

Sandy beach fisheries as complex social-ecological systems: emerging paradigms for research, management and governance

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INTRODUCTION

The current global fisheries crises have provoked a wide variety of management solutions and alternatives that are closely aligned with small-scale resource extraction conservation approaches (McClanahan *et al.* 2009). Small-scale fisheries provide direct employment to over 50 million fishers that generate around 30 million tons of annual marine catch for food (from a total of ~70 million tons). In this context, artisanal, small-scale fisheries developed in sand beach ecosystems have critical socioeconomic connotations, mainly in developing countries. These fisheries represent a source of food for subsistence, providing employment and generating important direct incomes to fisher communities and, in some cases, high export revenues to the countries. Moreover, several commercially stocks show restricted geographical distributions, are endemic or have important ecological roles in the macrobenthic community (Defeo & de Alava 1995, McLachlan *et al.* 1996). In addition, many beach species have a strong recreational component notoriously difficult to manage, since numbers of harvesters can usually not be controlled and precise spatial and temporal information about catch and effort appears very difficult to obtain (Defeo 1989, Schoeman 1996, Kyle *et al.* 1997). This implies that sandy beach fisheries are amongst the poorest understood systems regarding connections between the structure and dynamics of stocks, a complex fishing process that involves recreational and commercial users and a management subsystem influenced by cultural, social and political factors.

TEMPORAL FISHERY PHASES

Commercial sandy beach fisheries could be characterized by 6 contrasting temporal phases (see also Defeo 2003): development, expansion, overexploitation, closures, stabilization and institutionalization/ consolidation. The historical periods in which these phases occurred varied among fisheries and countries, mainly as a response of fluctuations in demand, management options implemented and inherent characteristics of each fishery. Not all the stocks are subject to external market forces (export) and that there are notorious differences in country-to-country fisher idiosyncrasies and legal regulations. These phases are not only based on stock size, but reflect a variety of influences,

such as changes in market, economic and political climates and regulations.

In recreational sandy beach fisheries, even though the scarcity of statistical and ecological information, it appears that only the former three phases occurred. In commercial fisheries with sale activities by corporate/collective organizations, the fourth phase was a common scenario because increasingly limited standing stocks and dropping catches and yields. Thus, stocks around the world are fully to heavily exploited, overexploited or depleted. Even though non-extensive detailed statistics are available for most of the small-scale sandy beach invertebrate fisheries, it can be stated that the above phases depict the present worldwide situation (McLachlan *et al.* 1996, Defeo 2003).

The most successful fisheries that achieved the last phases (stabilization and institutionalization/ consolidation) are characterized by high success in the social organization and regulation of resources, even though there is poor evidence for improved ecosystems, which are still poorly evaluated and managed in even the most progressive small-scale fisheries (McClanahan *et al.* 2009). Based on evidence provided by these fisheries, a change in policy towards the management of small-scale sandy beach fisheries should include major avenues of problem solving that focus on facilitating social-ecological processes rather than primarily promoting a high level of quantitative science and implementing findings, technological concepts, or tools (Castilla & Defeo 2001, Defeo & Castilla 2005).

MANAGEMENT OPTIONS

A multidisciplinary approach has been developed to aid decision-making with the purpose to achieve a sustainable fishery development in sandy beach resources. However, sustainability has been far more difficult to achieve that is commonly thought, with most sandy beach stocks being fully exploited or even overexploited or collapsed (see also McLachlan *et al.* 1996, Defeo 2003). Among the multiple reasons that have been invoked to explain this fact, some inevitably arise from the inherent characteristics of both, the resource and the fishery. Most of these fisheries are open access, which is a necessary and sufficient condition for resource overexploitation. Moreover, ocean beaches are open and extended systems (e.g., thousands of km) readily accessible to commercial and recreational resource

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users, but also to intentionally free riders or unauthorized harvesters. The easy access to high unit value resources make sandy beach fisheries notoriously difficult to manage: the number of harvesters cannot be controlled, and management measures are extremely difficult to enforce and appear to be beyond the finances of most management agencies (Defeo 2003).

In order to sustain resource allocation over time, successful management of sandy beach fisheries must integrate different kind of operational management measures and institutional structures for governance.

Operational management tools include minimum size limits and global reductions in catch or in fishing effort. Moreover, given the sedentary-life history characteristics of the species and the aggregated nature of their fishing process, most operational management measures should take into account the spatial dynamics of the resource and the fishery for sustainable exploitation of sandy beach stocks (Defeo 2003). Spatially explicit management strategies such as rotation of fishing grounds, experimental management with spatial controls, stock enhancement through restocking and seeding, and a combination of the above through management redundancy, have been applied with success in sandy beach resources (reviewed in Caddy & Defeo 2003).

Institutional governance structures include centralized management, co-management, community-based management and different forms of allocation of property rights (e.g. TURFs). In most cases where global catch/effort quotas and season/area restrictions were implemented by a command-and-control centralized management approach, the exclusion of fishers from policy formulation and implementation during the management process precluded success (reviewed in Defeo 2003). In this context, the importance of fisher participation in planning, formulation, monitoring, control and surveillance of management plans, defined here as co-management, is essential (Castilla & Defeo 2005). The legitimization of the participation of fishers in the management process mitigates the usual lack of stability in the decision-making subsystem and promotes a greater enforcing of the usual costly regulations in sandy beach fisheries (Defeo 1996). Even though co-management has been increasingly endorsed as an effective approach to promote sustainable resource management, few attempts have been made to develop general models to support this approach to sandy beach fisheries.

In summary, the status of the sandy beach world's fisheries is worrying and the factors that have led to the global decline are of biological, social, political, and cultural nature. This has occurred in the context of a well-developed fisheries science that has largely focused on the resource and the biophysical aspects that control them, but with less focus on the societal aspects of the management and the ability of science and management recommendations to be ignored in

favor of short-term political and economic needs. High information, enforcement and policing costs to implement management schemes and to allocate property rights attenuate an efficient resource allocation over time. This approach should be changed via innovative and pro-active ways to manage fisheries that have led to increase fisheries catches or reverse declines (Defeo 2003, McClanahan *et al.* 2009). The high costs of management regulations stress the importance of fishers' participation in all management phases through adaptive co-management as the desired institutional arrangement. Moreover, the cross-linkage between experimental management protocols and the active participation of fishers in them represents an important step towards successful fisheries management and macrofauna conservation in these dynamic ecosystems that dominate the coasts all over the world (Defeo 2003).

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