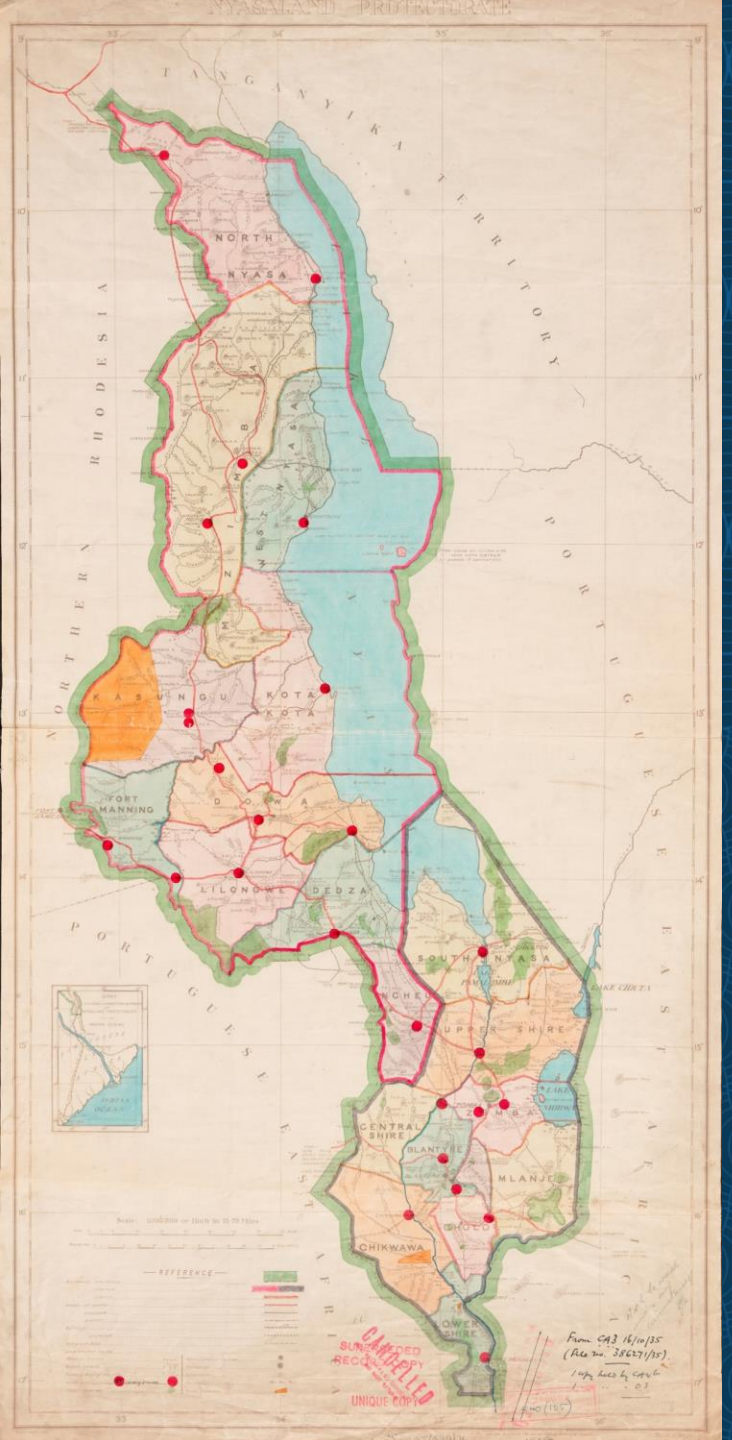

Fishing (in) the Past to Inform the Future: Lessons from Lake Malawi and Mbenji Island

UKRI Natural Environment Research Council

UKRI Arts and Humanities Research Council

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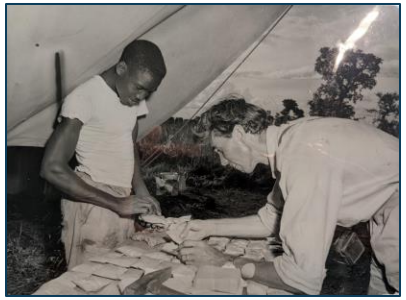
Introduction to the Project

A comparative investigation of the history of two distinctive fisheries management regimes in Lake Malawi originating in the mid-twentieth century:




Colonial Fisheries Governance & Mbenji Island Fisheries Governance

Exploring the **principles** and **ideologies** underpinning these regimes and their **long-term impacts**

Three research components

- Archival Research
- Oral History
- Environmental Sampling

A Brief History of Colonial Fisheries Governance

"the easiest way to make the fullest use of all the fish stocks on a long-term basis would probably be by having unified and Government control over all the separate fisheries"

- Rosemary Lowe,

Report on the Tilapia and other Fish and Fisheries of Lake Nyasa, 1945-7 (1952)

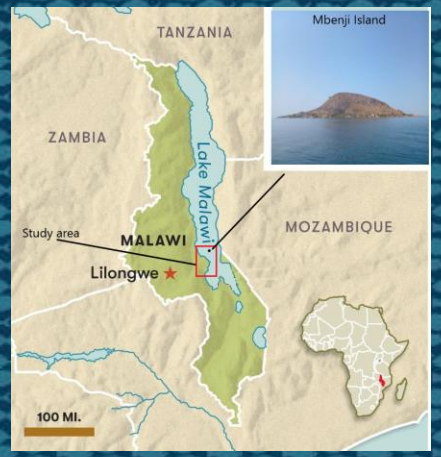
- Foundations in 1930s following expansion of non-African fishing efforts & concerns of overfishing of chambo (tilapia) stocks
- Three fisheries surveys – 1939, 1945-47, 1954-55 – focused on attaining the "optimum yield" through greater governmental oversight and technology transfer
- Need for sustained data on fishing efforts & yields as well as fish habits, biology, mortality, and recruitment
- Disregard for existing protocols and regulations by lakeshore leaders
- **Resulting in a patchwork of fisheries governance concentrated mainly on chambo stocks in southern arm of lake**

A Brief History of Mbenji Island Fisheries

"We have set these strict regulations to preserve Mbenji Fisheries for the future generation. We will not accept any violations."

- Chief Makanjira, 15 April 2023

- Oral histories were conducted with 24 elders from Mbenji, including Senior Chief Makanjira, to understand the origins and history of Mbenji Fisheries management.
- We also attended opening and closing ceremonies where speeches about the origins and progress of Mbenji Fisheries were shared.
- On the origins, Mbenji started in the 1950s by two prominent fishers from Likoma, Mr Kalemba Assani and Mr Kampunga.
- As fishing expanded, Chief Makanjiira established regulatory laws for fishing and settlement.
- Since the 1990s, the government recognised Mbenji fisheries regime as part of decentralisation.
- The success of Mbenji revolves around: the **charismatic leadership** of Senior Chief Makanjira; **strict regulations** of fisheries in the area; and **traditional beliefs**.



Fisheries Analysis in Mbenji and Surrounding Waters Background

- Two main fisheries governance schemes in Lake Malawi:
  i) Govt-controlled scheme (based on colonial/western science/laws)
  ii) Traditional scheme (based on traditional laws, indigenous knowledge) at Mbenji Island under Senior Chief Makanjira

- These regimes responded to similar concerns of potential overfishing but were based on different authorities and outlooks

- It had been rumoured Mbenji fisheries were doing better than government-managed fisheries, but scientific evidence was lacking: **Was it true? If true, was it due to management? Or water quality?**

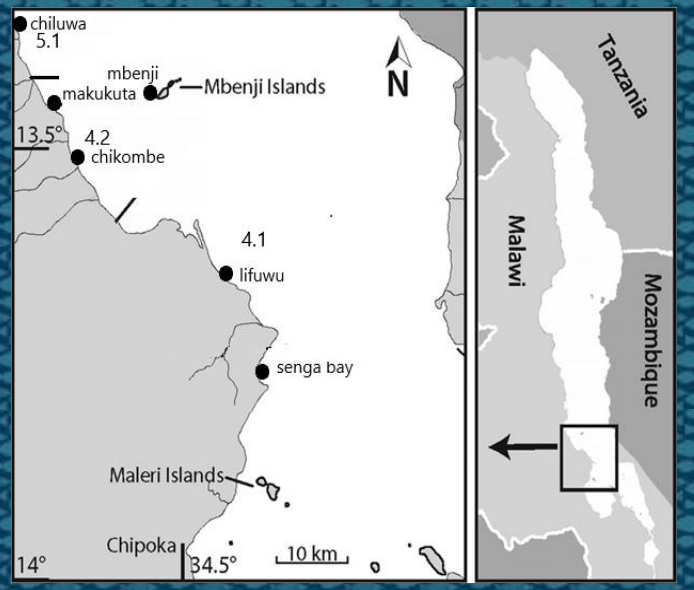
Fisheries Analysis in Mbenji and Surrounding Waters Objectives

i) Main Objective

- Analyse the performance of fisheries at Mbenji Island and at surrounding Government-controlled areas in Salima, Lake Malawi

ii) Specific Objectives

- Assess water quality conditions between Mbenji and Govt-controlled areas
- Compare the health of fish stocks at Mbenji and Govt-controlled areas



Methodology

336 water quality sampling stations were analysed for physico-chemical and biological parameters

462 fish samples (Utaka) were analysed for their TL, BW, LWR

Table 2: Sample size (N) of water quality stations and fish samples

Fishing Strata	4.1	4.2	5.1	Mbenji	Total
Water Quality Sampling Stations (N)	90	82	82	82	336
Fish Samples (N)	154	103	154	51	462

NB: 4.1: Senga Bay; 4.2: Domira Bay; 5.1: Nkhotakota South; N: Sample size

Results

Water quality **did not differ** significantly

	Unit	Fishing strata				F-value	p-value
		5.1	4.2	4.1	Mbenji		
Temp	^{o}C	24.3±0.4	24.5±0.3	24.2±0.3	24.4±0.2	1.76	0.15
DO	mg L^{-1}	7.4±0.1	8.2±0.2	8.3±0.4	8.5±0.6	1.01	0.09
Z_{SD}	m	6.2±2.4	4.8±1.5	5.8±1.7	4.5±2.4	1.14	0.12
pH	-	8.3±0.1	8.4±0.2	8.2±0.2	8.4±0.1	1.20	0.12
Cs	µS cm^{-1}	243±4.8	245±7.1	244±9.2	246±8.5	3.75	0.17
TDS	g L^{-1}	0.26±0.1	0.28±0.1	0.27±0.1	0.29±0.1	1.03	0.09
SRP	µmol L^{-1}	2.7±0.3	3.8±1.1	2.8±1.5	4.5±1.0	2.28	0.10
Chl-a	µg L^{-1}	1.2±0.4	1.4±0.3	1.7±0.5	1.8±0.6	2.19	0.12

Fish were **heavier (plump) at Mbenji**, and **slender** in government areas

	Stratum			
	5.1	4.2	4.1	Mbenji
$W = a L^{b}$	$0.059 (L)^{2.305}$	$0.111 (L)^{3.114}$	$0.034 (L)^{2.761}$	$0.009 (L)^{3.574}$
R^2	0.980	0.983	0.848	0.987
SE(b)	0.026	0.040	0.094	0.058
CI(b)	2.253-2.357	3.034-3.194	2.574-2.949	3.457-3.691
p-value (t-test)	0.000	0.160	0.012	0.000
p-value (regression)	0.000	0.000	0.000	0.000
Growth	-ve allometry	Isometry	-ve allometry	+ve allometry
Kn±SD	0.922±0.05	1.186±0.09	1.199±0.75	1.207±0.08

Fisheries Analysis
Conclusions & Recommendations

- The Mbenji fish stocks are healthier than the Government-controlled fisheries, not because of water quality differences but likely their management attributes.
- Communities can take charge of their fisheries resources, with government merely providing support
- Longer closed season allows fish to breed and grow more successfully
- Total ban of fishing gears during closed season conserves diverse fish stocks more effectively by preventing unintended fishing
- Stringent enforcement, with greater surveillance and high certainty of detection and deterrence are important aspects of successful fisheries management
- Government, NGOs, and other partners need to provide tangible support to fishing communities for the development of a successful self-regulated fishery

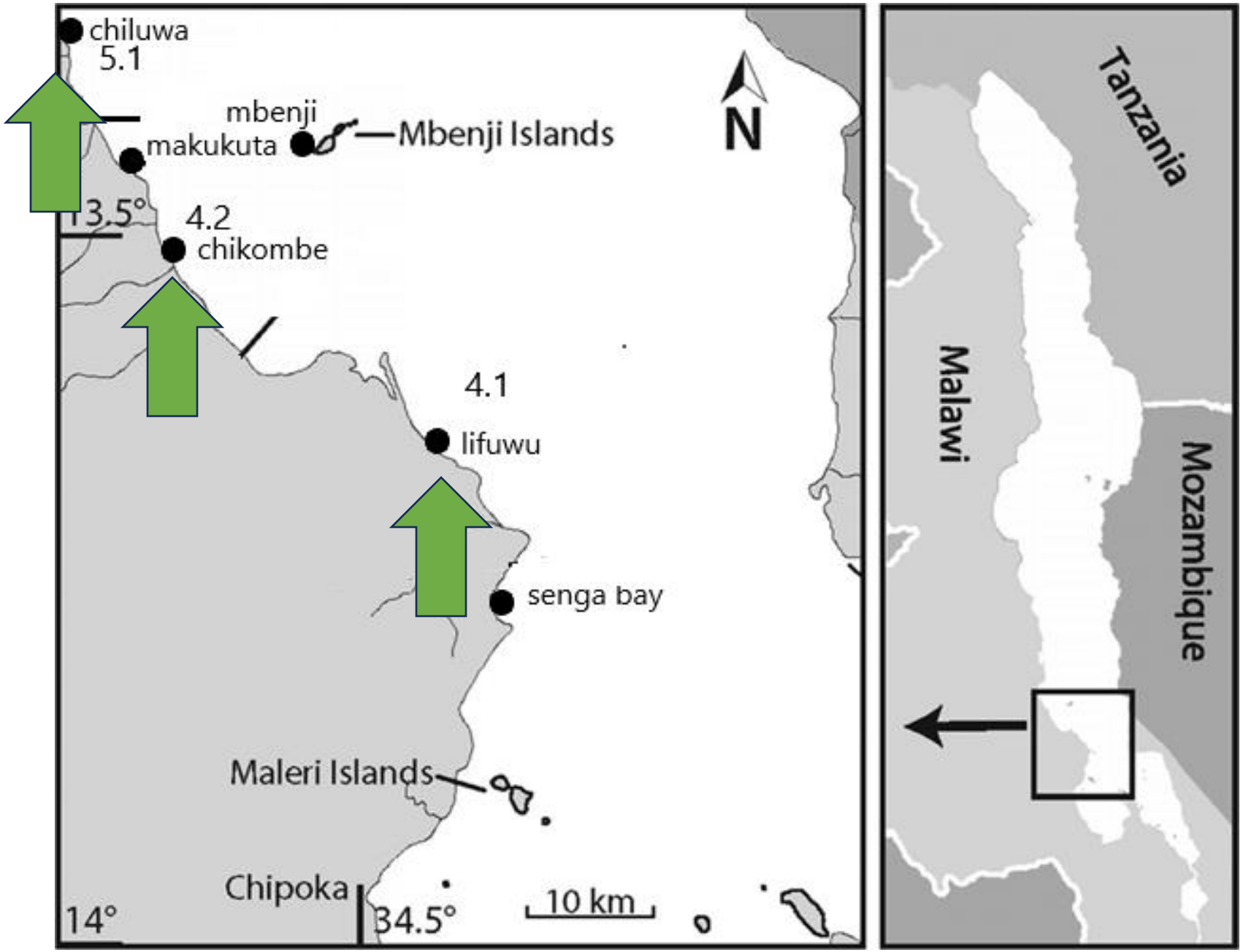
The catches of lighter fish in nearby government-regulated waters suggests overfishing is occurring …

… whereas the heavier fish caught at Mbenji indicates much more sustainable fishing levels

Management attributes	Government areas	Mbenji
Length of closed season	2 months	4 months
Nature of closed season	Target Chambo	All fish stocks
Gears restricted	Beach seines	All gears
Environmental protection	No rules	Environment protected
Enforcement	Inconsistent	Very stringent, timely
Sanctions/punishment	Lenient	Serious fines
Knowledge base	Western science	Indigenous knowledge

Table: Current management attributes in government and Mbenji waters

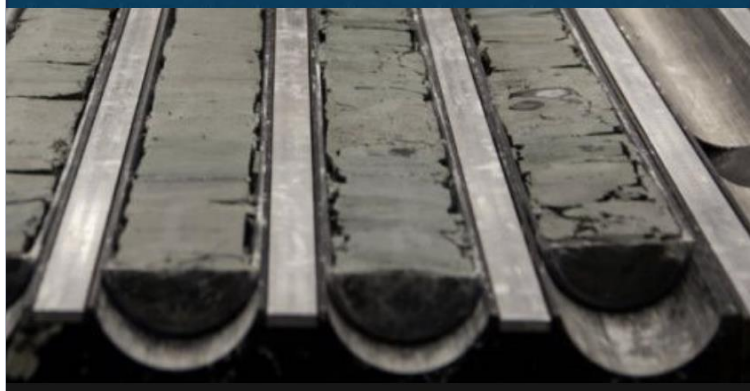
Tracing Pollutants in the Sediment



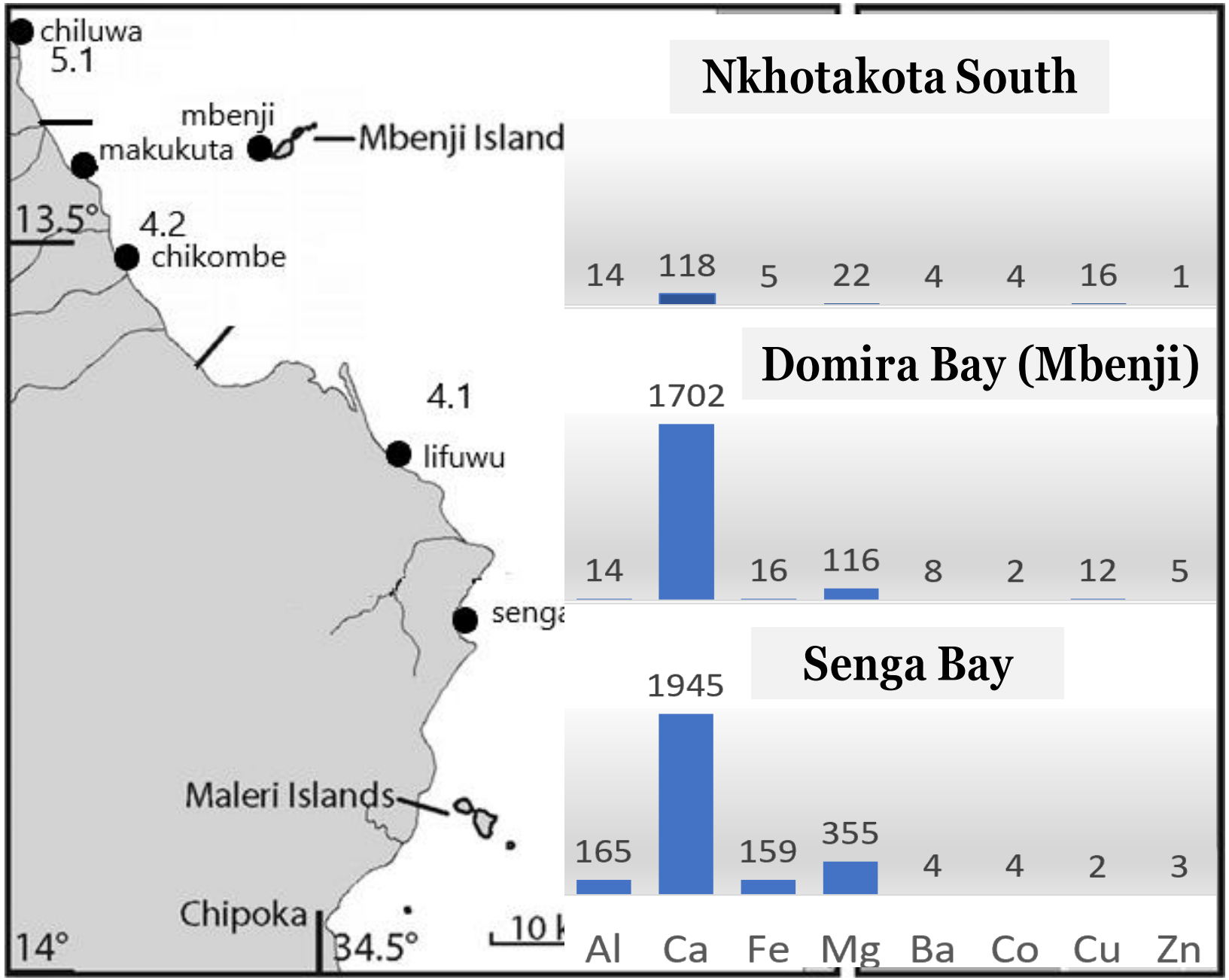
Sediments were collected to obtain a sense of current and historical environmental pollution (60cm)

Same locations as the water sampling:

- 4.1: Senga Bay
- 4.2: Domira Bay (Mbenji)
- 5.1: Nkhotakota South



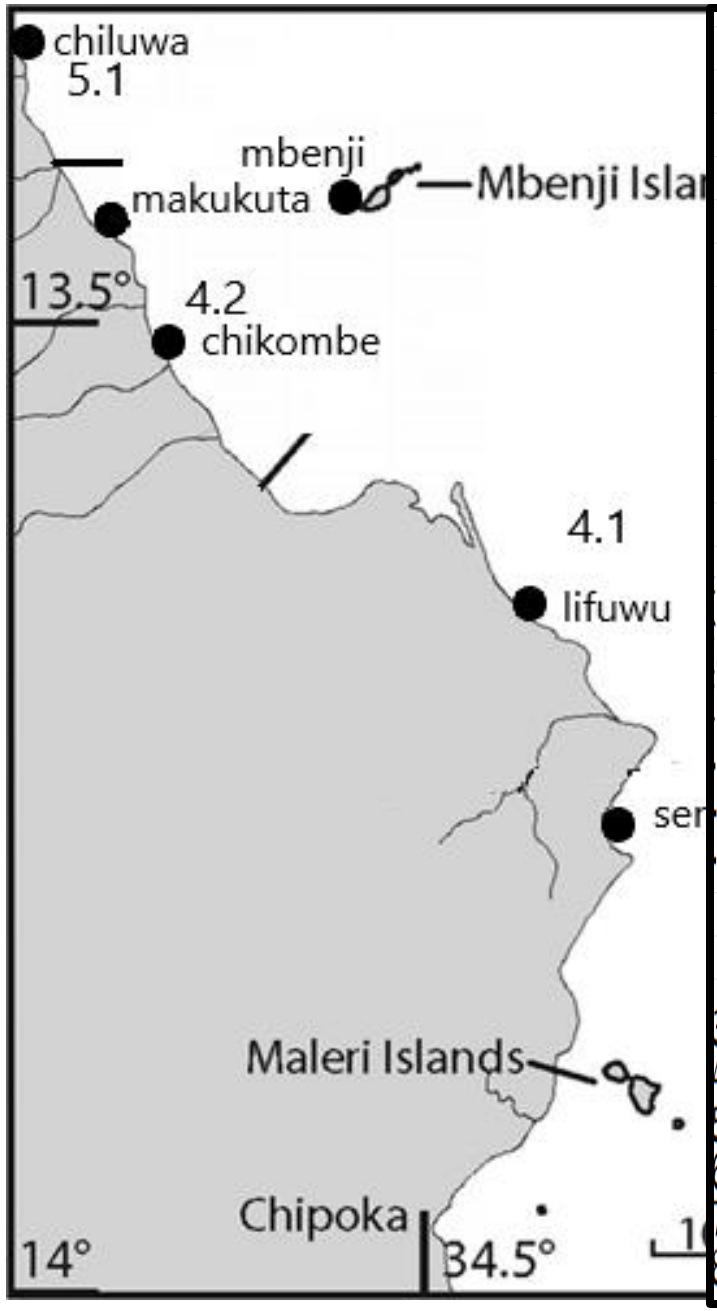
Tracing Pollutants in the Sediment

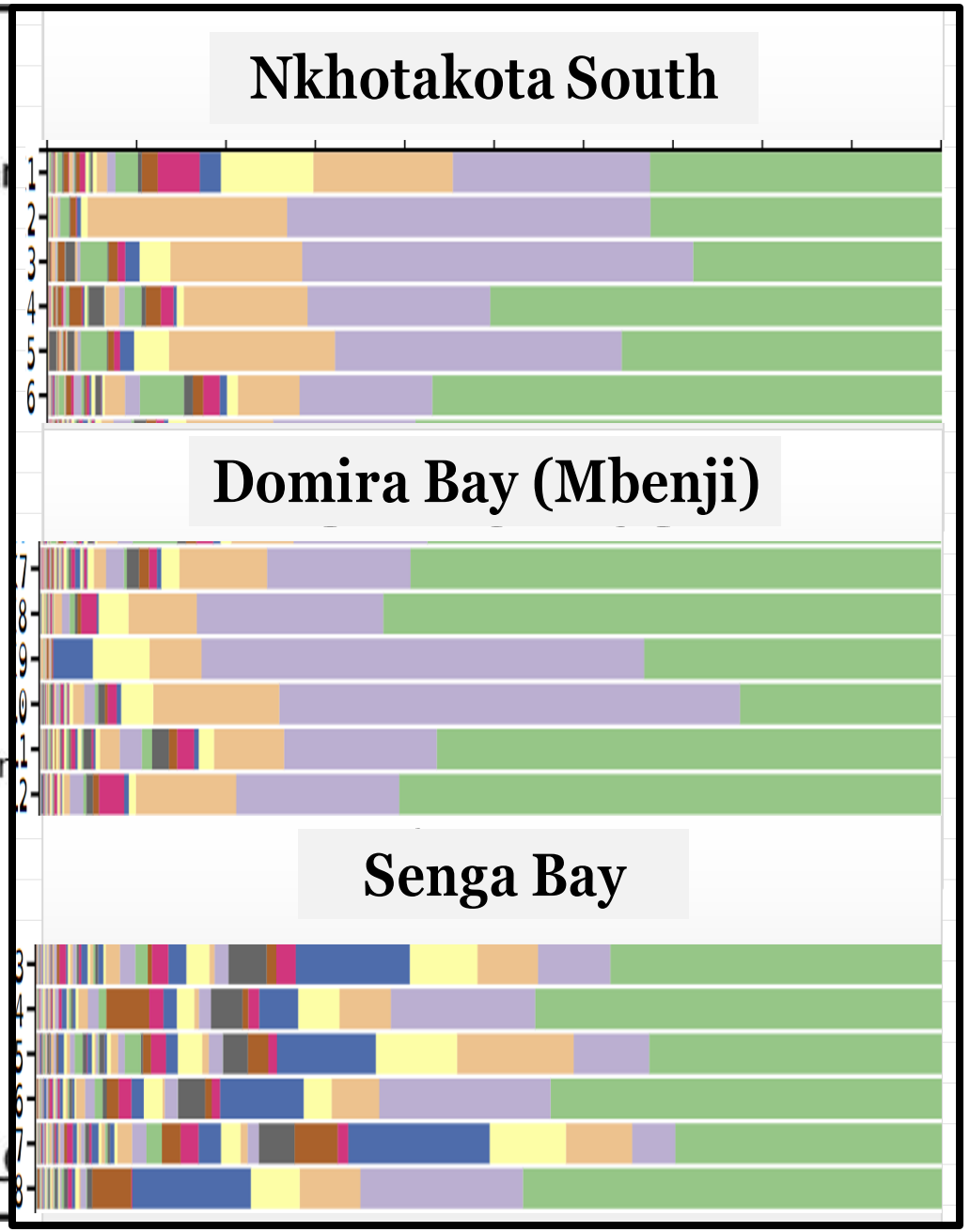


BIOAVAILABLE METALS were measured to determine possible pollutant levels (mg/kg)

- Most metals (those on left) reflect the geological conditions
- Metal (on the right) represent possible pollutants
- Nkhotakota South has highest levels of Copper
- A lot of Iron at Senga and Domira Bays

Tracing Microbes in the Sediment





Bacterial community:

- Nkhotakota South and Domira Bay have similar abundances and bacterial diversity with highest levels of faecal contamination
- Senga Bay has 10x more bacteria, and a greater diversity.
- Pathogen concentrations increasing in all areas across time

- **Green = γ –proteobacteria** (very common, Gram negatives)
- **Purple = Bacteroides** (commonly associated with faeces/gut microbiome)
- **Orange = α-proteobacteria** (soil bacteria, plant symbionts)
- **Yellow = Firmicutes Clostridia** (Gram-positive, soil bacteria)

Tracing Microbes in the Sediment

Extracellular DNA of common fish pathogens

Targeting the DNA in the water can forewarn of vectors (and invasive species)

- *Aphanomyces invadan*
- Acanthoamoebae

Becoming very prevalent at Senga Bay

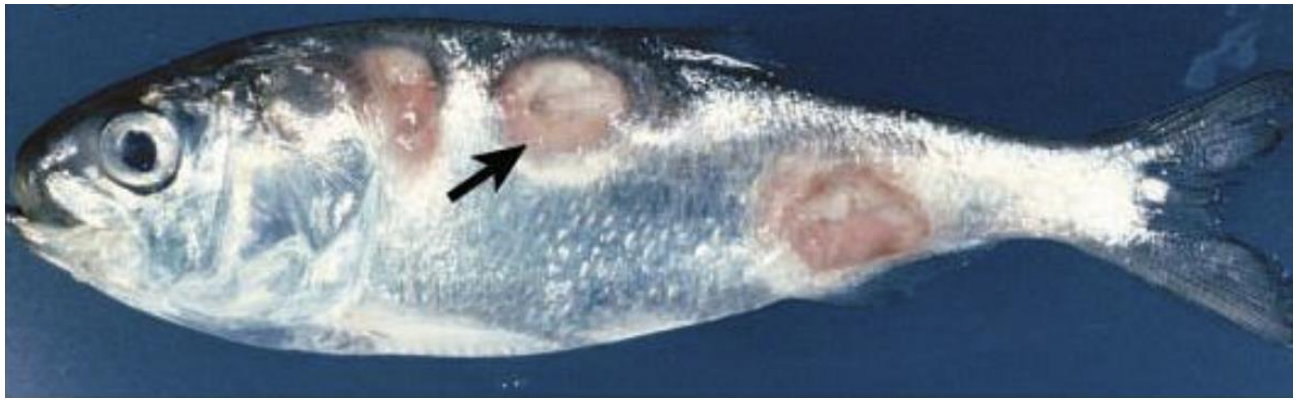


Photo: Kiryu et al. (2003) Infectivity and pathogenicity of the oomycete *Aphanomyces invadans* in Atlantic menhaden *Brevoortia tryannus*. Diseases of Aquatic Organisms 54: 135-146

AMR risk

- Often associated with environmental pollution
- Identified across all sampled areas
- Can impact food security and health.

Relative abundance of resistances genes (per "total bacteria")

	4.1	4.2	5.1	Prevailing genes
Aminoglycosides	6.3%	6.9%	12.6%	*aac*(3), *apc*N, *aad*A, *aac*(6)
Beta lactamases	4.3%	4.4%	8.5%	bla_{OXY}, *pen*A, bla_{SFO}, bla_{MIR}, bla_{ACT}
Integrases	0.4%	0.3%	0.0%	*intI*1
Multidrug resistance	6.2%	6.5%	12.6%	*opr*D, *mdt*H, *mdt*A, *emr*D, *mex*A
Mobile genetic elements	11.2%	12.6%	25.7%	IS1111, Tn5403, orf37-1526, IS1247, IS1133
MLSB	5.5%	7.4%	15.1%	*erm*X, *mph*A, *pnc*A, *erm*E, *erc*A
Other	2.0%	1.9%	2.5%	*bac*A, *mer*A, *arr*3, *qac*EΔ1
Phenolics	0.7%	0.7%	1.4%	*cmlV*, *cmlA*, *cmx*A, *flo*R, *cat*A3
Quinolones	6.2%	5.6%	9.5%	*qep*A, *qnr*B, *qnr*S
Sulphonamides	1.1%	0.7%	0.5%	*sul*3, *sul*2, *sul*1, *sul*4
Tetracyclines	1.4%	2.1%	4.2%	*tet*D, *tet*G, *tet*L, *tet*A, *tet*R
Trimethoprim	0.5%	0.8%	0.8%	*dfr*A
Vancomycin	2.0%	2.7%	6.6%	*van*T, *van*A, *van*HB, *van*YB, *van*B
"Total bacteria"	$10^{8.7}$	$10^{8.8}$	$10^{9.6}$	Bacteria/gram sediment

RECOMMENDATIONS

The successes at Mbenji are a result of the collective elements of the management regime so that the technical aspects cannot be simply isolated & applied elsewhere.

- **LEGITIMACY & EMBEDDEDNESS**
  - Technical principles that recognise ecological complexities are not enough. Successes at Mbenji are a result of targeted technical regulations combined with strong leadership, proactive enforcement, long-term realisation of benefits, transparency, and embeddedness in existing institutions and beliefs.

- **CONNECTEDNESS**
  - We need to better understand how far different management regimes connect with and are reliant on each other. Part of Mbenji's sustained success has been a result of the ability of fishers to make their livelihoods in government waters during the extended closed season.

- **LEADERSHIP & COMMUNICATION**
  - Strong leadership has been crucial at Mbenji Island. This centres on shared accountability and responsibilities through the Mbenji Island Fisheries Committees as well as transparency and communication with fisheries participants through meetings and speeches during the opening and closing ceremonies that centre on news of successes and enforcement challenges.

- **SUPPORT**
  - There needs to be greater governmental support for community management by providing tangible resources for instructive and enforcement activities. This includes resources for community-led science to gather and disseminate data that can inform situated management decisions.

- **HISTORICAL AWARENESS**
  - We need to persistently acknowledge, consider, and address how the ideologies & beliefs driving past management regimes continue to shape present day governance practices, even as these adopt participatory language and institute new participatory frameworks.

NEXT STEPS

Sustainable Fisheries Governance through Transformative Community Engagement: Perspectives of One Health from Lake Malawi (proposal not yet funded)

Project aims to increase public education and awareness through a One Health approach to promote positive behaviour change for sustainable fisheries governance and environmental management in Lake Malawi

1) Engaging with fisheries governance (oral and archival histories and fisheries science, including fish yields and sustainability)
2) The active investigation of environmental and public health conditions (environmental science, public health, and interviews with community members and fisheries stakeholders)
3) Creatively engaging stakeholders to convey findings and co-develop solutions and plans

Q & A