other factors, including resource ecology (the habitats available and their degradation by any external influences); river hydrology (flooding durations, depths and areas etc.); fish ecology (the species available, and their potential productivity and resilience to overexploitation); fishing practices (the intensity of fishing, the gear types in use and their seasonality); and historical changes in any of these factors. Though the 'control' sites were selected to be as similar as possible to the study sites (geographically, physically and ecologically), there are essentially no sites that provide truly valid comparisons.

As an alternative to with-without studies, the use of 'edge effect' approaches was also considered, as used to infer the 'spillover of adults' from marine reserves by Sluka et al (1997). These approaches are considered invalid in floodplain systems due to their high spatial variations in habitat. A reserve in a floodplain lake may have good fish stocks in its surrounding floodplains simply because they are deeper than those further away, and not because they are closest to the reserve.

'Before-after' studies of new harvest reserves

Where reserves have not yet been established, there are opportunities for studying their impacts using 'before-after' studies, for example by comparing 'baseline' pre-reserve catches with those in the years after implementation. The use of such approaches is constrained in floodplain river systems by the high year-to-year variability in flood strengths and resource productivity, and the long-term trends in external catchment influences, such as deforestation and pollution. Where a new reserve coincides with a poor flood year or an unrecognised pollution outbreak, for example, the impacts of the reserves may be masked by the negative effects of the other factors.

'Controlled' studies of new harvest reserves

It should be clear from the above comments, that the real benefits of reserves may only be determined by the use of properly controlled experiments, combining the features of the with-without and the before-after scenarios. In such experiments, indices of benefits would be compared before and after a reserve was introduced, *relative* to the changes in the same years in nearby, non-reserved control sites.

This conclusion is nothing new: it simply advocates the application of standard scientific principles to the study of reserve benefits. The same conclusion has previously been reached by Roberts and Polunin (1991), and effectively controlled studies of reserve impacts have been made by Polunin and Roberts (1993), Russ and Alcala (1996), and Lincoln Smith et al (1997). These points are made to clarify some of the important design principles necessary for the improved assessment and management of river fishery reserves. The following sections draw together the preceding material to demonstrate how such controlled experiments may be made for riverine reserves as part of an ongoing management strategy.

AN ADAPTIVE CO-MANAGEMENT STRATEGY FOR RIVER FISHERIES

This section describes a collaborative, adaptive strategy by which different types of reserves, or other river fishery management tools, may be assessed and managed for the maximum long-term benefits. The strategy is based on the appropriate use of simple and understandable tools, and the ongoing monitoring of their impacts to ensure the achievement of selected stakeholder objectives. The strategy avoids the use of any underlying population dynamics model, as such tools may never fully account for the local, ecological complexities of floodplain river fisheries (Walters et al, 1998). The alternative, *adaptive* strategy is 'management objective driven' rather than 'stock assessment driven' (Mahon, 1997), and may be applied by resource managers and communities without the

need for highly academic training. The recommended approach is described in much greater detail by Hoggarth et al, in press (b).

Co-management

There is a growing trend towards the use of stakeholder participation in both the design of resource management strategies and their actual *co*-management (see e.g. Pomeroy and Williams, 1994; Bohnsack, 1997). A co-management approach may provide access to the 'traditional ecological knowledge' (TEK) of local people, most familiar with their natural resources. TEK is particularly required for floodplain resources due to their high spatial variability. Local people may often know where different blackfish species survive over the dry season, and how they may be protected. Reserve sites should be selected jointly by fishers and managers, and defined with reference to recognised local ecological features, rather than to abstract measures such as grid references (Neis, 1995). Communities may also be best placed to enforce regulations and resolve conflicts, but only where they perceive that their participation will meet their own needs and desires. Communities should not be expected to enforce regulations, designed top-down 'on their behalf', simply to relieve the work load of the fisheries department.

While co-management approaches do have strong appeal, they are neither simple to apply nor suitable for all situations. A wide range of preconditions have been identified where community management has been successful (Pinkerton, 1989; Ostrom, 1990; Pomeroy and Williams, 1994). Such preconditions include clearly defined boundaries around resource management units, recognition and respect by fishers for management institutions (either community or government), strong monitoring and conflict-resolution systems, and legal support for local participation in management. Some preconditions are better met in some floodplain locations than in others. In Indonesia, the strongly hierarchical administration and the low mobility of traditional fishermen give good prospects for floodplain fishery co-management, as is indeed already practiced in some villages and districts (Hoggarth *et al*, in press (a)). In Bangladesh, external support from NGOs in encouraging the wide participation of all stakeholders has been required to achieve co-management goals (Middendorp *et al*, 1996; Rahman *et al*, 1996).

Co-management thus involves many different roles, which must be well recognised and clearly allocated (Hoggarth et al, in press (b)). Local community management may only be successful when legislative support is provided such that fishermen have clear rights to participate in the management process and to benefit from such participation. Significant changes may be required in national fisheries legislature, to achieve the appropriate conditions for such community management (Bailey and Zerner, 1992).

Co-management, then, will require new levels of communication and cooperation between stakeholders. A co-management approach implies a move away from the scientific search for the 'optimum' reserve design, destined for universal, top-down implementation, and towards more flexible solutions designed by management partnerships for each local situation. Co-management of river fisheries requires a 'process' approach, and not a 'blueprint' one.

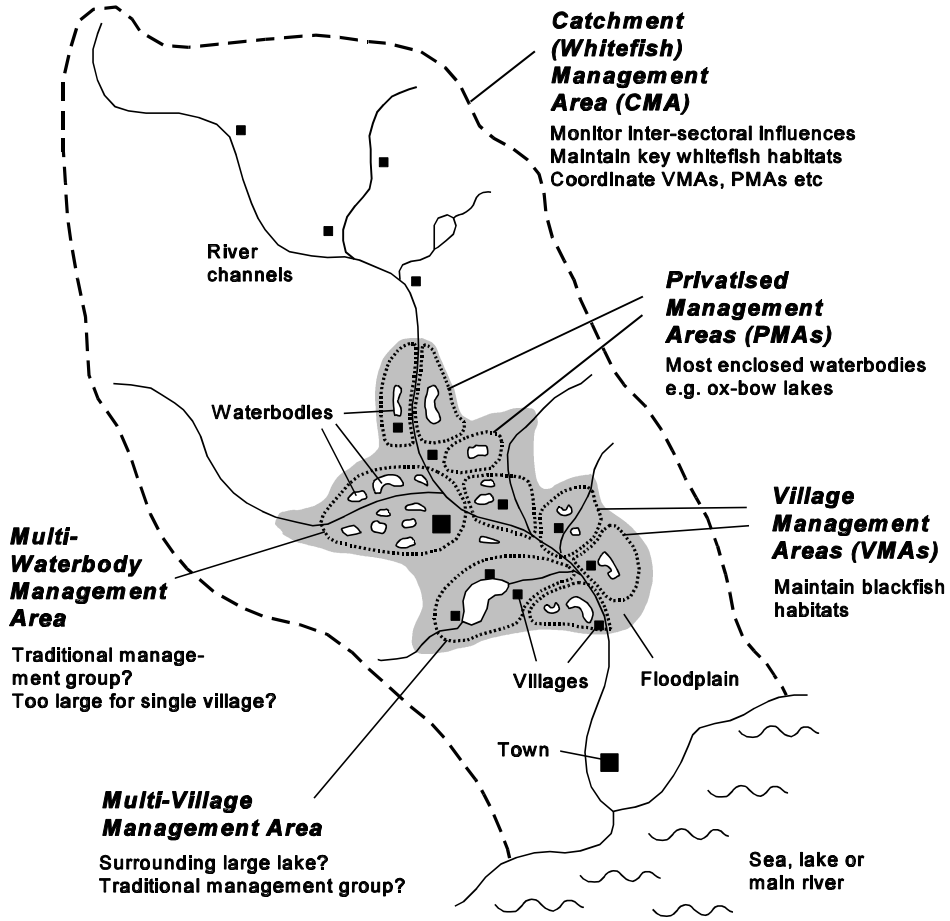
Fishery units and spatial management

As described earlier, floodplain river fisheries display high spatial variability in their environment, their fish and their fishing communities. Such diverse resources may be managed by sub-dividing them into spatial 'management units'. Management responsibilities may then be split between a catchment management authority and a number of other smaller agencies, each managing a local sub-unit. Within reasonable limits, management objectives and tools may vary between the sub-units, to accomodate the preferences of local communities and the ecological characteristics of each locality.

At least five different types of management units may be recognised (Figure 1). The largest 'catchment management areas' (CMAs) would cover the full distribution ranges of whitefish, and may include either full river basins, or sub-catchments within them. The smallest units would be closer to the distribution ranges of blackfish species, and may be either village-based (VMAs) or privatised (PMAs) in the most enclosed waterbodies. Between CMAs and VMAs, there may be a range of other possible management units, depending on the spatial relationships between waterbodies and communities. These may include single large waterbodies (floodplain lakes) fished by two or more surrounding villages, and single villages or towns lying alongside large, multi-waterbody floodplain systems (see Figure 1).

CMA managers should be responsible for (1) managing migratory whitefish stocks for the overall benefit of the catchment's fishers, (2) coordinating management activities in the smaller fishery units, and (3) representing fishery interests in sectoral talks on integrated catchment management. The smaller management areas should be responsible for managing their own local fish stocks, using appropriate tools. VMAs and PMAs provide the strongest management opportunities for *local* blackfish stocks, where fishing communities have traditional control over their own local waterbodies, in areas small enough to manage effectively. Simpler management tools may be needed for the intermediate-level management units, due to the increased difficulties of monitoring, coordination and enforcement in these larger areas. Guidelines for the types of tools appropriate in each type of unit are given by Hoggarth et al (in press (b)). Harvest reserves are only one of a range of alternative options for river fisheries, and may be more suitable for some places than others due to the combination of hydrological, ecological and social factors.

Figure 1. Examples of alternative river fishery management units



To subdivide a river into management units, existing government administrations (e.g. village boundaries) and any other traditional institutions should be built upon where available. Such units may take advantage of existing management skills, local knowledge and systems of authority. In addition, however, CMAs should be identified if possible on hydrological grounds, as the geographic area from which water and pollution etc. drains into the river system. Management units should also be selected to achieve the maximum overlap between the range of authority of the selected local agency (e.g. a village), and the distribution range of a fish stock. Sub-division of the catchment into sub-units thus requires information on the spatial distribution of four items: waterbodies, fish, fishing and any existing management institutions. Regional data on some of these subjects may be available from existing records of the fisheries departments and planning agencies; local data may need to be collected by interviewing key members of each fishing community.

Adaptive management and controlled comparisons

Dividing a river catchment into management sub-units would serve two purposes. Firstly, it would allow locally acceptable management tools to be used in each of the different units, as appropriate to their local conditions. Secondly, it provides a framework by which the impacts of reserves or other management tools may be assessed using controlled comparisons. While a range of tools may be appropriate in different units, their detailed impacts in each situation are difficult to predict in advance. A comparative adaptive management approach would enable such effects to be determined, and gradually fine-tuned across a catchment.

Under adaptive management, the *level* of a management tool may be adjusted (either up or down), or the mixture of tools used may be modified, until the specified objectives of management are achieved. If it is found, for example, that a new reserve does not improve a given objective as much as hoped, it may be possible to introduce another reserve in a different waterbody, or to add a ban on a certain dry season gear in other nearby waters. As discussed earlier, the true impacts of such *before-after* studies may only be assessed using controlled studies, relative to other unmodified areas. Adaptive management of a sub-divided catchment therefore requires both local monitoring *within* units such as VMAs, and broader comparisons between units at the CMA level. CMA-level managers may further improve their ability to distinguish management impacts from those due to external factors by talking with the managers of other sectors, and monitoring long-term trends in the catchment.

The monitoring approaches required for adaptive management are given in Hoggarth et al, in press (b). In addition to monitoring the *outputs* from the fishery (as related to the selected objectives), managers should also monitor any changes in the *inputs* to the fishery. Important factors may include both the overall level of fishing (the numbers of fishers and gears etc.), and environmental factors such as water levels, and changes in land use patterns.

Monitoring of the fishery should best be undertaken as a collaboration between the fishing community and the management agency. In the case of VMAs and the other smaller blackfish management units, the fishing community and the management agency may essentially be one and the same. Fishers then have the maximum incentive to participate in the management and monitoring activities, as their results have the most direct relevance to themselves and their community. Involvement of the fishing community in the monitoring programme has the following advantages: (1) fishers will be able to see, for themselves, the impact of the management strategy; (2) fishers will be more likely to believe the data produced, if they are involved in its collection, and (3) fishers may supplement the capacity of government management agencies, who usually have insufficient resources and staff to monitor fisheries on their own.

For the larger CMA whitefish management units, the management agency may need to collect monitoring data from across a wider area, without having direct links to the fishing communities. CMA managers may thus need to rely mainly on data from their own field staff, possibly supplemented by data from any villages also managing their own fisheries.

Whoever is involved in the data collection, managers should always try to report the results of the monitoring programme to the community, preferably showing whether or not the community's objectives for the fishery are being achieved. Results should be displayed in public places and presented to fishers and other stakeholders at public discussion meetings.

Summary of requirements for successful management

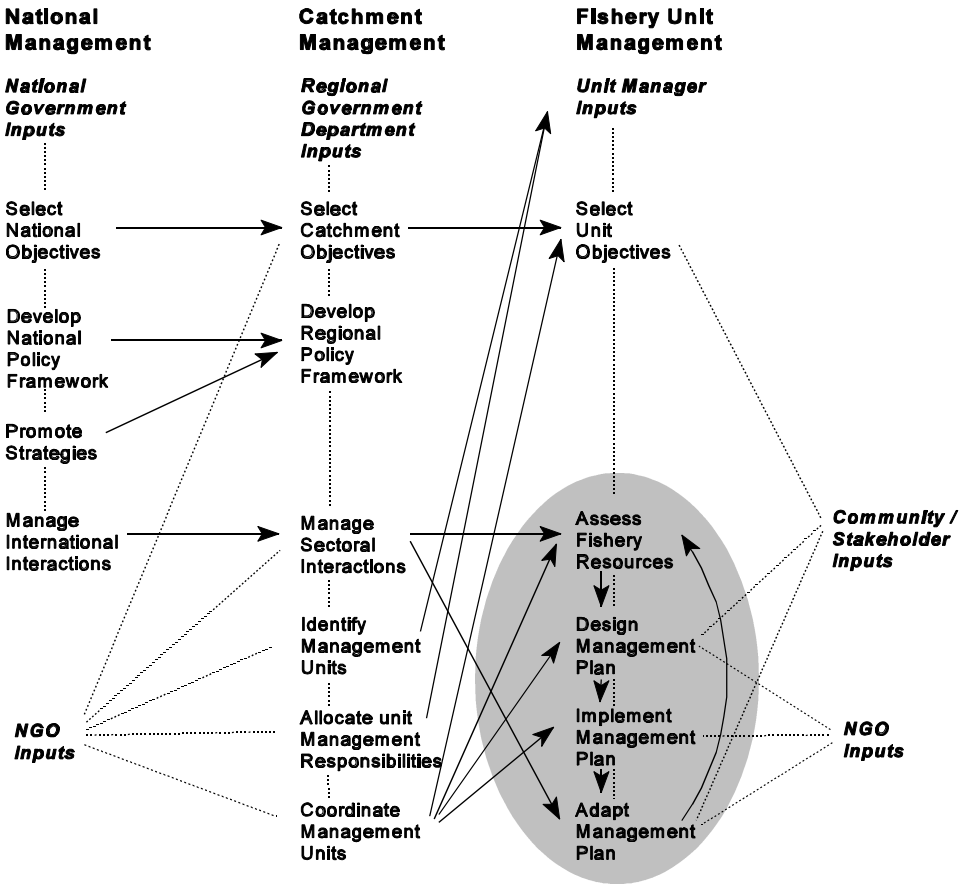
In summary, it is clear that effective adaptive co-management of reserves and other management tools for floodplain fisheries will require many important steps. Effective contributions are required at three levels: by national-level policy makers; by catchment managers; and by the managers of the individual fishery units from CMAs down to VMAs. The necessary steps are summarised in Figure 2, and described in far more detail in Hoggarth et al, in press (b).

The main responsibilities of national level fisheries agencies (the fisheries ministries / directorate generals etc) must be for the promotion of improved management systems, and the endorsement of activities at the lower management levels. Decentralised management can not proceed effectively until the rights of local people and agencies to manage are recognised and clearly stated in the legislation.

At the catchment level, the main requirements are to provide the necessary leadership and coordination of the lower management units, and to act as the overseers of any controlled comparisons between fishery management units, designed to improve understanding of the fishery. The actual management of river fisheries would take place at the lowest levels, within the different types of fishery management unit, from VMAs etc. for blackfish, up to CMAs for whitefish. The actual adaptive management process within the management units is relatively simple in itself (see the shaded area in Figure 2). Though some communities have practiced such 'adaptive' approaches for centuries, their understanding of their resources may still be enhanced by the interpretation of results at the catchment level. Catchment managers, who will nearly always be government staff, are thus responsible both for managing whitefish stocks in their CMA-level units and also for coordinating and assisting the managers of all of the other smaller sub-units. While the strategy thus emphasises the decentralisation of management responsibilities to the lowest possible levels, it is clear that this process still requires major inputs from all levels of government.

The strategy proposed here represents the culmination of several years of detailed technical studies on Asian floodplain rivers. It must be acknowledged, however, that the recommended approach has yet to be fully field tested or validated, and it is inevitable that many clarifications or modifications will be required. It is nevertheless suggested that some form of hierarchical and spatial sharing of management responsibilities between government and local communities, accompanied by strong coordination and communication, and an adaptive approach, may yield many benefits for floodplain river fisheries.

Figure 2. Management activities required for effective co-management of fishery units (dotted lines indicate inputs by different agencies; solid arrows indicate the flow of information between different activities; the shaded area indicates the main components of the ongoing adaptive management process)



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