An Analysis of Spatial and Temporal Variations in the Okavango Delta Fishery: Towards the Development of a Fisheries Management Plan

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Abstract

This paper discusses the structure of the Okavango Delta fishery within the background of several management plans that exist in the Delta. It is observed that the Okavango Delta fishery is not a homogenous entity but is characterized by spatial variations in the nature of the fish stocks/communities and the exploitation regime. There is higher species diversity and fishing effort in the upper Delta, while the opposite prevails in the lower Delta. The lack of a national fisheries policy, the development of a well intentioned but unfocused panhandle management plan, and the weak legal framework of the wildlife management areas (WMAs) and controlled hunting areas (CHAs) have contributed to an incoherent management of the Delta's fish resource. However, it is anticipated that the situation will be ameliorated through the on-going Okavango Delta Management Plan project, and the integration of the Fisheries Division into the Department of Wildlife and National Parks.

Introduction

This paper synthesizes information from various sources that discuss spatial and temporal variations in the fishery and fish community structure of the Okavango Delta. The Okavango Delta is the largest freshwater body (Merron, 1993), and supports the largest fishery, in Botswana (Mosepele, 2000). It is found in northwestern Botswana (Figure 1), and is possibly an extension of the East African Rift Valley system (Gieske, 1996). The Delta is a major tourist attraction (Anon, 1975; Kolding, 1996; Mbaiwa, 2002), receiving approximately 50,000 tourists annually (Mbaiwa, 2002); a main water source for north central Botswana (Lund, 1970; McCarthy, 1992); and also supports small-scale commercial, subsistence, and recreational fisheries (Merron and Bruton, 1995; Mosepele, 2001).

The Okavango Delta fishery is a major source of rural livelihoods for local communities that live within its periphery (Mosepele, 2001, 2002). There are several factors, however, that determine fish resource availability to these local communities. The seasonal hydrological cycle has effected spatio-temporal variations in fish abundance (fish community structure) (Mosepele, 2000), which affect resource availability to local fishermen. Diametrically opposing land-use management regimes in the Delta (open access *vs*. restricted access) have either restricted access to fish (Kolding, 1996; Mosepele, 2002) or have contributed to stakeholder conflict (Nengu, 1995; Bills, 1996; NRP, 2001b). This paper discusses the structure of the Okavango Delta fishery within the context of these factors, and concludes with a preliminary assessment of the merits and demerits of restricting access in the lower Delta as a fisheries management tool or land use policy.

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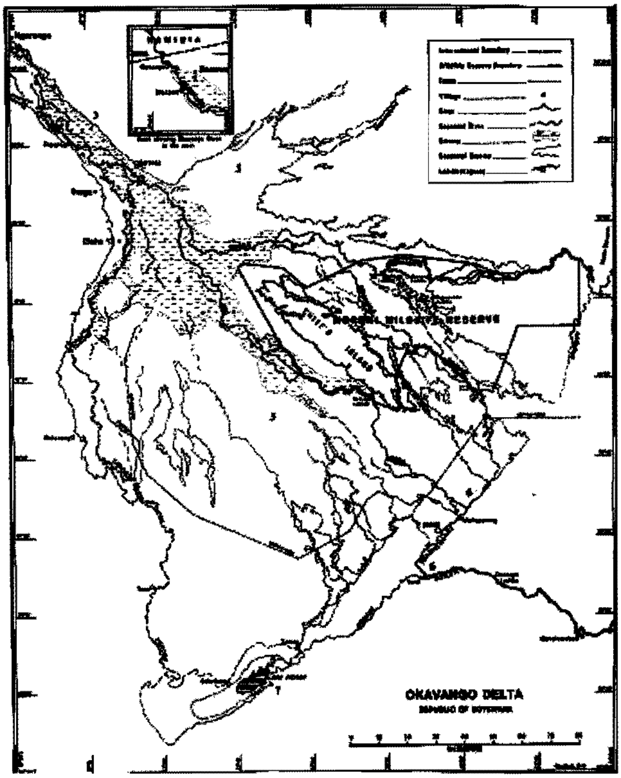

Figure 1. The Okavango Delta in Botswana. The main fishing villages in the upper Delta are shown. Shakawe and Kaoxwe are shown in the inset. The numbers indicate the major biomes of the Delta. 3: Okavango riverine floodplain. 4: Permanent swamp. 5: Seasonal swamp. 6: Drainage rivers. 7: Lake Ngami. (Adapted from Skelton *et al*, 1985).

Definition of Concepts

Fish stock abundance and catch per unit of effort*:* The basic assumption in fisheries theory is that catch per unit of effort (CPUE) and stock abundance (or standing biomass, B) are related by):

$$CPUE = q\overline{B}$$

Where is a 'catchability' coefficient (Hillborn and Walters, 1992; Kolding and Giordano, 2001; Jul-Larsen *et al*, 2002). Therefore, CPUE can be used to illustrate spatio-temporal variations in catch rates of fish stocks under exploitation.

***K* and *r*-selected species**: *K* and *r* refers to parameters of the logistic growth equation, where *K*-selected species have life history strategies that tend towards efficient exploitation of resources and *r*-selected species towards productivity. Therefore, *r*-selected species are characterised by a small body size and fast growth rates while *K*-selected species are generally bigger sized, slower growing individuals (Lowe-McConnel, 1987).

There are four main objectives of fisheries management that fall into four categories (Welcomme, 1979; FAO, 1986; Hillborn and Walters, 1992; Krueger and Decker, 1993):

1. **Biological Objectives**: Sustained optimization of mean fish catches *ad infinitum*, normally called maximum sustainable level (MSY), is one of the primary objectives of classical fisheries management. A contemporary variation of F_{MSY} (fishing effort at MSY), based on the precautionary principle of fisheries management, is the widely used $F_{0.1}$ policy, which simply suggests giving up 10% of the projected MSY.

2. **Economic Objectives**: Maximization of profit from a fishery (F_{eMSY}) is the primary economic objective in fisheries, where $F_{MSY} > F_{eMSY}$ (effort at F_{eMSY} > effort at F_{MSY}). This objective is based on the premise that fish harvesting requires society's resources, and that the cost of additional social resources required to increase the catch (so that $F_{eMSY} = F_{MSY}$) is not justifiable.

3. **Recreational Objectives**: Generally, fish size is the primary recreational objective in some fisheries.

4. **Social Objectives**: Fish is an important source of food, especially in marginalized communities, and this supersedes all the other objectives. In situations where social issues dominate fisheries policy, the imperative is to preserve the traditional community structure and lifestyle instead of achieving economic optimization.

Fluxes in Fish Community Structure

Several studies have shown that permanent swamp fish specie populations have spatio-temporal variations (Figures 2 and 3), due to the hydrological regime (Maar, 1965; Fox, 1976; Merron and Bruton, 1988; Mosepele, 2000). Mosepele (2000) conducted the most recent and comprehensive study that described seasonal and spatial variations in fish species abundance (Figures 2 and 3). These pulses in fish species abundance have been attributed to lateral and longitudinal migrations in the Delta as a response to the flood regime (Merron and Bruton, 1988; Merron, 1991). Subsequently, the availability of fish species to exploitation is dependent on a 'dilution and concentration' effect that characterizes floodplain fisheries (Lowe-McConnell, 1979; Welcomme, 1979; Kolding *et al*, 2003).

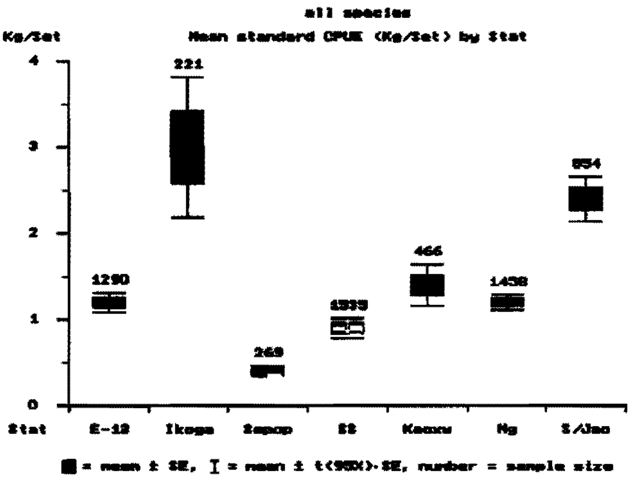

Figure 2. Spatial variation in fish catch rates (mean standard CPUE).

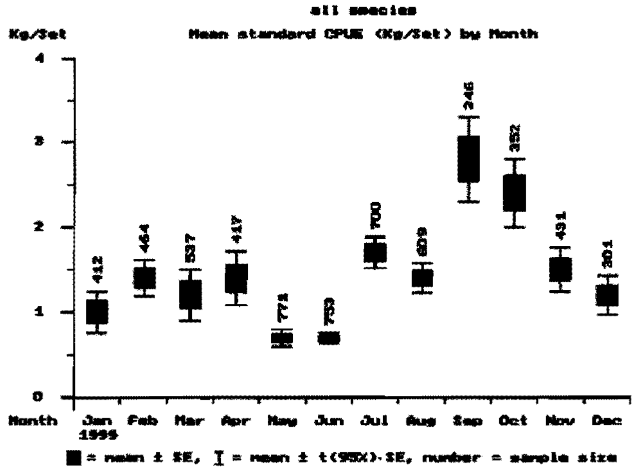

Figure 3. Temporal variation in fish catch rates (mean standard CPUE) (Mosepele, 2000).

Merron and Bruton (1988) and Merron (1991) showed that species abundance and composition in the seasonal floodplains follow spatio-temporal variations due to the hydrological regime. While the permanent swamp was characterized by higher abundance of *Hydrocynus vittatus* (tigerfish), *Clarias gariepinus* (sharp-tooth catfish), and *Oreochromis andersonii* (three spot tilapia), the lower Delta community structure was dominated by *Schilbe intermedius* (silver catfish) and *Hepsetus odoe* (African pike) (Merron and Bruton, 1988). In fact, *H.vittatus* does not occur in the seasonal swamps (Fox, 1976; Merron and Bruton, 1988; Merron, 1991) except during years of exceptionally high floods.

According to Merron and Bruton (1988), similar fish species follow different life history strategies between the permanent swamps and seasonal floodplains. They proposed that seasonal floodplain species are *r*-selected while permanent swamp species are *K*-selected. Mosepele (2000) showed that *Oreochromis andersonii* and *O.macrochir* from seasonal and permanent swamps have different growth rates (Figures 4a and b). Some recent research has revealed the possible occurrence of at least two separate populations of these species in the Delta (Mosepele and Mosepele, 2003; Basimane, 2004). Twedle *et al* (2003) suggested the

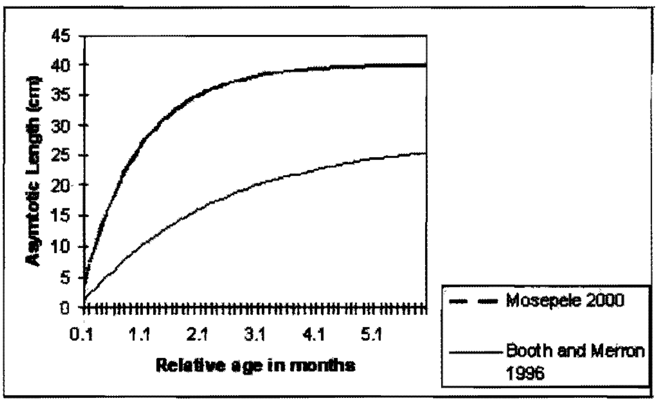

Figure 4a. Comparison of growth parameters between Booth and Merron (1996), and Mosepele (2000) for green-head tilapia.

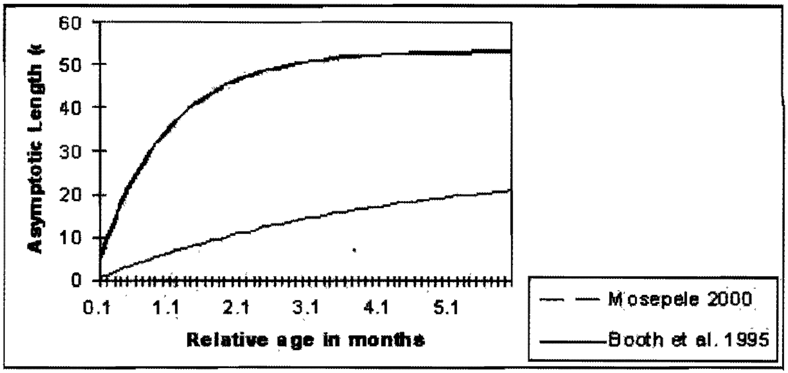

Figure 4b. Comparison of growth parameters between Booth *et al* (1995) and Mosepele (2000) for three-spot Tilapia.

possible existence of smaller, faster growing fish in the seasonal floodplains contrasted to similar species in the permanent swamps. Spatio-temporal changes in fish community structure are also described in Kolding *et al* (2003), among and between the permanent and seasonal floodplains which are characteristic of floodplain, fisheries (Welcomme, 1979; Lowe-McConnel, 1987).

The large fluctuations in seasonal floodplain flooding regime have therefore not only resulted in lower species diversity (Bruton *et al*, 1984; Merron and Bruton, 1988; Merron, 1991; Twedle *et al*, 2003), but also variations in life history strategies of similar species in different habitats (Merron and Bruton, 1988). Diminishing water levels in the seasonal floodplains concentrate fish stocks so that they exceed the habitat carrying capacity (Fox, 1976; Welcomme, 1979). This increases their natural mortality quite significantly (Lowe-McConnel, 1987), where the fish are preyed on heavily by birds (Fox, 1976), or might die from getting trapped in isolated lagoons as these dry out (Bruton *et al*, undated; Merron, 1990; Kolding *et al*, 2003). According to Welcomme (1979), this scenario constitutes one of the greatest components of natural mortality in floodplain fisheries.

Spatio-Temporal Variations in Fishery Structure

Several studies have estimated the total number of fishers in the Okavango Delta fishery (Anon, 1975; Norplan, 1985; Norfico, 1986; Skjønsberg and Merafe, 1987; Anon, 1989; Mosepele, 2001). Mosepele (2001) estimated 3,200 fishers in the entire fishery, whose numbers fluctuate in time and space (Skjønsberg and Merafe, 1987; van Hoof, *et al*, 1991). The high proportion of traditional fishing gear in the fishery (Mosepele, 2000) suggests that it is predominantly artisanal (Mosepele *et al*, 2002), therefore fishing is primarily seasonal (Norfico, 1986; Mosepele, 2001; Mosepele, 2002). Most fishers do not consider fishing a primary activity (van Hoof *et al*, 1993), but rather a 'social safety net' (Mosepele, 2000) dominated by women and children (Mosepele, 2001, 2002). The highest fishing effort from the traditional fishery occurs at low flood levels when the fishing gear is most effective (Mosepele, 2001, 2002; Mosepele *et al*, 2002). Likewise, there are seasonal variations in the gill net fishing effort in the Delta (Mosepele, 2000, 2001, 2002; Mosepele *et al*, 2003). However, Mosepele (2002) suggested that over time, fishermen numbers might decrease due to increased economic opportunities as Botswana's economy continues to grow.

The preponderance of traditional fishing craft in the fishery also restricts fishing effort in space (Norfico, 1986; van Hoof *et al*, 1993). However, infrastructural development and overall population density in the region have had the most fundamental effect on spatial variations in fishery structure around the Delta (van Hoof *et al*, 1993; Mosepele, 2001). According to van Hoof *et al* (1993), 14% of the men in the eastern part of the Okavango Delta indicated fishing as their secondary activity while 22% of the men in the western portion indicated fishing as their secondary activity. Similarly, Mosepele (2001) indicated that only 39% of all fishers in the Okavango Delta fishery came from the eastern portion of the Delta, while the remaining 61% of fishers came from the western and lower portions of the Delta. While no data is given for fishermen numbers from the seasonal floodplains, their proportion is definitely much lower.

Property Rights and Stakeholder Conflicts

Save for an outdated Fisheries Act, there are currently neither fishery regulations (Nengu, 1995; Bills, 1996; Mosepele, 1997) nor a national fisheries policy (Nengu, 1995; Mosepele, 2001). Currently, the Okavango fishery is open access, which in the past few years has contributed to friction between the various resource stakeholders (Nengu, 1995; Bills, 1996; Mosepele, 2001; Mosepele and Kolding, 2003; NRP, 2001a, b). This friction, initiated by recreational fishers, was founded on the premise that commercial gill net fishing was causing fish stock decline (Nengu, 1995; Bills, 1996; Ramberg and van der Waal, 1997; Hagget, 1999; NRP, 2001b). However, the recent Okavango River Panhandle Management Plan (NRP, 2001b) recommends several regulations to manage the panhandle fishery. In its totality, the plan recommends some form of licensing (fees), gear restriction and some fishing protocol (section 4.5 '*unacceptable fishing practices*'). It accepts traditional fishing gear, and recommends a four month closed season (NRP, 2001b). Nonetheless, clearly defined user rights, which are important ingredients in a management regime (FAO, 1986), are non-existent in the fishery, and this has accentuated the conflict (Kolding, 1996; Ramberg and van der Waal, 1997). Moreover, user rights have been enhanced with co-management regimes in other fisheries elsewhere (Jul-Larsen *et al*, 2002), which does not exist in the Delta.

The weak legal framework of the wildlife management areas (WMA) and controlled hunting areas (CHA) has also contributed to fisheries management problems in the seasonal (lower) Delta (Kolding, 1996). Fishermen have always argued that tourist operators, especially in the WMA's, claim exclusive rights to fish resources within their concessions (Kolding, 1996; Ramberg and van der Waal, 1997). Allegedly, the tour operators base their arguments for exclusive access on the tourism policy (Government of Botswana, 1990), which confers *de jure* rights within the concessions (DWNP, 2000), except in situations where citizens have *de facto* rights (GOB, 1990; van der Heiden, 1991; Ecosurv, 1996). Therefore, while access rights might be predominant fisheries issues in the panhandle, they are more entrenched in the lower Delta where fishing by local fishermen (both subsistence and commercial) is restricted either in WMA's or CHAs (Nyame, 1997, pers. communication). Moreover, fishing is forbidden in Moremi Game Reserve (Botswana Government, 2000).

Free vs. Restricted Access: Diametrically Opposing Management Regimes for Whose Benefit?

According to Kgathi *et al* (2003), the permanent swamps fishery is open access which makes it a common property resource (in contrast, the presence of WMA's in the lower Delta have made the fishery restricted access). The development of the Okavango Delta fishery has been well documented (Mosepele, 2002). Mosepele (2001) also highlighted the economic value of the gill net fishery (commercial and subsistence), while Mosepele *et al* (2003) discussed the value of the artisanal fishery. It is worth noting that despite concerns of over-exploitation that have been raised (Hagget, 1999; Kolding, 1996), the Okavango Delta fishery is not over-exploited (Bills, 1996; Mosepele, 2000; Mosepele and Kolding, 2003), but appears to be under-exploited (Mosepele, 2000). According to Bills (1996), there is no significant decrease in mean size of the 'principal' species in the fishery, which, according to Welcomme (1999), suggests no over-fishing. Moreover, Mosepele *et al* (2002) concluded that the current effort and multiple-gear use in the fishery ensures a proportional utilization of all the trophic levels in the fish community structure, which is expected to safeguard fish biodiversity (Jul-Larsen *et al*, 2002).

Generally, over-exploitation necessitates the implementation of classical fisheries regulations (effort limitation, mesh size regulation, gear restrictions, etc.), modelled on North American and European single species temperate fisheries These are, however, not only expensive to implement, but also have had questionable efficacy (Gulland, 1982; Hannesson, 1993). The case of the Okavango Delta fishery then begs the question of the need for restrictive regulations, especially if the fishery is self-regulating in terms of effort (Mosepele, 2000; Mosepele *et al*, 2003). Self-regulating mechanisms are characteristic of traditional fisheries (Scudder and Conelly, 1985), of which the Okavango Delta is no exception. Notwithstanding, open access fisheries usually become ecologically degraded (Hannesson, 1993; FAO, 1986). Moreover, several case studies (from the Amazon, Middle Zambezi and Kafue) by Scudder and Conelly (1985) show that traditional self-regulating mechanisms are invariably broken down by commercialization. Kgathi *et al* (2005) has argued that commercialization of the Okavango Delta's fishery has resulted in the breakdown of some of the traditional self-regulating mechanisms in the fishery. Therefore, the proposals for the management of the panhandle fishery (NRP, 2001b) would be a welcome development if they were based on the most reliable data and research (FAO, 1986), which appears not to be the case.

It can be argued that the management decisions proposed in NRP (2001b) might not be necessary since the fish stocks are not in danger of biological over-exploitation (Mosepele, 2000; Mosepele and Kolding, 2003); neither can the decision be economic, since neither F_{MSY} nor F_{eMSY} have been identified due to low fishing effort in the fishery (Mosepele, 2000; Mosepele and Kolding, 2003). Now, since the current conflict exists between recreational and commercial fishermen, the management decision could therefore have been taken to safeguard the interests of either or both groups. However, the proposed mesh size limitation (NRP, 2001b) will not only lead to 'gear conflict', where two different gears target similar species at the same life-history stage (Marr, 1982), but would also change the fish community structure towards *r*-selected species (Welcomme, 1979; Jul-Larsen *et al*, 2002). Therefore, the management decision appears to have been crafted to safeguard the interests of either the traditional or recreational fishery at the expense of commercial operations.

But then there is a fundamental question that persists: what form and character should the fisheries management regime take? Moreover, for whom or for what should the fishery be managed? What objectives should the fisheries manager have to formulate and implement a management plan for the fishery? This then raises the issue of the current management regimes that exist in the Delta (i.e. upper and lower Delta) and their efficacy towards rational and comprehensive management of the fish resource. Scudder and Conelly (1985) advocate the integration of traditional knowledge systems into fisheries management paradigms. FAO (1986) underscores the need and importance of management regimes in small-scale fisheries (like the Okavango Delta) to adopt social objectives.

Fish are explicitly excluded from the Wildlife Conservation and National Parks Act (Botswana Government, 1992; Kolding, 1996), and remain the sole preserve of the Fisheries Section (Kolding, 1996; Mosepele, 1997; Mosepele, 2000), except in game reserves and national parks (Botswana Government, 1992). Therefore, fisheries management is excluded from the wildlife management areas (WMAs) and controlled hunting areas (CHAs) (van der Haiden, 1991; DWNP, 2000), even though reference is made to fisheries (commercial and recreational) monitoring in photographic areas (Ecosurv, 1996). Notwithstanding, fish (as part of the fauna) are not only excluded from Moremi Game Reserve management goals (DWNP, 1991), but also from the revised plan (DWNP, 1996).

It can be seen from the preceding discussion that fisheries management in the lower Delta is crafted on 'fuzzy policies', since it is difficult to ascertain any prevailing/pertinent management objectives. As already discussed, the fish resource in the lower Delta is subject to heightened natural mortality at receding floods. Preserving this resource (such as in Moremi Game Reserve) might only result in what Welcomme (1979) calls 'wastefulness'. If the fish are not harvested, most of them will die as already discussed. Welcomme (1979) argues that, if perchance the fish stocks (in the isolated pools/lagoons) enter the permanent riverine system, this might give rise to increased density-dependent mortality that would still reduce the populations. In effect then, this is a no-win situation unless fishing was allowed to crop the surplus biomass that is otherwise 'wasted'. If the lower Delta fish species are *r*-selected (e.g. high P/B rations) making them highly resilient, then limited fishing can be allowed as described by Scudder and Conelly (1985). Lastly, Welcomme (1999:13) argues that *laissez-faire* policies may not be disastrous 'in that the resilience inherent in flood regulated systems allows for recuperations even in the face of extremely heavy exploitation', which is non-existent in the Okavango Delta fishery (Mosepele, 2000; Mosepele and Kolding, 2003).

Conclusion

We have shown in this paper that a blanket management plan for the Okavango Delta fishery would be ill advised due to the spatio-temporal variations in the fishery structure and the fish community structure that exist. The existing 'management plans' were not based on any rational and comprehensive scientific fact, which therefore makes it difficult to determine the management objectives. Notwithstanding the above, it is vital that the socio-economic imperative of fisheries management be upheld in any purported plan for the Delta that has a bearing on the fishery. In essence, it is difficult to ascertain the benefits of the current/proposed management regulations to the local communities that utilize these resources. However, while fisheries management is presently fuzzy within the Okavango WMA, it is expected that the recent formation of a new Ministry of Environment, Tourism and Wildlife (which includes the Fisheries Section) will be a positive development. Moreover, the on-going Okavango Delta Management Plan (NCSA, 2002) process is expected to accentuate fisheries concerns in the Okavango Delta and contribute towards the development of a coherent and comprehensive fisheries management plan for the Okavango Delta.

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