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"FISH MANAGEMENT AND CONSERVATION STATUS OF FRESHWATER FISHES : A RIVIEW"

Dr. Pushpa Singh[1] and Dr. Umesh Prasad Patel[2]
[1]Department of Zoology , Govt. Vivekanand P.G. College Maihar, Distt.- Satna (M.P.)
[2]Govt. Swami Vivekanand College Teonthar, Distt.- Rewa (M.P.)

ABSTRACT
The management of freshwater fish for human benefit is undertaken on differing levels throughout the world. In the industrialised countries, freshwater fish are often principally exploited for recreational purposes, whereas in developing countries food production is paramount. In this latter case the detail of what constitutes a fishery, and what are the requirements of the user (Larkin 1980), may be secondary to the more formal management objectives of assessing the fish yield of a water body. Nevertheless, all managers must be aware of the behaviour of their target species, whether this relates to, for example, how vulnerable the fish are to angling, or the success of an artificial reef in acting as a fish attractor.

KEYWORDS: *human benefit , freshwater fish , target species.*

INTRODUCTION
Fishes are cold-blooded, gill-bearing aquatic craniate vertebrates that include both the bony and the cartilaginous fishes but sometimes jawless fishes too. They belong to phylum: Chordata, subphylum: Vertebrata and super class: Pisces. The fishes are not only used as good source of food for mankind, having economic importance from medicinal point of view but also play a crucial role in the second tropic level of the aquatic ecosystem.

The management of freshwater fish for human benefit is undertaken on differing levels throughout the world. In the industrialised countries, freshwater fish are often principally exploited for recreational purposes, whereas in developing countries food production is paramount. In this latter case the detail of what constitutes a fishery, and what are the requirements of the user (Larkin 1980), may be secondary to the more formal management objectives of assessing the fish yield of a water body. Nevertheless, all managers must be aware of the behaviour of their target species, whether this relates to, for example, how vulnerable the fish are to angling, or the success of an artificial reef in acting as a fish attractor. The investigation of animal behaviour, particularly from a theoretical viewpoint, has recently been one of the principal areas of biological research, and the subject has a wider connotation than the traditional ethological approach (Barnard 1983; Huntingford 1984). Such developments may not have been wholeheartedly embraced by all fisheries managers, but whether such information is a necessity to the manager could be a similar debating point to that of the relevance of the more theoretical aspects of ecology to fisheries eclogists (Kerr 1980; Werner 1980). It would certainly be true to say that the application of some behavioural theories, such as optimal foraging, have not been warmly received by all fisheries biologists (Regier, Paloheimo and Gallucci 1979 and discussions in Stroud and Clepper 1979). Although fisheries management must rest ultimately on the application of ecological principles, social and financial factors are major considerations.

The marrying of these often conflicting aspects may prove to be difficult, particularly where economically important species are concerned. Harris (1978), for example, notes the lack of any rigorous attempt to assess the numerous stockings of Atlantic salmon eggs and juveniles in the rivers of England and Wales. By comparison, it is relatively straightforward to evaluate the success or failure of supplemental stocking using the 'put and take' approach; where fish of a desired catch size are added to a water body and are caught and removed quickly by anglers so that the natural constraints of population regulations are bypassed. Although management objectives that set and meet a target of satisfying the demands of the recreational fishery consumer in terms of catch rate may totally disregard scientifically derived information on fish behaviour, such approaches may nevertheless be successful.

However, in those areas such as the improvement of degraded habitats and supplemental stockin of a species where natural recruitment is occurring, there is a necessity for careful consideration of population biology, and fish behaviour therefore becomes important. There are no universal criteria for management practices, and cultural differences mean that some of the widely disseminated fisheries literature from the North American sport-fishery field, which centres on piscivorous fishes, may not be directly applicable to some European recreational fisheries. Taking just two examples to illustrate this point, the pike (Esox ludus) and the carp (Cyprinus carpio) are often managed completely differently. In Britain, pike may be subject to vigorous, if often unsuccessful, attempts to reduce their density, both in salmonid and non-salmonid waters, because they are considered by so me to decrease the abundance of more preferred species. On the other hand, pike are actively and widely stocked in North America. The reverse situation pertains to carp, which are much vilified in North America and subject to active removal whereas in much of Europe the fish is widely eaten and is also an important recreational species stocked in many countries.

However, if such differences are borne in mind, the transposition of knowledge can usefully be made in attempts to enhance or reduce fish numbers in the manner required by management. This account will centre on recreational fisheries, and no major attempt will be made to discuss aquaculture in relation to food production, although there is equally a need for an appreciation of behaviour (Bardach, Magnusson, May and Reinhart 1980). Freshwater life-history stages of diadromous fishes will be considered since they are of major importance, particularly anadromous species, and because of the considerable management effort expended on stock enhancement. Given the broad scope of the subject of fisheries management, some selection of the information available has been necessary. Inevitably there are differences in depth of cover~ age, but four subject areas (general aspects, movements and migrations, habitat and direct stock manipulation) have been recognised in which fish behaviour can be directly related to management.

DISCUSSION:

Managing habitat Purpose of habitat management Alteration and loss of habitat as a result of non-fishing-related anthropogenic activities are major threats to freshwater fisheries (Richter et al., 1997a) and on global scale have had greater impact on fish communities than inland fishing (Arlinghaus et al., 2002). It is thus not surprising that habitat management is the focus of many management initiatives ranging from policies that protect habitat to various enhancement and restoration techniques. Fisheries managers turn to habitat management where there is a bottleneck that limits a critical life stage and the productivity of target species (Cowx & Welcomme, 1998; Bain & Stevenson, 1999). The bottleneck can arise from many sources, from insufficient spawning habitat through disruption to lateral and longitudinal connectivity to bottlenecks in the juvenile rearing stage and loss of habitat diversity. Conceptually, the structure and function of habitat provide an upper bound on the stock–recruitment curve and also affect the slope of this curve (Hayes et al., 1996). By modifying habitat, fisheries managers can attempt to increase the slope and hence the productivity of exploited stocks (Walters & Martell, 2004). Also, managers may attempt to alter the asymptote (i.e. the carrying capacity) of a stock–recruitment curve.

Habitat management may also be used to conserve threatened species. Given the fundamental role of habitat in supporting freshwater fish populations and fisheries, protection of habitat from ongoing anthropogenic change is of primary concern. Obviously, not all freshwater habitats can be protected from alteration in light of societal trade-offs and priorities (e.g. for flood control or hydropower), so alternative approaches are often explored. Most contemporary efforts of habitat management focus less on restoration (i.e. attempting to reach a historical state) per se in favour of rehabilitation (i.e. attempting to achieve some elements of a past state) or enhancement (i.e. improvements over existing conditions).

Mitigation is focused on refining development plans for fresh waters such that their impact on fish habitat is minimized (Cowx & Welcomme, 1998). An example includes installation of fish passage devices at newly constructed barriers in river ecosystems. Compensation is different in that it recognizes that habitat alterations are inevitable and requires that the user of ecosystems compensates for the loss in habitat. Examples include installation of artificial reefs, constructed wetlands or other fish habitat structures (Rubec & Hanson, 2009) or the building of hatcheries for stocking. Having strong habitat protection policy is obviously a prerequisite for applying the concepts of mitigation and compensation in a regulatory framework. Even when such regulations exist, there is evidence that mitigation and compensation activities are not always effective. An audit of fish habitat compensation projects in Canadian freshwater systems, for example, revealed that although there were reasonable attempts to replicate structural elements of fish habitat, function (as measured by a reduction in productive capacity of fish habitat) was reduced in 63% of the compensated sites relative to the altered habitat prior to its alteration (Quigley & Harper, 2006). Also, there is ample evidence that stocking can rarely compensate for severe habitat loss (Walters & Martell, 2004) and hence must always be seen as a measure of last resort. Such examples emphasize that habitat protection for productive fisheries is more desirable than mitigation or compensation whenever socio-economically feasible. For habitat management to be effective, one must consider both structure and function (Hobbs & Harris, 2001). Habitat management, however, often fails to address the functional outcomes and instead focuses on enhancing structure (Quigley & Harper, 2006).

Managing for structure is certainly easier, and metrics of success are often straightforward (e.g. area of habitat restored, number of rocks added to river and number of trees planted in riparian zones). By contrast, the function of habitat (e.g. nutrient cycling and recruitment) is more difficult to monitor but is the critical factor for ensuring success of habitat management actions. Habitat management is often popular among fishers because it is an obvious way of improving a fishery (Arlinghaus & Mehner, 2003; Hickley et al., 2004), but due to non-linear and cross-scale effects, managing habitat is often as much art as science (Van Diggelen et al., 2001). Every year, millions are spent on habitat restoration activities that fail to address the underlying problem that is limiting productivity (Miller & Hobbs, 2007). In some cases, habitat management may not be the best tool for the job. Often, there are also severe budgetary and institutional constraints that prohibit engaging in large-scale habitat restoration activities (Cowx & Welcomme, 1998). The Society for Ecological Restoration developed a series of guidelines intended to assist practitioners in establishing the processes needed to engage in effective habitat management, which serves as a suitable starting point for anyone considering a habitat management project (Clewell et al., 2000). Further planning guidelines, particularly for river restoration and rehabilitation, can be found in Cowx and Welcomme (1998), Welcomme (2001) and Roni et al. (2002). Common habitat management techniques There is a wide range of habitat management approaches available for lotic and lentic fresh waters. Some focus more on addressing fisheries-related issues, while others are focused more on biodiversity, ecosystem health and environmental quality. We primarily describe habitat management techniques that have the potential to address a limitation or constraint on fisheries productivity. We direct readers to a rich literature on habitat management and ecological restoration in general (Hobbs & Norton, 1996; Falk et al., 2006) and more specifically for wetlands (Zedler, 2000), lakes and reservoirs (Olem & Flock, 1990; Cooke et al., 2005), large rivers (Cowx & Welcomme, 1998), small streams (Hunter, 1991; Roni & Beechie, 2012) and catchments (Frissell & Ralph, 1998; Roni & Beechie, 2012).

Managing habitat in Rivers are subjected to many pressures, which are driven by societal requirements for land development, flood protection, water supply, hydropower generation, waste disposal, recreational amenities and navigation. These pressures alter transport of water and sediment, morphology and physical characteristics of the river, and trophic subsidies and interfere with migratory pathways (Poff et al., 1997), all of which can disrupt ecosystem function and affect fisheries yield (Postel et al., 1997). The expanding field of ecological river rehabilitation endeavours to rehabilitate rivers that have suffered anthropogenic disturbances by reintroducing habitat diversity while considering the broader landscape, riparian zones, upstream areas and fluvial geomorphology (Hobbs et al., 2011).

Management of physical habitat modifications in lotic systems The scale of physical habitat management needed to achieve positive outcomes depends on the size of the system and the factors limiting productivity or otherwise contributing to degraded conditions. In large rivers, creating physical structure is a technological challenge. Channel structure can be modified to improve meander patterns through extensive placement of boulders and channel profiling (Nagayama et al., 2008). Materials such as large woody debris can also be added to increase complexity and provide cover for fishes. Some researchers have questioned whether river restoration can succeed given the scale at which systems need to be modified (e.g. meanders and connecting backwater areas; Gore & Shields, 1995). Monitoring of such activities has been infrequent, precluding an assessment of success probabilities in large rivers (Roni, 2005). There are, however, some examples of where physical structure placement or other large-scale habitat modifications in large rivers have resulted in improvements in fish productivity (Cowx & Welcomme, 1998 for popular actions). As large rivers are always downstream of many smaller rivers and they have large catchment areas, a watershed approach to restoration of large lotic systems is usually preferred (Cowx & Welcomme, 1998; Roni & Beechie, 2012). Given the smaller scale of streams and their catchments, physical habitat management activities often result in more immediate results than in larger rivers (Roni et al., 2002). Restoration of streams must include riparian habitats given the importance of shade, woody debris and plants to most stream ecosystems (Naiman et al., 2005). Maintenance of buffer strips (Osborne & Kovacic, 1993) and fencing of livestock to exclude them from streams (Platts & Wagstaff, 1984) represent important riparian-focused management activities. Placement of instream structure is common in small streams and is often done by volunteers or angling clubs (Middleton, 2001). Some structures are intended to deflect water to reduce erosion and create riffle–run–pool sequences, while others provide overhead cover or spawning habitat (Welcomme, 2001). Although stream restoration occurs on a diversity of systems, certainly the most effort has been directed towards salmonids (Hunter, 1991). Instream habitat enhancement appears most effective when employed after restoring natural processes (e.g. provision of connectivity and functional riparian system; Roni et al., 2002).

The science of fishways is continually improving, and what was once a science based on salmonids now has rich examples from many species and regions (Pavlov, 1989). There is also a movement to question the need for passage as barriers serve as means of restricting invasive species and passage of fishes from riverine environments into an upstream lentic reservoir may cause an ecological trap (McLaughlin et al., 2013). Downstream passage requires that fishes are provided a safe path avoiding turbines or other physical damages. As such, various guidance strategies including lights, bubble curtains and louvres are used to direct fish towards bypass channels or other fish collection devices (Coutant & Whitney, 2000).

Diadromous species including the juvenile life stage of Pacific salmonids Oncorhynchus spp. and the adult phase of European eel Anguilla anguilla represent examples for which there is much desire to develop effective downstream passage. Flow management in rivers Virtually all lentic ecosystems are controlled by the hydrological regime (Junk et al., 1989). The changing quantity of water flowing in a river provides habitat and influences water quality, temperature, nutrient cycling, oxygen availability and the geomorphic processes that shape river channels and floodplains (Poff et al., 1997; Richter et al., 1997b). Natural riverine landscapes (riverscapes) are characterized by floodplain, natural flow regime, high hydraulic connectivity, a successional landscape mosaic with high habitat heterogeneity and complex land–water coupling and exchange (Fausch et al., 2002).

The shape and size of river channels, the distribution of pool–riffle habitats and the stability of the substratum are all largely determined by the interaction between the flow regime and local geology and landform (Bunn & Arthington, 2002). Flow regime is thus a critical factor in determining both physical habitat structure and diversity in rivers and needs to be properly managed. Existing methods for the estimation of environmental flows differ in input information requirements, types of ecosystems they are designed for, time which is needed for their application and the level of confidence in the final estimates (Hucksdorf et al., 2008).

The methods range from purely hydrological methods, which derive environmentally acceptable flows from flow data and use limited ecological information or eco-hydrological hypotheses, to multidisciplinary, comprehensive methods, which involve expert panel discussions and collection of significant amounts of geomorphological and ecological data (Hucksdorf et al., 2008). Dammed rivers often have highly regulated flow regimes, and rehabilitation requires changes to dam operations to provide more natural environmental flows (Welcomme, 2001). In peaking systems with flows that vary on a diel basis relative to hydropower demand, regulators often prescribe the range of acceptable flows as well as the rate at which flows can be changed (i.e. ramping rates; Smokorowski et al., 2011) in an attempt to minimize stranding (Nagrodski et al., 2012). In some instances where flows have been modified to yield low and stable flows, the use of strategically timed pulse flows can be used to stimulate upstream movement of migratory fishes (Hasler et al., 2012) or to motivate spawning (Welcomme, 2001). In situations where flow rate is too fast (usually due to channelization) and young fishes are drifted away, decreased releases of flow from upstream control structures may be advisable (Welcomme, 2001).

Managing habitat in lakes and reservoirs Possibly, the most important pressures acting of lake and reservoir fisheries are linked to water quality and water level perturbations (Moss, 2009) and less to physical habitat modification as in rivers. The quality of water is influenced by pollutants including organic wastes, nutrients, metals, poisons, suspended solids and cooling water from urban, industrial and agricultural sources. These drivers can act directly on the fishes, for example, toxicity of chemicals, or indirectly by changing environmental conditions and consequently the suitability of the habitat for fishes, mainly through eutrophication. Slight eutrophication arising from organic effluent discharges and run-off of nutrients can benefit fisheries through increased production (Hanson & Leggett, 1982; Stockner et al., 2000). When the nutrient load is too high and a hypertrophic ecosystem state is reached, however, excessive algal and plant growth may lead to reduced fish production and loss of fish diversity throughout periods of lethally low dissolved oxygen concentrations, especially in the hypolimnion (Schindler, 2006). Acidification of lakes due to acid discharge has the opposite effect because its final stage is an almost dead lake with no decomposition taking place. This type of pollution is most notable in North Europe and Canada where large numbers of lakes have been affected (Stoddard et al., 1999).

Finally, natural fluctuations in water level are a common feature of most lakes and reservoirs as a result of seasonal and climatic variation in rainfall (Ploskey, 1986). The problem is, however, exacerbated in lakes and reservoirs used for water supply and hydroelectric power generation, which control the water level in response to supply demand and power generation requirements. This drawdown, and the way in which it is achieved, may be disadvantageous to the development of fisheries in reservoirs (Beam, 1983; Ploskey, 1986). The littoral zone can become barren, with exposed rock, gravels and sands, reducing the potential spawning and nursery areas for many fish species. In particular, the rapid drawdown associated with hydropower generation has an adverse effect on fishes that spawn in the littoral zone, killing eggs and larvae and thus reducing future recruitment to the fishable stocks of these species (Nagrodski et al., 2012). If this is the case, dedicated management interventions to combat pollution and flow are needed. These actions may be complemented with management of structure and refuges in the productive littoral zones of lakes (Winfield, 2004).

Managing pollution control, treatment and prevention in lakes and reservoirs There are many and varied pollution control and prevention methods to reduce the impact and discharge of potentially polluting effluents to improve water quality and fisheries in lakes and reservoirs including removal of phosphate from detergents, which is increasingly being adopted in Europe and America to reduce eutrophication (Hammond, 1971); phasing out the use of persistent pesticides (Sun et al., 2006); control of acidic emissions (Schindler, 1988); and diversion of effluents (Beklioglu et al., 1999). Diversion of effluents may be desirable to allow one waterbody to be sacrificed for the sake of another; diversion may not merely transfer the problem elsewhere if the recipient system affords greater dilution or is more resilient in other ways. This technique, however, needs careful prior assessment to avoid unseen pitfalls.

The persistence of pollutants and their transport and cycling mechanisms in the environment are major factors affecting the probable success of such measures once pollution has occurred (Connell, 1988). Even though pollution may not be removed, its adverse effects on organisms may be ameliorated by adjusting water quality. Direct intervention can result in dramatic improvements, such as the aeration and destratification (Ashley, 1985) and liming (Clair & Hindar, 2005). These must, however, be considered short-term measures while more permanent pollution control measures are implemented. Natural purification processes can often provide longer-term solutions that form part of the pollution control strategy, such as the provision of riparian buffer zones (Osborne & Kovacic, 1993), which help to filter the effects of pollutants entering lakes, especially as a result of land use practices. Some pollutants can be removed by harvesting plants and animals, which have absorbed or incorporated them into their tissues (Susarla et al., 2002). This offers the possibility of using organisms to bioconcentrate pollutants to clean up environments through selective harvesting.

Flow management and silt deposition in reservoirs In particular, reservoirs suffer from flow-related habitat disturbances and sediment erosion, transfer and deposition resulting from inflow and pulsed flow. Too rapid withdrawal of water can cause stranding of fishes and loss of breeding sites and eggs attached to marginal bottom substrata, reducing survival and reproduction (Welcomme, 2001). Accelerated flooding will also destroy rooted vegetation and release sediments. Increased rate of silt deposition in reservoirs can only be managed through changing land use and control of upstream operations to avoid downstream release of sediments. Drawdown or overly rapid filling in reservoirs necessitates the active management of discharge patterns during reservoir operations. In some cases, drawdown can even have positive effect on some trophic layers by exposing prey fishes to predators as the refuges in the littoral zone are lost. Dewatering during spawning time might also be strategically used to control unwanted species that spawn in littoral zones.

Managing people with regulations Purpose of regulations Regulations are the most ancient inland fisheries management measures (Hoffmann, 1996). Most inland fisheries regulations are promulgated in laws, bye-laws and official regulations in public fishing rights systems and are sometimes further extended by the holder of the fishing rights under private fishing rights systems such as those in Central Europe or by informal institutions on a voluntary basis (Cooke et al., 2013). The purposes of most fisheries regulations include managing social issues (e.g. attempt to distribute harvest more equitably), preventing overfishing, maintaining a suitable stock structure, maintaining fish welfare (for instance by demanding a rapid killing process; FAO, 2012) and manipulating an aquatic community (for example predator–prey interactions) (Arlinghaus et al., 2002). Many regulations such as quotas or length-based harvest limits are predominately directed towards selected commercially valuable or highly appreciated species of the fish community. Many regulations, however, are not backed up by controlled, replicated scientific studies but rather set arbitrarily and reflect practical experience (Johnson & Martinez, 1995; Wilde, 1997; Radomski et al., 2001). Because pressure on habitat and fish stocks will continue to intensify, the role of regulations in inland fisheries management will probably increase in the future (Noble & Jones, 1999).

Regulations of harvest and landings are present in almost all inland fisheries and are particularly advisable when fishing mortality is high on otherwise self-reproducing stocks. Regulations can either be input controls (regulating the amount and manner of fishing or inputs) or output controls (regulating the fate of the catch and the amount of harvest, the output; Morison, 2004), and they can either be formal or informal based on social norms and mutually agreed-upon rules of behaviour (Cooke et al., 2013). Popular input controls include closed areas, closed seasons, gear restrictions and other forms of access and effort controls, such as licensing. Common output controls include quotas, daily or weekly bag limits, length-based harvest limits and harvest tags, or specifically in recreational fisheries harvest bans via total catch-and-release policies (Table 6.3.2). While effort restrictions (e.g. limited entry) are relatively rare in inland fisheries as compared to marine commercial fisheries (Cox & Walters, 2002), managers can use a variety of indirect methods of manipulating the intensity of fishing. For example, requiring licences and fees or avoiding the development of access roads and boat ramps may prevent some from participating, and gear restrictions such as fly fishing-only sections or barbless hooks are frequently used to reduce the appeal and efficiency of recreational fisheries without directly controlling the amount of fishing effort.

Genetic management Three main sets of issues are associated with the genetic management of hatchery programmes: (1) potential disruption of neutral and adaptive spatial population structure due to translocation, (2) impacts of hatchery spawning and rearing on genetic diversity of stocked fishes and consequently after release on the enhanced, mixed stock and (3) impacts of hatchery rearing on the fitness of released fishes and their naturally recruited offspring. Wild fish populations show spatial structure in selectively neutral markers where isolation has been sufficiently strong and long term (Utter, 2004). Hatchery practices should reflect and maintain this structure by using brood stock of local origin where possible and through appropriate brood stock management (Verspoor, 1997). Not doing so has been shown to carry substantial penalties in terms of post-release fitness, with implications for both enhancement effectiveness and risks to the wild population (Araki et al., 2008; Fraser, 2008). The main risks to genetic diversity arise when wild populations of small effective population size are 'swamped' by hatchery fishes derived from comparatively small numbers of breeders (Ryman & Laikre, 1991). Loss of fitness is more difficult to avert than loss of diversity. Measures aimed at minimizing fitness loss include rearing in near-natural environments, minimizing time in captivity, partially replenishing brood stock with wild fishes in regular intervals, equalizing family size or fragmentation of brood stock to reduce potential for adaptation (Araki et al., 2008; Frankham, 2008; Lorenzen et al., 2012). Reduced fitness of cultured fishes reduces the effectiveness of enhancements but still poses risks to the wild population component, which are greatest when fitness is only moderately compromised (Lorenzen, 2005). Several excellent guidelines and policies have been developed for genetic management of enhancements, including Miller and Kapuscinski (2003) and Tringali et al. (2007).

Diseases Impacts on wild stocks from diseases introduced by or with the stocking material may occur via three mechanisms: (1) introductions of alien pathogens, (2) transfer of pathogens that have evolved increased virulence in culture and (3) changes in host population density, age and size structure or immune status that affect the dynamics of established pathogens. Introductions of alien pathogens are associated with the most dramatic disease impacts of stocked on wild fishes so far documented (Johansen et al., 2011). Controlling parasites in cultured fishes is crucial to minimizing disease interactions with wild fishes, but is not always effective and may not be sufficient, particularly where parasite transmission from wild to cultured fishes is difficult to avoid. It is therefore important to implement an epidemiological, risk-based approach to managing stocking-induced disease transmission that accounts for ecological and evolutionary dynamics of transmission and host population impacts (Bartley et al., 2006). Human dimensions Human dimensions, the motivations, attitudes and behaviours of fishing stakeholders and the governance arrangements in place to regulate the enhanced fisheries can have major implications for management outcomes (Lorenzen, 2008b). Three issues shall be mentioned here. Firstly, it is usually stakeholder needs that demand and justify stocking programmes (van Poorten et al., 2011).

Moreover, many stocking programmes are user financed through licence fees, for example, in angling clubs. Stakeholder desires may also result in illegal translocation of fishes, which contributes to spread of non-native fishes (Johnson et al., 2009). Secondly, individual and collective responses of fishers to an enhancement programme may have unintended consequences such as an increase in fishing pressure on wild stock components (Hilborn & Eggers, 2000). Such responses may be used purposefully in recreational fisheries where increasing fishing effort and related economic benefits may be a key management objective (Loomis & Fix, 1998). Lastly, initiation and successful maintenance of enhancements depend on governance systems that allow for regulation of resource use and ensure that benefits of enhancements accrue to those bearing the costs (Lorenzen, 2008b).

CONCLUSION:

The old adage that fisheries management is as much people as fish stock management is particularly true in the many small- scale freshwater fisheries. This is because of the multi-use patterns characteristic for most freshwater ecosystems where local inland fisheries are social–ecological systems nested within other regional social–ecological systems and sectors such as agriculture. Because of resulting tight cross-scale interactions among systems, sustainable inland fisheries are heavily dependent on decisions made elsewhere with respect to water management, flood control, hydropower and navigation. Therefore, within the details of planning and implementing particular fisheries management interventions such as harvest regulations or the type and amount of stocking, the fishery manager must ensure to be well represented in all external decisions that spill over to the quality of the fishery. Unfortunately, with few exceptions (e.g. North American Great Lakes), inland fisheries are often marginalized in the wider freshwater ecosystem management and suffer from low sociopolitical priority that reduces political and administrative support (Arlinghaus et al., 2002). Therefore, an inclusive planning and management approach that integrates fisheries within the broader scope of aquatic ecosystem management is often needed for sustainable inland fisheries. The reader is directed to relevant sources that outline elements of an integrative approach to inland fisheries planning and management (Cowx, 1998; Lorenzen, 2008b). A range of more specific studies may also provide concrete guidance for deciding about the concrete fisheries management actions that have been outlined in this chapter (e.g. introduction of fishes: EIFAC, 1988; Welcomme, 1988; fish stocking: Cowx, 1994; Welcomme, 2001; Arlinghaus et al., 2002; harvest regulations: Johnson & Martinez, 1995; FAO, 2012).

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Dr. Pushpa Singh
Department of Zoology , Govt. Vivekanand P.G. College Maihar, Distt.- Satna (M.P.)

Dr. Umesh Prasad Patel[2]
Govt. Swami Vivekanand College Teonthar, Distt.- Rewa (M.P.)