Lake Ngami: A Fluctuating Lacustrine Fishery

Glenn S Merron*

Abstract

This paper presents an overview of events leading up to a ban on fishing at Lake Ngami in 2015 and 2016. The ban was put into effect after fears were raised that the fish resource was being overexploited by illegal fishermen, often from foreign countries. The illegal fishing posed a threat to local fishermen who depend on the resource as an important component of their economic livelihood. Steps have been taken by the government of Botswana to curb illegal fishing including a ban on the exportation of dry fish from Ngamiland to the Democratic Republic of Congo (DRC) and Zambia. The ban on fishing was lifted on 1 December 2016 and only fishermen with valid licenses are permitted to fish. Suggested fisheries actions by the author are based on an understanding of the distribution and abundance of fish in the Okavango system.

Introduction

The Okavango Delta is a dynamic ecosystem constantly in motion. The Okavango system originates in the highlands of Angola as the Cubango River and flows through Namibia as the Kavango River before entering Botswana as the Okavango River. The timing, magnitude, and duration of the annual flood regime are dependent on rainfall levels in the Angolan highlands. Lake Ngami is a large waterbody at the southwest corner of the Delta (Figure 1). In some parts the lake can exceed 50 kilometres in length and 11 kilometres wide. In 2015 its average depth was estimated to be 3.99 meters with a surface area of 287 square kilometers (Mosimanyana *et al*. 2015).

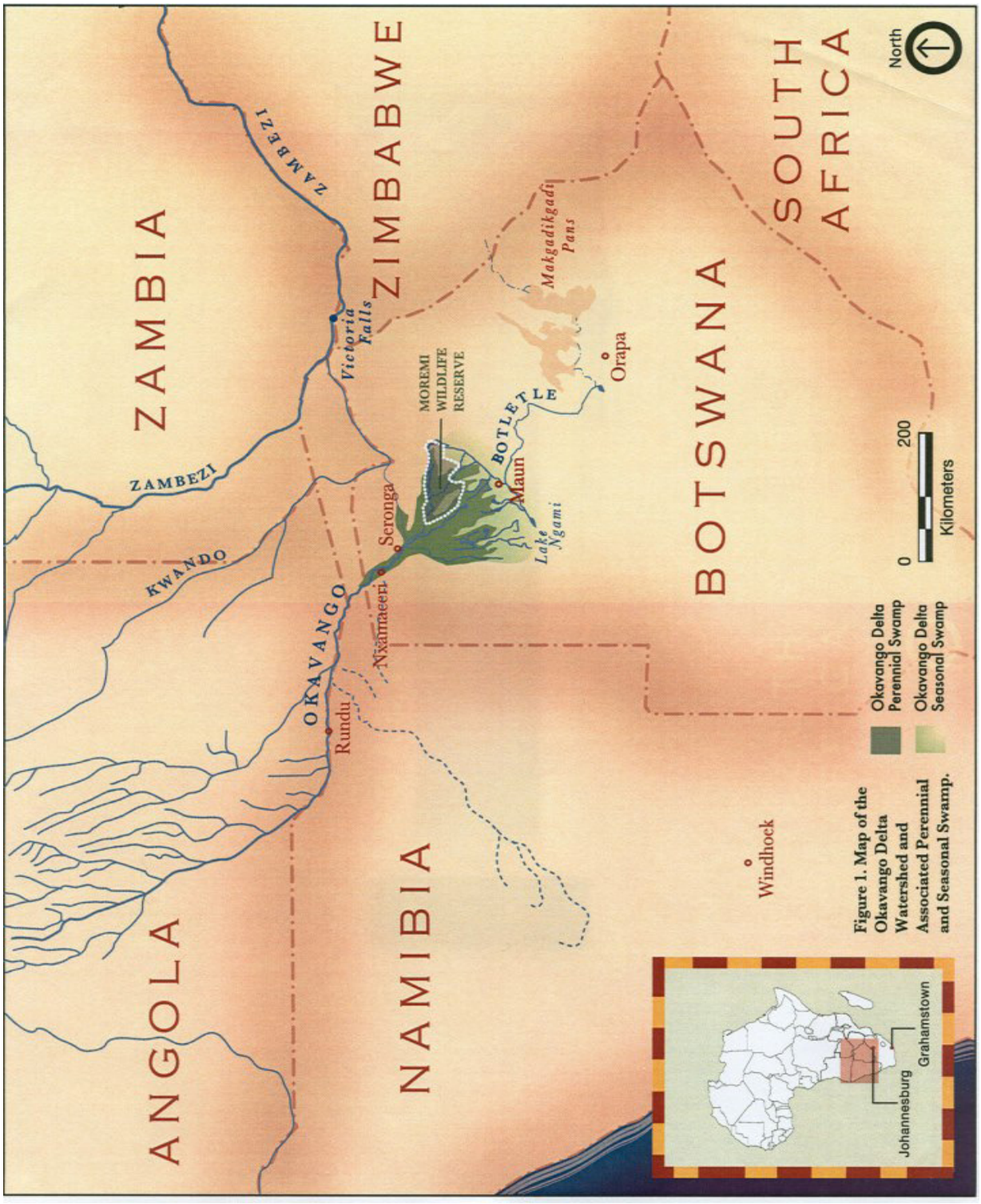
The Lake has periodically dried up completely. It was dry for the decade 1900 to 1910, again in 1930 and in from 1973 to 1974 (Shaw 1985) It almost dried up in the 1960s, then flooded, but was dry again by 1983. Due to the low water levels in the Okavango system during the 1980s and 1990s, the Lake was largely dry (Wolski and Murray-Hudson 2006). During the early 2000s water flowing from the Kunyere River on the western side of the Delta reached the Lake. Changes in water flow through the channels of the Delta occurred since the late 1990s with a greater distribution of water flowing down the western channels towards Lake Ngami (Wolski and Murray-Hudson 2006).

The Nhabe River to the east of the Lake provides minimal, if any, flow since most of the water flowing down the Nhabe River is diverted down the Boteti River to increase flow for irrigation farming and other activities (Merron and Bruton 1988).

As the Lake began to fill in the early 2000s, a biologically productive fishery resource emerged. Fish migrated into the Lake with the inflowing water and began to multiply, especially various species of tilapia and catfish. A key component of the proliferation in fish productivity lies in the thousands of cattle which roamed across the dry lakebed leaving behind substantial quantities of manure. When inundated in warm waters the manure is rapidly assimilated into the aquatic food chain resulting in high fish growth rates and multiple spawning (Merron and Bruton 1988).

* Glenn S Merron, Inland Ecosystems, Reno, Nevada. Email: gmerron@inlandecosystems.com

Figure 1: The Okavango Delta with Lake Ngami located at the southwest corner.



Source: *map created by Inland Ecosystem, Reno.*

The increasing number and biomass of fish in the Lake attracted Ngamiland fishermen but also a large number of fishermen from Zambia and the DRC (*Botswana Guardian* 20 August 2015). The fishery

began to be increasingly exploited. Numerous fishermen were observed salting, drying and packing fish along the Lake's shores ready to be transported to northern countries. Increased exploitation of the fishery was occurring and reported in numerous media articles (Table 1). What developed affected local communities surrounding Lake Ngami who raised fears that the fish resource was being overexploited and a threat to local fishermen who depended on the resource as an important component of their economic livelihood. The biologically productive nature of the Lake's fishery also represents critical dietary protein in the region.

Table 1: Select Media Articles Pertaining to the Lake Ngami Fishery

Source	Title	Date
Weekend Post (Botswana)	Government extends fishing ban at Lake Ngami	2 March 2015
Botswana Daily News	Suspension of Fishing at Lake Ngami Important	13 July 2015
Sunday Standard (Botswana)	Fishing Ban Leads to Illegal Activity at Lake Ngami	12 March 2015
Botswana Guardian	Illegal Fishing continues in Lake Ngami	20 August 2015
The Patriot on Sunday(Botswana)	Clash over Lake Ngami fish	11 January 2016
Sunday Standard (Botswana)	Fishermen, Police Rivalry Continues in Lake Ngami	12 May 2016
The Patriot on Sunday(Botswana)	Illegal Fishing Continues at Lake Ngami	20 July 2016
The Botswana Gazette	Ngami Lake illegal fishing spiralling out of control	18 August 2016
Daily News (Botswana)	Residents Call Govt to Open Fishing at Ngami	28 August 2016
Botswana Guardian	Lake Ngami residents want fishing reinstated.	2 September 2016
All Africa News	Anglers, Law Enforcers Stand-Off At Lake Ngami	19 September 2016
Botswana Daily News	Lake Ngami Comes to Life Again	12 December 2016
All Africa News	Botswana, Assistant Minister Kwerepe Follows Up on Fish Export Ban	4 April 2017
Sunday Standard (Botswana)	Tshekedi Bans Dry Fish Exportation	9 April 2017

Oxpeckers Centre for Investigative Environmental Journalism located in South Africa (OXIEJ 17 March 2016) indicates that by 2014 a reported 3,000 fishermen were fishing throughout the Lake. Numerous references in Table 1 cite significant controversy surrounding overcrowding at informal fishing camps, pollution, littering, and criminal activities which all contribute to environmental impact. Apparently, there was limited government policy, procedures, and monitoring in place to curb the illegal fishing and cross border distribution of the resource.

Early Fisheries Research at the Lake

The early history of fisheries research in the Okavango River and Delta system from Angola to Botswana is reviewed by Skelton *et al.* (1985) which were largely aimed at collections of fish for taxonomic research. Early programmes that focused on the fishery as a food source was provided in the 'Report on Fisheries Survey in Bechuanaland [Botswana] in the Years 1963/64' prepared by Marr (1965) and the Oxford Committee for Famine Relief (OXFAM). This was before Botswana attained independence from Britain in 1966. After independence the government of Botswana subsequently drew on these beginnings and funded further developments through the Botswana Development Corporation (BDC).

Fisheries research at Lake Ngami and in the Okavango Delta that Rhodes University, South Africa started in 1979 was led by Professor Mike Bruton and included a multi-disciplinary team of natural resource scientists. In June 1980, Professor Bruton led a second expedition to Lake Ngami with assistance from Pete Smith, a botanist from the Botswana Government, Department of Water Affairs. The research team

recorded a well-established local commercial fishery primarily for tilapia and catfish operating at the Lake (Merron and Bruton 1988).

In December 1982 the JLB Smith Institute of Ichthyology (now renamed the South African Institute for Aquatic Biodiversity) launched a follow up expedition to Lake Ngami and also made collections of fish from the Kunyere River. The research team's objective was to investigate the way in which the fish had responded to the drastic reduction in size of the lake from over 45 square kilometres in 1979 to less than 1 kilometre in 1982 (Skelton *et al.* 1982). Massive concentrations of sharptooth catfish (*Clarias gariepinus*) were found in the remnant of the Lake and isolated pools in the Kunyere River. Only two other species were collected, the straightfin barb (*Enteromius paludinosus*) and silver robber (*Brycinus lateralis*). Local commercial fishermen and their families were observed collecting hundreds of large catfish that were filleted and sun dried. These fish were distributed throughout areas of Botswana under the government funded drought control and food supply programmes (Merron 1993).

During the mid to late 1980s there was little fisheries research as the Lake was dry. However, comprehensive fish sampling was carried out throughout the Delta and the Okavango River in Namibia (Skelton and Merron 1984, 1985 and 1987). Approximately 85 species of fish have been identified from the system. A comprehensive account of fish communities in different habitats of the delta (e.g., mainstream river channels, lagoons, and floodplains) based on species composition, relative abundance and mass contributions in various mesh-size gillnet and seine-net collections is provided by Merron and Bruton (1988). These authors indicate that during their research the total catch of the fishery was within sustainable use levels, a conclusion also reported in Mosepele (2000) and Tweedle *et al.* (2003).

The available information on the response of various fish species to the annual flood regime and the factors which limit their distribution and abundance was synthesized by Merron (1991). During the early 1990s several research papers on the fish of the Okavango system were prepared for various international journals (Merron *et al.* 1990, Merron 1993a, Merron 1993b, Merron and Bruton 1995, Merron and Mann 1995). These scientific papers include species that would naturally colonize Lake Ngami.

A fisheries workshop entitled 'Development and Conservation of Okavango Fishes' was organized in Maun by the Kalahari Conservation Society in February 1991. The objective of the workshop was to share research information and discuss recommendations with various stakeholders in the Okavango. Forty delegates representing various government departments and non-government organizations, safari camp owners, local fishermen, and interested individuals attended the workshop (Merron 1993).

The fishery consists of three user groups including subsistence, commercial and recreational fishers. The commercial fishery utilizes gill nets set from both the traditional *mokoro* (dug-out wooden canoe) and motor boats, and harvest fish mainly for sale. The commercial fishery was largely controlled through the government's Financial Assistance Programme (FAP) in the 1980s which administered fishing grants to fisherman (Merron and Bruton 1988). The commercial catch at the time was dominated by several species of tilapia and catfish with tilapia being the most preferred species.

When flood waters began arriving at Lake Ngami in the early 2000s, migrations of fish into the vacant habitat would have been immediate. Highly variable ecosystems like Lake Ngami can produce outstanding fisheries yields in a short period of time. Tilapia and catfish are eurytopic, exhibit high growth rates and reproductive productivity, and are capable of tolerating a wide range of environmental conditions.

Surprisingly, despite the fact that fish is an important natural resource, it has not attracted a level of investment in terms of government development of the sector. Development of fisheries in Ngamiland is constrained by insufficient funding compared to other agricultural, industrial, and recreational sectors. Serious investment in the fishery sector can help diversify the economy of Ngamiland.

2015-2016 Government Actions

In February 2015 as a response to the influx of illegal fishermen and overexploitation of fish stocks, the Minister of Environment, Wildlife and Tourism, Tshekedi Khama, announced a year-long fishing ban at Lake Ngami (*WeekendPost* 2 March 2015). The ban was initially for a 12-month period to allow time to implement protective regulatory measures to address environmental concerns as a result of uncontrolled fishing activities. An Environmental Impact Assessment (EIA) was underway to address fishing concerns including campsites, ablutions and other necessities to accommodate fishermen who would be licensed to fish at Lake Ngami. The fishing ban imposed on Lake Ngami in 2015 was to expire on 1 March 2016. However, management of the fishing activities at the Lake was reportedly not fully developed and a result, the 2015 fishing ban continued into 2016.

An article in *The Patriot* of 11 January 2016 (Table 1) stated 'that hungry and broke fisherman who in 2015 were banned from catching fish are now engaged in illegal fishing at the Lake'. While the fishing season was to resume on 1 March 2016, the government ban remained in place largely citing environmental impacts posed by the magnitude of uncontrolled fishing. The fishing ban did not deter fishermen who continued to illegally fish at Lake Ngami as reported by the government's *Botswana Daily News* on 28 August 2016 (Table 1). Apparently, while law enforcers tried to keep illegal fishermen away from the Lake, many people continued to fish with on-going violations of the ban reported. When apprehended, illegal fishermen were fined for engaging in fishing activities without a permit.

The *Botswana Guardian* reported on 2 September 2016 (Table 1) 'that residents with loans intended to invest in fishing are [now] carrying out the activity illegally as they are in financial debt and depend on fish for their livelihoods and a food source for their families. The fishing ban was lifted on 1 December 2016 stipulating that only fishermen with valid fishing licenses will be allowed to fish in 2017.

2017 Government Actions

On 1 March 2017 fishing season at Lake Ngami opened with a ban on the exportation of dry fish from Ngamiland to Zambia and the DRC. The ban was contained in the *Government Gazette* of 10 March 2017. As reported on 9 April 2017 in the *Sunday Standard* (Table 1) the Minister of Environment, Wildlife and Tourism stated that the ban was important as the increasing export of fish may result in Botswana possibly facing a scarcity of the resource in the near future. However, in contrast, the Lake Ngami Conservation Trust General Manager, Galefele Maokeng, requested the minister to suspend the export ban, as both fishermen and buyers apparently had stockpiles of fish to be exported to Zambia and the DRC and Zambia (*Botswana Guardian* 2 September 2016). He further pointed out that the ban was an economic hardship for fishermen, 60 of whom were beneficiaries of various government schemes and were granted permission to fish at Lake Ngami.

For the 2017 fishing season 200 licenses were approved, of which 150 were put aside for the six villages that have been designated as member communities in the Lake Ngami Conversation Trust while outsiders had to compete for the remaining fifty licenses (*Botswana Daily News* 12 December 2016). About 87 existing licenses were still valid until the end of 2017 and the holders were allowed to fish. This meant that a total of 287 fishermen and women were entitled to fish at the Lake in 2017 with both genders involved in different aspects of the fishery. The presence of women and children in the fishery attest to the important role that fish play in rural livelihoods, especially as a major source of protein (Mosepele and Ngwenya 2010).

Discussion

The Okavango Delta is designated as a wetland of international importance under the Ramsar Convention.

This global pact aims to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain. On 22 June 2014 the Delta was designated as the 1000th UNESCO World Heritage Site. According to UNESCO, the Okavango effectively illustrates how to integrate conservation and preservation with sustainable use.

Potential fisheries management steps at Lake Ngami might include certain of the actions below. Some of these management steps are already being implemented by responsible government sectors. The following actions are only suggestions for government sectors with jurisdiction over the fisheries resource and include:

- Review existing legislation and develop regulations to more effectively manage fishing activities.
- Adopt stiffer penalties for fishermen engaged in illegal fishing with a staggered severity scale based on the number of violations for an individual (e.g., 1st, 2nd or 3rd offence).
- Review non-citizen entry and work permit requirements and screening for non-Botswana citizens fishing at the lake.
- Prohibit the export of fish to neighboring countries unless under a strict export license with an annual fee with documentation of the volume and value of fish leaving Botswana.
- Fishing licenses should be non-transferable with only license holders permitted to fish. Some reports indicate that at times several people fish under one license and/or some fishermen share licenses with unlicensed fishermen for monetary gain.
- Issuing fishing licenses might be carried out on a lottery basis to fish certain areas of the lake with citizens given preference when awarding licenses.
- Increase enforcement to police the lake's number of fishermen and monitor the size of gill nets to ensure that the terms and conditions of fishing licenses are adhered to.
- Licenses should be issued on an annual basis with possibly a fishing quota depending on quantitative surveys of fish population estimates.
- Gillnet sizes should be regulated as they are selective for certain size ranges of fish. Consideration might be given to a slot-size range of 24-30mm size gillnets for smaller adult species such as *Brycinus lateralis* (silver robber), *Barbus paludinosus* (straightfin barb), and *Tilapia sparrmanii* (banded tilapia). The use of gillnets larger than 110mm should be prohibited as these target large sexually mature tilapia and catfish that would contribute to maintaining a self-sustaining fishery during extended periods when Lake levels are high.
- The purchase of gillnets in Ngamiland and other regional outlet stores should only be made to licensed fishermen. Consideration might be given to fining distributors for selling gillnets to non-licensed fishermen.
- Gillnets should not be permitted to enter Botswana from neighboring countries. The invasive aquatic plant, *Salvinia molesta* or Kariba weed, can be spread by commercial gillnets and contaminated boats as well as several other dispersal pathways. The establishment of *Salvinia* leads to the exclusion of sunlight within rivers and lakes, thereby reducing one of nature's fundamental biological processes known as photosynthesis and prevents aquatic plants from manufacturing oxygen in water. Consequently, fish life is adversely affected and the standing stock of fish is much lower in *Salvinia* infested waterbodies as demonstrated in the Kwando River (Merron 1989).
- Consideration could be given to establishing no fishing zones in highly productive spawning and nursery areas around the Lake. Tilapias are communal nest builders while other tilapia species such as the three-spot (*Oreochromis andersoni*) and greenhead *(O. macrochir*) are mouth-brooders and congregate in groups, often in specific areas during spawning and rearing of young.

- Consider monitoring the Lake's fishery by periodic aerial surveys while recording GPS locations of informal fishing camps for on the ground enforcement patrols.
- Consider carrying out annual population surveys with hydroacoustic technology to establish standing stock estimates. Other survey techniques exist and a variety of well-established methods carried out simultaneously may be needed for statistically valid population estimates. Mark and recapture with multiple seining could be used to provide first-order standing stock estimates to build on utilizing other scientific methodologies. The total number of fishing licenses and catch quotas could then be set yearly based on standing stock estimates.
- Increase the monitoring of commercial fishing camps and maintain accurate log books of the number of fish and species caught.
- Consider preparing a 'Fishing Rules and Regulations' pamphlet provided with the purchase of each license that would explain each regulatory measure and the do's and don'ts of fishing at the Lake.
- Additional local economic benefits may be realized if adequate storage and transport facilities were available to market fresh fish in population centres such as Francistown and Gaborone. Sun-dried fish can last for an extended period.
- Consider management options for an inherently boom-and-bust fisheries resource driven by climatic cycles of high and low periods of rainfall in the Angolan highlands.

Conclusion

The fishing ban imposed on Lake Ngami in 2015 was to expire on 1 March 2016. However, management of the fishing activities at the Lake was reportedly not fully developed and a result, the 2015 fishing ban continued into 2016. The on-going ban was criticized by local communities because it was regarded as restricting the use of a natural resource as a food supply and a means to generate income.On 1 December 2016 the fishing ban at Lake Ngami was lifted.

The opening of the 2017 fishing season at Lake Ngami was 1 March with a ban on the exportation of dry fish from Ngamiland to the DRC and Zambia. The ban is important as the increasing export of fish may result in Botswana possibly facing a scarcity of the resource in the near future. For 2017, the Lake Ngami Conservation Trust received an allocation of 200 licenses to be issued. A further 87 had been previously issued, meaning a total of 287 fishermen and fisherwomen were entitled to fish at the Lake during 2017 under the supervision of the Trust.

The Lake undergoes dramatic hydrological cycles of extended periods of receiving flood waters and extremely dry periods depending on prevailing climatic conditions in the Angolan highlands. Many ecological interactions are tuned to the ecology of the Lake including unparalleled habitat for a myriad of other fauna and flora. In the case of the Lake's fishery, it may be considered a 'boom' resource during periods of high waters but also a 'bust' resource when dry.

Fishery development should proceed in a way that maximises the economic status and quality of life for people while minimizing the ecological degradation of the lake. Conservation does not mean preservation but wise utilization of natural resources for the benefit of people. The ultimate aim is to improve the quality of life of all people by integrating conservation and development in a sustainable way.

Acknowledgements

Okavango Delta conservationists Shane Seaman provided valuable information in preparation of this paper.

References

Official documents and reports

Marr, A 1965. Report on Fisheries Survey in Bechuanaland [Botswana] in the Years 1963/64. London: Oxford Committee for Famine Relief (OXFAM).

Mosepele, K and Ngwenya BN 2010. 'Socio-Economic Survey of Commercial Fishing in the Okavango Delta, Botswana', Okavango Report Series No. 7. Harry Oppenheimer Okavango Research Centre, University of Botswana.

Merron, GS and Bruton, MN 1988. Biology and Management of the Fishes of the Okavango Delta, Botswana, with Specific Reference to the Role of the Seasonal Floods. Final Report submitted to the Government of Botswana, Ministry of Agriculture, Fisheries Division.

Skelton, PH, Bruton, MN Merron, GS and van der Waal BCW 1985. The Fishes of the Okavango Drainage System in Angola, South West Africa and Botswana', Ichthyological Bulletin of the JLB Smith Institute of Ichthyology No. 50.

Skelton, PH and Merron, GS 1984. 'A Survey of the Fishes of the Okavango River in South West Africa with Reference to the Possible Impact of the Eastern National Water Carrier', JLB Smith Institute of Ichthyology Investigational Report. No. 9: pp.1-32.

Skelton, PH and Merron, GS (1985) A Second Fish Survey of the Fishes of the Okavango River in South West Africa with Reference to the Possible Impact of the Eastern National Water Carrier. JLB Smith Institute of Ichthyology Investigational Report. No. 14, pp.1-26.

Skelton, PH and Merron, GS 1987. A Third Fish Survey of the Fishes of the Okavango River in South West Africa with Reference to the Possible Impact of the Eastern National Water Carrier. JLB Smith Institute of Ichthyology Investigational Report. No. 24, pp.1-21.

Skelton, PH, Hocutt, CH Bruton, MN Merron, GS 1982. JLB Smith Institute of Ichthyology and the Albany Museum 1982 Expedition to Lake Ngami, Botswana. JLB Smith Institute of Ichthyology Internal Report, pp.1-6.

Tweedle, D, Bill, R, van der Waal, B, Skelton, P, Kolding, J and Nengu, S 2003. Fish Diversity and Fisheries in the Okavango Delta, Botswana. In: A rapid biological assessment of the aquatic ecosystems of the Okavango Delta, Botswana: High Water Survey. RAP Bulletin of Biological Assessment 27. Conservation International, Washington DC.

Wolski P and Murray-Hudson, M 2006. Flooding dynamics in a large low-gradient alluvial fan, the Okavango Delta, Botswana, From Analysis and Interpretation of a 30-year Hydrometric Record. Hydrology and Earth System Sciences Discussions, European Geosciences Union, vol. 10, 1, pp.127-13.

Secondary sources

Merron, GS, Holden, KK and Bruton, MN 1990. 'The Reproductive Biology and Early Development of the African Pike (Hepsetus odoe) in the Okavango Delta, Botswana', Environmental Biology of Fishes, vol. 28, pp.215-235.

Merron, GS 1991. 'The Ecology and Management of the Fishes of the Okavango Delta, Botswana, with Particular Reference to the Role of the Seasonal Flood', PhD Thesis, Rhodes University, Grahamstown.

Merron, GS 1993. 'Pack Hunting in Two Species of Catfish, Clarias gariepinus and C. ngamensis, in the Okavango Delta, Botswana', Journal of Fish Biology, vol. 43, pp.575-584.

Merron, GS 1993. 'A Synopsis of Presentations and Discussions on the Fish and Fishery in the Okavango Delta, Botswana', Botswana Notes and Record, vol. 25, pp.133-140.

Merron, GS and Bruton, MN 1995. 'Community Ecology and Conservation of the Fishes of the Okavango Delta, Botswana', .Environmental Biology of Fishes, vol. 43, pp.109-119.

Merron, GS and Mann, BQ 1995. 'The Reproductive and Feeding Biology of Schilbeintermedius in the Okavango Delta, Botswana', Hydrobiologica, vol. 308, pp.121-129.

Mosepele, K 2000. 'Preliminary Length Based Stock Assessment of the Main Exploited Stocks of the Okavango Delta Fishery', MPhil Thesis, University of Bergen.

Mosimanyana, E, Kurugundla, CN and Murray-Hudson, M 2015. 'Analysis of the Hydrological Processes of a Semi-arid Region Lake: The Case of Lake Ngami, Botswana', Prepared for the Botswana Symposium on Wetlands and Wildlife, 17–19 March 2015.

Shaw, P 1985. 'The Desiccation of Lake Ngami: An Historical Perspective', The Geographical Journal, vol. 151, 3, pp.318-326.