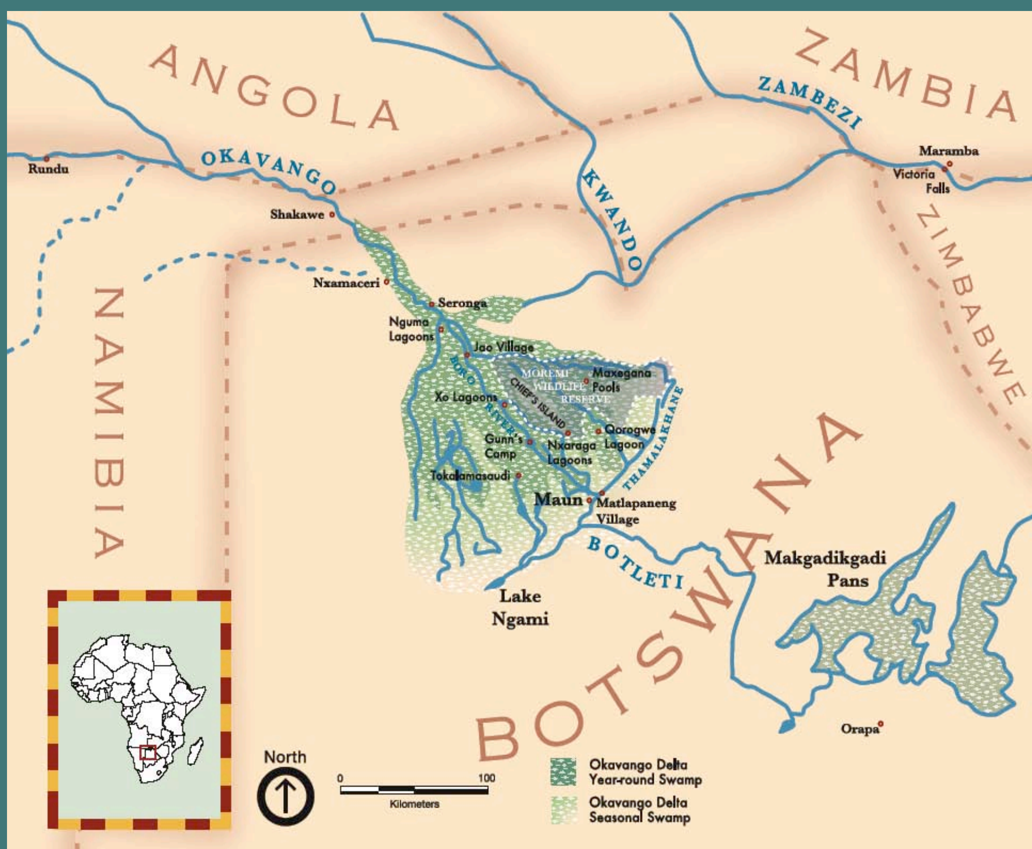
"Ra Ditapia"

Stories From The Okavango Swamps



By
Glenn Merron

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STORIES FROM THE OKAVANGO DELTA

CHAPTER 1 – HOW THE JOURNEY BEGAN

I have been fascinated by fish all my life. As a kid growing up in New York City, I spent much of my time traveling around various neighborhoods in search of fishing spots. One morning my fishing pole lunged into Flushing Meadows lakes in Queens, New York. I frantically ran into the water to retrieve it and, with park attendants and on-lookers cheering me on, I finally got the fish to shore. It was the biggest fish I had yet caught. The Long Island Press was alerted and on April 31, 1968 an article about my struggle to land the fish appeared in the sports section of the newspaper. It was a Common Carp (*Cyprinius carpio*) weighing in at 14 pounds and I was 12 years old.

Photo 1. My prize fish caught in New York City, April 1968.

As a teenager I wanted to travel away from the metropolitan New York area and decided to go to the State University of New York at Geneseo located approximately 40 miles south of Rochester, New York. Geneseo is a moderately sized university town and I had a student job in the Biology Department for three years (1976-78) assisting Professor Robert M. Roecker with the care of a variety of fish, mammals, poisonous and non-poisonous snakes, and other reptiles and amphibians. I also had the opportunity to work under Professor Howard L. Huddle and assisted him with several of his biology related classes as a laboratory assistant. Under these Professors supervision I was educated in fish biology and ecology and knew this was the career direction I wanted to pursue.

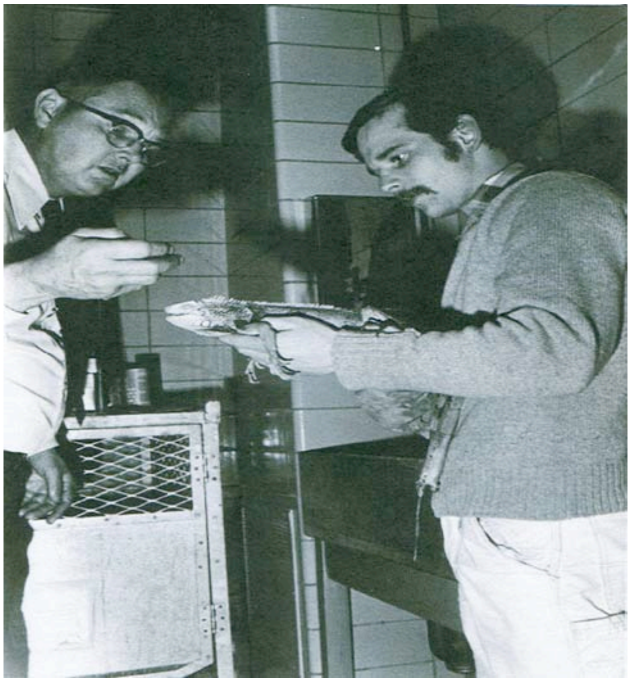


Photo 2. Professor Robert M. Roecker and the author in the Geneseo Biology Department animal laboratory in 1977.

Before graduating with my Bachelor’s degree from Geneseo, I had applied to the University of Michigan (U of M) where an internationally recognized fishery scientist named Professor Karl F. Lagler taught. I visited the U of M in March 1978 to meet and interview with Professor Lagler, who had been at the University since the 1940s. He had supervised hundreds of graduate students and authored thousands of scientific papers, research articles, and textbooks on fish and fisheries biology.

Professor Lagler wanted to know why I was so interested in fish and studying under his supervision. I told him about my passion for fish and how I had furthered my understanding of fish biology and management while studying at Geneseo. I mentioned that it was his textbooks on fish biology that were used by Prof. Roecker. I looked at Prof. Lagler and said that it would be a great honor to continue my graduate studies under his guidance.

He mentioned that he had recently completed a fisheries management program on the Kafue Floodplain in the southern African country of Zambia. I was fascinated by his stories of the fishes in this ecosystem. I discussed a research paper I had recently prepared on the invasion of the American Great Lakes by the Sea Lamprey, a voracious fish predator that led to the decline of the Lake Trout population, a fish that was native to the lakes. The decline of the Lake Trout, which kept the Great Lakes food chain in balance, led to the explosion of another invading fish species the alewife, which at times littered the shores of Lake Michigan by the millions. Fortunately, fishery biologists from both the U.S. and Canada were able to implement a creative management program, including the stocking of Pacific Ocean salmon, to establish a balanced fish community. Professor Lagler needed to get to his next class and I returned back to Geneseo.

After weeks of keeping my fingers crossed in hopes of receiving positive news regarding my admissions application to the U of M, the letter arrived. I was accepted into the graduate program and would study under Professor Lagler.

I said goodbye to Professors Roecker and Huddle who I had come to deeply admire for the guidance they had given me. I went into the Biology Department's "zoo", gave all the animals I cared for almost everyday for three years an extra helping of food, and headed for Ann Arbor, Michigan. I had a 1967 Chevy truck, $108, and my dog Shortstop.

I spent the next four years expanding my knowledge of fisheries biology and management under Professor Lagler's supervision. I had the opportunity to work for the Michigan Department of Natural Resources on the AuSable River, which flows through the City of Grayling, Michigan. The AuSable River is one of America's premier trout fishing rivers and my job focused on improving fish habitat in the river. Under Professor Lagler's guidance I completed my Master's thesis in 1982 on the biology of Brown Trout (*Salmo trutta*) in the river.

Photo 3. Professor Karl F. Lagler and the author at the University of Michigan, School of Natural Resources. Photo taken 1979.

Professor Lagler had fisheries research contracts in many countries throughout the world. During 1981 he assisted Professor Mike Bruton with fisheries research at the Justin Leonard Bruce (JLB) Smith Institute of Ichthyology in Grahamstown, South Africa. When Professor Lagler returned to Michigan later that year, he told me about Professor Bruton and the Okavango Delta fisheries research project he wanted to develop in the neighboring country of Botswana.

At the time, I was staying at Professor Lagler's home with Shortstop. On a Sunday morning, January 31, 1982, he handed me an article that appeared in the Detroit Free Press. The article captured the mystery and suspense of the Okavango Delta and its untouched waterways. It was like reading a story out of the Wild West.

Professor Lagler mentioned that no one has done a comprehensive study on the biology and ecology of fish in the Okavango Delta and that such research would be an important contribution to the country of Botswana and the scientific world. I contacted Professor Bruton and he invited me to conduct my Ph.D. research under his supervision. I was excited about the opportunity to explore the pristine and unstudied Okavango Delta.

CHAPTER 2 - THE OKAVANGO WATERSHED

The Okavango Delta, a giant oasis in the Kalahari Desert of southern Africa, is an immense alluvial fan created by the rivers that drain the highlands of Angola. The Okavango River originates from a series of headwater streams on the southern slopes of the Angolan highlands (See Figure 1). These streams flow south and southeast and then gather to form a large mainstream channel between the countries of Angola and Namibia. The catchment of the Okavango is approximately 112,000 km-2.

As the Okavango River enters Botswana it begins to overflow its banks onto a broad floodplain that spans about 100 kilometers long and 15 kilometers wide (See Figure 1 and Photos 4 and 5). The river then splits into three main branches, the Thoage to the east, the Jao/Boro in the center, and the Nqoga in the northwest. These rivers spread out into hundreds of smaller channels and lagoons (Photo 6). Two prominent geologic fault lines running north-east to south-west create a bowl like depression between them slowing the water and creating the enormous swamps that give the Okavango Delta its hand-like appearance (See Figure 2). The present wetted Delta ecosystem covers about 8,000-16,000 km-2 depending on season and year.

The Okavango can generally be broken up into five broad habitat types that are ecologically integrated into one another and from northwest to southeast include the riverine floodplain (or known locally as the panhandle), perennial swamp, seasonal swamp, drainage rivers, and terminal lakes such as Lake Ngami (pronounced Na-gom-e).

Within the riverine floodplain, the Okavango River flows throughout the year and can be as deep as 15-20 feet. Flanking the river is a dense growth of papyrus (pronounced pa-pie-rus), an emergent plant that is widespread in African swamps. Papyrus is what the early Egyptians used to make paper. This plant is a useful indicator of prevailing environmental conditions in the Okavango and thrives only where water flows throughout the year. There are numerous tributaries and lagoons associated with the main river channel in the riverine floodplain and perennial swamp. Each year the Okavango Delta receives a pulse of energy in the form of an annual flood that originates from rainfall runoff in southern Angola. The mean annual inflow of water into the Okavango Delta from Angola is approximately 11 billion tons of water. The floods periodically connect all the lagoons, swamps, and floodplains to the main river channel and facilitate migrations and spawning of various fish species.

Although all areas of the Okavango are subject to flooding, the enormous size of the Delta (8-16,000 square kilometers at high flood) causes the timing of flooding to vary with the greatest fluctuations occurring in the southern end of the system (See Photos 7 and 8). The floodwaters reach the riverine floodplain in January and February but do not reach the southernmost portions of the Okavango until June or July.

The water output through the Thamalakane River in the south represents less than 5% of the inflow of water from Angola. The primary loss of water through the Okavango is from evaporation and transpiration, the latter process occurring from the extensive plant communities taking up water through their root systems. Although rainfall over the Delta can influence local hydrological conditions, the timing, magnitude and duration of the annual flood is determined primarily by rainfall in southern Angola that can change from year to year.

While most of the water in the system is lost through evaporation and transpiration, in wet periods there may be some overflow into rivers to the northeast of the Okavango including the Kwando and Linyanti river systems which ultimately empty into the Zambezi River. The most important feature of the Okavango's flood is that it revitalizes the system by bringing in a new set of environmental conditions. It could be said that the only permanent thing in the Okavango is change!

At the southern end of the system, the Boro and Santandadibe rivers are the main drainage channels leading out of the Okavango. These rivers flow into the southwestward flowing Thamalakane River which parellels a geologic fault line. The Thamalakane River abruptly changes course to the southeast at its junction with the Nghabe (pronounced Na-ha-be) and Botletle rivers. The Nghabe River flows into Lake Ngami, at the southwestern corner of the Okavango. Lake Ngami was once fed by the Thoage River, on the west of the swamps. Dr. David Livingstone, who in 1849, became the first European explorer to visit Lake Ngami, wrote that the lake covered an area of roughly 810 square kilometers or roughly 300 squate miles. However, the gradual drying up of the Thoage River system, due to Papyrus blockages formed over decades, has led to lower lake levels.

At high flood levels the Botletle River empties into Lake Xau (pronounced Dow) and into the extensive Makgadikgadi (pronounced Ma-gut-e-gut-e) Salt Pans. However, unlike most rivers that find the sea, the mighty Okavango waters end gracefully beneath the sands of the Kalahari Desert demonstrating a rare natural phenomenon.

The Okavango ecosystem is also home to a wide variety of fish, wildlife, birds, plants, and insects. The largest island in the Okavango is Chief's Island where large populations of elephant, lion, zebra, giraffe, buffalo, and other wildlife thrive. Several tourist camps are located throughout the Okavango and thousands of tourists visit the Delta annually which generates considerable revenue for Botswana.

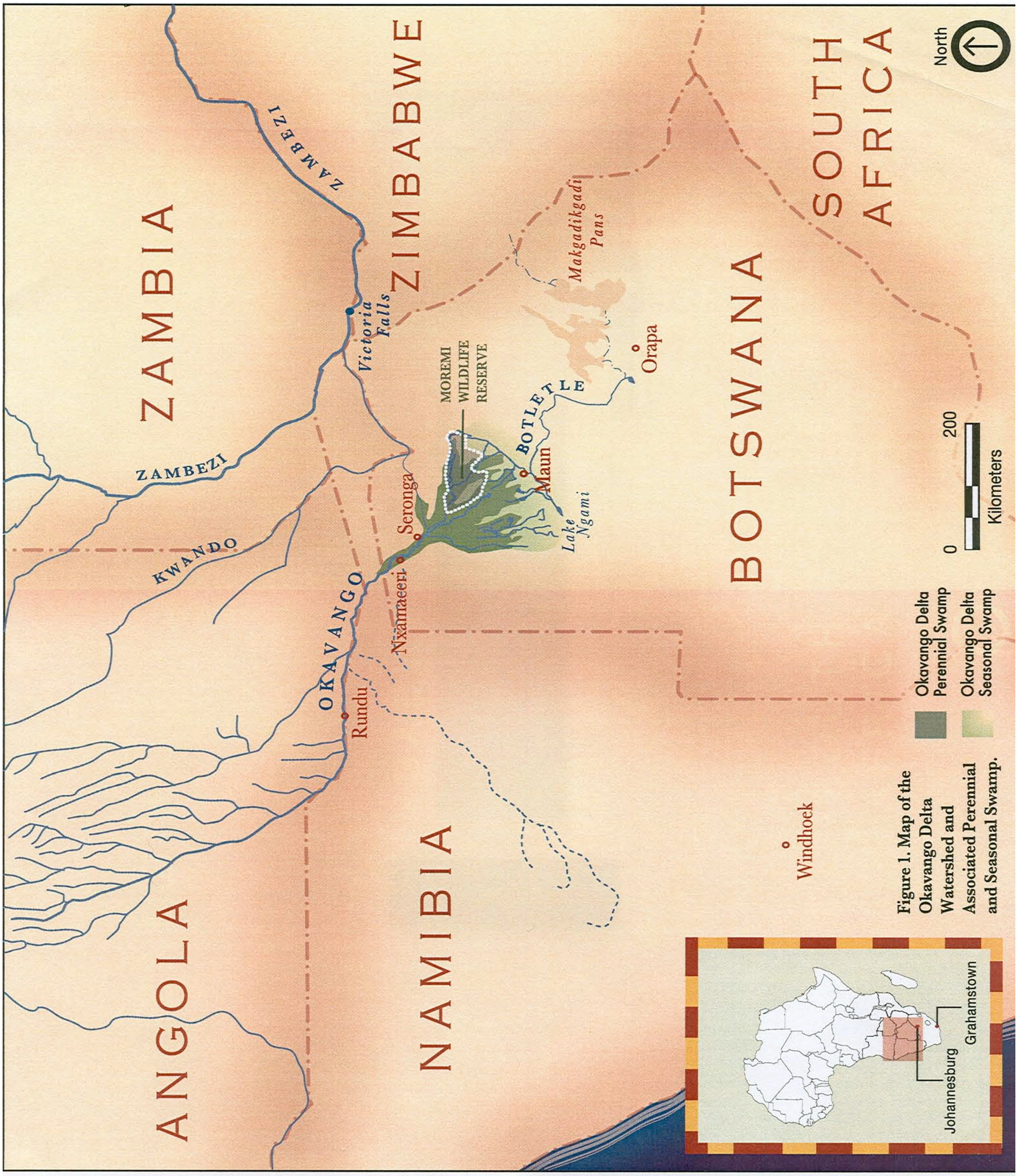


Figure 1. Map of the Okavango watershed which covers southern Angola, Namibia, and Botswana.

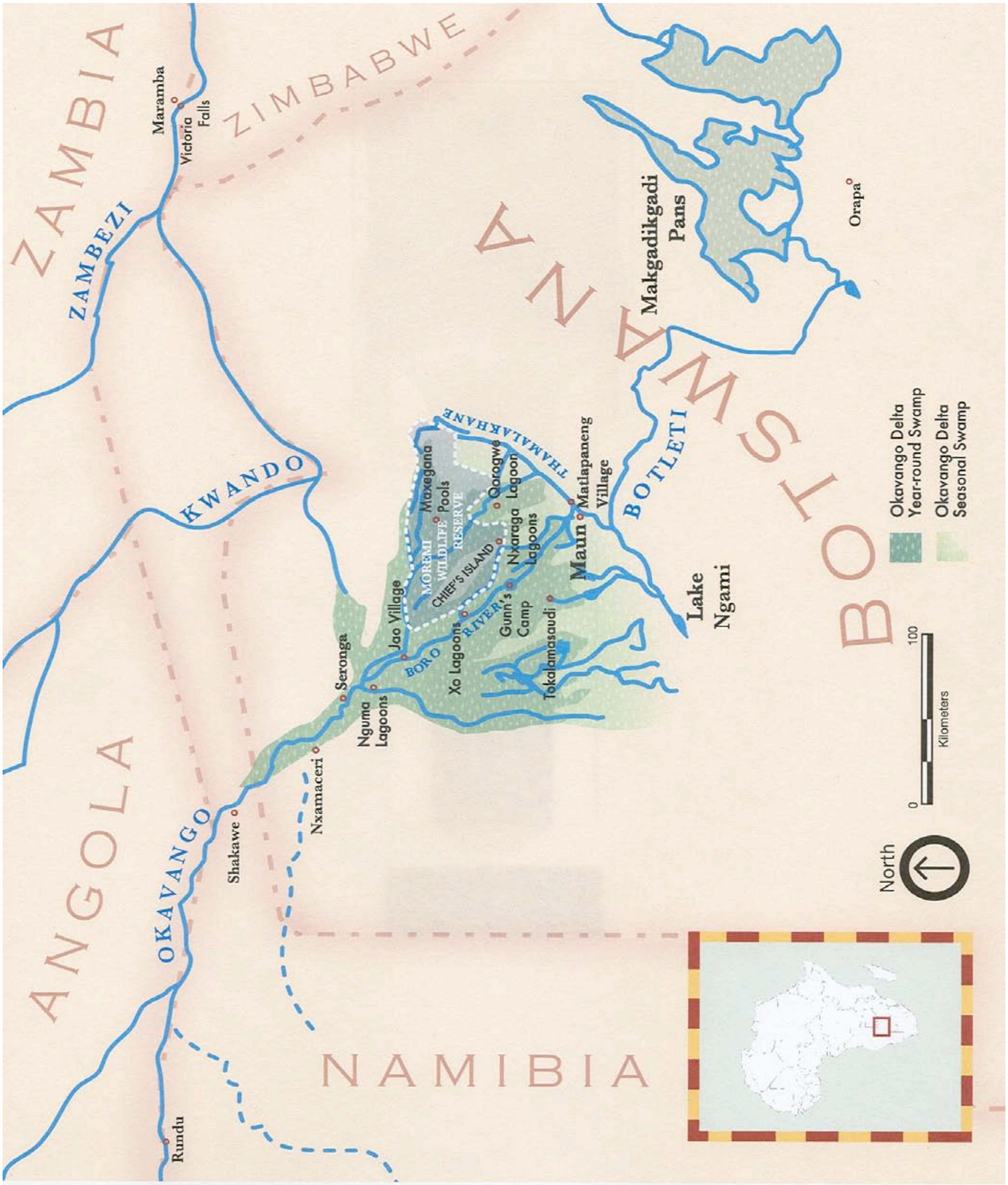


Figure 2. Map of the Okavango showing the different areas and sampling sites used during the fisheries research program.

Photo 4. Channels of the northern Okavango River system.

Photo 5. Aerail view of the southern Okavango swamps.

Photo 6. One of the many river channels that flow through the central Okavango Delta.

Photo 7. The Thamalakane River at high water level in June 1984.

Photo 8. The Thamalakane River at low water level in March 1984.

CHAPTER 3 - THE OKAVANGO FISHERIES RESEARCH PROGRAM

In February 1983 I flew from New York to Johannesburg, South Africa and then drove for five days in a truck covering only 500 miles to reach Nxamaceri (pronounced Nam-a-ceri) in the Okavango riverine floodplain (See Figure 2). Covering a distance of 100 miles a day through northern Botswana was a tremendous feat! I was in awe of the African landscape and the majesty of the Okavango, wondering what might be in store for me as I began my fisheries research. Shortly after reaching Nxamaceri, a small Cessna airplane landed on the floodplain with Professor Mike Bruton, Dr. Paul Skelton, and other staff from the JLB Smith Institute of Ichthyology on board.

After introductions we set up a tented camp next to PJ Bestelink's fishing lodge. Sport fishermen from all over the world come to PJ's lodge to catch the famed Okavango tigerfish, a fierce and acrobatic fighting fish (See Photo 9). A variety of other fish species including beautifully colored tilapia are also caught. PJ was interested in the Okavango's fishes and invited Mike Bruton to base this first fish survey in this area of the Delta.

Over 60 species of fish were collected during the survey. Many of the species had never been previously collected in the area, or even known in the scientific community. A poster depicting several of the Okavango fish species is shown in Figure 3.

In addition to collecting fish for scientific studies, the primary purpose of the survey was for Mike Bruton and me to meet John Rogers, the Botswana Fisheries Officer, and to discuss my proposed research program on the fish in the Okavango. John expressed his expectations for the fisheries research program and wanted to see a balance of academic research linked to socio-economic needs of the commercial fishermen who made their livelihood from fishing. Together we all sat down while looking out over the Okavango and formulated the goals of the research programs as follows:

1) To identify fish distribution, abundance, biology, and ecology throughout the Okavango and how it relates to the annual flood cycle, and
2) To use this information to improve the harvest of fish while maintaining the ecological integrity of the fish stocks.

During my research in the Okavango there were less than 100 commercial fishermen, though there were thousands of subsistence fishermen who primarily catch fish to feed their families. At the time, fish were caught by commercial fishermen using gillnets which entangle fish by their gills with fine mesh netting (See Photo 10). The fish caught were then dried in the sun, salted, and sold back to the Fisheries Department for distribution throughout Botswana.

It was also clear that the research program would need to incorporate concerns that sport fishermen expressed. Tigerfish, not a commercially sought after fish because of its bony flesh, were also being caught in gillnets and many sport fishermen expressed concern about the commercial gillnet operations and the impact to the tigerfish population.

I discussed with John and Mike that several sampling sites would be needed throughout the Okavango in various habitat types such as river channels, lagoons, and backwater floodplains to allow a complete picture of where and when certain fish species lived and to determine their biological and ecological responses to the annual flood cycle. We were all in agreement with the study design. The Government of Botswana approved the project and I received a permit to carry out the fisheries research.

I established fishery sampling sites throughout the Okavango from the northern riverine floodplain to the southern drainage rivers. On many of my research trips I was accompanied by native Botswanan people, whom I hire to help me with the surveys.

In early 1984 I met James Molefne (pronounced Mo-lef-ne) who was 14 years old at the time. James was looking for work and he gave me a hand with repairing gillnets that had been torn by crocodiles and hippopotamuses which I encountered almost daily. He spoke no English but had a keen sense of learning how to set and repair the nets. He became one of the best field assistants I have ever known and, after a couple of years, had a good command of the English language. I still keep in touch with James who is a guide in the Moremi Wildlife Reserve (Figure 2). Another field assistant who started working with me was Vuyisile Yose (aka Punky). Punky quickly learned how to identify the fishes, particularly the many smaller species.

Sampling the fish populations required mobility. Some sampling sites could only be reached after several days by boat. At times the river channels would be blocked by millions of papyrus stalks that had broken away from the fringe of the mainstream channels. Unfortunately, you could never anticipate these barriers being there and either have to turn around or pull the boat and equipment over the top of them (See Photo 11). We never did turn around!

Some sampling sites were accessible by truck (See Photo 12) while others required the use of a helicopter (See Photo 13).

Sampling of the fish populations entailed the use of a variety of techniques, with gillnets being the primary sampling method. Gillnets were set at dusk and retrieved at dawn. I had set up several satellite camps throughout the Okavango where we would hide fuel and extra fishing equipment and canned food (See Photo 14).

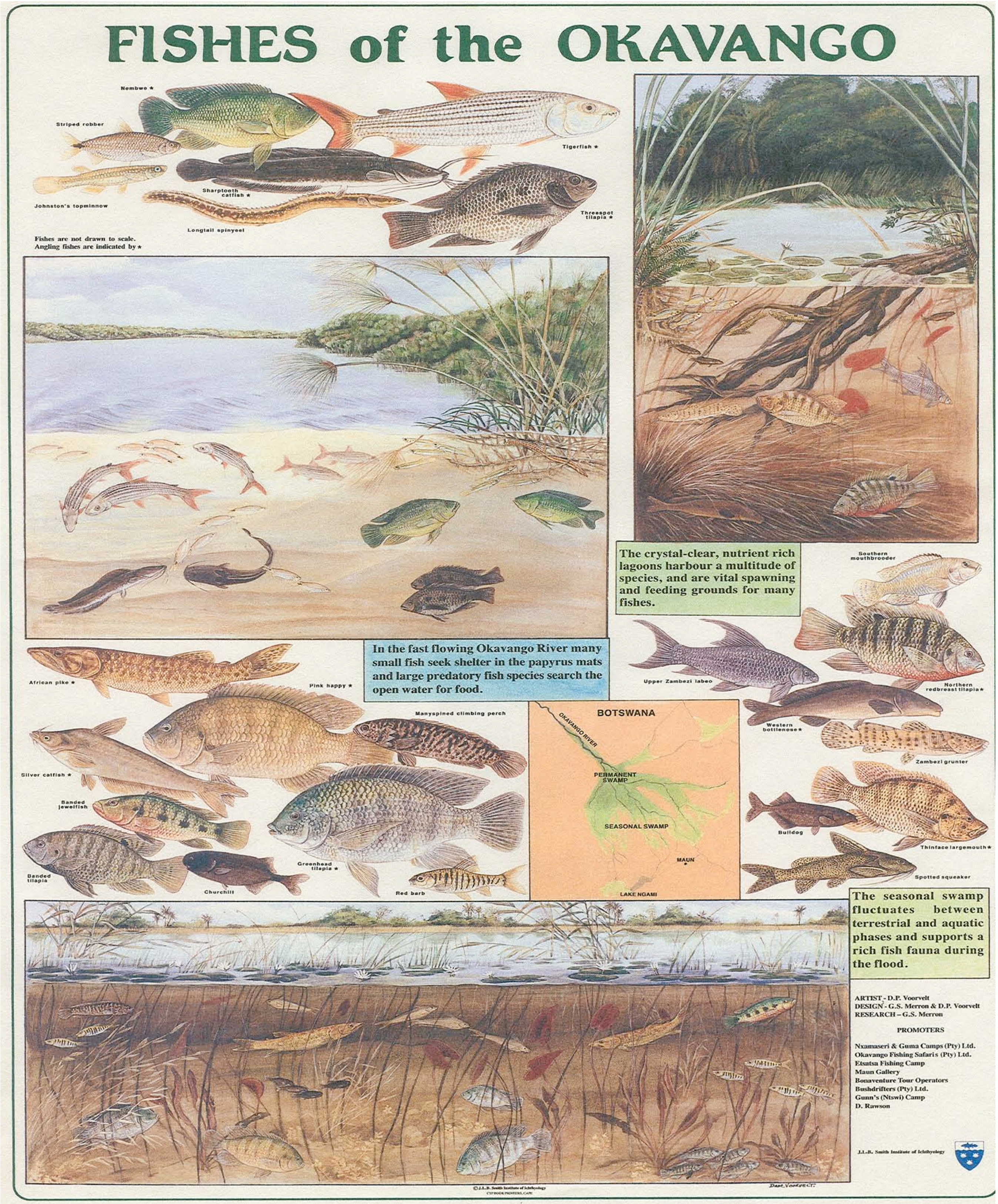


Figure 3. Fishes of the Okavango Poster.

Photo 9. A sport fishermen shown here with one of the fiercest fighting freshwater fish, the tigerfish, caught on hook and line.

Photo 10. Two of my field assistants holding up a gillnet with fish entangled by their gills.

Photo 11. Getting through one of the many papyrus blockages in the Okavango.

Photo 12. The Land Rover Forward Control that was used as a mobile research lab in the Okavango. Photo taken 1985.

Photo 13. At times a helicopter was the only way to get into the remote areas of the Okavango. Photo taken August 1986.

Photo 14. The author at one of the satellite camps used during the fisheries research program. Photo taken 1984.

CHAPTER 4 - THE TOWN OF MAUN

In 1984 the DeBeers (Debswana) Diamond Mining Company allowed me to use their camp located on the Thamalakane River about 15 km (6 miles) north of the town of Maun. The camp was originally constructed as a base camp for labor and equipment during the dredging of the lower Boro River (See Figure 2) in the early 1970s. At that time only 4 kilometers of the river was dredged to facilitate the flow of water down to the Orapa Diamond Mine in the central Kalahari Desert (See Figure 1). Botswana's diamond industry is one of the largest sources of revenue in the country. The dredging proved to difficult and by 1974 was suspended. The De Beers camp had not been used in ten years but, with the help of my staff, we turned the camp into a research facility.

As I covered a large area of the Okavango during my surveys, people in Maun would often ask me "where's the flood?" As previously mentioned the annual floodwaters from Angola arrive in the northern Okavango Delta in January but do not reach the southern Okavango and the Thamalakane River, which flows through Maun, until approximately June. When the flood waters do arrive the river comes alive. With the rising waters comes a surge in the river's productivity as nutrients are quickly assimilated by the prolific growth of plants, fish, and insects. However, during periods of drought, a trickle of water, if any at all, reaches the Thamalakane River.

When the floods arrive the Thamalakane River serves as a social gathering place for the local people. They come down to the river to wash, fish, and harvest thatch and reeds which are used to construct their homes (Photo 15). Fishing is an extremely important activity and many people spend their afternoons fishing for their evening meal. Many families depend on fish in their diets as a readily available high protein food source.

People of the area have adapted their lifestyles and activities to the seasonal cycle of resources available in the river. Fields of corn are planted as the Thamalakane recedes, exposing the fertile soil that has been washed down with the flood. Indeed, the fishes themselves adjust to the changing water levels by producing large numbers of young to ensure that some will survive the fluctuating water levels. Most fish do not manage to get back to the deeper water of the Okavango, often becoming trapped in isolated pools. This provides a short-lived, yet plentiful, resource that can be fully harvested by the local people (See Photo 16) and commercial fishermen (See Photo 17), and consumed by various predators like crocodiles, pelicans, and other fish eating birds.

Photo 15. Typical dwellings along the Thamalakane River. Photo taken October 1983.

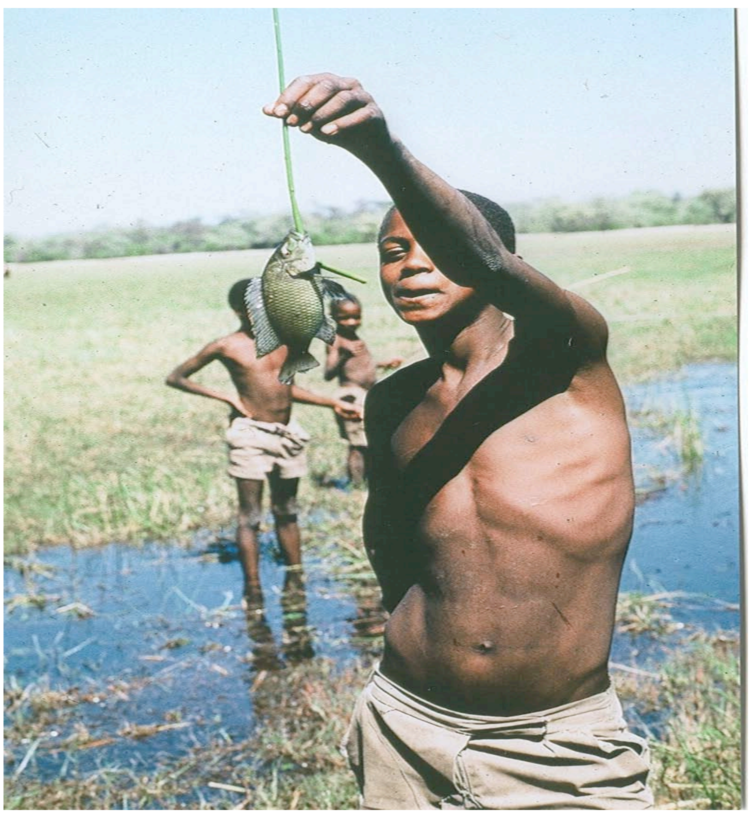


Photo 16. Young boys fishing along the Thamalakane floodplain for an evening meal. One boy is holding up a tilapia fish species that was carried back home on reeds.

Photo 17. A commercial fishermen on the banks of the Thamalakane River holding up his catch. The wooden boat is called a mokoro and his gillnets are lying in the boat.

As the fisheries research program progressed, I began to see patterns in the distribution and abundance of the various fish species in the Okavango. There was a clear distinction in the composition of the fish communities between sampling sites in northern perennially flooded sites verse the seasonally flooded habitats. The northern Okavango riverine floodplain and perennial swamp were characterized by a greater variety of fish species, many of which reach a large size such as the tigerfish and catfish. In contrast, the southern seasonal swamp and drainage rivers, which experience a wider fluctuation in annual flood levels, was characterized by a lower variety of fish species, and their overall body size was smaller.

The top predators also vary between the northern perennial and southern seasonal swamp. The tigerfish is the top predator in the fast flowing riverine habitats in the northern Okavango while the African pike is the top predator in the slower-flowing, well-vegetated southern seasonal swamps. The African pike is an ambush predator and relies on dense vegetation for cover while waiting for prey. The absence of the tigerfish from the seasonal swamp and drainage rivers is likely because this species requires large perennial river channels and lagoons to complete its life history including reproduction.

It was evident that the fish of the Okavango depend on the annual flood cycle from Angola for their survival. With the rising floodwaters drier areas are connected to the river. Fish migrate and spawn in these newly flooded areas and care for their offspring that are in their early stages of development. This flooding suddenly creates an availability of nutrients as terrestrial plant and animal matter are integrated into the aquatic system. This increase in nutrients then allows large blooms of plankton to develop, providing the primary source of food for juvenile fish. This annual cycle of flooding reflects the strong mutual interactions between the terrestrial and aquatic components of the Okavango ecosystem.

I determined that the main factors influencing the fish communities in the Okavango were a combination of the length of time the water is present, and the nature of its flow. These factors determine other physical features such as the type of aquatic plants present and the oxygen levels in the water, both of which influence the type of fish community that is found. In the Okavango, the higher the magnitude of the annual flood, the longer the retention time on the floodplain will be. This leads to a longer spawning period and greater overall production of fishes. Although there are wide oscillations in the timing, magnitude and duration of the annual flood from Angola, the Okavango does receive a flood each year and a relatively constant pattern in the response of the fish communities is apparent.

A large part of my research involved interacting with commercial fishermen throughout the Okavango in villages such as Shakawe, Ngarange, Nxamaceri, Sipopa, Seronga, Jao, and Maun (See Figure 2). The Botswana Fisheries Department held training courses at these villages to introduce commercial fishermen to fishing techniques, primarily proper repair of gillnets and ways of preserving fish (See Photos 18-21). I participated in several of these training courses and observed that they always attracted a lot of enthusiasm from the commercial fishermen.

Photo 18. The fisheries training courses I participated in taught commercial fishermen how to make and repair gillnets (seen here) and to preserve their catch.

Photo 19. John Rogers (second from left) and staff from the Fisheries Department at the village of Jao in the central Okavango during a training course in 1984.

Photo 20. The author holding a three-spot tilapia (*Oreochromis andersonii*), a sought after commercial and recreational fish species.

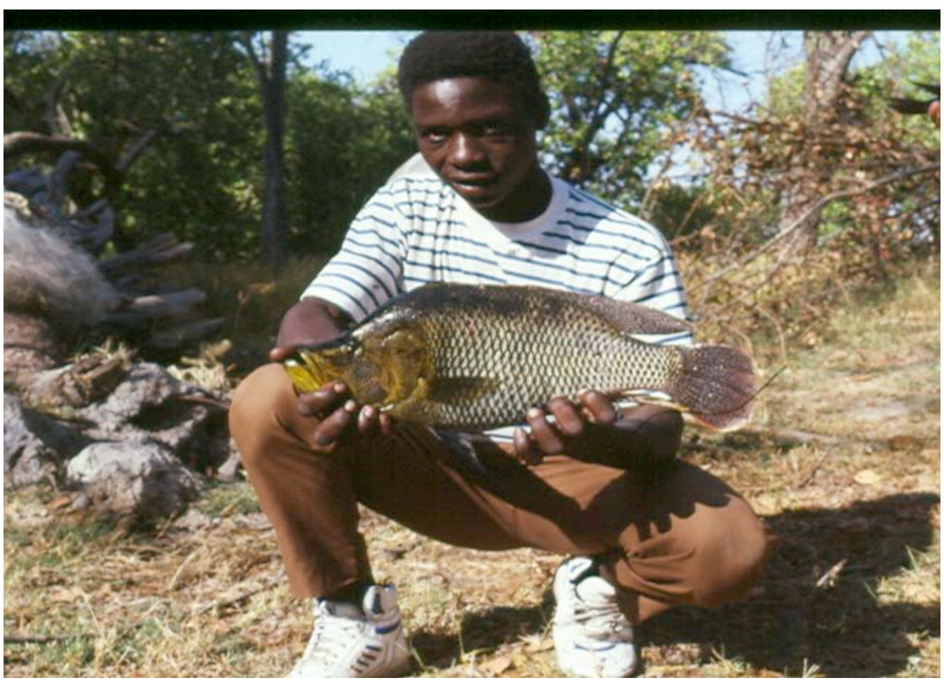


Photo 21. One of my field assistants, Judge, holding up a thinfaced largemouth tilapia (*Serranochromis angusticepts*), a sought after commercial and recreational fish species.

CHAPTER 5 - THE OKAVANGO CATFISH RUNS

During a fisheries training course at the village of Seronga in the northern Okavango in October 1985, John Rogers came racing back to camp with news that he observed a mass concentration of catfish swimming near the surface of the Okavango River. With great excitement we set out to uncover one of the Okavango's most fascinating ecological events, the annual catfish runs.

As we went upstream we could see hundreds of fish-eating birds along the papyrus vegetation which lines the river channel (See Photo 22). Upon reaching this section of river we heard a continual slapping and slurping noise. The source of the noise came from large catfish literally sucking in fish living along the papyrus fringe of the river channel (See Photo 23). Vast numbers of birds including species such as great white egrets, pied kingfishers, marabou storks, and fish eagles also feed on disoriented fish. The whole area, where the catfish activity took place, turned into a banquet for the predators. We caught a few catfish and when I dissected them we were amazed to find that predominantly the Bulldog fish (*Marcussenius macrolepidotus*) was in their stomachs (See Photo 24).

Photo 22. A scene from the Okavango River during a catfish run in 1986. Note the presence of all the birds.

Photo 23. Catfish pack-hunting along the edge of the papyrus vegetation lining the Okavango River.

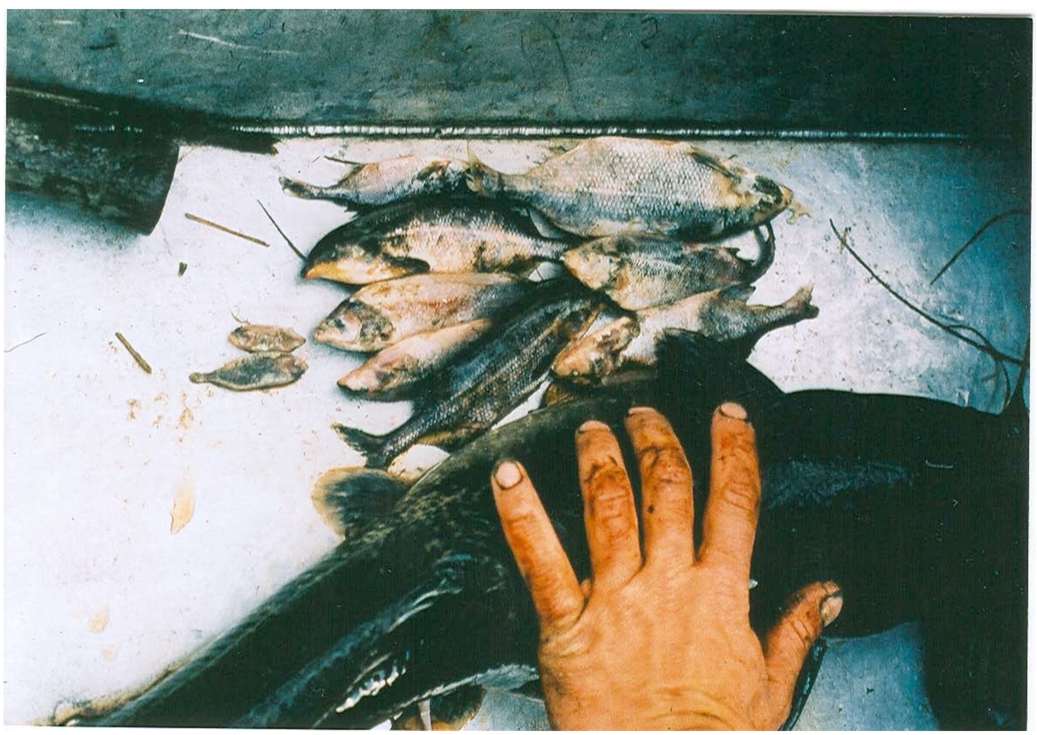


Photo 24. Stomach contents of one large catfish dissected during the catfish runs. There were 8 fresh Bulldog fish in its stomach.

My theory was that the catfish were carrying out an organized pack-hunting strategy. I was anxious to study this phenomomon in greater detail and I set out with my staff for a two-month study to follow the feeding migrations of the fascinating catfish.

Once we located a catfish run it was possible to follow it on a daily basis and to determine the direction of travel and distance covered. My observations indicated that the overall movement was upstream at a speed of 3-4 km per day.

The start of catfish pack-hunting varies from year to year depending on the magnitude of the annual flood which affects the timing of the Okavango River's low water phase when the catfish runs occur. The largest shoals of catfish and highest intensity of feeding were observed from September to November. I recorded at least four distinct catfish runs operating simultaneously at different places on the main channel, often on the same day, between the villages of Shakawe and Seronga. The average length of the runs was approximately 500 meters. Each individual run lasted only a few days afterwhich thousands of fat catfish were observed passively drifting downstream only to begin the journey upstream again when they have digested their food.

For the next several years we conducted an annual study of the catfish runs. One afternoon in November 1986 during another fisheries training course being held at Seronga, I took a ride in the boat to look for catfish activity. After about an hour on the river, I heard thousands of birds, a sure sign of a catfish run. I came around one of Okavango's majestic meanders and it was a big catfish run, almost a kilometer in length, and thousands of birds in the area were bobbing their heads up and down trying to capture the disoriented fish. I fished the run for a few hours and had about 100 catfish in the bottom of the boat. It was now dark and I camped for the night on an island adjacent to the river. I made a fire and fell asleep amongst the sounds of catfish beating the papyrus, birds yapping away, hippos snorting, and crocodiles lurking in the river.

As dawn came, I was off to Seronga with the fish. When I arrived, my staff and several of the commercial fishermen looked in the boat. There were catfish crawling everywhere. I had thrown a few buckets of water on the catfish the night before, enough to keep them moist and alive throughout the night. The Okavango's catfish are very hardy fish and capable of breathing air!

During my years of travel around the Okavango, I would always give the fish I had analyzed to the local people. It wasn't long before I would be called "Ra Ditapia (Di-tap-e)" translated in the local language as the "Father of Fishes".

This name came to be recognized in villages and among many of the people in the Okavango. While I do not envision myself as a father of fishes, it was the local peoples' way of recognizing the research I was conducting. Of the roughly 100 catfish that were analyzed and given to the local people that day, almost 75% of them had Bulldog fishes in their stomachs (Photo 25).

Photo 25. The author analyzing catfish at the Seronga boat launch before giving them to the people in November 1986.

Sport fishing is an important tourist related activity in the Okavango (See Photo 26). In October 1987 I was traveling up the northern Okavango River on a reconnaissance survey looking for catfish runs and met several sport fishermen including Charles Norman, one of Africa's well-known fishermen. Charles was writing a book entitled "African Angling" which features a chapter on sport fishing in the Okavango. The fishermen invited me to camp with them for the night and we swapped fishing stories about the one that got away.

The dawn brought rain but that didn't dampen our spirits. I told the fishermen about a catfish run that I had a hunch was probably not too far from where we were camped. With excitement they jumped into their boat. I guided them from my boat and after about 20-minutes we saw the fish eating birds and I knew we were going into a catfish run.

We went over to see thousands of catfish hunting in the papyrus fringe of the river channel. One of the sport fishermen couldn't resist the action. He cast out his line and a large catfish immediately took the bait. We slowly backed away from the papyrus and the angler played the massive 20-pound fish for about 10 minutes. When it surfaced next to the boat, its head was the size of a dinner plate and its stomach was full of fish!

We then began fishing in the center of the main river channel and, within seconds the fishermen were hooking beautiful tigerfish. Tigerfish patrol the main channel, hunting for prey that may have escaped the onslaught of the catfish feeding along the papyrus fringe.

Fishing reels were screaming and many lines would snap like a shot. The fishermen must have hooked 20-25 tigerfish, many of which, with a twist of the head, flung the metal fishing lures back at the boat in a gesture of defiance. Only a few tigerfish were landed!

The fishermen were shouting back and forth with excitement over all the commotion coming from the birds and fish. We kept a few tigerfish and catfish. The fishermen wanted to hear more about this fascinating event and I explained the ecological significance of the catfish runs, as I dissected the fish back at camp.

I mentioned that one of the most interesting findings pertaining to the catfish runs was that the stomach content analyses I conducted to date revealed that the catfish fed largely on Bulldog fishes. I mentioned that Bulldogs generate a weak electrical signal that they use for navigation. I went on to explain that catfish are able to detect electrical currents through their "whiskers", enabling the catfish to selectively home in on Bulldogs. I believe these small fishes are frantically emitting their electrical current during the massive onslaught by catfish. The act of catfish preying specifically on Bulldogs appears to be a unique feeding specialization in the Okavango.

I discussed the ecology of the Bulldog fishes in greater detail. My theory is that as the annual flood begins to recede, smaller-sized Bulldogs respond by migrating out of backwater lagoons, typically the Bulldogs preferred habitat, and into the main river channel. This occurs because they are outcompeted by larger-size Bulldogs due to the limited habitat remaining in backwater lagoons. The larger adult fishes appear to remain in the backwater lagoons. The heaviest mortality on Bulldog fishes, due to catfish predation in the main river channel, is thus on the smaller and younger fish. The backwater lagoons, therefore, serve as important refuges that harbor populations of sexually mature fishes at low water level.

During my surveys, I rarely encountered commercial fishermen taking advantage of the concentration of fish and setting gillnets during an active catfish run. The reason for this may be that the wooden boats, or "mokoros", that were used for commercial fishing at the time could be very unstable in the middle of a catfish run on the mainstream Okavango River. From the observations I made, the catfish runs were an ecological phenomena that was relatively untouched by humans. The research I had conducted on the catfish runs was subsequently published in the scientific literature (Merron, 1993).

Photo 26 (a)-(b). Sport fishermen from the Etsatsa Fishing Camp (top) and Nxamaceri Fishing Camp (bottom) fishing in the Okavango panhandle.

CHAPTER 6 - FISH FROM THE SKY AND THE AFRICAN PIKE

One day at the village of Seronga, my assistant James Molefne and I were sorting through some of the fish we had collected earlier that morning. One of the commercial fishermen came over to see what I was doing and pointed to the climbing perch (*Ctenopoma multispinus*) and called it a "Bontho" (pronounced bun-to, Photo 27). The climbing perch is easily identified from other fish in the Okavango by its course scaly body pattern, elongated dorsal fin, and notched gill covers. A series of zigzag black markings are present along the side of the dark brown body. Its average length is about 125 mm (5-inches).

The fishermen explained that this fish falls from the sky during periods of high rainfall. This was a fascinating story and I wanted to know more. The fishermen reasoned that they fall from the sky because these fish appear on land far from the swamps during periods of heavy rainfall. I asked whether he had ever seen this fish fall from the sky, and he said "No, but this is how they get there". I acknowledged his account of the fish and proceeded to show him the serrated gill cover, which is a special adaptation of this species, that is used like a pulley for traction over muddy and moist landscapes.

Climbing perch literally crawl out of the swamps and across rain soaked land, possibly in search of food. The climbing perch is able to breath air directly from the atmosphere through a second adaptation which is a lung-like organ. I explained to the fishermen that the reason the climbing perch were found away from the swamps was because they crawled out of the water, not that they came from the sky. He shook his head and chuckled at the stories "Ra Ditapia" had to tell!

Photo 27. The many-spined Climbing Perch.

Another fascinating fish discovery in the Okavango occurred during a visit by Professor Mike Bruton in 1985 when we came across saucer plate size clumps of foam bubbles. Not far from the clumps of foam, adult African pike (*Hepsetus odoe;* See Photo 28) were observed. We were convinced these were the foam nests of the African pike.

Pike are a torpedo-shaped, ambush predator, with a long jawed mouth containing numerous sharply pointed teeth. The adult fishes are cryptically colored brown with irregular transverse bands. Pike prefer quiet backwaters and are found throughout the Okavango Delta although they are more common in the southern Okavango waterways.

While observing the foam nests and the behavior of guarding adults, we discovered tiny baby pike clinging to the bottom of the nests (See Photo 29 and Figure 4). The nests ranged from those with a firm high dome of tightly-packed foam bubbles with embedded eggs to more flattened configurations with embryos suspended below.

The nests were typically circular and pierced to varying degrees by plant stalks, which probably serve to stabilize their location when the nests are subject to wind-induced wave action. The adults exhibited territorial behavior in the vicinity of the nests and added foam as necessary to the nests when the juveniles were being guarded. The foam is secreted through two pairs of dermal flaps on the upper and lower jaw of pike. The young pike remain by the nest for approximately two weeks before swimming away on their own to establish territories.

Subsequent to this observation my field staff and I would often encounter pike nests and observe the behavior of the adults and young fish. My staff would call the foam nests the "Spit of God". This research work was later published in the scientific literature (Merron et. al., 1994).

Photo 28. An adult African Pike.

Photo 29. A foam nest made by adult African pike.

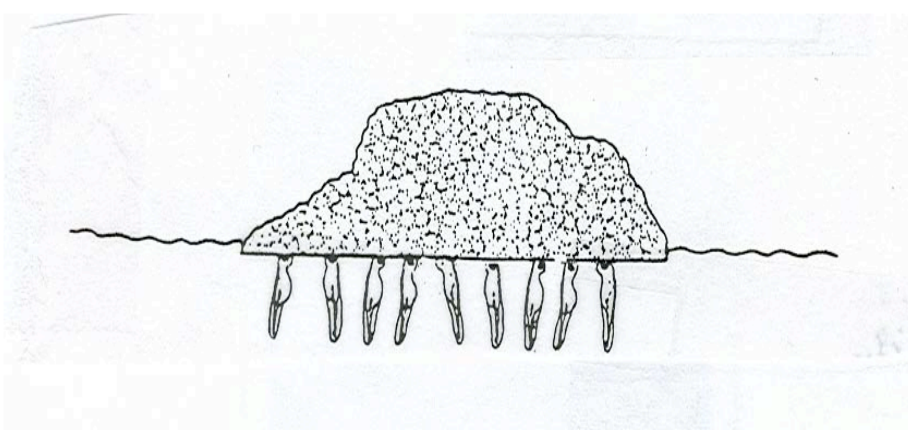


Figure 4. A diagrammatic illustration of young African pike clinging to a foam nests built by the parents.

CHAPTER 7 - OTHER OKAVANGO FISH SPECIES AND THEIR DIETARY PREFERENCES

A total of 70 fish species, comprising 12 fish families, were collected throughout the course of the fisheries program. Rarely were more than 15-20 species found to be common in any one type of habitat such as river channels, lagoons, or backwater swamps.

During my research I dissected thousands of fish in order to determine what they fed on and how the food chain of the fish community operates. I determined there are eight major types of fish feeding groups in the Okavango, including predatory fish that feed on other fish, and fish species that feed on plant material, organic sediments, mollusks, crabs, aquatic insects, and plankton. There are also fish species that are generalist and will eat anything. The dietary preferences of select Okavango fish families are below.

The characin family (pronounced char-a-cin) consists of four species in the Okavango that have a generalized feeding habit with a wide selection of food being eaten. The tigerfish (See Photo 30), however, feeds almost exclusively on other fish (with snakes and small mammals also recorded in stomach contents). Other species of characins analyzed especially the striped robber (*Brycinus lateralis*; See Photo 31) had undigested seeds in their lower intestines consumed from submerged plants found along the banks of the river channels and lagoons. This undigested matter indicates that this material passes through the digestive tract and out in the feaces. I believe the characins play an important role in spreading seeds and allowing plants to germinate in recently inundated areas throughout the Okavango.

The cichlid family (pronounced sic-lid) commonly called tilapia, includes at least 12 species in the Okavango. Several of these species are widespread throughout the ecosystem. The southern mouthbrooder (*Pseudocrenilabrus philander*; Photo 32) feeds predominantly on bottom sediments and algal material. Other species of fish in this family such as the nembwe (*Serranochromis robustus jallae*; See Photo 33) are predatory and feed on live prey organisms. The redbreast tilapia is a herbivore and found to feed almost exclusively on aquatic plant material.

The clariid family (pronounced clar-e-id) includes the Okavango’s four catfish species. The most common species is the sharptooth catfish (See Photo 34) which feeds on a wide variety of food items including fish, aquatic and terrestrial insects, seeds and fruit, amphibians such as frogs, small mammals, and bird hatchlings. As previously discussed catfish congregate in the Okavango River yearly between September through November and carry out organized pack hunting, targeting Bulldogs.

The cyprinid family (pronounced sy-prin-id) commonly called minnows is the most diverse group of fishes in the Okavango and represented by 14 species. These species are typically generalist feeders that will consume a wide variety of prey items. The Upper Zambezi Labeo (Photo 35) is the largest member of this family inhabiting the Okavango and feeds primarily on detritus.

The afromastacembelus family (pronounced afro-mas-ta-cem-belus) are unique Okavango habitat specialist and live primarily along the fringe of the main river channels. The spiny eel (*Afromastacembelus frenatus*; Photo 36) feeds predominantly on aquatic insects and plant material and is a very elusive fish to collect.

The mormyrid family (pronounced mor-my-rids) consists of five species in the Okavango that feed predominantly on aquatic larval insects. Only a very small percentage of mormyrids had empty stomachs. The reason for this is that nearly all the Okavango's mormyrid species feed principally on small organisms and large quantities of food are ingested daily. The mormyrids, such as the churchill (*Petrocephalus catostoma*; See Photo 37) utilize a major proportion of the aquatic insect fauna as a food source.

The schilbeid family (pronounced schil-be-id) has only one representative in the Okavango, the silver catfish (See Photo 38). These fish consume a wide range of prey items including fish, terrestrial and aquatic insects, crustaceans, and amphibians. This species was one of the few fishes that were found to feed exclusively on flying termites when they hatch after summer rains. Silver catfish are equipped with sensory barbels, a large mouth, and jaws armed with numerous small teeth. Prey is swallowed whole, often resulting in gross distension of the stomach. The silver catfish is abundant in the Okavango and its importance in food chain dynamics is considerable. Because it feeds heavily on terrestrial insects it represents a major pathway by which terrestrial resources are introduced into the aquatic environment.

Photo 30. The author analyzing tigerfish stomach contents in October 1987.

Photo 31. A small species of characin, the striped robber, which is commercially harvested species as a result of the fisheries research program.

Photo 32. The southern mouthbrooder which brood newly hatched offspring in their mouth.

Photo 33. The nembwe is one of the many species of cichlid or tilapia species found in the Okavango.

Photo 34. The sharptooth catfish, another commercially harvested fish species.

Photo 35. The Upper Zambezi Labeo feeds predominantly on detritus and is a relatively common fish in the Moremi Wildlife Reserve.

Photo 36. The spiny eel inhabits the dense root zone of the papyrus mats and feeds on a variety of aquatic insects.

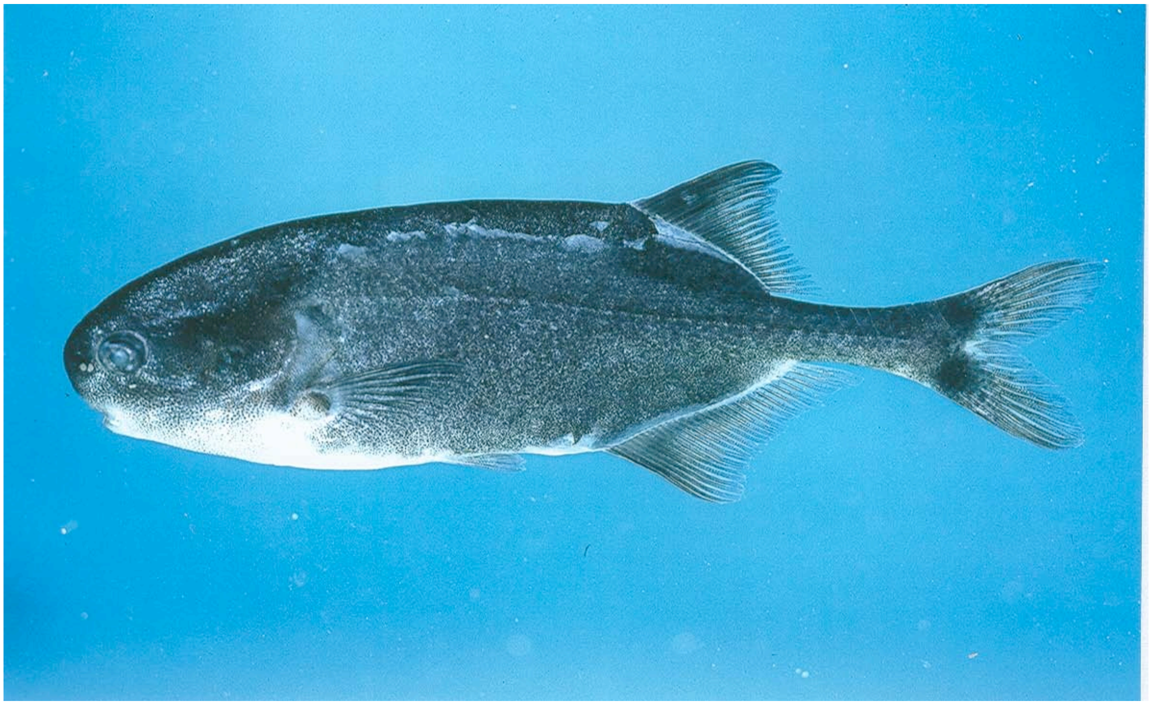


Photo 37. The mormyrid fish called the Churchill feeds primarily on aquatic insects.

Photo 38. The silver catfish, which also became harvested as a result of the fisheries research program, is a true opportunist and eats a variety of food items.

CHAPTER 8 - TRAVELING AROUND THE OKAVANGO

Travelling around the Okavango to conduct the fisheries survey work was always eventful and no two days were the same. My field assistants and I encountered a variety of wildlife and lions were a particular problem at several places we camped. During one trip, my field assistant Punky and I were driving to Nxaragha Lagoon on the Boro River (See Figure 2) when the clutch on the "Land Rover" research truck gave up. After several hours, a Department of Water Affairs truck came by and I got a lift back to Maun. Punky stayed with the research truck. There was enough food and water for several days.

I found the Fisheries Officer John Rogers in Maun and explained the situation. It was late in the afternoon and he mentioned that one of his drivers could take me and a local mechanic I knew back to the truck in the morning. The mechanic and I then tried several places to locate a second clutch but finding, or shipping, a working clutch for our Forward Control land rover in those days could take several weeks!

It was late afternoon the next day when we reached Punky and found him locked inside the truck. Upon closer examination we could see lion tracks all around the truck. I told Punky it was now safe to come out of the truck. He said that several lions had approached the truck the previous night and he was sure they were still around. We calmed Punky down and began repairing the truck. The sun was setting and we camped for the night.

By the sounds of the lions they were not too far away. The only relief we had was that we had past a large herd of Cape Buffalo (Photo 39) earlier in the day that was not too far from our camp, and we all hoped that would be a much better attraction for the lions. We did, however, build up the camp fire and stack lots of wood close by!

Punky stayed in the cab of the truck and would not move! The next day we adjusted the clutch enough so that once the RPMs were just right, you could "forcibly" push the gear lever in place.

Photo 39. A herd of Cape Buffalo near Nxaragha Lagoon.

During a fisheries survey in 1984, Professor Mike Bruton and other scientists were visiting and we camped at one of the sampling sites in the Moremi Wildlife Reserve. One of the scientists, a specialist in fish parasites, needed to keep his fish alive until he was ready to study them. He set up a small holding facility for the fish in buckets behind the shade of the Land Rover truck.

One night he checked his fish and pronounced them safe and sound. We could all hear the sounds of lions in the distance. I retired to the back of the Land Rover truck with my wife Sue who was along with me on this trip. Mike Bruton and the scientists stayed in a large six-person tent. During the night I got up to answer a call from nature.

As I got out of the Land Rover my eyes caught those of a lioness in the brush not far from the camp. I backed up into the truck and with the door ajar proceeded with my business.

When the scientists awoke everyone was looking at the lion tracks around the camp, although the specialist in fish parasites was muttering something about his fish that had somehow died during the night. I told my wife Sue about the lions being around and she went over to the area where the scientist had placed his fish by the Land Rover. She then quietly said, "Glenn I think you peed in the fish bucket". We told Mike Bruton what we thought happened and had a good laugh. We quickly mobilized and got the scientist another sample of fish.

Elephants were also common throughout the Okavango and, fortunately, I only experienced one unpleasant encounter with these terrestrial giants (Photo 40). One afternoon while in the Moremi Wildlife Reserve, my staff and I came upon a herd of elephants along the road. On this survey, I was using an open backed Toyota pick-up truck, and with me was Dan, a tourist from California who had been giving me a hand and wanted an inexpensive way to see the Okavango. My field assistants were sitting on the camping and fishing equipment in the back of the truck and Dan was in the front cab with me.

In an instant elephants were all around us. I told Dan not to worry. With the exception of Dan, my staff and I had encountered elephants on numerous occasions with no problems.

However this occasion will remain a vivid memory in my mind forever. I began to slowly back up the truck. As I was backing up Dan mentioned there was one, very big, elephant a few hundred feet away and turned directly at the truck. It didn't move but had its head bent low. All of a sudden the elephant came charging at us. I yelled to everyone to hold on and backed up as quickly as possible. The elephant was rapidly approaching and I thought the only way out of this was to try and spin the truck around and drive off in the direction we came.

There was a small opening between the trees and I cranked the wheel of the truck around but got bogged down in sand. The elephant was almost on top of us.

I yelled “run” and Dan and I flew open the doors of the truck, jumped out, and ran into the forest. My field staff were already ahead of us. We must have ran a few hundred feet.

The elephant had stopped at the truck and was smashing the cab with its trunk and tusks. The door on the driver’s side was buckled and the window broken. Fortunately, the episode ended within seconds, and the elephant returned to the herd. My field crew was rambling on in Setswana, the native language of Botswana, and everyone was shaking from the adrenalin pumping through our bodies.

I looked at Dan and he looked down at his foot. While running through the forest he was impaled by a 4-inch long thick acacia tree thorn. I pulled the thick thorn through his foot and we all sat down for a minute. We gave a Dan a hand as he hobbled and we returned to the truck.

We looked at the trashed yet not demolished truck and Dan’s foot, concluding it could have been much worse. I bandaged up Dan’s foot and my staff pushed the roof of the truck cab and door back into reasonable shape and cleaned up the glass. We continued with the sampling program.

Later that day we met Doug Skinner who managed a safari lodge at Xakanixa (pronounced Ka-kan-a-ka) Lagoon in the Moremi Wildlife Reserve (See Figure 2). Doug always provided logistical assistance with the fisheries research if I needed it while I surveyed this area of the Okavango. He asked what the heck happened to the truck. I explained the experience.

Doug mentioned that there was a group of people in the area who were apparently harassing the elephants. He said we probably came across a very uptight herd and was glad we were okay! Doug invited Dan and I for dinner and, of course, he asked us to explain the experience again. The tourists looked at the damaged truck and all ears were listening to the story!

Photo 40. One of the thousands of elephants inhabiting the Okavango swamps.

Due to the nature of the fisheries research, crocodiles and hippopotumeses were also common animals we encountered. Crocodiles would often get tangled in the gillnets while trying to feed on the fish caught in the nets. These encounters typically resulted in an early morning tug-of-war, with the crocodiles winning most of the time and tearing through the nets.

However, one morning at Qorogwe (pronounced Gor-o-ke) Lagoon, we could see a large crocodile was caught at the far end of the nets. Its snout was completely wrapped in the net and its front right leg was also tangled. A huge clearing in a field of lily pads in the lagoon was testament to how this croc must have twisted and twirled in an effort to get free of the gillnets.

I knew that trying to free this croc from the net was not going to be easy. With me was Judge, one of my staff, who took control of the boat. I reached for the gillnet and slowly started pulling it towards the boat in an effort to get as much net out of the water as posssible.

The croc came along for about a minute and then went ballistic! I quickly cut what netting had been reclaimed and waited. I cut away about 25 meters of net, but there was still too much gillnet left in the water for the croc to get tangled in further, and possibly causing it to drown. I told Judge we needed to go through the exercise again. I grabbed the net again and began to pull ever so slowly. Five, ten, fifthteen meters and the croc started pulling back on the net. It was time to cut it again.

The enormity of the beast was breathtaking. It was about 20 meters from us and I decided to make one final effort to cut more net. I looked at the croc, a creature that has gone unchanged for millions of years. Why change, Mother Nature had already made it the perfect predator. The croc was about 16-18 feet long and half as wide as the boat.

Although still tangled I figured the croc would go for us, possibly use its tail to trash or tip the boat or worse hit us with it. I had about 10 more meters of gillnet left and knew that I had better cut the net now. As I did the croc started rolling around in the water and we backed away. It was ripping and tearing at the net and its front leg became untangled. It headed back to the field of lily pads, still with its snout tangled up in the net.

We could see the croc thrashing around for what seemed forever when in reality were only minutes. It then submerged. All of a sudden it breached the surface of the water like a whale, tearing at the gillnet around its snout. The croc submerged again. Seconds later it broke the surface of the water again. It was free of the net and we could see the beast swim through what remained of the lily pad field. I looked at Judge and we sat in the boat for a few minutes exhausted from the ordeal. We had just witnessed an unforgettable Okavango moment. I went over to pick up the rest of the torn gillnetting and we returned back to camp to tell the story.

Photo 41. Qorogwe Lagoon, one of the many lagoons where crocodile encounters were common.

The hippos (See Photo 42) posed a different problem. I always maintained a healthy respect for these aquatic giants. Hippos play an important role in maintaining open channels throughout the Okavango and enriching its waters with their nutrient rich feaces. Numerous times my staff and I came around a bend in the river and there they were: three, four, or five of them wallowing in a deep 10-foot pool. Normally, they would submerge and I would drive the boat over the top of them without hitting them. You don't get too much time in the Okavango to ponder a decision!

On one occasion, a hippo charged the boat in a lagoon while two of my staff were setting gillnets. I was writing up field notes on shore and when I looked up I couldn't believe what I was seeing.

The two of them jumped overboard and like Olympic swimmers they were on shore within seconds. The hippo submerged and surfaced next to the boat and then went to the middle of the lagoon where other hippos had congregated. The dilemma now facing us was how to retrieve the boat. We waited for over an hour in hopes that the wind would push the boat towards shore. However, it was getting dark and we needed to retrieve the boat. James Molefne then tied a rope around me, and I cautiously swam out, grabbed onto the boat and I was quickly pulled back to shore by my staff.

Photo 42. The author and a field assistant distancing themselves from a group of hippos in 1985.

Hippos weren't always aggressive. During a fisheries survey two of my field staff and I were on our way back to Maun from Seronga through the heart of the Okavango by boat. It was about 9 p.m. and we were in the lower Boro River, near the junction with the Thamalakane River. Jambe, another excellent field assistant, pointed out that there was a hippo up ahead. The river was about 15 feet wide and only about 4 feet deep with fairly steep banks on either side. There wasn't enough room to pass safely around the hippo or deep enough to go over the top of it.

We stopped the boat and removed the important equipment. I looked at the hippo and said "We just came from the swamps and need to pass". I gave the boat a gentle push and it drifted with the slow current. We walked on shore around the hippo.

We watched as the silver boat drifted past the dark gray hippo ever so slowly. The hippo could have easily knocked the boat out of the water but it drifted past the hippo without incident. It was another magic Okavango moment for my staff and me.

We retrieved the boat downstream of the hippo and continued our way back to the DeBeers base camp. I looked back at the hippo and said "Thank you".

Over the years traveling up the Boro River we passed this particular hippo on several occasions without incident.

Unanticipated events in the field were relatively common and plans needed to be made to adjust to varying circumstances. During one of Professor Mike Bruton's visits in 1989 we were headed to Qorogwe Lagoon by helicopter to survey the fish population. My field assistants and I had put a considerable amount of effort into making this a well-equipped satellite field camp in preparation of Mike's visit. However, upon reaching the site I could see that the area had recently been burnt (See Photo 43). Mike Bruton summed up the situation very well when he wrote an account of the event (Appendix A) as follows:

> "Once on an expedition to the Okavango, Glenn Merron was keen to show me his meticulously prepared bush camp from which he conducted research. During the helicopter flight to the site, Dr Merron enthused over the beautiful setting and about the devotion which his camp attendants had prepared the camp for my arrival. We were horrified to find, however, when we reached the site, that a bush fire had swept through it and all the equipment had either been burnt or melted into little black knots of congealed plastic. The tents, ground sheets, ropes, boxes, and other equipment had all been incinerated. We nevertheless had to continue the sampling program, sleeping outside in the ashes and making do as best we could. At the end of the sampling period, we caused a sensation at the Maun airport when we arrived there by helicopter, black as the ace of spades!"

Photo 43. Professor Mike Bruton at Qorogwe Lagoon in August 1989.

Fishery expeditions were often suspenseful. On one occasion Dr. Paul Skelton (Photo 44), who is the Managing Director of the South African Institute for Biodiversity in Grahamstown (formerly the JLB Smith Institute of Ichthyology), approached me about assisting him with a fisheries expedition to the Okavango River along the South West Africa and Angola borders in February 1984. The surveys were part of an environmental assessment by the South West Africa Department of Water Affairs for the multi-phased Eastern National Water Carrier (ENWC). The ENWC may draw water from the Okavango River under a future scenario that could link the river to the country's interior.

At the time, the country of South West Africa was under the control of the South African Government. The South West African People's Organization (SWAPO) was at war for control of the country. Rundu (Figure 1) was a military town and a launch for South African troops into southern Angola where SWAPO bases were located. SWAPO ultimately gained control of the country in 1990 which was renamed to the Republic of Namibia.

Paul and I began our journey which led us through the central Kalahari Desert. The Kalahari is not a desert like the Sahara Desert where rolling sand dunes cover a vast area of northern Africa. The Kalahari Desert boast a fair amount of grasses, shrubs, Acacia trees, and the occasional giant Baobab tree that can survive cycles of drought. The Kalahari also has a rich wildlife community including eland, zebra, wildebeest, lions and hyenas.

The road we traveled was a single lane, sandy track that rattled our teeth loose and left our bodies covered in grit. The constant bouncing caused the back window of our Toyota 4x4 to fall out. After three days driving through the desert and passing, maybe, half dozen vehicles along the way, we made it to the Namibian border. We then traveled on to the capital city of Windhoek where we meet up with other expedition members.

After a briefing with Government Officials in Windhoek we started out for the town of Rundu on the banks of the Okavango River (Figure 1). Once we arrived, Paul needed to inform the South African military commander of our activities. There were bunkers all around and military "Caspers" (similar to the modern day Humvee) patrolling everywhere. We fully appreciated the danger of this war zone and carried out our surveys with the utmost concern for security. We sampled the Okavango River along the borders of these countries over the course of a week, making the first comprehensive collections of fish in the area.

One evening, however, during a dark, moonless night we were sitting around the campfire along the river when we suddenly saw mysterious shapes floating downstream with the current. The shapes were amazingly like men with guns in an upright position. One of the expedition members, a former South African soldier, ran over to one of the vehicles to get his gun and shine the lights. With the lights on we could see these enormous islands of papyrus mats that had broken free from the massive papyrus swamps as a result of rising flood waters. The men we thought we could see with guns turned out to be giant 8-foot high papyrus stalks! We all had a very thankful sigh of relief!

Photo 44. Dr. Paul Skelton, standing center in boat sampling fish along the Okavango River.

During another fisheries survey with Paul in October 1984 we stopped at the village of Sipopa on the west side of the Okavango panhandle to collect fish in the area. We launched the boat and located a sampling site about a mile downstream from our camp. We made an excellent fish collection from underneath the thick papyrus mats, but while heading back upstream, our outboard engine quit, and probably the result of to many bounces over the rough roads.

The strong current of the river made our attempts to row upstream futile. We then tried to pull the boat along the dense papyrus fringe of the river which proved equally as futile. Dusk was rapidly approaching and we were faced with a very long, cold, hungry and mosquito-filled night on the river tied up to the papyrus. Suddenly, we heard the sound of an outboard engine in the distance and both of us hoped that we would be rescued from this most uncomfortable predicament. The boat turned out to be a Botswana Police boat coming from the village of Seronga and, with the sun setting, the policeman kindly towed two greatly relieved scientists back to Sipopa for the night.

CHAPTER 9 – IMPROVEMENTS TO THE COMMERCIAL FISHERY

Over 70 species of fish were collected during the Okavango fisheries research program and it is likely that more species are present. The goals of the fisheries research program were:

1) To identify fish distribution, abundance, biology, and ecology throughout the Okavango and how it relates to the annual flood cycle, and
2) To use this information to improve the harvest of fish while maintaining the ecological integrity of the fish stocks.

One of the main research findings was that the abundant silver catfish (*Schilbe intermedius;* See Photo 38) could be harvested to increase the yield of fish to local fishermen. The silver catfish was caught in smaller mesh gillnets (50-60 mm or 2-inch stretch mesh). This large stock of fish was previously not being caught because of the use of only large mesh gillnets (110 mm or 5-inch stretch mesh).

It was first thought that the use of smaller mesh gillnets would catch immature fish, thereby affecting the overall fish population. However, my research showed that few immature fish were caught in smaller mesh gillnets because they inhabit the dense plant communities for up to two years before they are large enough to move into open water areas and co-exist with larger predatory fish, such as tigerfish. The silver catfish, on the other hand, co-exist with larger predators in the open water, where gillnets were typically set. Silver catfish have evolved a defense mechanism in the form of sharp pectoral and dorsal spines that afford a degree of protection from the larger predatory fish. I believed that shifting some of the fishing effort to harvest silver catfish would also benefit the sport fishery by reducing the number of tigerfish that were caught in the larger mesh gillnets that were being used by commercial fishermen.

Silver catfish, with their sharp spines are, however, difficult to remove from gillnets. Pliers were often needed to break off the spines of these fish before removing them from the nets. I realized there needed to be an incentive for commercial fishermen to spend extra time removing these well-armored fish from the gillnets. My idea was that the commercial fishermen should be paid a higher price per pound for silver catfish than the other commercially harvested species that were caught with larger mesh gillnets. After discussing the idea with John Rogers, the Fisheries Department implemented a monetary incentive program whereby commercial fishermen were encouraged to catch the silver catfish using smaller mesh gillnets. The increased harvest of silver catfish was especially successful in the more nutrient-rich waters of the southern Okavango drainage rivers, especially the Thamalakane and Botletle. In addition, the research results showed that the use of a 24 mm (1-inch) gillnet was effective in catching the striped robber (*Brycinus lateralis;* See Photo 30), which could also be targeted by the commercial fishery.

The use of longlines (See Photo 45), which consist of a series of baited hooks hung along a 100 foot section of nylon rope and set overnight, was found to be another way of increasing the yield of fish to local fishermen while maintaining the integrity of the fish stock. Over 90% of the catch on longlines consisted of large catfishes. Because of this selectivity, longlining is an ideal way to target the abundant catfish without affecting the populations of other fish species. A longline is inexpensive, easy to use and simple to maintain, all crucial factors for the success of any new fishing method.

A fisheries workshop, entitled "Development and Conservation of Okavango Fishes", was also organized to share the research information and discuss fisheries recommendations with various fisheries 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 (See Merron 1992).

During the workshop I expressed the need to determine the level of fishing effort and catch associated with the subsistence fishery. These are men, women, and children who catch fish for their meals and include thousands of people. At the time the relatively unknown subsistence fishery was probably harvesting more fish than both the commercial and sport fisheries combined. Subsistence fishermen caught fish using a variety of techniques that included hook and line, fishing traps, hand held baskets, gillnets, bow and arrow, and spears (See Photos 46 through 50). A second poster entitled "Okavango: Man and Fishes" that depicts commercial, sport, and subsistence fishing methods had also been produced and distributed in Botswana (See Figure 5). It was sponsored by several of the safaris camps and local businesses in the Okavango.

Workshop delegates also discussed the need to address the impacts of large scale burning of the papyrus swamp that was occurring in the northern Okavango between the villages of Shakawe and Seronga. Local people largely conduct burning as a pastoral practice. Prescriptive burning events could, however, extend beyond the control of whoever set the fire as, for example, the large scale-burning event in 1990 (See Photos 51 and 52). I was acutely aware of the need to assess the impact of large scale burning and its affect on water quality and fish populations. Large scale burning would not allow the annual floodwaters sufficient time to naturally filter through the papyrus mats. Instead floodwaters would quickly pass through an area, picking up a heavy load of organic ash that would affect water quality by depriving the water of valuable oxygen, thereby affecting fish and resulting in fish kills.

Photo 45. James Molefne holding up a longline with a sharptooth catfish.

Photo 46. A subsistence fishermen fishing with a wooden stick from a “mokoro”.

Photo 47. A subsistence fish trap made from reeds and local material in the Okavango swamps.

Photo 48. Women fishing with baskets in the Okavango River.

Photo 49. Subsistence fishing with a bow and arrow.

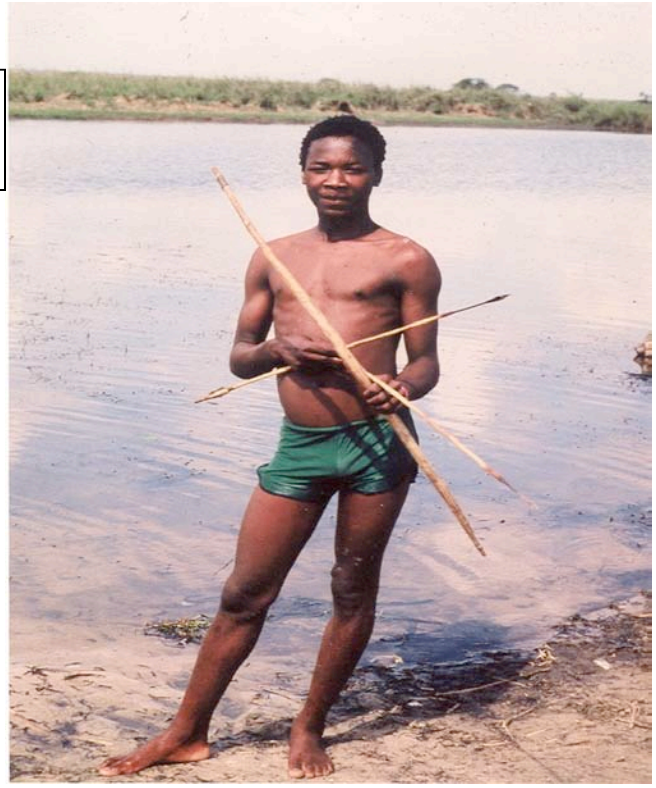


Photo 50. A subsistence fishermen setting his gillnets.

Photo 51. The author viewing a large-scale fire set in the northern Okavango near the village of Sipopo in November 1989.

Photo 52. A close up of the papyrus vegetation along the Okavango River as it was being burnt.

Figure 5. Okavango poster entitled "Man and Fishes".

CHAPTER 10 – AN ALIEN AQUATIC WATER PLANT

The Okavango contains a rich variety of natural aquatic vegetation, particularly the extensive papyrus swamps of the northern perennial regions. However, *Salvinia molesta* or Kariba weed (Photo 53) is an alien aquatic plant that was brought to Africa from South America in the 1900s as an attractive plant to place in garden ponds for the European settlers. This plant has now spread throughout vast areas of the African continent clogging waterways and necessitating numerous control programs at considerable cost to many governments.

In northern Botswana, *Salvinia* has occurred for over 50 years along the Kwando and Chobe river systems (See Figure 2). An account of *Salvinia* control in Botswana is provided by Pete Smith, former Head of the Aquatic Weeds Control Unit, within the Department of Water Affairs (See Smith 1985). In the absence of any natural predators, *Salvinia* can spread rapidly. It is a floating plant that moves with the flow of water and has a very high growth rate. It is able to double itself in size within a month and form huge mats. The problem with the establishment of *Salvinia* is that it leads to the exclusion of sunlight within rivers and lakes, thereby reducing one of nature's fundamental ecological processes known as photosynthesis. Photosynthesis is the process by which energy from the sun's rays is absorbed by a green pigment, called chlorophyll, found in the stems and leaves of aquatic plants. The process triggers a chemical reaction whereby life-sustaining oxygen is made available to a host of organisms. *Salvinia* effectively shades out the sun's energy and prevents aquatic plants from manufacturing oxygen in water. Consequently, fish life is adversely affected and the diversity of fish is much lower in *Salvinia* infested waterbodies.

The first outbreak of *Salvinia* in the Okavango Delta appeared in the Moremi Wildlife Reserve in 1986. Its spread to the Okavango was attributed to either a boat or vehicle coming from *Salvinia* infested water outside the Okavango. Due to the tremendous efforts of the Aquatic Weeds Control Unit, the area around the infestation was fenced off and the masses of *Salvinia* were collected and burnt.

In 1989 Pete Smith invited me on a *Salvinia* survey with Dr. Wendy Forno, a leading expert in biological control of aquatic weeds. Dr. Forno was assisting Pete and the Botswana Department of Water Affairs with a very successful biological control program using a small weevil (*Crytobagous salviniae;* See Photo 54) from South America. The weevils feed solely on the *Salvinia* plants and reproduce so well that their population exponentially increases and the *Salvinia* mats sink and are destroyed due to the sheer combined weight of the many weevils on top of them. As the mats sink the weevils either have to jump ship and find other clumps of *Salvinia* or sink with the mats. The weevil's diet is so specific that they pose no threat to any indigenous plants or animals. An account of this biological control program was published by the Government of Botswana, Department of Water Affairs in 1992.

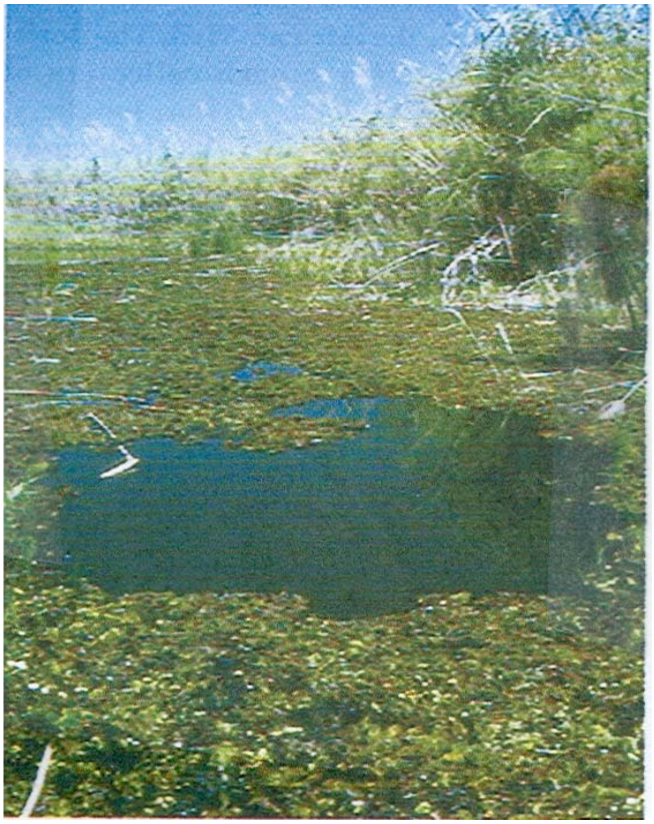


Photo 53. The alien Salvinia plants within the papyrus fringe along the main channel of the Kwando River in northern Botswana, December 1986.

Photo 54. The tiny weevil (*Crytobagous salviniae*) that feeds specifically on the alien *Salvinia* plants which can adversely affect the health of the fish population.

CHAPTER 11 – OKAVANGO WATER: TO USE OR NOT TO USE

In 1990, a heated debate flared up over utilizing the waters of the Okavango. The project was known as the Southern Okavango Integrated Water Development Project. One of the objectives of the project was to form a reservoir on the Thamalakane River near Maun. Establishing a reservoir could have many benefits for fish and wildlife resources, agriculture, and other industrial uses. The problem facing the Government was how to get the water into the reservoir. The project called for dredging 42 kilometers of the Boro River to enhance the flow of water into the reservoir. The people of the Okavango and the international environmental community would not accept the dredging. The dredging of the Boro River in the early 1970s had already altered the configuration of the river by creating a single narrow channel that flowed out of the central swamps (See Photos 55 and 56). In 1991 the Government of Botswana put the project on hold pending further investigation of its environmental and socio-economic effects. The World Conservation Union was invited to undertake these investigations, and its findings suggested that an increased use of surface and ground water resources might better solve the water needs of northern Botswana. The Government of Botswana then terminated the project.

Botswana is not the only country looking to utilize the Okavango's waters. There are other water development schemes in countries that share Okavango water, such as Namibia, where the multi-phased Eastern National Water Carrier has the potential to divert water from the Okavango River before it enters Botswana. Depending on the degree of diversion this could have serious consequences to the ecological dynamics of the Okavango Delta in Botswana. As previously mentioned, Dr. Paul Skelton and I had the opportunity to conduct the initial fisheries surveys that were part of an environmental assessment for the project during the mid-1980s. At that time a small percentage of water was already being diverted from the river (See Photo 57). Project engineers also discussed construction of a dam and hydroelectric facility on the Okavango River at Popa Falls, which could also affect the Okavango Delta in Botswana. While writing this account I came across an article entitled "Meeting Namibia Water Needs While Sparing the Okavango" (International Rivers Network, 2002). The article states that by incorporating alternative water resource strategies, such as tapping groundwater resources, Namibia can meet future water needs while sparing the Okavango. Another article published in 2003 entitled "NamPower studies Okavango environment" discusses the proposed Popa Hydro Project at Popa Falls (Photo 58) and the Environmental Assessment that is being carried out in order to determine whether or not to proceed with the project. The Angolan Government has also proposed more than ten dams for the headwaters of the Okavango as a way of improving the quality of life of its people in this once war-torn country.

The Okavango watershed will increasingly need to be addressed on a regional basis. The Okavango River Basin Commission (OKACOM) was established in 1994 so that increased utilization of the Okavango waters can be determined holistically for the benefit of the long-term conservation of the whole Okavango system. Providing water and electricity in the most economically and environmentally safe way is an enormous challenge for the countries surrounding the Okavango. In 1997 Botswana became a contracting party to the Ramsar Convention, which is an internationally recognized treaty on the conservation and sustainable utilization of wetlands. The Okavango Delta is now the largest wetland designated under the Convention which will provide additional international oversight to ensure development of the Okavango's waters are conducted in a sustainable way.

Photos 55 and 56. A dredged (top) and undredged (bottom) area of the Boro River.

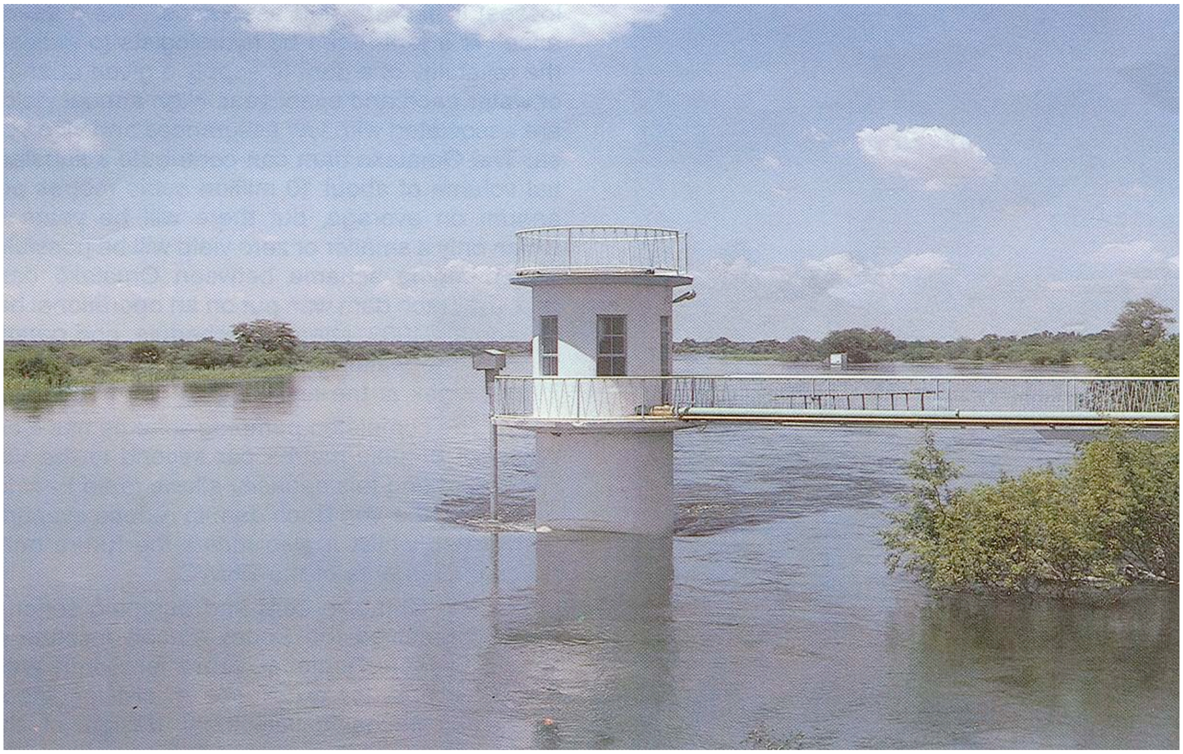


Photo 57. A water intake structure in the Okavango River at the town of Rundu in Namibia. Photo taken February 1984.

Photo 58. This stretch of the Okavango River in Namibia is called Popa Falls. Photo taken October 1984.

CHAPTER 11 – OKAVANGO FISH AND TSETSE FLY CONTROL

The tsetse fly (*Glossina morsitans;* See Photo 59) transmits a deadly parasite that causes sleeping sickness (*Trypanosomiasis*) in humans. It also causes a debilitating disease in cattle called nagana. In the early-1970s large-scale aerial spraying of the Okavango using the insecticide, endosulfan, was initiated. The advantages of aerial spraying of insecticides included rapid mortality of tsetse flies and the ability to control large areas of the Okavango more effectively. The disadvantage is that it entailes blanket application of insecticides in the swamps, which led to problems with fish mortality.

Fish monitoring conducted in the 1970s while using endosulfan (See Matthiessen 1983) concluded that about 1% of the fish population was killed directly and more were picked off by fish eating birds as a result of behavioral disturbances. The physiology of surviving fish was impaired for several months. The most significant observation was a large reduction in the nest building activity of cichlid fish. This led to a reduction in young fish recruited to the population and could have serious long term consequences. Aerial spraying was conducted using two modified fixed wing planes (See Photo 60) or one larger DC-3 typically during the evening hours when atmospheric inversions exist above the Okavango.

In an attempt to reduce fish mortality while achieving more effective tsetse control, Dr. Jeff Bowles, the Chief Tsetse Fly Control Officer stationed in Maun, changed the insecticide formulation in the early 1980's by reducing the amount of endosulfan used and adding a small amount of another group of insecticides called pyrethroids.

This insecticide "cocktail" proved to be more effective against the tsetse fly. However, mortality to fish still occurred under certain conditions and was exacerbated by airplane navigational errors during insecticide application.

Under Dr. Bowles' leadership aerial spraying of insecticides for tsetse fly control typically began in July-August and lasted through October. Depending on what area of the Okavango was being sprayed, the program entailed four or five, one week long, spraying cycles, each spaced approximately 21 days apart.

In August 1986 Dr. Bowles asked me to assist him with investigating fish mortality after an aerial insecticide spraying campaign. I carried out a detailed assessment of the impacted area with Dr. Bowles. The assessment revealed that fish mortality had occurred in certain shallow swamp habitats while the deeper river channels and large lagoons exhibited no fish mortality (Photo 61).

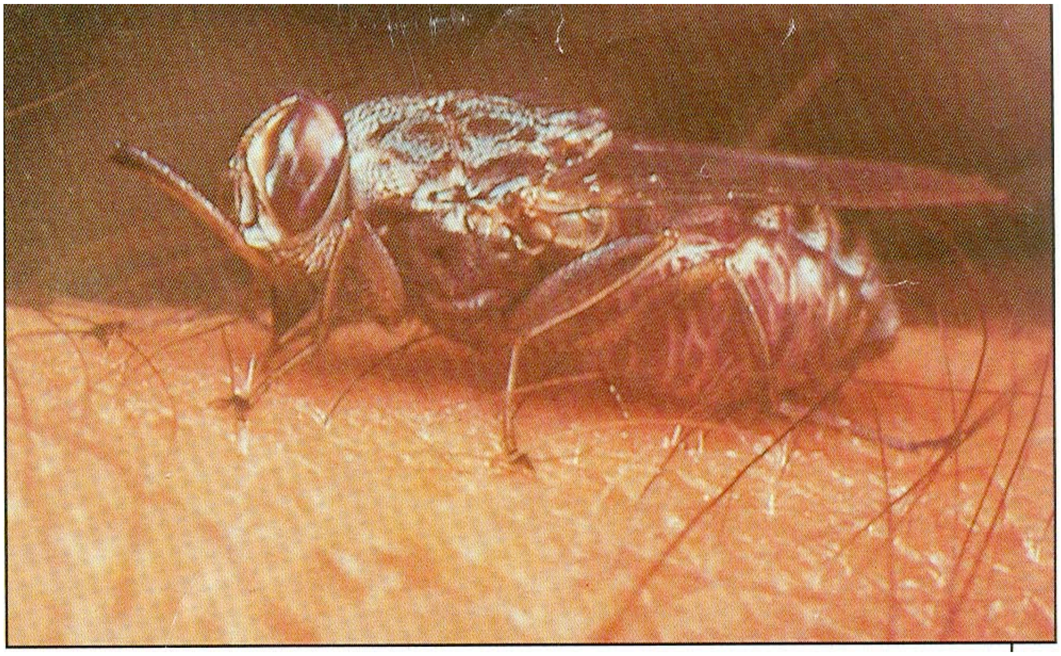


Photo 59. The tsetse fly (*Glossina morsitans*), carrier of a deadly parasite that causes sleeping sickness.

Photo 60. A modified fixed wing aircraft used for aerial spraying of insecticides to control the tsetse fly in the late 1980s and early 1990s.

Photo 61. The shallow water habitats of the Okavango were especially vulnerable to the aerial insecticide spraying.

In 1988 Dr. Bowles mentioned to me that another round of aerial spraying for tsetse fly control would be required in the Okavango between 1989 and 1991. Tsetse flies had invaded the Okavango from neighboring countries to the north including Zambia (See Figure 1).

Dr. Bowles was confident this would be the last aerial spraying campaign in the Okavango. The next step, he said, was to knock down the tsetse fly population along the Kwando River in northern Botswana with one final aerial insecticide spraying treatment in 1992 (See Figure 1).

Dr. Bowles mentioned future reinvasion into Botswana would then be avoided by setting up a line of defense in northern Botswana using more passive control methods like odor-baited traps that attract and kill tsetse flies.

Dr. Bowles asked me if I could provide full time fisheries monitoring during the insecticide spraying program and make recommendations for avoiding impacts to fish. I welcomed this opportunity and had always wanted to study the effects of the spraying program on fish which time would not permit while assisting the Fisheries Department. However, now that John Rogers had implemented the fisheries recommendations and the Fisheries Department was carrying out their own monitoring, it was now an opportune time to assist Dr. Bowles with an independent assessment of his Department's activities.

I prepared a proposal to determine what effects the tsetse fly control operations were having on fish and to identify ways to minimize potential impacts on the aquatic environment. The proposal was reviewed by Dr. Bowles and Professor Bruton and then submitted to the World Wildlife Fund (WWF) in Switzerland for potential funding.

In July 1989 I was notified that the proposal to conduct this important research had been successful and WWF would fund the research. This was the beginning of an intensive assessment of the tsetse fly aerial insecticide spraying program (Photo 62). The research program had three primary aims:

1) To identify the optimal time of year to conduct aerial spraying operations.
2) To derive the best method of application.
3) To determine which insecticide to apply.

I set up a research camp in the middle of the Okavango close to Chief's Island and aerial spraying commenced in August 1989. My staff and I observed fish mortality in shallow floodplain habitats where many juvenile fish are found (Photo 63). Throughout the course of the 1989 aerial spraying program, Dr. Bowles joined me on several occasions in the field to discuss the program operations.

After the completion of the 1989 spraying campaign which ended in late October, I suggested to him that it would be environmentally safer to begin aerial spraying during the cooler winter months when fish are physiologically less active and not spawning. Dr. Bowles mentioned that spraying in the cooler months was effective against the tsetse fly and agreed to change the 1990 spraying season to occur during the Okavango's cooler months (May through August). This change in timing was a positive step taken by Dr. Bowles to minimize fish mortality.

Photo 62. Dr. Jeff Bowles (on left) and the author discussing the tsetse fly aerial spraying program in August 1989.

Photo 63. Quishum (aka Rambo), using a wooden pole and standing in a "makoro" to transport the author through the Okavango swamps in September 1989. The depth of the water is about 3 feet and entirely covered by vegetation. I am discussing the tsetse fly control program with one of the Tsetse Control Division field staff.

Both field and laboratory toxicity tests were set up to evaluate the potential impacts to fish using the endosulfan cocktail. From December 1989 to January 1990 Professor Mike Bruton and graduate students from the JLB Smith Institute conducted the initial experiments at PJ and Barney Bestelink's safari camp at Guma Lagoon (See Photo 64).

The research team monitored the response of fishes to various applications of the endosulfan cocktail to determine its toxicity in deep verse shallow water and with varying rates of flow and vegetation cover. These initial experiments demonstrated that mortality to fish occurred under certain environmental conditions, especially in shallow water, combined with warmer water temperatures and lowered dissolved oxygen levels.

Dr. Bowles' and I also set up a series of fish tanks in his laboratory in Maun and conducted several tests on the endosulfan cocktail (Photo 65). The toxicity experiments conducted here added further support to the fact that the endosulfan cocktail affected fish under certain conditions and dosage rates.

Photo 64. Professor Mike Bruton and student, Kathy Holden, collecting fish affected from the endosulfan insecticide mixture applied along a shallow papyrus fringe at Guma Lagoon in December 1989.

Photo 65. Dr. Jeff Bowles' laboratory in Maun where several of the toxicological experiments were conducted under his supervision in the fish tanks.

The 1990 spraying season started in June during the cooler winter months when fish are are physiologically less active and not spawning. Although it was apparent from the experiments that the endosulfan "cocktail" could still be toxic to fish under certain conditions, Dr. Bowles and I had not yet identified a superior alternative insecticide.

We hoped that moving the aerial spraying program to the cooler months in 1990 would minimize impacts to fish that we observed in 1989. I published an article in Botswana's Kalahari Conservation Society newsletter describing the research program and the progress being made to date (Merron 1990).

To monitor the 1990 spraying season a research camp was set up in the Okavango at Tokalamatsaudi (pronounced To-ka-la-mat-saudi; See Figure 2) and next to one of the sport hunting camps where I knew the hunters. This was important if we wanted to eat! The hunters, like Soren Lindstrom, would always provide my staff and I with fresh meat such as impala and buffalo. Warthog tasted surprisingly like a loin of pork!

Early into the 1990 spraying season there was still evidence of some fish affected by the insecticide, although the number and type of fishes affected was less than in 1989. I attributed the reduced mortality to moving the aerial spraying program forward to the cooler winter months.

However, as the spraying program continued over the next couple of months, airplane navigational errors resulted in an overdosing of insecticide leading to a large number of fish affected and observed by my field crew (See Photo 66) and the hunters who also covered vast areas of the swamps everyday.

Dr. Bowles had arranged for Alan Pope, who represented the manufacturers of the endosulfan "cocktail", to fly by helicopter to my camp to assess the impacted areas (See Photo 67). I estimated that more than half of the fish population in the Tokalamatsaudi area was affected by the insecticide.

I returned to Maun in August and discussed with Dr. Bowles my concern with the overdose events, and the resulting effects on fish. I concluded that the use of the endosulfan "cocktail", especially considering the problems experienced with over spraying, did not provide a sufficient safety margin and was having a negative effect on the fish population in certain areas where spraying occurred. I submitted my report to Dr. Bowles, the World Wildlife Fund, and the Botswana Kalahari Conservation Society.

Photo 66. Two field assistants collecting fish affected during the 1990 tsetse fly aerial insecticide spraying program at Tokalamatsaudi.

Photo 67. The helicopter leaving Tokalamatsaudi in July 1990 with the suppliers of the insecticide on board.

It was now the time of the year to follow the catfish! My staff and I headed back into the swamps towards Seronga, Etsatsa, and Nxamaceri. Throughout my years in the Okavango, PJ Bestelink at the Nxamaceri Fishing Camp and Geoff Randall at the Etsatsa Fishing Camp and their lovely wifes and dedicated staff always assisted with the fisheries research.

Without this assistance (and great dinners!) my efforts in this area of the Okavango would have been greatly hampered. Geoff's wife, Nuki Randall, I often felt was the "Mom" looking after me. It was a special priveledge for me to know these people. As in previous years we found the catfish runs and again recorded the history of this fascinating event.

In November 1990 I returned to Maun. Sue Carver at Maun Office Services had radioed PJ that there was a telex for me from Alan Pope informing me about environmental surveys conducted in the neighboring country of Zimbabwe using an insecticide called deltamethrine for tsetse fly control.

The research on the environmental side effects of deltamethrine in Zimbabwe concluded that this insecticide was less toxic to fish than the endosulfan insecticide. I immediately returned to Maun and phoned Alan. He mentioned that international donor organizations, which assist African countries with tsetse fly control, had long requested industry to develop an alternative insecticide to endosulfan. This was welcome news.

I informed the staff of the Tsetse Control Division that I wanted to test the toxicity of the deltamethrine insecticide to Okavango fishes and compare it against the research findings that had been generated with the endosulfan cocktail. I phoned Dr. Bowles, who had retired to Scotland after almost 20 years of service to the Government of Botswana, and told him of my intentions. Everyone agreed that the deltamethrine needed to be tested under the Okavango's environmental conditions. Another aerial spraying campaign was being planned over the Moremi Wildlife Reserve for 1991 and the ecological implications of the program were paramount.

I refueled the boat and headed back towards the Etsatsa Fishing Camp where Geoff Randall allowed me to set up a research environment. The deltamethrine insecticide was tested in a series of fish tanks and under field conditions between December 1990 and January 1991. That Christmas I was away from my family, but with their love, Santa Claus did come on December 25th.

My results on the toxicity of the deltamethrine insecticide to Okavango fishes demonstrated no mortalities at dosage levels that would be required for tsetse fly control. I also tested higher dosages to simulate a potential over spraying event and observed a wider safety margin for fish when compared to the same dosages with the endosulfan "cocktail".

In January 1991 I returned to Maun and discussed the research findings on deltamethrine with the tsetse fly control staff and by phone with Dr. Bowles, Professor Bruton, and Alan Pope. I told them that I wanted to recommend to the Botswana Government that deltamethrine be used for the 1991 aerial spraying program scheduled to begin in June.

I prepared a report to the Tsetse Control Division recommending that endosulfan be replaced with deltamethrine for the 1991 spraying program. Based on the results that indicated no mortality to fish, the Government of Botswana selected for the first time to spray ultra low volumes of deltamethrine for large-scale tsetse fly control in 1991 (See Merron 1992). An upgraded satellite navigational system was also installed in the two airplanes run by Aer Kavango, which significantly improved navigational accuracy over the Okavango.

In May 1991 my field staff and I set up a base camp at Magwegqana (pronounced Max-e-gana) Pools in the Moremi Wildlife Reserve. These pools had served as one of the sampling sites used while conducting the previous fisheries research for the Fisheries Department and I was very familiar with this area of the Okavango.

My friend and colleague Pete Smith arrived at my camp to see the activity. We discussed how the new insecticide might affect the weevils used for the control of the *Salvinia* plant. Pete kindly asked me to assess any impacts to the weevils and report to him. He left in the morning. Pete was a great man who I considered the "Godfather" of the Okavango.

The 1991 spraying season was about to begin and my staff and I were determined to follow the aerial spraying program throughout the northeastern Okavango. I anxiously waited to see how the deltamethrine insecticide would perform under actual aerial spraying conditions for both tsetse fly control and environmental sensitivity, such as impacts to fish and other non-target organisms, in the Okavango.

Dr. Jeff Bowles' replacement, Dr. Ray Wooff, had arrived from England in June 1991 and was the new Chief Tsetse Fly Control Offcier. Dr. Wooff's previous experience included tsetse fly control operations using endosulfan in the African country of Somalia.

I made an overnight trip back to Maun to introduce myself to Dr. Wooff. He made it clear he was not pleased that the spraying program was using deltamethrine instead of endosulfan. I was bewildered at what I was being told.

A second article I wrote on the tsetse fly program and the environmental implications to fish had just appeared in Botswana's Kalahari Conservation Society newsletter summarizing my reasons leading to the change in insecticide to deltamethrine for the 1991-spraying season (Appendix B). I gave a copy to Dr. Wooff who looked at me with an angry stare. I headed back to the swamps with my wounds and wondered what I just heard and saw from the new Tsetse Fly commander.

On July 4, 1991 two airplanes began spraying deltamethrine over the Moremi Wildlife Reserve and northeastern Okavango swamps. The next morning my field staff and I carried out extensive field observations in search of any affected fish. No fish mortality was recorded and mortality to tsetse flies appeared excellent based on conversations I had with tsetse fly control staff monitoring the new insecticides effectiveness. My staff and I continued our monitoring program over the next 10 days.

When I returned to Maun a letter was waiting for me from Dr. Wooff stating that he found it ***"…very difficult to comprehend how you could recommend the use of deltamethrine than endosulfan in such an environmentally sensitive area as the Okavango."*** …and requested ***"full details of my involvement with Alan Pope and Roussel Ulcaf, manufacturers of Deltamethrine "***.

I had also just received a letter from Dr. Wooff's supervisor, Dr. Mosienyane, Director of Animal Health and Production within the Ministry of Agriculture. The letter stated that according to Dr. Wooff, I had not provided him with the reason why I recommended deltamethrine for the 1991 spraying program nor the study design of my research. The letter (See Appendix C) stated that ***"It would be wrong for you to hide anything from us as this will be undesirable for this country".*** The letter was also sent to the Office of the President where my research permit had been issued. I realized this was a very severe allegation.

Dr. Bowles returned from Scotland for a visit to the Okavango in September 1991. He was able to join my field staff and me for several days during one of the aerial spraying cycles. I was pleased that Dr. Bowles could personally witness the field results on the use of deltamethrine. Throughout the course of the 1991-spraying season there was no noted gross effect on the environment.

The debate over which insecticide was more environmentally safe to use in the Okavango had now reached the British Government's Overseas Development Administration (ODA). Prior to its independence in 1966, Botswana was a British Protectorate. After independence, the British maintained an influence in the country by providing administrative and technical assistance. It was the ODA that had conducted the initial research on the endosulfan insecticide in the 1970s and Dr. Wooff had previously been affiliated with ODA. I was informed by ODA that my research would be subject to an external review process. I put together 150 pages of data files, reports, and correspondences for the review process.

On October 9, 1991 Dr. Ian Grant, with the ODA Natural Resources Institute (NRI) in England, came to Maun to arrange a meeting with Dr. Wooff and myself (Appendix D). During the meeting I expressed to Dr. Grant and Dr. Wooff that based on the field observations during the 1991 spraying cycle, deltamethrine should be used over endosulfan for any future aerial spraying program.

On October 30, 1991 Tom Barrett, also affiliated with ODA, came to Maun to meet me. When I met with Tom I told him that, given the problems experienced with fish mortality using the endosulfan formulation, the use of deltamethrine for tsetse fly control in the Okavango had been environmentally safer. I went on to explain that because letters had been written to the Office of the President that questioned my research findings, my permit to work in the Okavango would not be renewed until the issue was resolved.

After the meeting with Tom, I returned the research boat back to the tsetse fly control department maintenance yard in Maun. The boat (See Photo 67) had been on loan to me for years and my staff and I had seen thousands of river kilometers without a serious problem. The Okavango was kind to us.

I said goodbye to my field staff, many of whom I had known since 1983. I walked down to the Thamalakane River. The river was drying up and the cows, donkeys, and goats were wading further out to drink.

I looked behind me at the swamps and thought to myself that no matter what allegations were made towards my research, knowing that the deltamethrine achieved tsetse fly control with minimal environmental effect in 1991 was professionally satisfying. I have not been back to the Okavango since.

Photo 67. The research boat that was used in the Okavango. One of my assistants, Jambe, is refueling the gas tanks at one of our camps in 1991.

CHAPTER 13 - BACK TO THE JLB SMITH INSTITUTE

When I left Maun I drove into a torrential rainstorm. The rain was a blessing. It would fill the Makgadikgadi (pronounced Ma-gut-e-gut-e) Salt Pans in the Kalahari Desert. The tiny brine shrimps, *Artemia*, which bury their eggs in the pans as they dry from the previous wet season, would hatch. Billions of brine shrimp would grow and form the base of the food chain for the tens of thousands of flamingoes that come to the Pans to feed on these tiny crustaceans.

I needed to complete my final report on the use of deltamethrine during the 1991 aerial spraying program and submit it to the Government of Botswana and World Wildlife Fund. Tom Barrett contacted me on December 20, 1991 indicating that ODA would appoint Dr. Peter Matthiessen, previously affiliated with ODA, to review my research findings. Professor Mike Bruton officially signed the Terms of Reference for the review on January 15, 1992.

I contacted the World Wildlife Fund in Switzerland with an update on the research review process and discussed presenting my data to the ODA-Natural Resources Institute scientists. In early February 1992 I flew to Chatham Maritime in England and gave a presentation of my research findings. During the discussion period I was told that one of their primary reasons for not recommending deltamethrine for tsetse fly control was that it cost 10 times more than endosulfan. I relayed this message to the manufacturer of deltamethrine who immediately faxed a letter back to ODA-NRI stating that deltamethrine is comparable in price to endosulfan with less environmental impact and that responsible agencies (like ODA) should encourage countries like Botswana to change for the better (Appendix E).

Flying back to Africa, I wondered what might have happened if Dr. Wooff chose to move forward with one more year of aerial spraying using deltamethrine in the Kwando River area of northern Botswana. I thought to myself that the tsetse fly control front could then be established using odor baited traps and other more passive control techniques as Dr. Bowles' envisioned. I wondered whether the objective of finally ending the era of large-scale aerial spraying in northern Botswana would finally be over. The JLB Smith Institute of Ichthyology and World Wildlife Fund never heard anything further from ODA-NRI about the review of my research findings.

On April 23, 1993 an article appeared in "The Okavango Observer" authored by Dr. Wooff stating that the Tsetse Control Division was now focused on tsetse fly control utilizing odor baited traps to kill tsetse flies instead of aerial spraying. The article states that the aerial spraying program of past years failed ***"because of the obsession with minimizing its effect on fish".***

For the next several years thousands of tsetse fly traps were placed throughout the Okavango at great costs to the Botswana Government. I was a strong advocate for the use of traps to control the tsetse fly once its population was under control along the northern Botswana border. However, this would have entailed another years spraying in 1992. A map of the tsetse fly distribution (Figure 6) shows the relatively small area of Botswana that needed to be quardoned off from the rest of Africa.

While writing this account of my experience with fish and tsetse fly control, I came across an internet article published in the scientific journal, Pesticide Outlook in April 2002 entitled "*Tsetse Control in Botswana – A Reversal In Strategy*" with the leading author being a British ODA scientist. The Botswana tsetse fly control program was going back to large scale aerial spraying in the Okavango. The article goes on to state that the original insecticide of choice was endosulfan but that due to environmental pressure "*robustly"* expressed by local and international environmental groups the insecticide ultimately used was deltamethrine.

My greatest satisfaction reading the article was knowing that the people of Botswana and the environmental lobby let their collective voices be heard regarding the use of deltamethrine as a superior insecticide to endosulfan in the Okavango. After the Government of Botswana funded an extensive and costly monitoring program during this aerial spraying campaign, the results showed that deltamethrine was effective in killing tsetse flies with negligible environmental impact (Allsopp 2002).

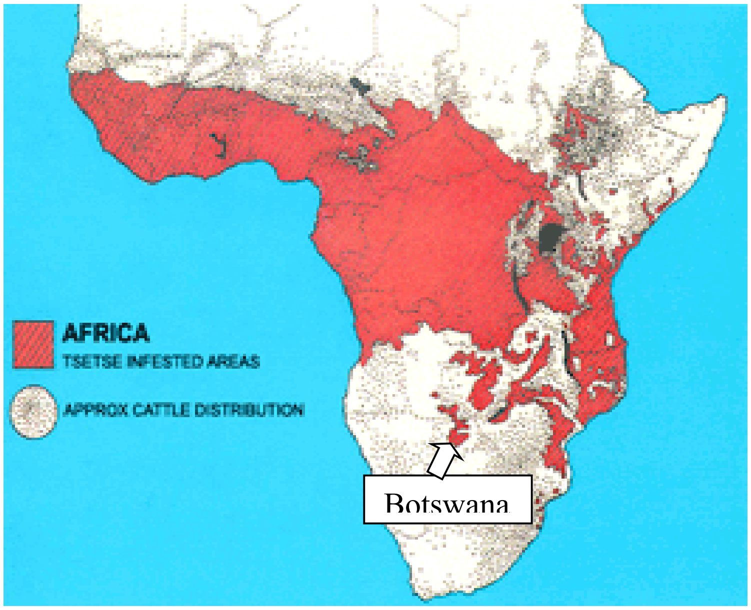


Figure 6. Map of the distribution of tsetse fly.

CHAPTER 14 – CONCLUSION

The fishes of the Okavango Delta are a valuable natural resource for the people of Botswana. Fish provide a key source of protein and revenue for many rural communities, and the fishes themselves form a vital link in the aquatic food chain. The commercial fishery is an important part of the local economy. The sport fishery is an important tourist based business that provides local employment and national revenue. Conservation of the fishes of the Okavango does not mean preservation but the wise utilization of this important natural resource for the benefit of the people of Botswana. This can only be achieved if the fish communities are managed in such a way that they can sustain themselves, which in turn depends on maintaining essential ecological processes, like the annual flood regime.

The Okavango is a dynamic ecosystem that can vary each year depending on the timing, magnitude, and duration of the annual flood. The fishes of the Okavango face many potential natural and unnatural changes, which include drought, habitat manipulation, water utilization schemes, introduction of unwanted alien species, and use of insecticides. These factors can have a profound influence on fish distribution and abundance.

The Okavango is becoming more developed and its waters may have to feature in the long-term plans for future development of the countries within its watershed. Development should proceed in a way that maximizes the economic status and quality of life for the people of these countries while minimizing the ecological degradation of the Okavango. People of the Okavango depend on the resources the many rivers, lagoons, and swamps provide, and tourism in the region contributes to national economies. The balance between the growing developmental requirements of these countries and the desire to conserve the natural wilderness of the Okavango is a challenge. The Okavango is one of the most important wetlands in Africa, providing a breeding place for a variety of mammals, reptiles, birds, insects, and fish.

Fishes are the dominant vertebrate group in the aquatic ecosystem both in terms of numbers and the complex interactions between species. Fish play the all-important role of converting resources at the bottom of the food chain such as plants, into food for higher forms of life, such as mammals. In the Okavango Delta in Botswana, the main flow of biological energy is from the northern panhandle and perennial swamp to the southern seasonal swamp and drainage rivers. Aquatic habitats in the southern drainage rivers, like the Thamalakane, that are subject to wide natural fluctuations are able to sustain a greater degree of human exploitation and change than the Okavango panhandle and perennial swamp. In the perennially flowing waters of the northern Okavango, the fish community is more diverse and ecological processes, such as seasonal migrations and feeding relationships, are more complex. These ecological relationships within the fish community, such as the annual catfish runs, have evolved over time and are finely tuned to the hydrology of the area. The widely fluctuating drainage rivers do not permit the time necessary for complex ecological fisheries interactions to develop.

Because of the complex ecology of the Okavango and the many user groups which exploit the fisheries resource, continual monitoring is required to understand the fluctuating nature of the swamps in relation to the distribution and abundance of fish. By monitoring the fishes, scientists can provide valuable information for the region's planners and decision makers as to the potential effects to the aquatic environment from proposed development actions. The ultimate aim is to improve the quality of life of all the people that utilize the Okavango's resources by integrating conservation and development in a sustainable way.

ACKNOWLEDGEMENTS

I would like to thank the Office of the President, Republic of Botswana for permission to perform fisheries research in the Okavango. The Department of Wildlife and National Parks is thanked for unrestricted access into the Moremi Wildlife Reserve. The DeBeers (Debswana) Mining Company is also thanked for allowing me use of their Maun Base Camp as a research station.

The research would not have been possible without the support of numerous people. John Rogers, Jeff Bowles, Pete Smith, Doug Skinner, PJ and Barney Bestelink, Geoff and Nuki Randall, Trevor Mmopelwa, Paul Sheller, Shane Seaman, Klaas and Marie Bolls, Mike and Lindy Gunn, Dan and Paula Rawson, Sally Barrow, Tim and June Liversedge, Tony Baker, Sue Carver, Tony Graham, Clive Steyn, Alan Pope, and Frank O'Shea all provided valuable assistance. Professor Mike Bruton was a first class Ph.D. supervisor and colleague throughout the research program. Dr. Paul Skelton taught me a great deal about the fishes of southern Africa for which I am grateful. Professor Tom Hecht, the Chairman of the Department of Fisheries Science at Rhodes University during my time in the Okavango, also provided considerable supervision during my Ph.D. research.

I had the opportunity to survey the Okavango with some of the finest staff I have known including James Molefne, Punky Yose, Jambe, Judge, Quishum (aka Rambo), Police, Bashi, Zexie, Kevin, and many others. I will always remember their outstanding field efforts. I would also like to thank the field staff from the Botswana Fisheries Department, Tsetse Control Division, and the Department of Water Affairs that assisted me during both the fisheries and tsetse fly research programs.

I am grateful to the staff of the JLB Smith Institute of Ichthyology and Rhodes University in Grahamstown, South Africa who provided assistance with the Okavango program. In keeping up with political change in South Africa, the JLB Smith Institute of Ichthyology has been renamed to the South African Institute of Aquatic Biodiversity. The Okavango research was funded by the JLB Smith Institute, World Wildlife Fund, Kalahari Conservation Society, Okavango Wildlife Society, Southern African Nature Foundation, Wildlife Society of Southern Africa, and Nampak.

This story would not be complete for me without expressing my sincere appreciation to Professors' Robert Roecker and Howard Huddle from the Biology Department at Geneseo, New York for their guidance while an undergraduate student from 1975-1978. To Professor Karl Lagler, thank you for encouraging me to study the fishes of the Okavango. Lastly, my family deserves my deepest gratitude for providing me with the support necessary to carry out my research work.

ABOUT THE AUTHOR

Glenn Merron received his Ph.D. in Fisheries from Rhodes University in 1991. His thesis entitled "The Biology and Ecology of the Fishes of the Okavango Delta, Botswana, with Particular Reference to the Role of the Annual Flood" has been widely used by Botswana Fisheries staff and the international scientific community. Glenn published numerous scientific and popular accounts of the fishes of the Okavango as a result of the research program (See Appendix F).

Glenn is currently President of Inland Ecosystems, Inc. with offices in Reno, Nevada and Geneseo, New York. The company specializes in fisheries and aquatic resource conservation. For more information go to www.inlandecosystems.com.

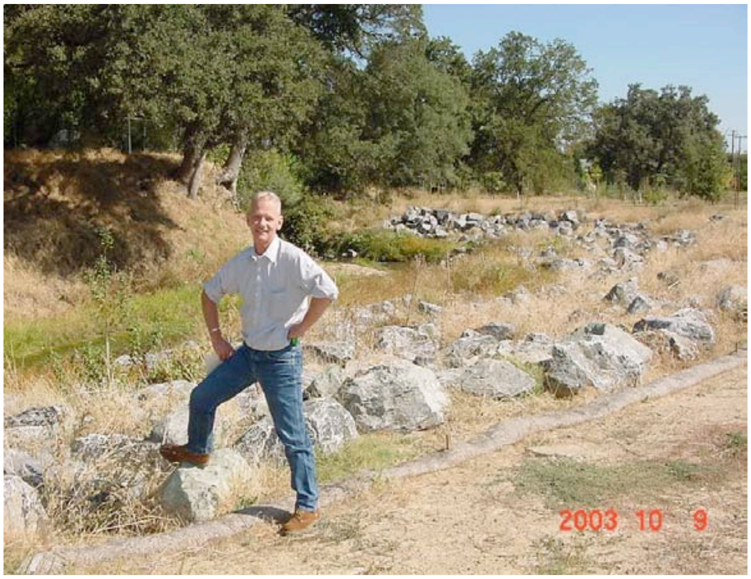


Photo 68. The author on a stream restoration project in central California, USA in 2003.

APPENDIX A: MIKE BRUTON'S ARTICLE

Switzerland with additional support from the Kalahari Conservation Society. The work is done in close collaboration with the Fisheries Division and the Tsetse Fly Control Unit of the Department of Agriculture in Botswana.

The aim of the research programme is to make recommendations to the Botswana Government which will result in

mine the toxicity of the insecticides in deep and shallow water and in water with different flow rates and vegetation cover. In addition, a series of experiments has been conducted in aquaria and plastic ponds, both in the Okavango and at the Institute in Grahamstown, on the direct lethal effect of various insecticide dosages on different species of fishes.

and a variety of biting insects are a constant threat, and enormously complex plans have to be made and carried out in order to bring the samples back to the research laboratories in proper condition. As Glenn is the African equivalent of Airwolf, perhaps we should call him aardwolf!

Mike Bruton

APPENDIX B: KALAHARI CONSERVATION SOCIETY NEWSLETTER

Tsetse Fly Control and Fishes in the Okavango

The objective of this conservation programme is to assist the Tsetse Fly Control Unit (TFCU) with minimizing the environmental side effects of using insecticides to control the tsetse fly which carries a parasite causing sleeping sickness in people and nagana in cattle. This follows on from work done in the late 1970s that showed that of non-target species affected fish were the most affected.

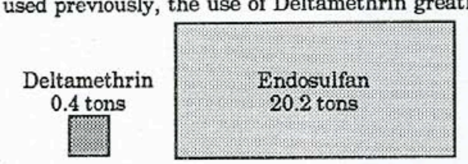
Three main areas of environmental research regarding tsetse fly control and fishes are: the time of the year when insecticide spraying is conducted; which insecticide is sprayed; and how it is sprayed.

Suggestions made to TFCU based on the results to date have been well received. The first major change was to propose that it is environmentally safer to begin aerial spraying during the cooler winter months when fish are less vulnerable to insecticides. This is because the water temperatures are lower and the fish are less active during this time. From the point of view of tsetse control, spraying in the cooler months is also more effective as deep temperature inversions exist at night which facilitate the spread of insecticides. During much of the 1980s aerial insecticide spraying was performed during the warmer months when fish were more active, with many species spawning at this time. As a result there were fish kills following spraying on some occasions.

Various insecticides are used throughout Africa to control the tsetse fly. However, some of these are significantly more toxic than others to fish and other aquatic organisms. The second major suggestion made to TFCU was to replace the insecticide in current use with one that is less harmful to the environment.

This year TFCU will spray ultra low volumes of Deltamethrin for the first time. The results of research on Deltamethrin with regard to its toxic effect on fish are very encouraging and show that it has a wider margin of safety when compared with that of insecticides used previously. Deltamethrin is insoluble in water and thus does not readily penetrate the aquatic environment.

Compared with Endosulfan-based formulations, used previously, the use of Deltamethrin greatly



Insecticide applied over a 4000 km² spray block.

reduces the total volume of insecticide applied over a given area as this diagram shows.

Clearly, although both insecticides are effective against the tsetse fly, the use of Deltamethrin will reduce, significantly, the overall loading of insecticides on the Okavango.

In addition to the type of insecticide sprayed, the method of application is also of extreme environmental importance. Advice has been given to TFCU on the preference of using two fixed wing aeroplanes rather than a single Dakota DC3 for aerial spraying operations. From the environmental viewpoint the use two smaller planes, spraying at 370 meter widths, is a tried and proven method of tsetse control. The DC3 sprays at 1000 meter widths and it is uncertain that a uniform concentration of insecticide is spread over a 1000 metres. Consequently, some tsetse flies may not be sprayed or may receive sub-lethal doses.

Some concern has been expressed about the effect of Deltamethrin on the weevils used in the biological control of *Salvinia*. This is an aspect which will be closely monitored this year. I believe that due to the low dosage of Deltamethrin applied (up to 50 times less insecticide than Endosulfan) and the weevil's habitat within the *Salvinia* plant that there will be minimal, if any, impact.

With the permission of the Department of Wildlife and National Parks, I will set up my research camp this year at Maxegana Pools in Moremi Game Reserve. Moremi offers a ready access to the sprayed areas and will enable the research team to cover larger areas of the spray block this year. This greater access will improve the effectiveness of our surveys, an especially important factor with respect to the changes that will be made in the programme.

The project also includes a strong educational component. Since 1989 my field assistants have gained hands-on experience with many aspects of environmental monitoring which should be of long term use to TFCU.

This conservation project is management orientated, with researchers working in close collaboration with the TFCU. In my opinion this working relationship, along with the sincere interest of other governmental and non-governmental bodies, demonstrates the genuinely positive approach towards solving an environmentally sensitive issue. Clearly there is room for conservation and development of the Okavango and the long term sustainable utilisation of its resources for the betterment of the people of Botswana.

I am grateful to the Office of the President and TFCU for allowing this project in the Okavango Delta. This project is funded by WWF and both the KCS and the JLB Smith Institute of Ichthyology play key roles in its implementation.

Glenn Merron

APPENDIX C: LETTER FROM GOVERNMENT OF BOTSWANA

TELEPHONE: 350500
TELEGRAMS: CHIVEBEC
REFERENCE: DVS/C/72 I

REPUBLIC OF BOTSWANA

DEPARTMENT OF ANIMAL HEALTH
AND PRODUCTION
PRIVATE BAG 0032
GABORONE
BOTSWANA

6 September 1991

Dr Glenn S Merron
P O Box 448
MAUN

Dear Dr Merron

I should thank you for the documents you have sent to me about the Research Institute you work with or for.

I am also convinced that Dr W.R. Wooff, our Chief Tsetse Officer, will have introduced himself to you as evidenced by several correspondence between the two of you.

The purpose of this letter is to prevent what might seem, probably in the future, a misunderstanding between yourself and the Tsetse and Trypanosomiasis Control Division headed by Dr Wooff under the Department of animal Health and Production which I head myself.

Dr Wooff has requested you kindly to provide him with the study design (protocol) of your research and unfortunately you seem to be either unwilling or reluctant to do that.

Also Dr Wooff was interested in why you recommended deltamethrin for our spraying this year and apparently you have not favoured him with an answer or at least satisfactory answers.

I would like to share with you few pieces of information.

1) That Dr Wooff is my representative, whatever he does I am responsible as he does it on my behalf, refusing to cooperate with him is refusing to cooperate with me.

2) The terms and conditions of the Research Permit you were given by the office of the President require your full cooperation with the Department your work relates to or falls under.

3) I believe you are ethical enough not to be hiding anything and we are ethical enough not to disclose your findings to anyone before you publish them. It would be wrong for you to hide anything for us as this will be undesirable for this country.

4) The office of the President gave you the research permit because they had trust in you and it is only logical to expect that your results be they negative or positive will assist us both, that is yourself and Botswana

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Government. If there is anything contrary to this spirit, then we are playing a game which has no rules.

I would like to advise you candidly to cooperate with us and release all the information that we require and give reasons for all questions we are asking you, in the interest of ETHICAL SCIENCE RESEARCH.

I thank you so much.

Yours sincerely

Dr M.G. Mosienyane
DIRECTOR OF ANIMAL HEALTH & PRODUCTION

cc. Office of the President
P.S. Ministry of Agriculture
Chief Tsetsefly Control Officer

APPENDIX D: LETTER FROM IAN GRANT, ODA

NRI
Natural Resources Institute

Central Avenue
Chatham Maritime
Kent ME4 4TB
United Kingdom

Telephone: National 0634 880088
International 44 634 880088
GTN: 3593
Fax: 0634 880066/77
Telex: 263907/8 LDN G
Telegrams: NRI Chatham

Overseas Development Administration

Dear Glenn, 17.10.91

ENVIRONMENTAL MONITORING: MEETING IN MAUN.

Sorry to have missed you at the airport; I had just boarded before you appeared. Our meeting was most enlightening and the problems aired were everything I had been led to expect.

My greatest concern, like yours, is that we can pull out of this mess a sensible, viable, financial and logistical monitoring framework which will produce a scientifically sound environmental impact statement. This will be no mean feat given the circumstances.

The greatest stumbling block appears to be the letter of the DVS to the JLBS, whose allegations of unethical practices will be very hard to retract by all parties. It is clear that Dr. Wooff feels he cannot put this to right with his Director, at least not immediately. Remedial tacks could be an approach from the Director of Fisheries instead (as we discussed), and the dressing of the causes as due to unfortunate misunderstandings/poor communication, the result of you being in the field for considerable periods. I am not at all sure how far that will get us, but if there is to be no spraying in the delta next year there may be time for some wounds to heal.

From our brief discussion I wasn't able to determine what plans you might have had for monitoring before the recent difficulties arose. I only understood that USAID was going to fund a riparian fishery study in the panhandle; but did you have in mind to incorporate in this project some degree of fisheries monitoring in the delta/Linyanti swamp or was a WWF extension to pay for this activity? If USAID involvement is anticipated I imagine you will make this clear to Dr. Wooff and provide him with a protocol of monitoring when appropriate.

Dr.Wooff will probably approach ODA through the normal channels to secure some funding for a three season monitoring study, along the lines we discussed. They will most certainly look upon the study more favourably if a collaborative approach is proposed, and if WWF was inclined to extend its present contract. Unfortunately I imagine that WWF will not fund any extension until they are satisfied about the causes and with the resolution of the present difficulties.

As discussed, I would anticipate NRI providing the ecotoxicologists for the terrestrial and aquatic invertebrate monitoring, plus any necessary measurement of impacts on critical microbial processes. JLBS would provide the necessary expertise for fish population/toxicity monitoring. Each Institute would provide necessary scientific equipment and Tsetse Control Division would provide field support. We also agreed to Dr.Wooff's suggestion that JLBS staff would be seconded to NRI for management purposes, and NRI would be directly responsible to him for reporting.

I should be grateful to be kept in the picture re. the ~~current impasse, but also in relation in relation to~~ USAID's and WWF's stance and any comments. I imagine you will be making overtures to WWF when the time is right.

Yours sincerely,

Ian Grant

Dr.I.F.Grant
Manager, Hazard Assessment

APPENDIX E: LETTER FROM ROUSELL UCLAF

ROUSSEL UCLAF

Fax: (44) 0442 870761	Telephone: (44) 0442 863333	Telex: 825477
Reference: FOS/NLD/3266	Date: 5.3.92	Total Pages: 2

Roussel Uclaf
McIntyre House, High Street
Berkhamsted, Herts HP4 2DY UK

Sender: F O'SHEA

Addressee: R ALLSOPP B DOUTHWAITE N.R.I. Country: UK

Fax No: 0634 880077 Complete Number (including dial codes)

Dear Reg/Bob —

DELTAMETHRIN PRICING

I was rather taken aback to hear from Glenn Merron that one of NRI's objections to the use of deltamethrin is it's cost and the quote "deltamethrin cost's 10 x's that of Endosulfan".

Whilst fully accepting that gram for gram deltamethrin is far more expensive than Endosulfan and DDT, and will always remain so due to intrinsic costs of manufacture. Nevertheless due to its very high activity against tsetse i.e 100 x's more active for kill, and 10,000 x's more active for knockdown than Endosulfan it can certainly be cost effective.

Our aerial spray formulations (Glossinex Aerial Spray) can be supplied at a price that results in the same total cost of applied chemical per programme as any Endosulfan, Endosulfan cocktail formulation supplied by a company producing at the same levels of total quality. The caveat added in that it is accepted that it is possible for small formulators to pick up cheap Endosulfan from a variety of sources (India, Israel etc) and produce a quick simple formulation i.e not bothering to complete 3 years storage stability date at a variety of temperatures, full QC of ai, excipients and final product.

Similarly our Glossinex 200SC used as a tsetse resting site spray does cost more than DDT due to use of deltamethrin but the work in Zimbabwe shows that the tsetse population is eradicated, the population crashes faster, the treatment is fire resistant and there are indications that (unlike DDT sprayed blocks) retreatment in following years is unlikely to be required).

Whilst fully accepting that DDT and Endosulfan are effective chemicals lets not forget that the tsetse world did request the chemical industry to develop alternatives - we have (after a decade of great expense). These formulations can certainly be cost effective, and cost comparable but it is recognised that the old cheap formulations are still an option.

Continued:-

Continued:-

Can I suggest that given that deltamethrin is a bio degradable pyrethroid, without obvious risk to fish, that responsible expert bodies, Governmental and NGO's should encourage donors and end users to change for the better.

Regards.

Frank O'Shea

JLB SMITH INSTIT.

CC DR GLENN MOEEN

TO AWAIT HIS RETURN.

GLENN — STILL TRYING TO NAIL HIS CONCEPTIONS.

APPENDIX F: SELECT PUBLICATIONS ON OKAVANGO FISHES

- **Peer reviewed Scientific Publications on Fishes of the Okavango**

Merron, G.S., and M.N. Bruton. 1995. Community ecology and conservation of the fishes of the Okavango Delta, Botswana. Environmental Biology of Fishes 43: 109-119.

Merron, G.S., and B.Q. Mann. 1995. The reproductive and feeding biology of *Schilbe intermedius* Ruppell in the Okavango Delta, Botswana. Hydrobiologica. 308: 121-129.

Merron, G.S. 1994. The Ecology and Utilization of the Fishes of the Wetlands of Northern Botswana, with particular reference to the Okavango Delta. Proceedings of the Conference on Wetlands, Kalahari Conservation Society, Gaborone, Botswana. pp. 41-57.

Merron, G.S. 1993. Pack Hunting in two species of catfish, *Clarias gariepinus* and *C. ngamensis*, in the Okavango Delta, Botswana. Botswana. Journal of Fish Biology 43: 575-584.

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Bruton, M.N., G.S. Merron. 1990. The Proportion of Different Eco-ethological Sections of Reproductive Guilds of Fishes in Some African Inland Waters. Environmental Biology of Fishes. Vol. 28, No. 1-4: 179-187.

Knauer, J., J.R. Duncan, G.S. Merron. 1993. Sublethal Effects of an Organochloride/ Synthetic Pyrethroid Insecticide Cocktail on *Tilapia rendalli rendalli* (Pisces: Cichlidae). South African Journal of Science. Vol. 89, No. 5: 249-251

Skelton, P.H., M.N. Bruton, G.S. Merron, and B.C.W. van der Waal. 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

- **Administrative Reports on Fishes of the Okavango**

Merron, G.S. 1992. The physiological and toxicological effects of aerial spraying with insecticides on the fish stocks of the Okavango Delta, Botswana. Final Contractual Report, World Wildlife Fund, Gland, Switzerland. 15pp.

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Skelton, P.H., C.H. Hocutt, M.N. Bruton, G.S. Merron. 1982. JLB Smith Institute of Ichthyology and the Albany Museum 1982 Expedition to Lake Ngami, Botswana. JLB Smith Institute of Ichthyology Internal Report: 1-6

- **Popular Articles on Fishes of the Okavango**

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