SESSION 5 REVIEW INFORMATION, KNOWLEDGE AND POLICY

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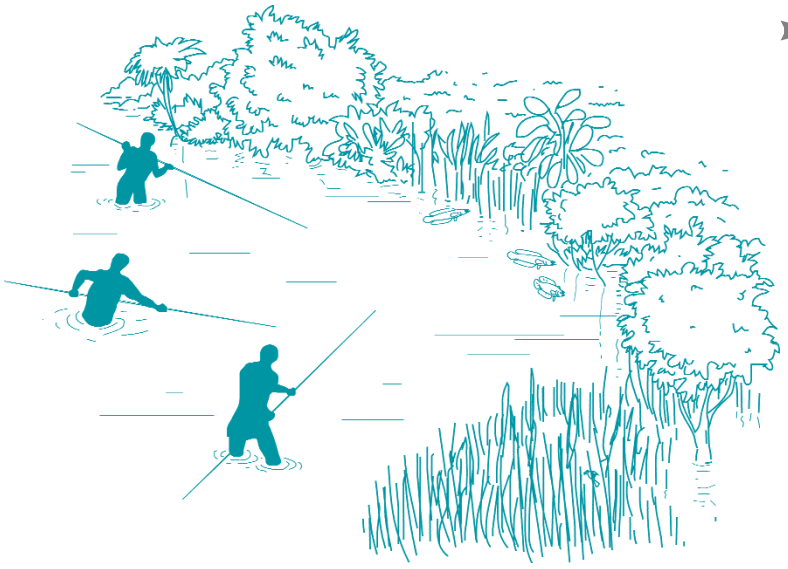


OVERVIEW

This review focuses on the links between information, knowledge and policies and in particular to identify gaps and areas where progress has been made and future needs. It assumes the following broad definitions: information – *facts or details*, knowledge – *information, understanding and skills that are gained through education and/or experience*; policy – *a plan, rule or way of acting, agreed or chosen*. The difference between information and knowledge is important. The latter recognises better the wealth of information available through

informal knowledge based sources, particularly local knowledge held by riparian communities.

Policies are obviously important, or should be. The general descriptions of the dire state of river fisheries and biodiversity imply that policies are lacking, inappropriate and/or their implementation is ineffectual. Some contributions to the symposium argue that policy execution is poor because different stakeholders have different policies (official or otherwise). Others blame the lack of appropriate management methods and capacity. These differences must be disaggregated. It is symptomatic that not a single contribution to this symposium dealt with policy analysis in any depth leading to the conclusion that such an analysis is urgently required.

The session assumed that "river fisheries science" should be management focussed. In only a few cases are links to improved management apparently absent, but in too many others they are not well articulated. Very few contributions dealt with information requirements and systems directly (e.g. Boivin *et al.* 2003; Bush 2003; Friend 2003; Hirsch 2003; Lerner 2003; Poulsen, Hartman and Mattson 2003; Suntornratana and Visser 2003) and none do so comprehensively. Applied research should be objective focussed and tailored to the information needs for management and policy development. A major problem is that with biologically, socially and politically complex river fisheries, information needs and priorities are often far from clear. It was also concluded that the information for river fisheries should be reviewed more thoroughly than can be achieved here. The lack of a professional body to guide river fisheries science perhaps contributes to a certain degree of randomness in current approaches.

Scientists often assume that the production of information, even where pertinent, will lead to improved policies and management. That this is not the case is patently obvious from the multitude of authors who recognise that many management requirements are not technology or information based. Hirsch (2003) draws attention to the complex relationships between information, knowledge and policies for river fisheries and the need to consider issues of ownership, participation and lines of tension between the various stakeholders. The way in which information is produced and used is equally, if not more, important than the information itself (Hirsch 2003; Friend 2003; Poulsen *et al*. 2003). The need to change governance systems for river fisheries, including appropriate modifications of information generation and flow, policy generation and decision making mechanisms, is a clear message from this symposium.

Amongst the advances in technological approaches to information generation, the field of remote sensing deserves particular mention. Boivin *et al*. (2003) summarised the subject noting that the technology is becoming more accessible and affordable and being used more widely. Considerable interest was shown at this symposium in such approaches and several presentations and posters illustrated the value of the technology.

RIVER FISHERY STATISTICS

Current statistics for river fisheries might be mistakenly regarded as the first point of call for relevant information. However, Coates' (2002) review of inland fisheries statistics in South-East Asia, noted an almost complete disconnect between national statistics and policies, planning and management. Constraints include the almost universal underestimation of river fisheries production and the general absence of accurate information on livelihoods dependency and biodiversity. A major drawback is that objectives, methods and assumptions for information generation are invariably based upon those derived for marine fisheries. There is an urgent need to develop information approaches more in-tune with the differing requirements for inland fisheries. The review is considered widely applicable to most other regions. Coates (2002)

and FAO (1999) should be consulted for recommendations for improved approaches. Unless detailed investigations indicate otherwise, with few exceptions, policies for river fisheries should not be based upon current national statistics and no contributions to this symposium question this conclusion.

Contributions to this symposium show that there is in fact a great deal of useful information available on large river fisheries. The problem is often in collating existing information and addressing constraints between information, management and policy. Information in country or regional reviews is often enhanced by incomplete research information synthesised by local fishery experts (e.g. Hossain *et al.* 2003; Lae *et al.* 2003; Quiros 2003) or incomplete survey or census information. In general, observed trends often paint similar patterns of over exploitation, increasing participation, falling catches or changing species composition (e.g. Catela 2003). Such generalisations are rarely substantiated by conclusive data. Only one paper presented to this symposium (Poulsen *et al.* 2003) suggests methodologies for improving meaningful statistical information. Friend (2003) questions the need for improved statistics as a priority, arguing that a better approach is to empower local communities in management decisions.

Despite the diffuse and diverse nature of river fisheries there are good examples of local fisheries that can, in theory, easily yield accurate catch-effort data for monitoring of trends (e.g. van Zalinge *et al.* 2003; Parsamanesh 2003). Commercial large-scale operations can be monitored using conventional approaches as long as transboundary factors for migratory stocks are considered (Baird and Flaherty 2003). One-off research surveys (e.g. Béné 2003; Lalèyè *et al.* 2003; Poulsen and Hartman 2003; Petrere 2003) provide useful 'snap-shot' information. However, methods for using such information in sustained monitoring and management are not well established (Coates 2002).

A more holistic approach to information systems for large river fisheries is required. This includes a shift of emphasis from classical, marine fishery derived, catch-effort information to improved information on the environment and socio-economic parameters and especially livelihoods related information (e.g. Lae 2003; van Zalinge 2003). This should be integrated with improved co-management approaches whereby resource users are better empowered to set management objectives and are more fully involved in the information and policy process (e.g. Poulsen and Hartman 2003).

CLASSICAL FISHERY MANAGEMENT APPROACHES

Classical stock-assessment models attempt to predict the level of effort at which the maximum amount of fish can be sustainably captured from a single stock. It is often not a useful approach for river fisheries, except possibly for those in undeveloped river reaches which concentrate on a few large species (e.g. Catella 2003; Vaz and Petrere 2003). The approach also has value in highly developed river basins (Schramm 2003). Recreational and sport fisheries are usually important in both kinds of systems and stock assessment approaches can provide valuable fisheries management/policy information. Most of the general review papers presented at this symposium include the use of time-series catch data (Chen, Duan, Liu and Shi 2003; Fashchevshy 2003; Lae 2003; Petrere 2003; Quiros 2003; Schramm 2003; Slynko 2003a) and some of them also include fishing effort data, though in most cases continuity of data is not ideal (e.g. Jackson 2003; Slynko, Kiyashovka and Yakovlev 2003b). River fisheries are usually based on a large number of species and a wide range of fishing gears. Such multi-species, multi-gear, fisheries are not generally amenable to the more classical methods of stock evaluation. Moreover, fishery resources in large rivers are affected greatly by environmental factors (both natural and human induced). Environmental degradation and habitat loss, not excessive fishing

effort, is reported as the major cause of declining fisheries in most rivers under stress. Multi-species models (see Welcomme 1999) predict better the behaviour of multi-gear riverine fisheries under both environmental pressure and increasing fishing effort (e.g. Chen *et al.* 2003; Faschevsky 2003; Lae 2003; Quiros 2003). The contributed papers are not explicit on how to separate the effects of overfishing and environmental change in complex systems where both effects are at play. Most relevant contributors to this symposium conclude that increased attention to management of the environment is required, but very few suggest how this can be best achieved. The suitability of catch-effort based approaches to river fisheries science is rarely addressed. It is therefore difficult to assess whether these approaches are adopted by choice, through proven management benefits, or whether they are a legacy of the marine fisheries roots of contemporary river fisheries science. Certainly, there are few cases cited where such approaches have actually resulted in improved management.

For the monitoring of fishing pressure, total fishing effort and catches, together with time-series data for water quality, for most important landing sites are argued to be a basic source of information (Baird and Flaherty 2003; Batista 2003). Such data can be easy and cheap to collect and are often a requirement for sound management (Evans 2003). This will also contribute to assessing important links between catches and hydrology. Large river floodplain fisheries exhibit a high degree of variation both between and within years. Long time series for data are therefore highly desirable, but often lacking due to the inability to sustain monitoring programmes. This is at least partly because knowledge/information systems are often externalised from users and stakeholders.

Methods of producing improved fisheries management information are implied in several papers and span several orders of spatial magnitude. These include at the basin level (Brenner *et al.* 2003; Darman 2003; Koehn 2003; Schramm 2003; Payne *et al.* 2003; Oliver 2003; Quiros 2003; Schiemer 2003; Sridar 2003), for long distance migratory fish (Baird and Flaherty 2003; Petrere 2003; Poulsen 2003), to fisher community involvement in fish management at the local level (Arjjumend 2003: Bocking 2003; Evans 2003; Friend 2003; Hirsch 2003; McGrath, Cardosa and Sa 2003; Poulsen and Hartman 2003; Ruffino 2003). Basin scale management requires linkages between fisheries and related environment policies, including sustaining migratory stocks. Riparian communities are better placed for improving policies for stock exploitation, resource management and environment protection at the local level. A major requirement, not yet adequately addressed, is to empower the latter group to have a major influence on environmental management, including at the basin level.

The papers presented at this symposium reflect the reality that river fisheries vary widely between regions. Relevant factors include management objectives, the state of the resources and environment, population pressures, levels of economic development and socio-political settings. Some of these factors are illustrated in Table 1. Policy development for large river fisheries needs to bear in mind this wide range of operating circumstances.

Table 1: A sample range of states of river fisheries and the potential applicability of stock assessment based management approaches

Management objective	Relevant fish size/habits	Maximisation	State of River Basin	Biodiversity Concerns Explicit in Management	Stock Assessment	Basin Examples	This Symposium Papers
Few and valuable large species	large size potamodromous	conservation (?) recreation	undeveloped or low developed	No	Yes	Upper Paraguay Amazon	Catella Vaz and Petrere
Few and less valuable large species	Large and medium size potamodromous	Economic Yield	Developing	No	No?	Ob-Irtysh basin Middle Parana Ponto-Caspian Region Orinoco Yangtze	Kasyanov Quiros Faschevsky Layman and Winemiller Chen
Any fish larger than minimum size for first reproduction	Medium and small size	Fish Yield	Developing	Not Prevailing	No?	Middle/lower Mekong Niger	Evans Lae
Limited management, fished-down fisheries, low value fish	Medium and small	Employment	Developing Developed	Not Prevailing	No?	Rio de la Plata Upper Mekong (?) Ponto-Caspian Region Yangtze Ganges-Bramaputra Niger Upper Parana Magdalena	Quiros Baird and Flaherty Faschevsky Chen Hossein, Das, Payne Lae Agostinho Mojica
Overall societal goals, preferred and possible state high valued fish	All sizes but still not many large	Conservation Recreation Aesthetics	Developed	Yes	Yes	Mississippi Murray-Darling Garonne	Brown Schramm Koehn and Nichol, Gehrke Brosse *et al.*

WATER RESOURCES MANAGEMENT

All relevant reviews at this symposium identify water resources management as a key factor in sustaining river fisheries and biodiversity. Not surprisingly, a large number of contributions to this symposium have explicit or implicit relevance to integrated water resources management (IWRM) in all regions (Table 2). IWRM is concerned with balancing spatially diverse multi-sectoral demands on the water resource system, normally within a defined policy framework that places socio-economic objectives uppermost alongside environmental protection and enhancement. IWRM strategies employ a mix of structural, non-structural, regulatory and economic measures to meet policy objectives. Water resource demands are viewed as either consumptive (permanently removing water from the system) or instream (maintaining flows and

water quality within specified limits). River (including floodplain) fisheries are examples of instream demands, alongside navigation and maintenance of water quality requirements. River fisheries have faced competing demands from principally the agricultural, energy, urban and industrial sectors. Furthermore, these same pressures have resulted in increased demand for fish, leading often to unsound and unsustainable fishery practices.

Interventions in the river system will alter the regime and impact upon fisheries. A major challenge for IWRM planners is therefore to devise strategies that establish river fisheries at an appropriate and sustainable level consistent with a balanced achievement of policy objectives. Thus policy makers and decision-takers need to be informed about what levels are realistically achievable (given the competing demands), what trade-offs are possible and the significance of these. To assemble this information requires the capacity to know what river regime conditions exist and how these may be impacted by alternative interventions, together with how those conditions impact upon on fish populations and their sustainability.

Technologies to collect relevant water resources information are generally well developed. In some countries however, extremely little direct information on water use is available, particularly where irrigation is the main consumptive use. Monitoring the impacts of water resources interventions on people and the environment, particularly with respect to fish, is less comprehensively applied, particularly in the developing world. Nevertheless, as this symposium suggests, new technologies are being developed and both generic and location specific studies are being taken up (Table 2). Public awareness of these issues is growing as a result of higher educational standards and the advocacy of grass-roots organisations, although few papers reflect this important aspect of environmental management.

Table 2: Contributions to this symposium by subjects related to Integrated Water Resources Management

Authors	River system	Region	Authors	River system	Region
Methods of collection of relevant water resources information					
No papers					
Monitoring water resources and water management interventions					
Monitoring technologies					
Boivin, Coates, Werle	General	General	English *et al.*	General	Canada S. America
Rajyalakshmi	Godavari	India	Suntornratana	Songkram Mekong	Thailand Southeast Asia
General impact studies					
Baird and Flaherty	Mekong	Cambodia Southeast Asia	Wei	Yangtze	China
Monitoring of specific interventions and/or locations					
Adite	Mono	Benin, Africa	Ekanayake	Mahaweli	Sri Lanka India
Jabeen	Indus	Pakistan, India	Jutagate	Pak Mun, Mekong	Thailand

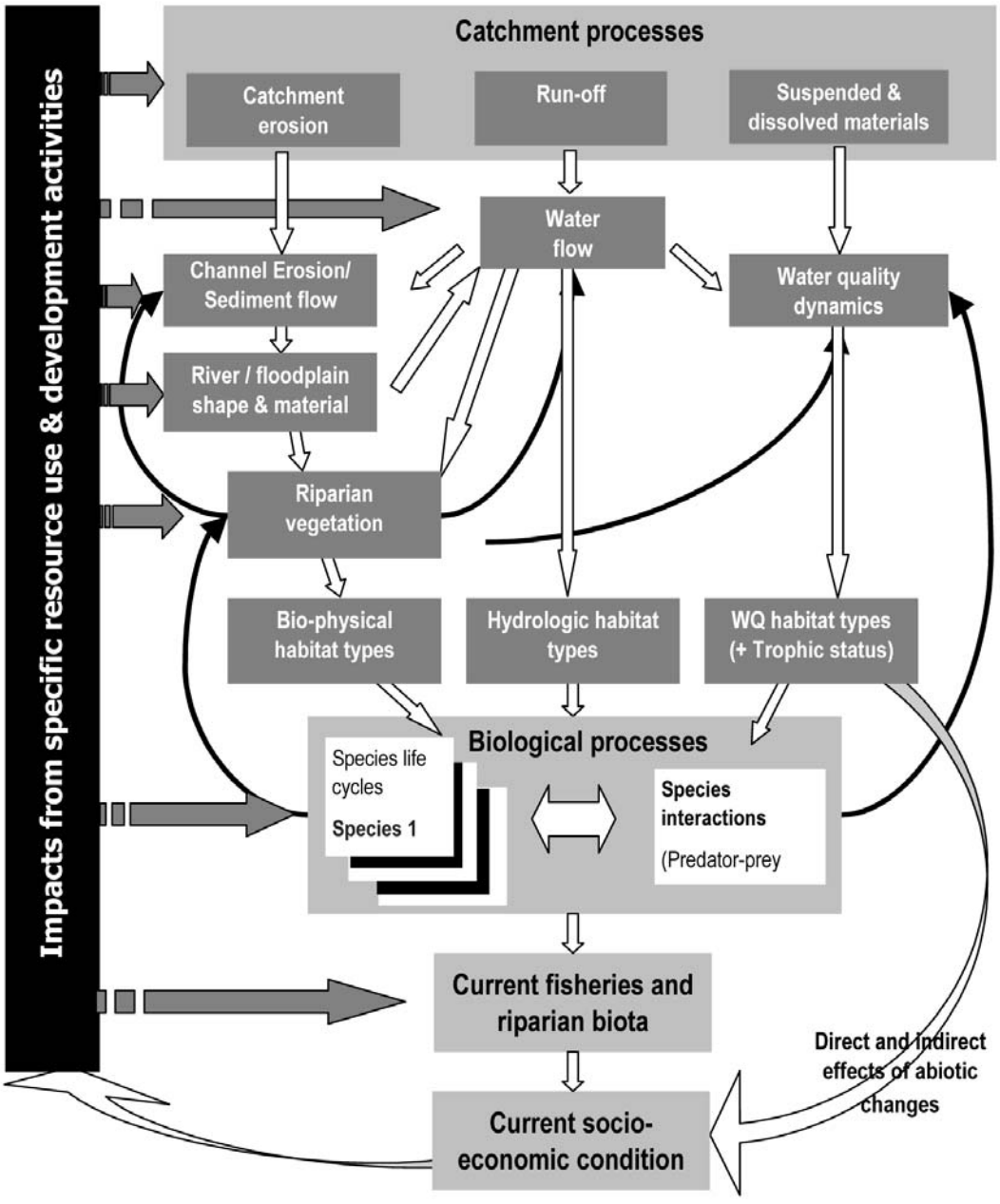
Authors	River system	Region	Authors	River system	Region
Kabir and Sharmin	Ganges, Brahmaputra	Bangladesh India	Slynko *et al.*	Volga	Russia Asia
Sripatrprasite	Pak Mun Mekong	Thailand Southeast Asia	Winter	Vecht Rhine	Netherlands Europe
Impacts of water resources management on fisheries					
Analytical techniques and models					
Arthington, Rall, Kennard	Orange	South Africa	Baran, Makin, Baird	Mekong	Cambodia, Southeast Asia
Halls and Welcomme	Brahmaputra	Bangladesh, India	Hortle *et al.*	Mekong	Southeast Asia
Humphries	Murray Darling	Australia	Junk	General	General
Kennard, Marsh, Pusey, Arthington	Mary	Australia	Marsh and Kennard	Mary River	Australia
Milhous	General	General	Morand	Mali -Niger River	Mali - Africa
Zalewski	General	General			
Studies leading to generic approaches					
Abell	General	General	Arrington and Winemiller	Orinoco	Venezuela, South America
Baras, Marmulla, Lucas	General	General	Brenner and Buisje	Rhine	Europe
Brosse, Lim and Lek	Garonne	France, Europe	Brummett	Rainforest rivers	Cameroon, Africa
Carvalho de Lima	Amazon	Brazil South America	Darman	Amur	Russia, Asia
Flotemersch	Yockanookany	USA North America	Gehrke	Murray Darling	Australia
Hossain *et al.*	Ganges	Bangladesh India	Layman and Winemiller	Orinoco	USA North America
Lim *et al.*	Kirindi Oya	Sri Lanka South Asia	Nguyen Khao *et al.*	Melun R.	Turkey Asia
Oz *et al.*	Melen	Turkey	Pacini	General	General
Pouilly	Mamore, Amazon	Bolivia South America	Poulsen	Mekong	Southeast Asia
Pusey and	N. Queensland	Australia	Pusey b	Burdekin	Australia
Quiros	La Plata	South America	Saint-Paul	Amazon	Brazil South America
Sousa, Fabre, Batista	Purus, Amazon	Brazil South America	van Zalinge	Mekong	Cambodia Southeast Asia
Welcomme and Halls	General	General	Winemiller	General	General
River specific studies					
Ahmed *et al.*	Titus Ganges	Bangladesh India	Alonso and Fabre	Amazon	Brazil, South America
Araujo-Lima	Amazon	Brazil, South America	Bart	Mekong	Southeast Asia

Authors	River system	Region	Authors	River system	Region
Boisneau	Loire	France, Europe	Brown	Susquehanna	USA, North America
Chen *et al.*	Yangtze	China	Crossa and Alonso	Amazon	Brazil, South America
Das *et al.*	Barak / Brahmaputra	India	De Silva	Nilwala	Sri Lanka India
Fashchevsky	Danube, Dneisr, Dnepr, Volga	Russia, Europe	Feunteun *et al.*	Loire	France Europe
Fu *et al.*	Yangtze	China	Hossain	Karnafuli R.	Bangladesh India
Jackson	Yazoo, Mississippi	USA N. America	Jimenez	Sao Francisco	Brazil
Kasyanov	Ob - Irtysh	Russia, Asia	Kurup *et al.*	Kabbini, Bharathapuzha, Chalakudy, Periyar and Kallada	India
Lae *et al.*	Niger	Africa	Lalaye	Oueme	Benin - Africa
Lewis	Orinoco	Venezuela South America	Mojica	Colombia Magdalena	Colombia South America
Nguyen Khao *et al.* b	Mekong	Lao PDR Southeast Asia	Olivier a	Rhone	France Europe
Ouch	Kompong Trelach, Mekong	Cambodia Southeast Asia	Petr	Amu Darya / Syr Darya	Russia Central Asia
Payne, Sinha, Singh and Huq	Ganges	Ganges India	Petrere	Amazon	Brazil, South America
Ruffino and Dalley	Amazon	Brazil	Schramm	Mississippi	USA South America
Shrestha	Koshi, Gandaki and Karnali	Nepal - India	Silvano	Jurua, Araguaia, Negro / Amazon	Brazil - South America
van Zalinge	Mekong	Southeast Asia	Vaz	Pantanal	Brazil South America
Information required from fisheries for sustainable management of water resources Management approach					
Abbott	Zambezi	Africa	Agostinho and Gomes	Parana	Brazil South America
Batista and Petrere	Amazon	Brazil, South America	Bene and Neiland	Logone Chari	Nigeria Africa
Chang, Park and Lek	Yangtze	China	Evans *et al.*	Guadiana Portugal	Portugal Europe
Filipe *et al.*	Guadiana	Portugal	Kibria	Ganges	Bangladesh
McGrath and Alcilene	Amazon	Brazil South America	Rai	Koshi, Gandaki and Karnali,	India Nepal

Authors	River system	Region	Authors	River system	Region
Oviedo and Ruffino Asia	Amazon	Brazil, South America	Sripatrprasite	Pak Mun, Mekong	Thailand Southeast
Assessment of socio-economic impacts					
Almeida, Lorenzen, Grath	Amazon	Brazil, South America	Bene and Neiland	Logone Chari	Nigeria Africa
Bush	Mekong	Lao PDR Southeast Asia	Hand and Voinov	Mekong	Cambodia Southeast Asia
Haque	Brahmaputra	Bangladesh	Kaunda	Malawi	Africa
Hassan	General	General	Kawanga	Luapula - Mweru	Zambia Africa
Alam	Buriganga	Australia	van Brakel *et al.*	Mekong	Southeast Asia
General assessment methods					
Darwall and Vie	General	General	Das	General	India
Flotemersch	General	USA North America	Friend	General	General
Halls, Shankar, Barr	General	General	Hogan	Mekong	S.E Asia
Lek, Brosse	Garonne	France Europe	Minte-Vera	Upper Parana Brazi	Brazil lSouth America
Means of influencing policies on water resources in relation to river and floodplain fisheries					
General knowledge of river systems					
Catella	Parana	Brazil South America	Faisal	Ganges, Brahmaputra, Meghna	Bangladesh, India
Gopal, Brij	General	India	Guo	Mekong	Viet Nam Southeast Asia
Education and awareness raising					
No Papers					
Appropriate political frameworks					
Arjjumend	Narmada	India	Castro	Amazon	Brazil, South America
Fuller	San Joaqqin Sacramento Rivers	USA North America	Gentes	General	Chile - South America
Koehn and Nicol	Murray Darling	Australia	Lerner	Mekong	Cambodia, Southeast Asia
Tun Myint	Rhine	Europe	Parveen	Ganges, Brahmaputra	Bangladesh India
Pettitt and Sim	Mekong	Cambodia Southeast Asia	Ruffino	Amazon	Brazil South America
Scanlon	Murray Darling General	Australia			

Institutional arrangements are often an impediment to comprehensive impact monitoring of interventions, with the often still-powerful water/agriculture /energy lobbies pitted against those from environment/fisheries. Institutional and policy reforms backed by new legislation are slowly redressing this situation, along with changing economic realities. There is a clear appreciation that the wider institutional issues need to be tackled.

The impacts of water resources management upon fisheries are complex with many factors to consider. Interventions directly impact on the physical and biological conditions, which in turn determine the quality of aquatic environment available for different species, thereby influencing socio-economic conditions and options (Figure 1).



■ **Figure 1:** Interactions between water resources use, physical and biotic factors, environment and fisheries in large rivers.

The relationships between physical interventions in the water resource system and the qualitative and quantitative conditions are relatively well understood and relatively easy to predict using a variety of well-established mathematical models. These tools are data intensive, however, requiring multiple geo-referenced layers of land, water, climate and physical information.

The relationships between qualitative and quantitative conditions in the water resource system and the productivity, diversity and sustainability of river and flood plain fishery resources is clearly complex and in need of continued study, as the wealth of papers submitted in this area reflects. It is particularly pleasing to note that many of these papers are directed at developing new analytical techniques as well as generic understanding of the issues. Scientists are always quick to claim limited data and understanding as a basis for demanding more research. But it is evident that there is already a clear basic understanding of how river fisheries function at the ecological, environment and social levels. Perhaps more than any other aspect of this symposium, the drawing together of this research is vital for the fisheries sector to lay claim to its share of water resources. There is a need to progress beyond the very generalised statements of the past to a coherent and rational justification of fisheries demands from the water sector. This requires stakeholders to articulate the case for river fisheries much better and to work closer with other users of water under an integrated policy and planning framework. It is clear that river fisheries managers are not doing this well enough.

Management of water resources requires strategies that provide a sustainable balance of socio-economic values gained from different uses in accordance with policy aims. In order to evaluate choices that include river and floodplain fisheries, the planner must be able to (i) know what range of conditions in the river system would be favourable to fisheries (and equally those which would not be) and (ii) given those conditions are provided what would be the socio-economic value of those fisheries under prevailing and future fisheries management practices. Then an analytical model linking the socio-economic costs of providing different conditions to socio-economic benefits of fisheries could be relatively easily constructed, based upon which trade-offs could be made with alternative uses of water. Whilst progress is being made in some of these areas it is not obvious from this symposium that river fisheries science has clearly and explicitly targeted these fundamental requirements. It should do so and urgently.

This symposium demonstrates that productivity and sustainability of river fisheries are *inter alia* a function of the way they are managed. The papers also show that evaluating the socio-economic benefits of fisheries requires a very clear understanding of the role of fisheries within society, locally, regionally and nationally. The conclusion has to be that fisheries and their nature are optional in rivers and subject to societal preferences. The mechanisms by which those preferences evolve and the information systems upon which they are based are therefore the most critical aspects of river fisheries management, yet the least studied.

Modern water resource management policies already commonly recognise the broad range of uses that a river system can be put to and the imperative of sustainable development. The inequities of the recent past have been highlighted with increasing recognition of the commercial and nutritional values of river and floodplain fishing and, in particular, the importance of the role that fishing plays in sustaining the poor and disadvantaged sectors of rural communities. This symposium has significantly reinforced this awareness. There are perhaps three key ways to further ensure that water resource management policies are appropriate to the needs of river and floodplain fisheries:

1. Improved knowledge

The socio-economic value of water for fisheries must be well understood; otherwise other uses inevitably will gain favour. Similarly, the opportunity costs of providing conditions favourable to fisheries need also to be evaluated, requiring that those conditions can be specified with reasonable confidence and transparency. Several papers reflect the value of taking a holistic view of fisheries within river basins and thus promoting a better understanding of these issues. Livelihoods based approaches also appear to offer an improved framework for making multi-sectoral comparisons of the benefits of developments. Further progress in this area is desirable as it is clear from this symposium that the outcome will likely be to the benefit of fisheries.

2. Education and awareness

Ideally, policies are supposed to reflect societal preferences. If the stakeholders are fully aware of the comparative importance of fisheries to them as individuals and to society as a whole, then policies will increasingly reflect that importance. None of the papers submitted directly address this important issue (Table 2). Fisheries science, in general, appears particularly inept at communication although it is clear that there is much useful and interesting information that could be used in well-targeted media campaigns.

3. Appropriate institutional, legal, regulatory and economic frameworks

Sound principles must be applied in all these four areas if policy decisions are to be effectively implemented. A number of papers address ways by which management at the sectoral level can be enhanced. There is also a clear message from this symposium that the lack of participation of relevant stakeholders (resource users) in policy formulation and implementation is a significant constraint to achieving sustainable development goals for river fisheries and natural resources more broadly. Governance issues override most others.

THE ROLE OF LOCAL KNOWLEDGE IN INFORMATION GENERATION

In most developed countries, the population at large is unlikely to have much direct interest in, or knowledge of river ecology. Scientists and technical specialists working on behalf of regulators and interest groups will dominate the information process, relying mostly on conventional scientific methods for their judgement (Lorenzen and Arthington 2003). In most developing countries the livelihoods of the majority of rural people are intimately linked to river ecology and local and traditional knowledge on relevant subjects is normally profound (Poulsen *et al.* 2003). Local knowledge is probably not more widely used because river fisheries science remains dominated by "westernised" approaches. This is counterproductive for improved participation of people in the information-knowledge-policy process and a significant waste of valuable knowledge.

Things are improving. There is an increasing awareness globally that conventional fisheries science, including its embedded information generation, is not adequate for management and policy-making in relation to river fisheries (e.g. Friend 2003; Poulsen *et al.*; Hirsch 2003). Traditionally, local knowledge has been disregarded in the "scientific" community, including fisheries science (Hirsch 2003). Attention is shifting to integrating local knowledge into the overall information systems upon which management decisions are based (Hirsch 2003; Friend 2003; Poulsen *et al.* 2003). Co-management is increasingly being advocated and implemented as a more sustainable management strategy for river fisheries compared to conventional management approaches (Bene and Neiland 2003; Evans 2003; Rai 2003; Kaunda and Chapotoka 2003; Bocking *et al.* (2003); Gentes 2003; Ruffino and Dalley 2003; McGrath and Cardoso 2003; Pettitt and Sim 2003; Koehn and Nicol 2003). Co-management implies the direct involvement of local resource users in the entire management cycle, including information generation (Coates 2002). Often, local knowledge can

bring conventional sample data into context and connect isolated data sets from different sites within the ecosystem. Baird and Flaherty (2003), for example, used local fishers, in combination with their own sample data, to hypothesize on large-scale fish movements in the Mekong River basin. With the silver eel fishery of the Loire River in France, cooperation with local fishers is increasingly seen as the appropriate way to obtain appropriate data and information on which to base management plans (Feunteun *et al*. 2003). Since fishers are present in the environment throughout the year, they are beginning to be seen as "environmental sentinels and partners" by environmental authorities (Feunteun *et al*. 2003). Cooperative research is often seen as a way to get fishers onboard in the management of the resources but it is equally valuable in getting research to be more relevant and effective. Consensus building, across very clear lines of tension between agriculture and conservation interests in California, was successfully achieved through mediation, cooperation and collaborative research (Fuller 2003). Local knowledge can contribute significantly to increased understanding of ecosystems at various scales (Poulsen *et al.* 2003; Bocking *et al.* 2003).

Information, data and knowledge alone do not guarantee knowledge-based decisions. Acceptance of local knowledge has to be accompanied by involvement of stakeholders, including local communities, in the management and decision-making process (Friend 2003). The political 'reality' of information/policy environments determines the type of information that is available and/or used (Hirsch 2003).

ENVIRONMENT AND RIVER FISHERIES

Environmental factors and harvesting are the two major factors limiting and in many situations reducing, river fishery resources. Fish stocks, biodiversity and relevant livelihoods cannot be restored or maintained if important environmental influences are not sufficiently understood.

Basic information on fish ecology is fundamental to both fisheries and environmental management. This symposium has contributed to the growing information base on this subject in large rivers (e.g. Alonso 2003; Baird and Flaherty 2003; Carvalho de Lima and Araujo-Lima 2003; Getahun 2003; Hogan 2003; Kennard *et al.* 2003; Panjun 2003; So and Volckaert 2003; Vieira, Fabre and Araujo 2003). A number of basic information areas for fish assemblages remain relatively unknown including: habitat requirements (physical/structural requirements and water quality and flow over the full life cycle of the species); migration routes and population structure (for many species migration patterns are as yet unknown, making it difficult to manage the stocks effectively); environmental cues (what triggers biological events such as migrations or spawning?); interspecific interactions; river hydrology (deserves special attention as an influential driver for habitat, migration patterns, as a source of environmental cues and a modifier of ecosystem processes, food webs and species interactions). All of these requirements are overlain by a need to collect focused information from well-designed studies that address specific and clearly defined questions. A major constraint in river fisheries science remains the dominance of studies on fish. Other taxa are also important to fisheries and obviously as components of the river ecosystem (e.g. Flotemersch and Blocksom 2003; Hossain 2003; Sripatrprasite and Kwei Lin 2003). There is an urgent need to improve knowledge of these other groups

The standard methods of data collection continue to be through conventional scientific studies using

"experts" and these were the most numerous types of papers presented at this symposium. More recently, increasing attention has been devoted to the compilation and use of local knowledge. This has proven particularly valuable in documenting fish distributions, habitat requirements and migration routes (Poulsen 2003). Community based studies are also being increasingly utilized both because they allow information to be collected cheaply over large geographical areas and because they promote community awareness and education as well as improved ownership of both resources and the knowledge/policy/management process.

In general fisheries have not been seen as ideal indicators of environmental stress in large rivers for several reasons. It is difficult, if not impossible, to disaggregate the impacts of fishing pressure and environmental stress on fish populations. Fish are also highly mobile and can move away from or through degraded areas. Particularly in large rivers, it often is difficult to obtain representative samples. The advantages of "auto-sampling" using fishers are often off set by the difficulties of obtaining accurate catch-effort data. Fish continue to be used as environmental sentinels, but usually in conjunction with other ecological indicators (e.g. Pouilly 2003) including other taxa, for example macro-benthos (Hossain 2003).

Environment information is currently constrained in three major ways: (1) knowledge is often lacking about fauna and flora (species/community levels) and ecological processes; (2) limited understanding (or monitoring) of interactions between human activities and the environment (including the effects of fishing) and (3) problems with access to information and its communication ("publication" of research is particularly a problem in developing countries coupled with poor information storage and retrieval support). Knowledge is often not passed on to, or used by, decision makers because of poor linkages, or because it is often not communicated in appropriate ways. Scientists often work in isolation from policy development and policy makers rarely attend technical or scientific meetings. This was reflected in the almost complete absence of policy-oriented papers presented at this symposium. Policy requires a good understanding of the technical issues, but also an appreciation of the cultural and community context to ensure that policy outcomes are achievable and appropriate. Scientists need to better consider this in research design and particularly in communication strategies.

Ecosystems, particularly large tropical rivers, are biologically complex. The realisation that they cannot be effectively managed on a species-by-species basis has prompted recent shifts towards ecosystem based management approaches (e.g. www.biodiv.org). A number of contributions to this symposium indicate further moves of river fisheries science in this direction. For example, "environmental-flows" (Arthington *et al*. 2003; Kennard *et al.* 2003; Pusey, Burrows and Arthington 2003; Scanlon 2003, Welcomme and Halls 2003), modelling and assessing links between environment and fish production (Barran, Makin and Baird 2003; Halls and Welcomme 2003; Lek 2003; Lewis 2003; Marsh and Kennard 2003: van Zalinge *et al.* 2003), system-wide remote sensing approaches (Boivin *et al*. 2003), ecosystem based conservation zones (Abell, Thieme and Lehner 2003; Filipe, Marques, Seabra *et al*. 2003) and other related approaches (Pouilly and Rodriguez 2003; Zalewski 2003). One of the most useful and enduring, ecosystem-based approaches to large river fisheries management (the flood-pulse concept) was also updated (Junk and Wantzen 2003). There is a need to better bridge the gap between ecosystem approaches and practical suggestions for improved policies and management. For example, Poulsen (2003) assesses migrations of a suite of species under an ecosystem framework and then looks at the implications of this for basin-wide management requirements. The dynamic nature of river ecosystems in both space and time has long been known to have a major influence upon river fisheries

and is well documented in the scientific literature. It is tempting to speculate that our understanding of "ecosystem based" requirements for policies and management are perhaps further advanced for river fisheries science than in some related disciplines. It is incumbent upon river scientists to adopt such approaches more widely and explicitly, for the benefit of both river fisheries management and as potential approaches to the management of other natural resource systems. In particular, there is an urgent need to synthesise existing knowledge on this subject within a management/policy environment. We need to know what exactly is our level of understanding and what needs to be done next.

LIVELIHOODS RELATED INFORMATION

Despite the title and objectives of this symposium, only a small proportion of the contributed papers deal directly with livelihoods. This reflects the historical focus of fisheries research on management of the biological resource system, rather than the resource users. Things are improving. There is certainly more attention to social aspects of fisheries management than at the first LARS (Dodge 1989), even if an imbalance still exists.

There is a general tendency to misuse the term "livelihoods" as a contemporary substitute for "socio-economic". Its specific meaning is important to the discussion of information. Recent thinking on "Sustainable Livelihoods" (Carney 1998) emphasises people centred, dynamic, approaches, micro to macro linkages, adaptive livelihood strategies and attention to the range of "capitals" in use within livelihood frameworks – including social capital such as knowledge. Most of the discussions on livelihoods information at this symposium focus on the type of information and methodological approaches for gathering it. There is less attention to whom the information is for and its purpose. The capacity to participate effectively in decision-making processes is an important aspect of this livelihoods approach. Traditionally, the emphasis in the debate on fisheries information has been on providing information to "policy-makers and planners", rather than on empowering fishery dependent communities to be fully engaged in the knowledge-information-policy setting. There is a clear shift in emphasis in this direction amongst this symposium contributions (e.g. Hirsch 2003; Friend 2003; Poulsen 2003; Bene and Neiland 2003; Mojica and Galvis 2003; Ruffino 2003; Oviedo and Ruffino 2003) including in developed countries (Mackay *et al.* 2003; Bocking *et al.* 2003).

Much of the livelihoods work has come out of a realisation that it is often the poor and vulnerable who are either excluded or receive less (or no) benefits from development interventions. This is very pertinent when applied to trends in river basin development (e.g. Das 2003; Evans 2003; Gentes 2003; Gopal 2003; Gurumayum *et al.* 2003; Hirsch 2003; Hossain *et al.* 2003; Kaunda 2003; Lae 2003; McGrath and Cardoso 2003; Mojica and Galvis 2003; Oviedo and Ruffino 2003; Pacini 2003; Parveen and Faisal 2003; Quiros 2003; Ruffino and Daley 2003; van Zalinge *et al.* 2003).

Traditionally the focus on information for river fisheries has been on catch/production, composition and financial value including effort, gears, habitats etc. (e.g. Ahmed, Hossain and Akhteruzzaman 2003), the numbers of fishers (where data tend to focus on 'professional fishers', but occasionally within the household (Bush 2003), economic costs and benefits, input/output (particularly for aquaculture), consumption and nutrition (e.g. Bush 2003; van Zalinge *et al.* 2003), or is comparative between different livelihood activities (e.g. van Zalinge *et al*. 2003). Less attention is given to the significance of fishing in the context of other livelihood strategies, the distribution of benefits within and between households/communities and access and control over resources (including marketing of resources (Bush 2003), how management decisions are made and their distributional impacts (Evans

2003), the composition and dynamics of 'communities' and households, vulnerability and 'poverty' and linkages between all of these. Information should have some predictive value, particularly if the purpose is to inform initiatives to address poverty and vulnerability. Several papers concerning management, particularly co-management, identify the significance of institutional support to successful management regimes (e.g. McGrath and Cardoso 2003), but more detailed analysis of institutional aspects is conspicuously absent from this symposium contributions.

Local communities themselves best express the importance of fisheries to livelihoods, not by external assessments based upon incomplete or inappropriate criteria (Coates 2002). Bush (2003), for example, points to the level of importance placed upon capture fisheries by rural communities in contrast to more aquaculture-focussed policies of government agencies. Relative importance should include the value of "safety net" aspects of fisheries and social and cultural values. In developing regions, inland fisheries are often regarded as an activity for the poor (e.g. Hossain *et al.* 2003) but can also be an activity for the more wealthy that can fuel economic differentiation (Bene and Neiland 2003). There is an urgent need for a better understanding how fisheries and their management contribute to, or are affected by, wealth differentiation (Hossain *et al.* 2003, Kaunda and Chapotoka 2003). This is particularly important when advocating 'community fisheries' and co-management. The high economic value of river fisheries in many developed regions should also not be discounted, nor the facts that people there also have their livelihoods.

Livelihoods are impacted by change, such as resource depletion (Oviedo 2003), water management schemes (Das 2003), access to resources, markets and economics (e.g. Hossain 2003) and institutional and legal transformation (e.g. Evans 2003). Targeting of management or investment interventions (e.g. van Brakel, Muir and Ross 2003) can be used to identify opportunities to improve livelihoods. This requires that stakeholders identify livelihood benefits (e.g. Bush 2003) and the use of fishers more as a source of management information (Poulsen, Hartman and Mattson 2003).

Current methods of information generation for "livelihoods" tend to focus on "socio-economic surveys" which can be expensive to conduct and difficult to interpret. Participatory approaches can provide improved quality of information but the results are often less preferred to "hard data" by policy makers. Official statistics, if available, tend to be based upon the former. The two approaches are not incompatible and a combination of both is often desirable. A key requirement with either is to clearly establish the objectives of the information generation exercise and how the information fits into the desired policy generation framework (Hirsch 2003).

BIODIVERSITY

Approximately 30 contributions to this symposium dealt explicitly, in part or in whole, with the subject of "biodiversity". Of these, 25 (83 percent) dealt exclusively with fish and two dealt with dolphins (Beasley 2003; Trujillo *et al.* 2003). Although this symposium deals with "fisheries", in most rivers, particularly in the tropics, other taxonomic groups are also very important including molluscs, reptiles, amphibia, crustacea and plants. The lack of attention to these and other taxonomic groups is a major problem. Even for fish, our cumulative knowledge of individual species is very limited. Darwall (2003) and Abell *et al.* (2003) both argue for a more broad based approach to biodiversity management and for greater recognition for the importance of other non-commercial taxa in supporting the ecosystems that maintain fisheries. Appreciation for the role of all taxa within the food webs upon which the fisheries are based must be integrated into management thinking for those fisheries. Although the debate continues, many people believe that complex, more speciose ecosystems are more sta-

ble than simplified systems. Managers should adopt the precautionary approach and manage fisheries to maintain species diversity.

There is a significant bias in "biodiversity" related papers to biological studies of species or communities. But the definition of "biodiversity" most widely used (ref. Convention on Biological Diversity) includes the concepts of both genetic diversity and ecosystem diversity as of equal status to "species" diversity. Two descriptive contributions directly further our knowledge of genetic diversity in river fishes (Hogan 2003; So and Volckaert 2003) and a number of others dealing with fish populations imply links to genetic diversity (e.g. Poulsen 2003). There appears to be a limited but growing interest in "ecosystem diversity" through the "ecoregion" (Abell *et al.* 2003) and "ecosystems" (Arrington and Winemiller 2003; Zalewski 2003) approaches. Environmental flows is a related partially ecosystems based approach (Arrington and Winemiller 2003; Saint-Paul 2003; Welcomme and Halls 2003). Most reviews confirm that it is loss of ecosystem diversity (and habitat area and quality) that is the main cause of the declines in both fisheries and biodiversity. Despite the progress being made, river fisheries science needs to more clearly target ecosystems as a basis for management. For example, although many authors recognise the need for more holistic (ecosystems based) approaches, few have presented convincing examples of how this has, or can be, achieved. In this process, care must be taken that management proposals based upon largely ecological criteria include adequate attention to relevant social and political considerations.

An analysis of the combination of "biodiversity" with other subjects at this symposium reveals the expected bias towards biology/ecology based approaches and a large proportion of contributions are purely descriptive. Less attention is paid to social, political, livelihoods and management aspects of biodiversity. Significantly, all papers that link biodiversity to livelihoods and social aspects of fisheries are based on examples from developing countries (Darman and Simonov 2003; Das 2003; Hand 2003; Haque 2003). This reflects the very different perceptions of the importance of biodiversity between developed and developing regions. Clearly, in developing regions and especially the tropics, biodiversity in rivers is a livelihoods (as opposed to primarily a "species conservation") issue. River fisheries science needs to focus better on the social and political dimensions of biodiversity conservation and management in large rivers. Linkages between biodiversity and economic development (including livelihoods) should be further elaborated, particular as this may influence investment policies for biodiversity related initiatives in large rivers. Until this link is made clear it will be difficult to convince donors that funding for the conservation of biodiversity will also provide benefits to help alleviate poverty.

CONCLUSIONS AND RECOMMENDATIONS – A VISION FOR LARS 3

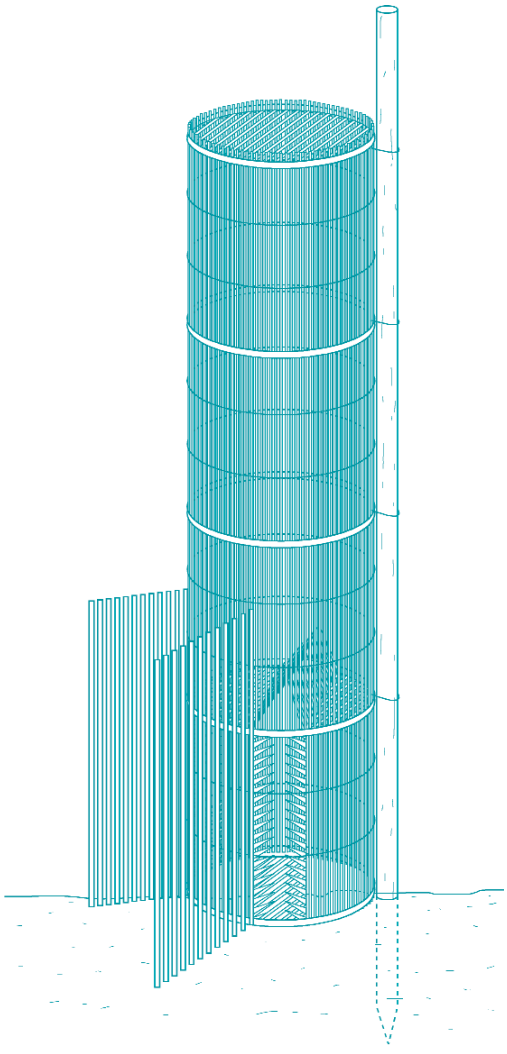
The utopian view of the status of river fisheries that should be reported at the next Large River Symposium (LARS3) would include their role in societies being fully acknowledged in policies and management, with fisheries, livelihoods and biodiversity all being sustained and improved - all fostered primarily through full participation of all stakeholders in the policy and management process, including information generation and those who depend most upon river resources, particularly the rural poor, empowered to influence management outcomes. Few would be optimistic that this will be fully achieved, but this symposium suggests that there is hope. Progress is being made on all these fronts. But how can changes to information, knowledge and policy processes help escalate this trend? The strongest argument is that fundamental changes to governance systems should stimulate the necessary adjustments.

River fisheries science can contribute by evolving in three major directions: better prioritisation of

information needs for river fisheries, including fuller consideration of the political and governance processes under which information is generated and used, including clarified linkages between research and information objectives; by providing more and better ammunition to increase awareness of the importance of improved river management (and especially better identification and quantification of the importance of river fisheries to livelihoods and associated linkages with biodiversity); and by providing an improved understanding of the technical, biological, economic and social basis for improved management (and in particular, the development of improved and practical holistic approaches).

River fisheries science needs to make a significant shift from more classical, primarily biological, orientated research agendas. Recent moves towards more social, cultural and political considerations are welcome but there is still much to do. Neither should the social sciences be blind to the fundamental importance of river ecology. Barriers between disciplines need to be removed if a truly holistic research and management agenda is to develop. River fisheries scientists need to look beyond the narrow confines of the fisheries sector and in particular to focus on environmental, ecosystem and social management, including viewing fisheries within mixed livelihoods settings, as key requirements in their art. Improved water resources management requires fisheries to be fully engaged in relevant policy processes and to contribute information of use to other stakeholders (in particular articulating the social and economic values of fisheries and water requirements to sustain these benefits).

Improved information systems that lead to improved policies and management must be based upon efficient and effective communication strategies. This symposium demonstrates that river fisheries science is generating much relevant information. It is also interesting, when suitably presented, even to the non-specialist. But it is far from clear that this is being effectively communicated. We need the right information to be sent to the correct targets, in the most appropriate form, via the most appropriate channels. It is in this area that perhaps the most progress can be made.



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