

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

## **Towards an Optimum Yield: Science, Technology, and Fisheries Development in Lake Malawi, 1930-1964**

### **Authors:**

- David Wilson, University of Strathclyde, UK
- Milo Gough, University of Oxford, UK
- Bryson Nkhoma, Mzuzu University, Malawi
- Elias Chirwa, Mzuzu University, Malawi
- Charles Knapp, University of Strathclyde, UK
- Tracy Morse, University of Strathclyde, UK
- Wapulumuka Mulwafu, Mzuzu University, Malawi

### **Abstract:**

In the late colonial period, fisheries science and colonial development programmes converged in blueprints to better exploit marine resources throughout the British empire. Yet, the historiography of science and colonial development has focused predominantly on the management and exploitation of terrestrial resources with only limited investigation of parallel schemes focused on marine and freshwater resources. Centring on the final decades of the British-ruled Nyasaland Protectorate, this article interrogates the role of science in shaping the regulations and development of Lake Malawi's fisheries. It argues that the late colonial fusion of scientific optimisation and legislative frameworks tethered government-led fisheries development programmes to a vision of optimal resource extraction, governmental custodianship, and technical development that was entrenched in a faith in scientific management but without the necessary data to monitor changes in fishing efforts or the capacity to enforce fishing regulations. Consequently, scientists' recommendations helped to embed assumptions of custodianship and control over watery environments within legislative frameworks that were increasingly disconnected from the evolving commercial, environmental, and technological contexts shaping indigenous-led and settler-owned fishing enterprises.

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

## INTRODUCTION

In 1938, Governor Harold Kittermaster of the British Nyasaland Protectorate (modern-day Malawi) warned that Lake Malawi (then Lake Nyasa) was in serious danger of “being depleted” due to intensive fishing “by natives and by Europeans using modern appliances and effecting catches on a wholesale scale.”<sup>1</sup> Characteristic of the increasing reliance on technical expertise in the late colonial period, Kittermaster lobbied for support for a scientific survey of Lake Malawi’s fisheries to inform “the extent to which their exploitation may be permissible.”<sup>2</sup> Three fisheries surveys of Lake Malawi were subsequently organised between 1938 and 1955, deploying British scientists to Nyasaland to assess fish stocks, evaluate fishing operations, and provide advice for the future development of the industry. Through these surveys, the burgeoning field of fisheries science and the post-war expansion of British colonial research and development programmes converged into a blueprint to better exploit and control the freshwater resources of Lake Malawi.<sup>3</sup>

This article interrogates the role of science in shaping the regulation and development of Lake Malawi fisheries during the final decades of the British Nyasaland Protectorate (after 1953, the Federation of Rhodesia and Nyasaland). It argues that the late colonial fusion of scientific optimisation and legislative frameworks failed to keep pace with technological and commercial transformations within lake fisheries while extending colonial influence over only a limited portion of Lake Malawi. One of the principal reasons for this was that scientist surveyors and government officials generally perceived a dichotomy between settler-owned fisheries—perceived as a threat to the long-term security of lake fish stocks and local food security—and indigenous-led fisheries—framed as underdeveloped and requiring guidance to improve efficiency and productivity. Building on scientists’ recommendations, the colonial government’s bifurcated legislative and development programme concentrated regulatory and monitoring activities on settler-owned fisheries while channelling underfunded technology transfer and commercialisation initiatives towards indigenous-led fisheries. Consequently, colonial fisheries development became

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

tethered to a vision of optimal resource extraction, governmental custodianship, and technical development that was entrenched in a faith in scientific management but without the necessary data to monitor changes in fishing efforts or the capacity to enforce fishing regulations. Ultimately, scientists' recommendations helped to embed assumptions of custodianship and control over watery environments within legislative frameworks that were increasingly disconnected from the evolving commercial, environmental, and technological contexts shaping indigenous-led and settler-owned fishing enterprises.

In making this argument, the article situates freshwater fisheries within the broader historiography of late colonial research and development programmes in Africa. In comparison to terrestrial contexts, especially agricultural and forestry development, colonial attempts to manage and develop marine and freshwater fisheries have been considerably understudied.<sup>4</sup> This is despite the vibrant historiography of fisheries and marine sciences, which has established the geopolitical, economic, and imperial contexts in which these sciences emerged in North America and Europe and the ways in which these sciences were exploited by North American and European governments to advance imperial, economic, and political agendas. Importantly, these studies have shown how the concept of an optimum yield—that is, the optimum catch of fish that could be harvested each year without damaging fish stocks—became a central tenet within fisheries science from the 1930s onward, underpinning legislative and developmentalist interventions in the fishing industry.<sup>5</sup>

While the intersections of fisheries science, regulation, and development have been investigated in the context of North Atlantic and North American fisheries, there has been only limited study of the role and impact of equivalent science-backed fisheries regulation and development programmes in other colonial contexts, especially in Africa. This is not to say that there have been no studies of colonial fisheries research in Africa with more recent surveys by Christian Jennings on British marine fisheries research in East Africa and Jack Talling on

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

freshwater fisheries research in African inland waters building on earlier appraisals by Leonard C. Beadle, Charles Jeffries, and Edgar Barton Worthington. Yet, these works concentrate on the organisation, scientific activities, and limitations of colonial fisheries research programmes with only passing analysis of their impact on fisheries development programmes, regulatory frameworks, and technological changes.<sup>6</sup>

Only the fisheries of Lake Victoria have received more thorough examination with Jan C. Breitingner and Paul Abiero Opondo revealing the limitations of scientific planning and colonial regulations in the face of dissenting opinions within colonial departments and fishers' resistance. Both emphasise how colonial governments deployed scientific expertise to 'optimise' fisheries harvests and 'free' indigenous fishers from their perceived backwardness. Scientific expertise then informed legal formulations that worked only to marginalise fishers' voices while proving unable to address the outcomes, whether the ill-fated introduction of Nile perch or the disconnect of government-led fisheries management from indigenous fishers' realities.<sup>7</sup> Building on these assessments, this article shifts focus to Lake Malawi, which received considerably fewer resources for fisheries research and development programmes than Lake Victoria. By doing so, it thus further develops on the work of Wiseman Chijere Chirwa, John McCracken, and Setsuko Nakayama, who have each analysed different aspects of fisheries regulation and transformation in colonial Nyasaland, but without considering the significance of fisheries scientists in shaping regulatory and development plans.<sup>8</sup>

The issues discussed in this article are not unique to Lake Malawi but echo the challenges faced within twentieth-century fisheries management more generally.<sup>9</sup> Lake Malawi, however, provides an insightful case study to explore how these issues played out in colonial Africa. Given the stark limitations of the regulatory and developmentalist frameworks that scientists influenced, the history of Lake Malawi fisheries also offers opportunity to connect with the largely terrestrial-focused historiography of technology and innovation in colonial Africa, exploring how freshwater

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

spaces too became open-air sites of experimentation and knowledge production through fishers' technological and commercial choices.<sup>10</sup> These developments sometimes aligned with scientists' visions and were sometimes influenced by technology transfer programmes enacted by colonial departments but, fundamentally, relied on fishers' receptiveness and experimentation with different fishing technologies.

The article investigates these issues across five sections. The first focuses on the development of fisheries and freshwater sciences in the British empire and the accompanying vision for colonial fisheries development. The second focuses on the beginnings of colonial interventions into the fisheries of Lake Malawi following conflicts between indigenous and settler fishing operations in the south-east lake. The third delves into the motivations, organisation, and activities of the three fisheries surveys. The detailed blueprints for fisheries development that these scientific expeditions produced are the focus of the fourth section. The final section then considers the impact of these recommendations throughout the lake.

## **Fisheries and freshwater science in Britain and the empire**

Limnological science developed as a professionalised field in the late nineteenth and early twentieth centuries, particularly through the establishment of freshwater research stations on the shores of European and North American inland water bodies. It was not until 1929 that a British organisation focused on fundamental limnological research was established. From then on, the Freshwater Biological Association of the British Empire (FBA) and its research laboratory in Windermere formed a central hub for the advancement of freshwater research in Britain and the empire.<sup>11</sup> Prior to the formation of the FBA, British limnological and taxonomic research had already been initiated on the African Great Lakes. The beginnings of such research is usually traced

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

to zoologist J. E. S. Moore's expeditions to Lake Tanganyika in 1894 and 1897 as well as crustacean expert W. A. Cunnington's follow-up expedition in 1904.<sup>12</sup>

The development of freshwater sciences and the careers of many prominent European freshwater scientists were intrinsically linked to the study of freshwater environments in colonial contexts and especially the African Great Lakes.<sup>13</sup> Compared to European inland waters, the sheer depth, breadth, diversity, and age of the African lakes paired with the diverse assemblage of biological communities—many of which are endemic to each lake—encouraged the sustained interest of European geologists, limnologists, and zoologists from the late nineteenth century. When opportunities to study the lakes arose to inform fisheries exploitation in the twentieth century, there was no shortage of emerging researchers who were keen to investigate these unique environments.<sup>14</sup> As Breitinger explains, twentieth-century scientific expeditions to the lakes established a new pattern of knowledge production, in which freshwater science became closely linked to the assessment of the potential economic utilisation of lake resources that colonial governments claimed custodianship over.<sup>15</sup>

As scientific interest in and knowledge of African freshwater fish advanced in Britain in the early twentieth century so too was there rising interest in the potential of fish production throughout the empire. Before the 1940s, however, a lack of resources halted any plans for a coordinated empire-wide programme of fisheries research.<sup>16</sup> Instead, limnological explorations of the Great Lakes relied on short-term and isolated investigations driven by individual scientists and colonial governments.<sup>17</sup> A series of scientific expeditions were organised between 1927 and the outbreak of the First World War in 1939 that brought British fisheries and limnological researchers to East Africa to study the biological and environmental features of several lakes. For the most part, these surveys lasted only a few months, but they generated important data on the compositional structure and dynamics of the lakes and their biological communities.<sup>18</sup>

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

These expeditions were sponsored and funded predominantly by British colonial governments that claimed full or partial custodianship over several East African lakes and which sought scientific research to inform the exploitation of the fish fauna therein. Government concerns were prompted especially by the introduction of new fishing technologies and the emergence of foreign-owned commercial fishing firms in the early decades of the century. This led to fears of overfishing threatening the availability of fish as a vital local foodstuff. The greater economic utilisation of the lakes was also a consideration, particularly the commercialisation of fish species that were not yet targeted by indigenous or foreign fishers.<sup>19</sup> These fisheries-related concerns emerged amidst a backdrop of wider discussions among colonial advisors surrounding surplus populations, food security, and malnutrition. As Joseph Morgan Hodge especially has charted, the 1930s witnessed the ascendancy of discourse concerning the need to protect colonised populations from the “vagaries of the world market” and, particularly, unchecked material development and its connection to nutritional and public health concerns.<sup>20</sup> Tied to this was anxiety that growing capitalist investment and unconstrained technological change within colonial fisheries endangered food security and community cohesion, threatening to upset colonial regimes. In response, fisheries surveys were organised throughout the decade in several East African lakes, with each expedition followed by scientific reports that included recommendations for government-controlled fisheries development and regulation.<sup>21</sup>

These early scientific expeditions are particularly notable in their contrast to the lack of British (and European) scientific research or interest in African marine environments and fisheries in the same period.<sup>22</sup> Still, the fisheries assessment and management approaches being developed in Europe, particularly to address overfishing in the North Atlantic, informed freshwater fisheries research in Africa.<sup>23</sup> British fisheries scientists E. S. Russell and Michael Graham—who led the first general survey of Lake Victoria in 1927—were among the first to formulate the overfishing problem on a mathematical basis. In 1931, Russell formulated that each year, the weight of the

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

total fishable population increased through recruitment—meaning the number of eggs that survive and develop past the juvenile stage—and the growth of individual adult fish and decreased as fish were caught or lost through natural causes. Based on this model, Russell suggested it would be possible to adjust optimal fishing efforts annually if recruitment fluctuations could be estimated in advance. This, however, was impractical due to the challenges of calculating future recruitment fluctuations.<sup>24</sup>

Nevertheless, Russell had conceived that the aim of a rational fishery was to optimise annual yields in a way that did not cause stock levels to go into decline. This aligned with Graham's Great Law of Fishing, also conceived during the 1930s, that "fisheries that are unlimited become unprofitable."<sup>25</sup> The idea of an optimum yield, therefore, focused on both conservation and exploitation based on harvesting potential, in which stocks were to be conserved from overall decline to ensure the continued viability and profitability of fishing efforts. Importantly, Russell and Graham were advocating a conservationist approach to fisheries management, in which regulations were required to limit fishing efforts.<sup>26</sup>

The freshwater surveys that occurred in East Africa prior to the 1940s adhered to these emerging principles, evaluating fishing capacities and assessing where and why overfishing was occurring. At the same time, these surveys sought to inform the future development and control of the fishing industry, particularly as an important and potentially underexploited source of nutrition for colonised populations. For the most part, however, these were ad hoc and short-term surveys, incapable of providing the data to inform long-term exploitation of the lakes, while colonial governments lacked the resources to control or develop fishing capacities to any real extent.<sup>27</sup>

This changed in the 1940s when the Colonial Development and Welfare Acts of 1940 and 1945 provided a new source of funding for colonial research and development. As has been well covered, this marked a shift in policy, in which the colonial administration became more

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

committed to and reliant on scientific expertise and solutions to inform the direct—and often violent—intervention of colonial governance over environments, resources, and peoples in the name of development.<sup>28</sup> Combined with advancements in fisheries science, this “technocratic turn” led to renewed support for colonial fisheries development schemes.<sup>29</sup>

In 1943, E. S. Russell was appointed as part-time colonial fisheries advisor and the Colonial Fisheries Advisory Committee (CFAC) was established. Both were to advise the Secretary of State for the Colonies. The Committee included staff of the Colonial Office and Ministry of Agriculture and Fisheries, representatives of the British fishing industry, zoologists and nutritional scientists, and the directors of the major British fisheries research organisations, including the FBA.<sup>30</sup> When fisheries researcher Charles Frederick Hickling replaced Russell as Fisheries Advisor for the Colonial Office in 1945, the groundwork had been set for an overarching imperial vision for fisheries development.<sup>31</sup>

Hickling’s vision focused on the ‘improvement’ of local fishing industries, expanding fish production to meet and encourage market demands by ‘modernising’ the gear and methods used by local fishers, including the introduction of motorised fishing vessels and government development loans.<sup>32</sup> This agenda closely aligned with similar plans for terrestrial industries, in which colonial administrations sought to convert resource users from methods and tools perceived as antiquated or inefficient to more intensive techniques. This centred on the introduction of mechanised tools that were seen as ‘modern’ or encouraging the use of manufactured materials to ‘improve’ existing tools.<sup>33</sup> Corey Ross argues that, in practice, the most successful technical interventions “generally revolved around the small improvements to indigenous implements rather than the wholesale introduction of more glamorous mechanical devices.”<sup>34</sup> Attempts at the large-scale reorganisation of indigenous systems of resource extraction regularly failed—sometimes spectacularly—while the most enduring changes were those initiated by indigenous resource users who invested in new methods and industries while incorporating these within existing systems.<sup>35</sup>

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

When it came to fisheries, CFAC sought to establish the infrastructure to manage and monitor food chains throughout diverse water bodies to feed colonial populations while encouraging commercialisation to provide for local economic development. Nutrition, and particularly an obsession with sources of protein, was closely connected to commercialisation and conservation in this vision of development. To inform this development programme, CFAC supported individual scientific expeditions alongside the founding of a string of inter-regional marine and freshwater research organisations throughout the empire to “give some guide to the maximum weight of fish which can be annually removed on a permanent basis.”<sup>36</sup> Consequently, it was the research and recommendations of marine and freshwater scientists that was to guide targeted technological interventions, advise on the best approaches to monitor fish stocks, and ensure the conservation and long-term viability of fish stocks. This vision conformed to the separation of fundamental and applied scientific work that characterised colonial research and development programmes in the late colonial period, in which scientists were expected to carry out fundamental biological, environmental, and technological investigations, which would then inform the direction of fisheries development and monitoring programmes led by separate colonial fisheries departments.<sup>37</sup>

Fisheries scientists, therefore, were to provide the blueprints that colonial governments would implement to better exploit and control marine and freshwater resources to their optimal nutritional and economic value. While it is tempting to see this overarching discourse as defining the shape of colonial fisheries research and development, the limitations of science-backed development schemes meant that such blueprints were only one of a myriad of factors shaping development in practice.<sup>38</sup> As was the case in Lake Malawi, the overarching vision for colonial fisheries development was severely constrained in its implementation but the recommendations produced by scientific expeditions played a fundamental role in shaping the management frameworks imposed over watery spaces by colonial governments.

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

## FISHERIES and Conflict in LAKE MALAWI

Lake Malawi is the third largest lake in Africa, approximately 560km in length, 50-60km in width, and with an average depth of 292m (maximum recorded depth 700m). The lake is home to more species of fish than any other lake in the world, including at least 650-700 species of Cichlid.<sup>39</sup> These fish have provided the basis of a significant fishing industry with fish caught for consumption and for trade with the interior highlands. Given the distinctive geography of the lake and particularly the contrast between the south of the lake—featuring shallow and gently sloping beaches—and the north of the lake—deeper and more vertiginous shores—fishers have tailored their methods to particular environments and species.<sup>40</sup> The richest fishing grounds have historically been in the south lake, where the primary commercial species of tilapia (*Oreochromis squampinnus-saka-lidole-karongae*)—known locally as *chambo*—were most abundant. However, *chambo*, *utaka* (*Haplochromis*), *nchila* (*Label mesops*), *usipa* (*Engraulicypris sardella*), and *mpasa* (*Barilius microlepis*) were all caught in considerable quantities throughout the lake.<sup>41</sup>

From the rocky and steep shores of the northern lake, as well as Likoma and Chizumulu islands, fishermen utilised the *chilimira*, an open water seine net worked from two dug-out canoes, and the *matchela*, a gill net. In the south-west and south-east arms of the lake, sloping beaches enabled the use of *makoka*, seine nets varying in length from 50 to 400 yards, manoeuvred into place by canoe and hauled to the beach using ropes (See Figure 1). These nets were originally constructed of local fibres (*bwaŵi* or *chopa*), although fishers increasingly made use of thread from old car tyres by the early twentieth century. In the numerous rivers running from the lake, a combination of fish weirs, traps, and baskets were used to catch fish running downstream to spawn.<sup>42</sup> Each method was refined according to acquired knowledge of fish behaviour, geographies, and currents.<sup>43</sup>

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

Fishing was particularly important to the economies of three lakeside groups, the Tonga who resided on the western shore of Lake Malawi, particularly around Nkhata Bay, and the Nyanja and Man'ganja people who inhabited the southern shores. While most fish caught were consumed locally, there was also a regular trade with agricultural communities in the highland regions, exchanging dried fish for maize and beans.<sup>44</sup> Although the right to fish was not restricted to particular groups, it is clear that some lakeshore leaders—especially among Nyanja and Man'ganja communities in the south who worked nets from beaches—were vested with certain rights over fishing grounds proximate to their domain. Through claims over beaches, lakeshore leaders could control fishing and demand tribute in the form of cash payment or a portion of fish caught. Lakeshore leaders also exercised general authority over fisheries, negotiating with neighbouring communities when conflict arose.<sup>45</sup>

Following nineteenth-century expeditions by British missionary-explorers to Lake Malawi (dubbed Lake Nyasa) and the subsequent establishment of missionary settlements in the region, the British Central Africa Protectorate (renamed Nyasaland in 1907) came into formation after the Anglo-German Heligoland Treaty of 1890 and the Anglo-Portuguese Treaty of 1891. In these treaties, Britain claimed the territory that is modern-day Malawi under its sphere of interest, extending British boundaries over most of Lake Malawi except for the central eastern shores bordering Portuguese East Africa (modern-day Mozambique, see Figure 1).<sup>46</sup> It was not until the 1930s and the expansion of European and Indian commercial efforts in the south-east lake that the colonial government would begin to intervene in the fishing industry.

In their separate studies, Chirwa and McCracken have covered the expansion of the fishing industry and subsequent conflicts centred on the south-east lake following the First World War. In particular, increased markets for foodstuffs during the First World War following the arrival of thousands of troops at Blantyre and Zomba encouraged at least one village headman, Mwamadi Matewere of Bala, to expand fishing efforts by erecting a reed barrier with fish traps at the mouth

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

of the Shire River in 1917. By 1931, an estimated 10,000 people were involved in the trade, and several European and Indian middlemen had started to purchase fish at the lakeshore for transport by motor lorry to Blantyre and Zomba.<sup>47</sup> These market opportunities then encouraged the development of European- and Indian-led commercial fisheries in the south of the lake with the entry of the Greek Yiannakis brothers marking the beginnings of substantial non-indigenous settler fishing efforts. Beginning with basket fish traps in the Shire River in 1933, the Yiannakis brothers then utilised *makoka* before importing large seine nets from England. In 1938, they began trawling operations, introducing ring, purse, and gill nets, substantially increasing their yields and employing a regular force of African wage labourers on board their fishing vessels and in their warehouses. The total number of fish caught by the Yiannakis brothers' fisheries rose from 74,700 in 1937 to 1,761,200 in 1943. Using lorries, fresh fish was transported to urban markets while fresh and dried fish was exported to plantations in Southern Rhodesia. The Yiannakis brothers also embedded themselves within local markets by selling fish to indigenous traders. Their success encouraged other European and Indian settlers, with three additional commercial fisheries in operation by 1938. By 1939, all suitable beaches between Mtimbuka and Fort Johnston were occupied by indigenous and settler-owned fisheries.<sup>48</sup>

As settler efforts developed, disagreements arose between settler-owned and indigenous-led fisheries, especially when it was found that the Yiannakis brothers were not confining their activities to the beaches they had leased. Instead, they moved to neighbouring beaches and “without any regard to the interests of the natives whose beach they were poaching from, have cast their nets and taken away in their lorry the load of fish caught.”<sup>49</sup> In some cases, it appears that this occurred “with the connivance of the native authorities,” but long-term conflicts also arose due to the brothers' sponsorship of unauthorised fishing activities. For example, Chief Mponda, whose authority extended over beaches in the south-east lake in the region surrounding Fort Johnston, refused to allow the Yiannakis brothers to extend their facilities in his domain due

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

to the bad conduct of Yiannakis-sponsored fishers who operated from beaches under Mponda's authority without permission and antagonised local fishers.<sup>50</sup>

Expanding settler enterprises and intensifying disputes encouraged the Nyasaland government to pass a series of fisheries regulations in the 1930s. To stop European and Indian fishers from erecting fish traps at the mouth of the Shire River, the Fishing Rules of 1930 and 1931 prohibited "non-natives" from fishing for trade or commerce within two miles of the mouths of any rivers entering Lake Malawi unless granted a permit.<sup>51</sup> In 1937, these rules were expanded to cover Lake Malombe and the southern arm of Lake Malawi, making permits obligatory for non-indigenous commercial fishers. These permits stipulated where non-indigenous fishers could fish, set mesh size regulations, and imposed monthly reporting on the average size of nets employed, the numbers of casts per net, approximate total catches, and average proportions of targeted species caught in each type of net.<sup>52</sup> Although the government placed a halt on new permits, there were no effort restrictions placed on existing firms, which continued to expand over the next five years.<sup>53</sup> While the regulation enabled government monitoring of catch and effort data from settler-owned fisheries, this data was effectively meaningless without parallel studies of fish biology, behaviours, recruitment, and stock health. Studies were also required to understand the impact of fluctuating lake conditions on fish populations. Consequently, the Fishing Rules proved largely ineffective in regulating fisheries development.<sup>54</sup>

Yet, these early regulations are indicative of the underlying assumptions driving colonial intervention in Lake Malawi fisheries. As Chirwa argued, these regulations were premised on the view that fishing and fish trading were "native" occupations, important for regional commerce and the sustenance of local populations.<sup>55</sup> In colonial reports, indigenous fisheries were characterised as essentially subsistence activities while settler-owned fisheries were represented as growth-focused commercial enterprises.<sup>56</sup> Such views were couched in racialised perceptions that indigenous fisheries were less enterprising, ambitious, and proactive than non-indigenous fishing

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

firms.<sup>57</sup> This aligned with dominant colonial beliefs about the technical inefficiencies of indigenous production methods and perceptions that rural populations were incapable of responding to commercial opportunities or increasing their exploitation of natural resources using existing tools and methods.<sup>58</sup> Aligning with rising colonial concerns surrounding capitalist development and food security in the 1930s, the growing export of fish to meet the demands to feed plantation labourers in Nyasaland and Southern Rhodesia also led to fears that settler-owned operations were redirecting an important economic and food source away from local markets and even away from the colony.<sup>59</sup>

Such perceptions ignored the hybrid nature of the burgeoning fishing industry in Lake Malawi, in which fish caught by indigenous and settler-owned fisheries entered local, urban, and export markets through connected lakeshore and roadside markets. Indigenous fishers regularly sold fish to settler-owned firms whose limited fishing facilities proved unable to meet the demands for fish to feed plantation labourers in Nyasaland and Southern Rhodesia.<sup>60</sup> Likewise, indigenous traders purchased fish from settler-owned firms for sale in local and interior marketplaces.<sup>61</sup> Through these competing and collaborative networks, indigenous and settler groups took advantage of the commercial opportunities brought about first by wartime demand and then the expansion of large-scale commercial plantations by increasing their fishing efforts and extending the distribution of their harvests.<sup>62</sup>

Largely disregarding the increased fishing efforts of indigenous fishers, colonial officials were concerned that the expansion of settler-owned fishing operations were “reducing the fish population of the Lake at a faster rate than that population can recruit itself by breeding and growth.”<sup>63</sup> This narrative of decline was also supported by some indigenous fishers who blamed intensive settler fisheries for the declining catches they observed by 1939.<sup>64</sup> Following the passage of the Fishing Rules of 1937, the Governor of Nyasaland, Harold Kittermaster, pushed for funding for a fisheries survey to address these concerns.<sup>65</sup> This drive for research was an attempt to move

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

away from reactive fisheries regulation and towards science-led fisheries management. The optimum yield in Lake Malawi became predicated on treading a fine line between commercial development and conservation, but this meant conservation of not only fish stocks but also conservation of indigenous participation in the industry. Such participation, however, was centred on development as envisioned by British scientists and supported by colonial advisory committees and officials.

### **Surveying Fisheries in LAKE MALAWI**

Before the late 1930s, research into Lake Malawi fisheries had been limited to investigation of specimens collected and sent to the British Museum of Natural History by British naturalists Rodney Wood and Cuthbert Christy in the first two decades of the century. Studying these specimens, ichthyologists Edgar Barton Worthington, Charles Tate-Regan, and Ethelwynn Trewavas taxonomized the lake's unique and diverse fish fauna.<sup>66</sup> This taxonomic research, however, could not inform fisheries management, which required on-site investigation of fish habits and lifecycles paired with analysis of fish catches and fishing efforts as well as greater limnological analyses. To fill this gap and offer recommendations for the future development of lake fisheries, three fisheries surveys were organised between 1938 and 1955.

The first survey was initiated in 1938 in conjunction with a colony-wide nutritional survey led by B. S. Platt of the British Medical Research Council. This was part of a wider initiative organised under the auspices of the British Economic Advisory Committee to conduct nutritional surveys throughout the empire.<sup>67</sup> Despite the significance of fish to local economies and diets in Nyasaland, a fisheries survey did not initially factor into these plans. Shortly after arriving in the colony, though, Platt offered support for Kittermaster's requests for scientific fisheries research, linking the concerns of the Nyasaland government with the nutritional research programme.<sup>68</sup>

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

Discussions then progressed as to who was available and best placed to undertake the survey. The British Museum of Natural History agreed to second Ethelwynn Trewavas and provide for her expenses, enabling her to build from her taxonomic work.<sup>69</sup> As Trewavas' focus would be biological research, there was also a need for a researcher with experience in more practical questions surrounding harvesting potential and fishing efforts. Edgar Barton Worthington—then director of the FBA who had also led earlier investigations to East African lakes in the 1930s before he was engaged to survey the progress of scientific research in Africa as part of Lord Hailey's African Survey—suggested that Kate Ricardo (later Bertram) be approached given her experience of surveying African lakes. Ricardo had trained in zoology at Cambridge and had acted as a research assistant for Worthington's Cambridge Expedition to the East African lakes in 1930-1931. In 1936-1937, Ricardo had also conducted her own research in Lakes Bangweulu and Rukwa in Northern Rhodesia (modern-day Zambia) and Tanganyika (modern-day Tanzania) respectively. When she was appointed to the Lake Malawi survey, Ricardo was a Yarrow Research Student in the Zoological Laboratory and Girton College at Cambridge.<sup>70</sup> In Nyasaland, Ricardo and Trewavas would be supported by H. J. H. Borley, a District Commissioner who had past experience as a naturalist, including investigating the sponge fishing industry in British Honduras.<sup>71</sup>

The expedition had three aims: first, to survey the fisheries and evaluate the place of fish in the local economy; second, to estimate total fish resources and the extent they were utilised; and third, to study how fish stocks could be best exploited over the long-term. As Worthington put it, the survey was to evaluate the resources not just “as they are” but “how they could be best developed to obtain *maximum production* in the future.”<sup>72</sup> Funding was secured by a £2000 grant from the Colonial Development Fund and £300 provided by the British Museum for Trewavas' participation. Alongside staffing and subsistence costs, £100 was provided for equipment including instruments, logbooks, various fishing gear, and storage for collected specimens. The

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

single greatest cost was £800 for local transport, including hire of a steamer to visit fishing beaches throughout the lake.<sup>73</sup>

Borley, Ricardo, and Trewavas commenced their survey at Nkhotakota in January 1939 proceeding to Fort Johnston in February before embarking on the S. S. *Malonda* for a two-month journey around the lake. Between May and June, the team surveyed dams, streams, and other lakes before returning to Nkhotakota. In mid-June, Ricardo and Trewavas returned to England where Ricardo planned to examine the gathered data before returning to Nyasaland to survey the most important fishing and breeding season between September and January.<sup>74</sup> The outbreak of the Second World War postponed this indefinitely, leaving a significant data gap about these crucial seasons.<sup>75</sup> Nevertheless, over the course of six months, the team collected substantial data from throughout the lake. Interviewing fishers from various lakeside communities including Nyanja, Man'ganja, and Tonga fishers alongside settler fishers based in the south-east lake, the team gathered information about methods and target species while assessing the size and composition of hauls of fish caught by different methods and in diverse fishing grounds, and examining fish biology and stomach contents. To support this work, African clerks were hired to keep continuous records of fish catches landed at Sani, Nkhotakota, and the Shire River between February and October. There had also been some limited experimental work using gill nets, long lines, and otter trawls. The survey report formed the first comprehensive account of the fishing industry in Lake Malawi. While this provided some basis for informing fisheries development, the authors stressed the need for greater data gathered over a lengthier period, particularly during the fishing and breeding season.<sup>76</sup>

This work would only be picked up as the war came to a close, prompted first in July 1944 by Worthington who wrote to E. S. Russell, then Colonial Fisheries Advisor. As Director of the FBA, Worthington was keen that researchers associated with the organisation actively engaged with research programmes outside of the Lake District and especially throughout the empire.

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

Worthington proposed that Rosemary Lowe, who had joined the FBA as a researcher after graduating from Liverpool University with a degree in Zoology and Botany, be dispatched to Lake Malawi to resume the survey. Worthington intended to engage Lowe on the new inter-regional East African Freshwater Fisheries Research Organisation that he was establishing in Lake Victoria. In the interim, he suggested that Lowe complete the research in Lake Malawi.<sup>77</sup>

Worthington's proposal was supported by Russell, CFAC, and Edmund Richards, then Governor of Nyasaland, with CFAC and Richards raising concerns about the considerable wartime expansion of settler-owned *chambo* fisheries in the south-east lake. The 1939 survey had found that *chambo*, previously thought to be one tilapia species (*Oreochromis squamipinnus*), was a complex of four closely related species (*Oreochromis squamipinnus-saka-lidole-karongae*). Management of the *chambo* fishery, therefore, required knowledge of the distinctive biology, life history, and habits of each of the main commercial species in order to better understand the impact of fishing on each. Lowe was to conduct this investigation. The expedition was funded by a £1000 grant from the Colonial Development and Welfare Fund (CDW), which would cover Lowe's salary with additional stipends of £200 for transportation and £200 for equipment.<sup>78</sup>

Lowe's survey lasted nineteen months between September 1945 and April 1947.<sup>79</sup> She was supported throughout this time by a team of African research assistants—referred to as “the survey ‘boys’” in her memoir.<sup>80</sup> For most of this time, Lowe concentrated on the *chambo* fisheries in the south-east lake, occasionally travelling as far north as Nkhotakota as well as spending one month in the northern lake. Lowe's investigation focused first on differentiating the main tilapia species before assessing their growth rates and life histories. Lowe also studied the effects of fishing on tilapia stocks, engaging with indigenous and settler-owned *chambo* fisheries, while observing other indigenous fisheries focused on *utaka*, *nchila*, and *mpasa*. Building on the first survey, experimental gillnets were set to test the potential of alternative fisheries for untargeted species (*Bagrus*, *Clarias*, and *Labeo*).<sup>81</sup> Lowe's report offered a comprehensive account of the life histories and habits of the

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

main tilapia species in the southern lake, as well as a detailed discussion on the effect of fishing on distinctive inshore and offshore dwelling tilapia stocks. This data formed the basis of a detailed blueprint for the control and development of the fishing industry, in which Lowe placed especial emphasis on reducing pressure on tilapia stocks in the south-east lake, especially the more inshore living species (*Oreochromis saka* and *Oreochromis squamipinnis*) as the evidence indicated these were already being overfished.<sup>82</sup>

Building on Lowe's recommendations, the third fisheries survey focused on the less-studied northern lake. Unlike the relatively ad hoc nature of the previous surveys, this expedition was part of CFAC's grander schemes to establish inter-regional research organisations in the post-war era. In March 1950, a proposal was put forward for a CDW grant to establish a freshwater fisheries research organisation for Northern Rhodesia and Nyasaland. The total approved request was for £62,000, although the two governments agreed to each provide £13,500 towards this. The Joint Fisheries Research Organisation for Nyasaland and Northern Rhodesia (JFRO) was established in 1951 with headquarters at Samfya on the western shore of Lake Bangweulu, Northern Rhodesia, and a substation to be established at Nkhata Bay on the northwest shore of Lake Malawi where Tonga fishers predominantly resided.<sup>83</sup>

The first two years of JFRO's existence were beset by construction delays at Samfya, which meant little scientific work progressed. It was not until October 1953 that the JFRO team—director Peter Jackson, scientific officer Derek Harding, and technical officer Mike P. Gilbert—decamped to Nkhata Bay to establish the substation while conducting a two-year fisheries survey of the northern lake. They were joined a few months later by recent graduates Derrick Iles and Geoff Fryer, who were employed as scientific officers.<sup>84</sup> The survey aimed to determine whether fishing on a commercial basis, particularly using gill nets, could be expanded in the northern lake as a means to alleviate pressure on southern stocks while providing greater economic opportunity

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

in the north.<sup>85</sup> As with the previous surveys, the core aim was to produce information to advise the direction of fisheries management and development.<sup>86</sup>

The research team faced a slow start due to a lack of facilities at Nkhata Bay plus a six-month delay awaiting arrival of their survey launch. Still, over the two years, the team undertook a wide and varied survey of the northern lake, experimenting with gillnets and other fishing gear, interviewing local Tonga fishers while studying the *utaka* and *usipa* fishery and *chilimira* and *usikite* gear, and investigating biological and physical features. The British scientists were supported in the laboratory by A. J. P. Mzumara and on the lake by fishermen and fisheries department employees, including Ranglely Phiri, Blackston Siska, Kajawa Mwenda, and Akusayinda Banda. By the end of their survey in October 1955, the team determined that the northern lake was not as productive as the south and a gill net fishery would not be profitable. However, there was potential that local *utaka* fisheries could be expanded with government support.<sup>87</sup>

Across these three surveys, the expertise of emerging freshwater scientists was deployed from Britain to inform the management and development of Lake Malawi fisheries. The organisation of fisheries research during these sixteen years exemplifies the growing faith in and lobbying for scientific research to inform the optimal exploitation of colonised environments that characterised development programmes in the late colonial period. Influenced by the expanding role that scientific and advisory organisations—in this case the FBA and CFAC—began to play in directing research and development agendas, these research programmes progressed from ad hoc governmental requests in the interwar period to the formation of inter-regional organisations by the mid-century. These scientific and advisory bodies also shaped the careers of graduating scientists by supporting and encouraging their employment in colonial research.<sup>88</sup> While generating new biological and physical knowledge of Lake Malawi, these scientists also compiled recommendations that formed the basis of fisheries regulations and development schemes enacted by the Nyasaland government.

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

## Scientists' Blueprints for Fisheries Development

Examining the proposals advanced in each survey report provides a clear view of how scientists' recommendations worked to reinforce colonial assumptions of custodianship over lake resources while forming the basis for legal scaffolding centred on government-led monitoring, regulation, and development. These also reveal how each survey attempted to respond to and keep pace with changing indigenous and settler-owned fishing efforts in the periods between each survey. Scientists' recommendations centred on three issues: fishing effort and the potential for expansion; regulation towards an optimum yield; and directions for development.

On the potential for expansion, the starkest contrast was between the first and second surveys, exposing the intensification of fisheries that had occurred during the war years. The first survey suggested that collective fishing efforts were not exhausting lake fish stocks, even advising that indigenous and settler fishing efforts could be increased for nutritional benefits.<sup>89</sup> Eight years later, Lowe observed that increased fishing efforts of settler-owned firms were not resulting in commensurate increases in catches, suggesting a declining catch per unit effort—a telltale sign of overfishing.<sup>90</sup> Warning that the limit for inshore tilapia fisheries had already been reached in the south-east, Lowe advised that any expansion had to focus on reducing strain on inshore stocks by developing other fisheries, including for open-water tilapia in the south and for *utaka* in the north where no settler firms yet operated.<sup>91</sup> The third survey followed up on the latter suggestion, but found that large-scale commercially-owned fisheries would prove unprofitable in the north. Yet, there was potential for expansion if this concentrated on “exploitation by small local units.” This would be best achieved by developing existing indigenous fisheries, particularly through concentration on the *utaka* fishery using *chilimira* nets.<sup>92</sup>

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

Suggesting that varying levels of expansion were possible for different species, each survey advocated for government-managed development. The first team emphasised that any growth “should be carried out under the control of some officer fully competent to judge the effect of the extension.”<sup>93</sup> Given the focus of the survey, which was linked to Platt’s nutritional survey of Nyasaland in the context of broader colonial concerns of malnutrition and undernourishment, their recommendations advocated primarily for safeguarding indigenous fisheries, which they observed were vital for local food security. Their main recommendations, therefore, centred on restrictions and monitoring of settler-owned fisheries to ensure that further commercial expansion did not lead to declining access to fish for local nutritional benefit. Their specific suggestions aligned with the rules already enacted—but ineffectively enforced—by the Fishing Rules of 1937.<sup>94</sup>

Lowe’s recommendations went further, concentrating on a long-term policy to restore tilapia stocks while working towards extracting the optimum yield from lake fisheries. The main aim of Lowe’s proposals was to allow each generation of tilapia to rear one brood of young before being caught while protecting immature tilapia and restricting fishing on spawning grounds. Lowe suggested this required government regulation of both indigenous-led and settler-owned fisheries, recognising that these enterprises targeted the same declining inshore fish stocks and that each had adopted methods that further threatened these stocks. Lowe emphasised that any regulations, however, had to be “elastic enough to change with changing conditions,” such as varying lake levels, the envisioned shift of settler-owned fisheries to open waters, and any resulting changes in inshore and open water species. Lowe’s recommendations included restricting additional permits for commercial tilapia fisheries, forbidding the capture of juvenile tilapia of less than six inches, raising minimum mesh sizes for settler firms from two to four inches, and introducing closed seasons in the south-east. Moving beyond just restrictions, Lowe advocated for greater enforcement and oversight through mandatory registration of all fishing nets while empowering Fishery Officers to move fishers and confiscate illegal gear and catches, whether indigenous or

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

settler owned. Providing the most comprehensive legislative proposals, Lowe advocated for a careful and flexible approach to fisheries management, but one which rested on more direct governmental intervention in the lake fisheries.<sup>95</sup>

Unlike the first survey team, whose recommendations were primarily focused on safeguarding indigenous fisheries to ensure optimal nutritional benefit, Lowe's recommendations centred on preventing the degradation of tilapia fish stocks. Controls on both indigenous and settler fisheries were, Lowe advised, crucial to the long-term viability of fisheries in the south-east lake. Such recommendations, however well meaning, were couched in assumptions that rationalised a considerable assertion of authority over lake fisheries by the colonial government.<sup>96</sup> As the third survey was focused on the potential for greater exploitation of northern fisheries, the recommendations were less about restrictions and, instead, advocated for governmental controls to raise fish prices while reducing the price of fishing gear to encourage commercial expansion of indigenous fisheries.<sup>97</sup> Each survey, therefore, suggested greater governmental control over lake fisheries to achieve nutritional, conservation, and economic benefits over the long term.

While recommending the containment of settler fisheries, each survey highlighted the importance of indigenous fisheries and suggested that these needed to be expanded and developed through targeted government-led interventions. This included the introduction of European-manufactured fishing materials—particularly twine, gear, hooks, and lines—that were more efficient and durable than those produced locally. While the first two surveys focused on importing European-manufactured gear and materials, the third recommended that development in the north focus on improving indigenous *chilimira* nets. The team described this fishing method as particularly refined, having developed through fishers' deep knowledge of *utaka* habits and the surrounding hydrology and geography of *utaka* dwelling grounds. However, while the operation and manufacture of *chilimira* required great skill, the survey team considered the net heavy and cumbersome. As part of their research, the team designed and experimented with an adapted

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

*chilimira* net made with synthetic fibres and smaller mesh size. This was more durable and yielded greater catches per haul. Beyond the introduction of adapted and imported gear, each survey also recommended the adoption of alternative watercraft to facilitate expansion of indigenous fisheries to open waters in addition to market controls and training in alternative curing and marketing methods to cultivate greater trade with distant markets.<sup>98</sup>

Hickling's post-war vision, as Fisheries Advisor for the Colonial Office, outlined above, had centred on technology transfer, refinement of indigenous fisheries paired with training in production method, and close monitoring of catch and effort statistics. In each of their survey reports, scientist surveyors adapted these visions to the local contexts they encountered and observed. In doing so, they worked to translate overarching colonial visions to local realities and practices in Lake Malawi, particularly by engaging with and relying on indigenous fishers' ideas, information, and knowledge throughout their enquiries.<sup>99</sup>

While indigenous fishing methods were often portrayed as effective and based on deep knowledge of fish species and environments, however, little weight or consideration was given to the effectiveness or efficiency of existing protocols and regulations governing indigenous fisheries.<sup>100</sup> Lowe was particularly concerned that regulations being made by separate authorities would hinder any attempt to develop a lake-wide fisheries policy. Instead, she recommended that 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."<sup>101</sup> This meant that fishers' knowledge was being folded into scientific reports, which were then used to inform regulatory regimes, from which the holders of that knowledge were excluded.<sup>102</sup> As Mavhunga argues, this was not a case of the conquest of Western knowledge over African knowledge but, instead, was a knowledge encounter occurring within an unequal relation of power, in which those who sought to control environments and peoples' relations with environments tapped into those peoples' deep environmental knowledge to do so.<sup>103</sup>

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

Although each team acknowledged that their proposals were idealised blueprints that required a much more substantive and sustained depth of data than was yet available, their collective recommendations were centred on the underpinning belief that the optimum yield of fish harvests—in which the optimum yield was framed in the language of nutrition, commerce, and conservation—could only be achieved through greater oversight and control by the colonial government. This required increased oversight of indigenous and settler-owned fisheries alike, although for distinctive ends. Through regulatory intervention and monitoring, settler-owned fisheries were to be contained to stem their impact on fish stocks and food security while indigenous fisheries were to be supported towards increased efficiency and productivity. Even as scientists—and especially Lowe—recognised that indigenous fisheries were undergoing a period of change, particularly in response to declining *chambo* stocks in the south-east lake, their recommendations were nevertheless rooted in perceptions that indigenous fisheries needed to be improved through governmental oversight.<sup>104</sup>

This vision reflects comparable development schemes focused on terrestrial industries that were progressing simultaneously throughout the British empire in Africa and beyond, casting expert officials as the only responsible stewards of natural resources who needed to oversee and manage the exploitation of natural resources.<sup>105</sup> Based on these ideas, these schemes amounted to, as Ross has argued, “an unprecedented escalation of state intervention into the lives of rural people, their use of the land, and the environments they inhabited.”<sup>106</sup> Yet, such development programmes rarely met the ideals that scientists and colonial planners envisioned. Instead, rural populations made, remade, and discarded such schemes and technologies according to their own interests and contexts.<sup>107</sup> Aligning with this pattern, what developed in Lake Malawi between the 1940s and 1960s was a patchwork of fisheries development, sometimes shaped by government regulations and development schemes but often occurring beyond colonial oversight.

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

## **A Patchwork of Fisheries Development**

The final two decades of colonial rule witnessed the further expansion of indigenous-led and settler-owned fisheries, in which new and adapted fishing gear and methods were adopted and disseminated throughout the lake. Although unable to regulate or develop lake fisheries to the extent envisioned in scientists' blueprints, colonial development programmes still influenced these changing fishing methods and technologies. Similarly, while regulations continued to pertain mainly to settler-owned firms, an expanded regulatory framework that aligned with Lowe's proposals vested substantial new powers within the Nyasaland government, creating the legal scaffolding for a government fisheries regime centred on scientific management and informed by fragmented and incomplete data.

The primary regulatory change in the final decades of colonial rule was the Fisheries Ordinance of 1949. Its expanded regulatory regime provided the governor with powers to prescribe closed seasons, protected areas, minimum landing sizes, gear specifications, licence and export restrictions, and net registration. This followed Lowe's suggestions, creating a legislative framework to monitor catch and effort data to inform regulation. The immediate aim was to extend the licencing system for non-indigenous fisheries to the entire lake while implementing mandatory registration of fishing nets to monitor where, when, and how many nets of each type were employed. This information was to be used to estimate indigenous fishing capacities in lieu of complete statistical data, providing some indication of whether optimum yields were being realised or surpassed. The ultimate power over net registration was vested in the newly created Director of the Department of Game, Fish, and Tsetse Control (GFTC), who could prohibit the registration of further fishing nets in a particular region if he judged stocks were being overfished.<sup>108</sup>

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

Established in 1950, GFTC was empowered to collect and monitor catch and effort statistics while implementing development programmes focused on indigenous-led fisheries. The two main fisheries branches of GFTC were the Fisheries Station at Fort Johnston and the Fisheries Laboratory at Nkhata Bay, which was established as part of the JFRO survey in 1953 (See Figure 1). Between 1950 and 1964, GFTC initiated various programmes from these two sites to gain greater data on catches and efforts within indigenous-led fisheries and to ‘improve’ fishers’ methods, tools, and business management skills. Such activities, however, were continually obstructed by a lack of resources. Yet, these programmes directly and indirectly influenced lake fisheries.<sup>109</sup>

Throughout the period that GFTC operated, restrictive regulations remained targeted at settler-owned fisheries with a one-month closed season imposed on non-indigenous seine and ring net fishing in the south-east arm every December from 1950. This was a direct response to Lowe’s findings of overfishing for tilapia. By 1960, the closed season was extended to include November following a continuing decline in catch per unit effort.<sup>110</sup> While the closed season did not halt the expansion of licenced fisheries, major famine between 1949 and 1950 also led to a prohibition on fish exports. This remained in place until increased catches encouraged a lifting of the ban from 1958 onwards.<sup>111</sup> Between 1958 and 1960, exports rose from 285 short tons of fish to 1,351 short tons, approximately 25% of total catches by settler-owned firms. These figures then declined in subsequent years, which was welcomed as a “sign of rising consumption within the territory.”<sup>112</sup> Export permission, therefore, was granted in the same year that witnessed significant indications of tilapia overfishing in the south-east, thereby suggesting that optimum yields had been surpassed. The export restrictions, however, were not put back in place.

Although instituting a regulatory framework seemingly centred on scientific modelling towards the extraction of optimum yields, governmental regulations centred mostly on technical prohibitions that aligned with scientists’ recommendations but that failed to proactively respond

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

to indications of overfishing when existing regulations proved unable to direct or limit settler-owned fishing efforts. Instead, the trajectory of settler-owned fisheries remained rooted in the commercial decisions of licence holders. From 1949 to 1962, between three and five settler-owned firms operated each year, continuing to concentrate on tilapia fisheries in the south-east as attempts to expand elsewhere failed. From 1949 onwards, these firms abandoned inshore fishing to instead target open-water species using ring nets. Although this was in line with Lowe's recommendations, offshore expansion was not driven by government policy but by falling inshore catches. Less than ten years later, by 1957, the previously unexploited open-water tilapia stocks showed signs of overfishing. Yields only appeared satisfactory again in 1962 following a lull in fishing efforts in 1961, again not due to government decisions but instead due to the withdrawal of one of the licensees and the changing ownership of another who suspended fishing operations until 1962.<sup>113</sup>

In contrast to the direct if limited regulatory interventions in settler-owned fisheries, there was continued reluctance to introduce any restrictions on indigenous efforts. This is best exemplified by debates surrounding the gradual increase in the distribution and use of *kambuzi* nets—small-mesh seine nets—by indigenous fishers. Lowe had warned that falling catches of tilapia in the south-east lake had prompted indigenous fishers to use *kambuzi* nets—formerly used exclusively in *utaka* fisheries—to catch juvenile tilapia (known locally as *kasawala*). Lowe had cautioned against a complete prohibition on *kambuzi* nets, however, as this would disproportionately impact *utaka* fisheries. After 1957, in an attempt to shift focus from their own expanding efforts, settler-owned firms persistently pointed to *kambuzi* nets as the reason behind declining tilapia catches in the south-east lake. This was disproven by GFTC fisheries officers who estimated that the numbers of *kasawala* landed by *kambuzi* nets were not substantial enough to account for the decline in tilapia stocks.<sup>114</sup> As such, the government did not seek to regulate *kambuzi* nets. Regulatory interventions, therefore, centred firmly on settler-owned fisheries while indigenous-led fisheries continued to operate largely beyond government enforcement. Instead,

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

when it came to indigenous-led fisheries, the priority of GFTC was to collect catch and effort data while implementing programmes centred on technology transfer and commercial guidance.<sup>115</sup>

On catch and effort, GFTC employed African fisheries assistants to collect data at several landing sites (See Figure 1). Unable to monitor every landing site, GFTC intended to pair this data with information collected through mandatory net registration, but such registration was never successfully implemented due to a lack of resources and compliance so GFTC could provide only a suggestion of overall indigenous fishing efforts.<sup>116</sup> In 1961, attempts were made to provide a more holistic understanding of indigenous fishing capacities by undertaking a comprehensive assessment of fishing efforts in the south-east.<sup>117</sup> The results suggested that yields were “far higher than previously thought probable,” requiring considerable revision of estimates of indigenous fishing efforts in the final years of colonial rule, thereby indicating how far the colonial government was from being able to accurately assess actual yields, never mind calculate optimum yields.<sup>118</sup> These limitations point to GFTC’s reliance on inadequate and flawed data to inform not only fisheries regulations but also development schemes that aimed to increase indigenous fishing potential without the ability to effectively monitor or calculate that effort.

One of GFTC’s significant initiatives was the introduction of more efficient fishing gear, which contributed to a marked increase in the use of gill nets and *chilimira* nets throughout the lake.<sup>119</sup> GFTC advocated for these as gill nets placed less focus on tilapia while *chilimira* nets caught virtually no immature tilapia, thereby fitting with Lowe’s recommendations to alleviate pressure on tilapia stocks.<sup>120</sup> From 1949 to 1953, GFTC bulk bought manufactured twine—including flax, cotton, and nylon—for resale to indigenous fishers.<sup>121</sup> These materials proved popular enough that commercial firms took over thereafter. By 1960, demand nearly outpaced supply as the use of gill nets increased dramatically.<sup>122</sup>

There was similar increase in the use of nylon *chilimira* nets, expanding from use in northern *utaka* fisheries to more widespread use in the south-east and Nkhata Bay. GFTC had supported

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

this expansion through experimentation with *chilimira* nets at the research station in Nkhata Bay alongside a demonstration unit that toured the southern lake providing hands-on information about gill and *chilimira* nets in 1962.<sup>123</sup> More importantly, increased *chilimira* fishing was driven by the return of Tonga labour migrants from urban centres with capital that they invested in nylon *chilimira* nets for use in the south-east. When catches began to decline and conflict arose between migrant and indigenous fishers, particularly between Tonga and Nyanja fishers at Cape Maclear, most Tonga fishers returned to their home areas around Nkhata Bay, where they continued to employ the nets.<sup>124</sup> Decreasing catches of tilapia in seine net hauls over the decade, and especially from 1957, was a key factor driving the increased adoption of gill and *chilimira* nets. These same conditions also led to the increasing use of *kambuzi* nets. GFTC's efforts may have expedited the introduction of imported twine, which helped to promote the adoption of alternative types of gear at locales near GFTC's bases, but it was fishers' receptiveness to these types of gear, paired with decreasing tilapia yields and new market opportunities, that encouraged their wider use.<sup>125</sup>

GFTC played a more proactive role in introducing alternative fishing vessels. While CFAC's vision advocated the replacement of so-called "primitive native craft" with motor-driven boats, GFTC advised that powered vessels were not yet a feasible option and instead focused on the gradual introduction of plank boats.<sup>126</sup> A "simple and practical type of plank boat" was designed by GFTC's Fish Ranger, H. Dunlop, in 1951. After which, indigenous carpenters were trained in their construction.<sup>127</sup> By 1962, there were around 150 plank boats in use throughout the southern lake, including over 100 with outboard engines. This appears to have been one of GFTC's more successful programmes, but its success was again determined by the receptiveness of indigenous fishers who adopted plank boats and outboard engines as part of their repertoire of fishing technologies.<sup>128</sup> Again, CFAC's overarching vision of mechanisation was adapted locally by technical officers who recognised the sheer impracticability of introducing fully motorized vessels without the infrastructure or resources to maintain, repair, and operate such vessels.<sup>129</sup>

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

The limited ability of GFTC to direct fisheries development beyond supporting technological shifts is seen in the failure of government-backed training and loan schemes to foster a “nucleus” of ‘commercial’ indigenous fishers.<sup>130</sup> GFTC defined commercial fishers as those who emulated settler fishing efforts, essentially business owners who maintained gill and ring net fisheries and who employed a regular labour force to carry out fishing operations from boats rather than canoes. In 1961, GFTC reported that “the acquisition of a loan and the opportunity to increase the scale of operations has led not to the expansion of a business but to its collapse.”<sup>131</sup> This was partly blamed on price controls imposed by lakeshore authorities, in which prices were fixed at a low rate compared with interior market prices. Most indigenous fishers and traders ignored these controls, circumventing areas where these were in place, but larger operators were not as mobile. Price controls also put indigenous firms at a disadvantage to settler firms, which were permitted by lakeshore authorities to charge higher prices at their depots than the prices imposed by the lakeshore.<sup>132</sup> Rather than emulating settler commercial enterprises, a new class of indigenous fishers emerged who invested capital in manufactured fishing gear, plank boats, and outboard engines while continuing to work within and adapt existing lakeshore markets and labour infrastructures.<sup>133</sup>

By the end of colonial rule, fisheries regulations and developments in Lake Malawi had developed on a patchwork and somewhat disconnected basis. The colonial regulatory framework that was established largely conformed to Lowe’s vision for a unified fisheries policy under government control and monitoring. In practice, however, government regulations remained concentrated largely on settler-owned fisheries, failing still to contain the expansion of existing settler companies. Without the resources to assess indigenous fishing capacities with any real precision, government regulations also proved unable to respond even to the intensifying efforts of indigenous fishers observed in GFTC reports, including the increased use of gears that Lowe had warned about. Similarly, the development activities led by GFTC aligned with scientists’

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

suggestions about the direction of technological transfer and commercial expansion. These regulatory and development programmes, though, were just one of several components shaping the commercial and technological trajectories of Lake Malawi fisheries. This was development as negotiated between colonial visions—itsself negotiated between scientists, colonial advisors, and fisheries department officers—and the commercial interests and technological decisions of diverse actors within the fishing industry. Sometimes encouraged or initiated by GFTC, this was primarily determined by the changing opportunities, yields, and competition within lake fisheries as observed by fishers rather than scientists or administrators. Just as settler fisheries continued to grow and intensify their efforts in the south-east, a new class of indigenous fishers emerged with access to capital and more efficient gear that enabled greater exploitation of fish stocks. This was occurring parallel to, and often beyond, the oversight and reach of colonial management efforts and scientists' recommendations.

## **Conclusion**

As the case of Lake Malawi demonstrates, the late colonial period witnessed an important watershed for the scientific exploration of inland waters and the exploitation of inland fisheries in Africa as indigenous-led and foreign-owned operations increased total yields through the combined deployment of indigenous and exogenous fishing technologies. These developments were intrinsically connected as fisheries scientists were deployed to advise colonial governments in the wake of expanding fishing operations. While scientists fashioned detailed blueprints to inform the managed expansion of fisheries to an acceptable optimum yield, indigenous-led and settler-owned fisheries continued to expand and adapt in response to ecological changes, increased competition, and changing market opportunities. Despite these changes, government efforts followed a bifurcated trajectory that sought to contain the expansion of settler-owned fisheries

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

while increasing the efficiency of indigenous-led fisheries. Both objectives, however, proved to be largely beyond governmental capacities. Consequently, scientists' recommendations were only ever implemented in fragments through ineffective regulations, limited development efforts, and inadequate catch and effort monitoring.

Reflecting common trends in science-led development schemes in late colonial Africa, the grand visions of scientists and administrators were hindered not simply by limited resources but by the choices of resource users who modified, challenged, or rejected development schemes and introduced or innovated technologies according to their contexts, practices, knowledge, and interests.<sup>134</sup> In Lake Malawi, scientist-backed programmes that aimed at the introduction of fishing technologies were limited in scope and implementation, but these found some success due to fishers' receptiveness to these technologies. Crucially, technology transfer schemes were recommended by scientists and implemented by the colonial fisheries department without adequate data concerning indigenous fishing efforts so that these were driven more by ideological assumptions surrounding the inferiority of indigenous fishing gear and the need to implement a modernising agenda to improve efficiencies. This was despite a lack of government capacity to monitor expanding catches and understand the limits of exploitation. This speaks to the contradictions and ambiguities inherent in the envisioned development of Lake Malawi fisheries—and the developmentalist agenda in general—which, on the one hand, attempted to raise the efficiency and intensify the productivity of indigenous extractive methods while, on the other, sought to control and manage natural resources to an optimum yield that would facilitate long-term exploitation. Scientists and technical officers were expected to provide the blueprints and generate the data to balance these two agendas but, in reality, schemes aiming at greater technological efficiency progressed even as technical departments proved unable to generate the data to effectively monitor the impact of the more intensive exploitation that such technologies facilitated.<sup>135</sup> Ultimately, fisheries development schemes were made and remade through the

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

movements and decisions of fishers who integrated and adapted new fishing technologies and methods within their repertoires as they responded to the fluctuating yields and ecological conditions shaping the fish populations, waters, and locations they targeted.

Beyond the limited technological programmes that were implemented, the primary outcome of these fisheries surveys was to influence the creation of legal scaffolding centred on government-led scientific monitoring and management. Even as scientists warned about the lack of data and resources available to manage and develop lake-wide fisheries, the expanded regulatory framework influenced by their recommendations vested considerable powers in colonial departments, thereby ensnaring the lake and lake resources within governmental nets. In reality, these regulations were impractical and unworkable, concentrated on and struggling even to manage the most important commercial fisheries of the south-east lake. This history is indicative of broader trends in colonial fisheries management that—like other forms of colonial natural resource management frameworks—may have had “long arms and weak fingers,” but which nevertheless worked to embed deep-rooted assumptions of custodianship and control within colonial-imposed legislative frameworks under the guise of scientific management. This entrenched a faith in and reliance on scientific management based on fragmented data and imperfect modelling, which continued long past independence and led to fluctuating levels of monitoring, enforcement, and compliance as fishers responded to changing political, environmental, and economic contexts when deciding where to deploy fishing technologies and which species to target.<sup>136</sup>

### **Contributing biographies:**

David Wilson is Senior Lecturer in History at the University of Strathclyde, 141 St James Road, Glasgow, UK, G4 0LT; [david.wilson.101@strath.ac.uk](mailto:david.wilson.101@strath.ac.uk).

Milo Gough, is ...

Bryson Nkhoma is ...

Elias Chirwa is ...

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

Charles Knapp is ...

Tracy Morse is ...

Wapulumuka Mulwafu is ...

### **Acknowledgements:**

The authors would like to thank the editors and anonymous peer reviewers for their comments on earlier drafts of this work. Their comments and insights have significantly strengthened this piece. The authors would also like to express their utmost gratitude and appreciation to Senior Chief Makanjira, the Mbenji Island Fisheries Committee, and Mbenji Island fisheries participants for their participation in, engagement with, and support of the larger research project from which this article was produced. The authors would also like to thank the Fisheries Department of the Government of Malawi for their support and participation, including with infrastructure and facilities to carry out components of the broader project work. Finally, the authors would like to express their gratitude to the participants of the research dissemination and validation workshop on 16 May 2023 in Salima, Malawi, for their valuable input and feedback on research findings. Thank you especially to the Centre for Environmental Policy and Advocacy (CEPA) for their facilitation of this workshop.

This research was supported by the Arts and Humanities Research Council (grant number AH/W009099/1). For the purpose of open access, the authors have applied a Creative Commons Attribution (CC BY) licence to any Author Accepted Manuscript version arising.

---

<sup>1</sup> TNA, CO 852/151/1, No. 20. Kittermaster to MacDonald, 31 October 1938; TNA, CO 852/151/1. Minutes by Eastwood, 25 November 1938.

<sup>2</sup> TNA CO 852/151/1, Governor Harold Kittermaster to the secretary of state for the colonies, 31<sup>st</sup> October 1938.

<sup>3</sup> See C. F. Hickling, "The Expansion of Fisheries in the Colonial Empire," *Journal of the Royal Society of Arts*, 1953, 101:4891, pp. 135-144, <http://www.jstor.org/stable/41365005>.

<sup>4</sup> For example Gufu Oba, *African Environmental Crisis: A History of Science for Development* (London and New York: Routledge, 2020); Corey Ross, *Ecology and Power in the Age of Empire: Europe and the Transformation of the Tropical World* (Oxford: Oxford University Press, 2017); Helen Tilley, *Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870-1950* (Chicago and London: The University of Chicago Press, 2011).

<sup>5</sup> Gregory Ferguson-Cradler, "The Overfishing Problem: Natural and Social Categories in Early Twentieth-Century Fisheries Science," *Journal of the History of Biology*, 2021, 54, pp. 719-738, <https://doi.org/10.1007/s10739-021-09655-4>; Carmel Finley, *All the Fish in the Sea: Maximum Sustainable Yield and the Failure of Fisheries Management* (Chicago: The University of Chicago Press, 2011); Michael S. Reidy and Helen M. Rozwadowski, "The Spaces In Between: Science, Ocean, Empire," *Isis*, 2014, 105:2, pp. 338-351, <https://doi.org/10.1086/676571>; Jennifer Hubbard, "In the Wake of Politics: The Political and Economic Construction of Fisheries Biology, 1860-1970," *Isis*, 2014, 105:2, pp. 364-378, <https://doi.org/10.1086/676572>; Naomi Oreskes, *Science on a Mission: How Military Funding Shapes What We Do and Don't Know about the Ocean* (Chicago and London: The University of Chicago Press, 2021); Jennifer J. Silver et al., "Fish, People, and Systems of Power: Understanding and Disrupting Feedback between Colonialism and Fisheries Science," *The American Naturalist*, 2022, 200:1, <https://doi.org/10.1086/720152>.

<sup>6</sup> Leonard C. Beadle, *The Inland Waters of Tropical Africa: An Introduction to Tropical Limnology* (London: Longman, 1981), pp. 7-19; Charles Jeffries, *A Review of Colonial Research, 1940-1960* (London: H.M. Stationery Office, 1964), pp. 150-169; Christian Jennings, "Unexploited Assets: Imperial Imagination, Practical Limitations, and Marine Fisheries Research in East Africa, 1917-53" in Brett M. Bennett and Joseph M. Hodge, *Science and Empire: Knowledge and Networks of Science across the British Empire, 1800-1970* (Hampshire: Palgrave Macmillan, 2011), pp. 253-274; Jack Talling, "The Development of Freshwater Science in Britain, and British Contributions Abroad, 1900-2000," *Freshwater Forum*, 2004, 22, pp. 22-80; E. B. Worthington, *Science in the Development of Africa: A review of the contribution of physical and biological knowledge South of the Sahara* (London: CCTA, 1958), pp. 216-235.

<sup>7</sup> Jan C. Breiting, "A Lake to Serve: The Exploration, Modification, and Degradation of Lake Victoria, 1920s to 1960s," *The Journal of Imperial and Commonwealth History*, 2022, 50:1, pp. 144-184,

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

---

<https://doi.org/10.1080/03086534.2021.1985212>; Paul Abiero Opondo, "Fishers and Fish Traders of Lake Victoria: Colonial Policy and the Development of Fish Production in Kenya, 1880-1978" (Ph.D. Diss., University of South Africa, 2011).

<sup>8</sup> Wiseman Chijere Chirwa, "Fishing rights, ecology and conservation along southern Lake Malawi, 1920-1964," *African Affairs*, 1996, 95:380, pp. 351-377, <http://www.jstor.org/stable/723572>; John McCracken, "Fishing and the Colonial Economy: The Case of Malawi," *Journal of African History*, 1987, 28:3, pp. 413-429, <https://doi.org/10.1017/S0021853700030115>; Setsuko Nakayama, "City Lights Emblaze Village Fishing Grounds: The Re-Imaginings of Waterscape by Lake Malawi Fishers," *Journal of Southern African Studies*, 2008, 34:4, pp. 803-821, <https://doi.org/10.1080/03057070802456763>.

<sup>9</sup> See Liam Campling and Alejandro Colás, *Capitalism and the Sea: The Maritime Factor in the Making of the Modern World* (London and New York: Verso, 2021), pp. 165-212; Finley, *Fish*; Jennifer Hubbard, *A Science on the Scales: The Rise of Canadian Atlantic Fisheries Biology, 1898-1939* (Toronto, Buffalo, London: University of Toronto Press, 2006); Helen M. Rozwadowski, *The Sea Knows No Boundaries: A Century of Marine Science under ICES* (Seattle and London: ICES).

<sup>10</sup> Shadreck Chirikure, "The Metalworker, the Potter, and the Pre-European African 'Laboratory'" in Clapperton Chakanetsa Mavhunga, *What do Science, Technology, and Innovation Mean from Africa?* (Cambridge and London: The MIT Press, 2017), pp. 63-77; Clapperton Chakanetsa Mavhunga, *Transient Workspaces: Technologies of Everyday Innovation in Zimbabwe* (Cambridge and London: The MIT Press, 2014), pp. 8-11; Kapil Raj, *Relocating Modern Science: Circulation and the Construction of Knowledge in South Asia and Europe, 1650-1900* (Houndsmill and New York: Palgrave Macmillian, 2007), p. 14.

<sup>11</sup> Talling, "Development," p. 26; E. Barton Worthington, *The Ecological Century: A Personal Appraisal* (Oxford: Clarendon Press, 1983), pp. 51-544.

<sup>12</sup> Beadle, *Inland*, p. 4, 18; Jack Talling, "A Brief History of the Scientific Study of Tropical African Inland Waters," *Freshwater Forum*, 2006, 26, pp. 3-37; Worthington, *Development*, pp. 227-228.

<sup>13</sup> G. Fryer and J. F. Talling, "Africa: the FBA Connection" in Freshwater Biological Association, *Freshwater Biological Association Fifty-fourth Annual Report* (Freshwater Biological Association, 1986), p. 97.

<sup>14</sup> Beadle, *Inland*, p. 18; Fryer and Talling, "Africa," pp. 97-99; Worthington, *Development of Africa*, pp. 226-228.

<sup>15</sup> Breitinger, "Lake," p. 150.

<sup>16</sup> Jennings, "Unexploited," pp. 255-259.

<sup>17</sup> Charles Jeffries, *A Review of Colonial Research, 1940-1960* (London: H.M. Stationery Office, 1964), p. 54; E. B. Worthington, *Science in Africa: A Review of Scientific Research relating to Tropical and Southern Africa* (London, New York, Toronto: Oxford University Press, 1938), pp. 243-246; Worthington, *Ecological*, p. 110.

<sup>18</sup> Fryer and Talling, "Africa," pp. 97-100; Talling, "Development," pp. 26-29; Talling, "Tropical," p. 10.

<sup>19</sup> Breitinger, "Lake," pp. 148-151; Chirwa, "Fishing," pp. 1-6; Fryer and Talling, "Africa," pp. 111-114; Jennings, "Unexploited," pp. 256-257; Opondo, "Fishers," pp. 103-142; Worthington, *Ecological*, pp. 13-15.

<sup>20</sup> Joseph Morgan Hodge, *Triumph of the Expert: Agrarian Doctrines of Development and the Legacies of British Colonialism* (Ohio: Ohio University Press, 2007), pp. 166-188.

<sup>21</sup> See Worthington, *Review*, pp. 241-244.

<sup>22</sup> Jennings, "Unexploited," pp. 257-259; Worthington, *Review*, pp. 243-245.

<sup>23</sup> Ferguson-Cradler, "Overfishing," p. 719.

<sup>24</sup> Hubbard, *Scales*, pp. 186-187.

<sup>25</sup> Finley, *Fish*, p. 85.

<sup>26</sup> Ferguson-Cradler, "Overfishing," pp. 733-735.

<sup>27</sup> Worthington, *Review*, pp. 237-244.

<sup>28</sup> Tilley, *Laboratory*, p. 71.

<sup>29</sup> Sabine Clarke, "A Technocratic Imperial State? The Colonial Office and Scientific Research, 1940-1960," *Twentieth Century British History*, 2007, 18:4, pp. 453-480, <https://doi.org/10.1093/tcbh/hwm017>, p. 479.

<sup>30</sup> "Colonial Fisheries Advisory Committee," *Nature*, 1943, 152, p. 501, <https://doi.org/10.1038/152501b0>.

<sup>31</sup> Jennings, "Unexploited," pp. 262-263.

<sup>32</sup> C. F. Hickling, "The Expansion of Fisheries in the Colonial Empire," *Journal of the Royal Society of Arts*, 1953, 101:4891, pp. 135-144.

<sup>33</sup> Corey Ross, "The plantation paradigm: colonial agronomy, African farmers, and the global cocoa boom, 1870s-1940s," *Journal of Global History*, 2014, 9, pp. 54-70.

<sup>34</sup> Ross, *Ecology*, p. 327.

<sup>35</sup> *Ibid.*, pp. 51-70; Hodge, *Triumph*, pp. 231-234.

<sup>36</sup> Hickling, "Expansion," p. 140.

<sup>37</sup> Sabine Clarke, *Science at the End of Empire: Experts and the Development of the British Caribbean, 1940-62* (Manchester: Manchester University Press, 2018), pp. 49-60; Jennings, "Unexploited," 265; Worthington, *Ecological*, pp. 114-115, 120-122.

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

<sup>38</sup> Christophe Bonneuil, "Development as Experiment: Science and State Building in Late Colonial and Postcolonial Africa, 1930-1970," *Osiris* 15 (2000): 258–81. doi:[10.1086/649330](https://doi.org/10.1086/649330); Clarke, *Science*, pp. 186-191; Hodge, *Triumph*, pp. 220-222; Ross, *Ecology*, pp. 355-359.

<sup>39</sup> Mafaniso Hara, Steve Donda, and Friday Njaya, "Lessons from Existing Modes of Governance in Malawi's Small-Scale Fisheries" in S. Jentoft and R. Chuenpagdee, *Interactive Governance for Small-Scale Fisheries* (Cham: Springer, 2015), p. 140; Friday Njaya, "Ecosystem approach to fisheries in southern Lake Malawi: Status of the fisheries co-management," *Aquatic Ecosystem Health & Management*, 2018, 21:2, pp. 159-167, <https://doi.org/10.1080/14634988.2018.1472504>, p. 161.

<sup>40</sup> McCracken, "Fishing," pp. 414-416.

<sup>41</sup> Ro Lowe-McConnell, *The Tilapia Trail: The Life Story of a Fish Biologist* (Ascot: MPM Publishing, 2006), pp. 32-33; John McCracken, *A History of Malawi, 1859-1966* (Suffolk: James Currey, 2012), p. 15.

<sup>42</sup> C. K. Ricardo Bertram, H. J. H. Borley, & Ethelwynn Trewavas, *Report on the Fish and Fisheries of Lake Nyasa* (London: Government of Nyasaland, 1942), pp. 70-71; McCracken, "Fishing," p. 416.

<sup>43</sup> Nakayama, "Waterscape," p. 812.

<sup>44</sup> Mafaniso Hara, "The history of the early development of the Southeast Arm of Lake Malawi fishery and conflicts" in Steve Donda, Mafaniso Hara, Maxon Ngochera, and Erling Berge (eds.), *Fragmentation of Resource Management on the South East Arm of Lake Malawi: Dynamics around Fisheries* (Zürich: Lit Verlag, 2014), p. 17; McCracken, *Malawi*, p. 15.

<sup>45</sup> TNA, CO 852/151/1. A Note on the Nyasaland Fishing Industry; TNA, CO 852/651/10. Report by a committee appointed to consider Dr. Ricardo Bertram's "Report on Fish and Fisheries of Lake Nyasa"; Hara, "Early development," pp. 29-30; Aaron J. M. Russell, Tracy Dobson, and John G. M. Wilson, "Fisheries Management in Malawi: a Patchwork of Traditional, Modern, and Post-modern Regimes Unfolds" in Schechter, M.G., N.J. Leonard & W.W. Taylor (eds.) *International governance of fisheries ecosystems: learning from the past, finding solutions for the future* (Bethesda: American Fisheries Society, 2008), p. 55. For historical examination of a specific chief-led fishery in Lake Malawi and its comparison to the colonial regime see David Wilson et al., "Fishing (in) the past to inform the future: Lessons from the histories of fisheries management in Lake Malawi and Mbenji Island," *Marine Policy*, 2025, 173, <https://doi.org/10.1016/j.marpol.2025.106589>.

<sup>46</sup> James Mayall, "The Malawi-Tanzania Boundary Dispute," *The Journal of Modern African Studies*, 1973, 11:4, pp. 612-4; McCracken, *Malawi*, pp. 50-7.

<sup>47</sup> Chirwa, "Fishing," p. 2-6; Hara, "Early development," pp. 17-18; McCracken, "Fishing," pp. 419-421.

<sup>48</sup> TNA, CO 852/151/1. A Note of the Nyasaland Fishing Industry; TNA, CO 852/651/9. Brief History of European Fishing Industry – Lake Nyasa; TNA, CO 852/651/10. Committee Report; TNA, CO 910/1, CFAC (46) 10. Nyasaland; McCracken. "Fishing," pp. 421-423; Russell et al., "Fisheries," pp. 59-60.

<sup>49</sup> TNA, CO 852/651/10. Committee Report.

<sup>50</sup> *Ibid.*

<sup>51</sup> *Ibid.*

<sup>52</sup> TNA, CO 852/651/10. Committee Report, Appendix C; McCracken, "Fishing," pp. 423-424.

<sup>53</sup> Bertram et al., *Report*, pp. 77; Rosemary H. Lowe, *Report on the Tilapia and other Fish and Fisheries of Lake Nyasa, 1945-7* (London: Her Majesty's Stationery Office, 1952), pp. 42-45.

<sup>54</sup> TNA, CO 852/651/10. Committee Report, Appendix C.

<sup>55</sup> Chirwa, "Fishing," pp. 2-3.

<sup>56</sup> TNA, CO 852/651/10. Committee Report.

<sup>57</sup> *Ibid.*; TNA, CO 910/1, CFAC (46) 10. Nyasaland.

<sup>58</sup> Michael Adas, *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance* (Ithaca and London: Cornell University Press, 2014), pp. 187-188, 386-387; Ross, *Ecology*, pp. 331-341; Oba, *Environmental*, pp. 101-127.

<sup>59</sup> TNA, CO 910/1, CFAC (46) 10. Nyasaland.

<sup>60</sup> *Ibid.*

<sup>61</sup> Chirwa, "Fishing," pp. 2-4.

<sup>62</sup> See also Bryson Nkhoma, "African Agricultural Production, Food Trade, and the State in Southern Malawi, 1859–1940," *International Journal of African Historical Studies*, 2022, 55:1, pp. 45-67.

<sup>63</sup> TNA, CO 910/1, CFAC (46) 10. Nyasaland.

<sup>64</sup> This same opinion was voiced by other Europeans living by the lakeshore, although these declines were likely at least partly exacerbated by changing water levels in the lake. TNA, CO 852/651/10. Recommendations by Barker and Borley.

<sup>65</sup> TNA, CO 852/151/1, No. 20. Kittermaster to MacDonald, 31 October 1938; TNA, CO 852/151/1. Minutes by Eastwood, 25 November 1938.

<sup>66</sup> C. Tate Regan, "The Cichlid Fishes of Lake Nyasa," *Proceedings of the Zoological Society of London*, 1921, pp. 675-727; E. B. Worthington, "The Fishes of Lake Nyasa (other than Cichlidae)," *Proceedings of the Zoological Society of London*,

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

- 
- 1933, pp. 285-316; Ethelwynn Trewavas, "A Synopsis of the Cichlid Fishes of Lake Nyasa," *Annals and Magazine of Natural History*, 1935, 10:16, pp. 65-118.
- <sup>67</sup> Hodge, *Triumph*, pp. 176-177.
- <sup>68</sup> TNA, CO 852/151/1. Platt to Eastwood, 7 October 1938; TNA CO 852/151/1, C.G. Eastwood to Mr. Hall, 31 October 1938.
- <sup>69</sup> TNA, CO 852/151/2. Eastwood to Hall, 31 October 1938. Natural History Museum (NHM), DF/ZOO/213/90. Zoological Department Minutes, 7 December 1938; NHM, DF/ZOO/213/90. Norman and Trewavas to the Keeper of Zoology, 31 October 1938.
- <sup>70</sup> TNA, CO 852/151/2. Worthington to Herklots, 22 October 1938; TNA, CO 852/151/2. Eastwood to Hall, 31 October 1938; "Kate Bertram," *The Times*, 24 August 1999, *The Times Digital Archive* (accessed 27 August 2024), <https://link.gale.com/apps/doc/IF0500966872/TTDA?u=ustrath&sid=bookmark-TTDA&xid=b8fabc49>; Talling, "Development," pp. 26-27.
- <sup>71</sup> TNA, CO 852/151/1. Kittermaster to MacDonald, 31 October 1938; TNA, CO 852/151/1. Eastwood Minutes, 25 November 1938.
- <sup>72</sup> Emphasis added. TNA CO 852/151/1, Worthington to Herklots, 22<sup>nd</sup> October 1938.
- <sup>73</sup> NHM, DF/ZOO/213/90. Governor of Nyasaland to Secretary of State for the Colonies, 23 November 1938; TNA, CO 852/151/1. Colonial Development Advisory Committee, Memorandum on Lake Nyasa Fishing Survey, 12 December 1938.
- <sup>74</sup> Bertram et al., *Report*, pp. 99-100.
- <sup>75</sup> *Ibid.*, pp. 10-11.
- <sup>76</sup> See *Ibid.*
- <sup>77</sup> TNA, CO 852/651/9. Worthington to Russell, 24 July 1944; Lowe, *Tilapia*, pp. 5-13; Worthington, *Ecological*, pp. 55-60.
- <sup>78</sup> TNA, CO 852/651/9. Richards to Stanley, 10 October 1944; TNA, CO 852/651/9. Survey of Fisheries of Lake Nyasa (Memorandum by the Colonial Office), November 1944; TNA, CO 852/651/9. Stanley to Richards, 19 December 1944; TNA CO 910/1, CFAC report "The Fisheries of Nyasaland and Northern Rhodesia", 1946; Lowe, *Report*, pp. 1-2; Lowe, *Trail*, pp. 29-30.
- <sup>79</sup> Lowe, *Report*, pp. ix.
- <sup>80</sup> Lowe, *Trail*, pp. 28-29.
- <sup>81</sup> Lowe, *Report*, pp. ix-x; Lowe, *Trail*, pp. 29-36.
- <sup>82</sup> Lowe, *Report*, pp. 58-65, 77-83; Lowe, *Trail*, pp. 44-46.
- <sup>83</sup> Peter Jackson, "Joint Fisheries Research Organisation," *Transactions of the Royal Society of South Africa*, 2000, 55:1, p. 1.
- <sup>84</sup> P. B. N. Jackson, T. D. Iles, D. Harding, and G. Fryor, *Report on the Survey of Northern Lake Nyasa, 1954-55 by the Joint Fisheries Research Organization* (Zomba: The Government Printer, 1963), pp. 3-4; Jackson, "Fisheries," p. 15.
- <sup>85</sup> Jackson, "Fisheries," p. 15; McCracken, "Fishing," p. 416.
- <sup>86</sup> TNA, CO 910/3. Hickling memorandum, 1955.
- <sup>87</sup> Jackson et al., *Report*, pp. 5-7; Jackson, "Fisheries," pp. 15-20.
- <sup>88</sup> Clarke, *Science*, pp. 52-71.
- <sup>89</sup> Bertram et al., *Report*, pp. 92-98.
- <sup>90</sup> Lowe, *Report*, p. 45.
- <sup>91</sup> *Ibid.*, pp. 54-5, 116-117.
- <sup>92</sup> *Ibid.*, p. 262.
- <sup>93</sup> Bertram et al., *Report*, p. 92.
- <sup>94</sup> *Ibid.*, pp. 93-94; TNA, CO 852-651-10. Committee Report, Appendix C; McCracken, "Fishing," pp. 423-424.
- <sup>95</sup> *Ibid.*, pp. 62-65, 77-78.
- <sup>96</sup> Ross, 2017, 273; Opondo, 2011, 147.
- <sup>97</sup> Jackson et al., *Report*, pp. 5-7.
- <sup>98</sup> Bertram et al., *Report*, pp. 94-96; Johnson et al. *Report*, pp. 6-7, 146-150; Lowe, *Report*, pp. 78-79.
- <sup>99</sup> Raj, *Relocating*, pp. 223-226; Tilley, *Laboratory*, pp. 26, 107; Laura Ann Twagira, "Introduction: Africanizing the History of Technology," *Technology and Culture*, 2020, 61:2, pp. S1-S19, <https://doi.org/10.1353/tech.2020.0068>, p. S6.
- <sup>100</sup> Johnson et al., *Report*, pp. 165-167; Lowe, *Report*, p. 53.
- <sup>101</sup> Lowe, *Report*, p. 80
- <sup>102</sup> Tilley, *Laboratory*, pp. 319-320.
- <sup>103</sup> Clapperton Chakanetsa Mavhunga, *The Mobile Workshop: The Tsetse Fly and African Knowledge Production* (Cambridge and London: The MIT Press, 2018), pp. 20-21.
- <sup>104</sup> Bertram et al., *Report*, pp. 92-98; Johnson et al. *Report*, pp. 5-7, 146-150; Lowe, *Report*, pp. 77-80.

This is the author accepted manuscript of: Wilson, D., Gough, M., Nkhoma, B., Chirwa, E., Knapp, C., Morse, T., & Mulwafu, W. (in press). Towards an optimum yield: science, technology, and fisheries development in Lake Malawi, 1930-1964. *Isis*, 117(1), 3-26. <https://doi.org/10.1086/739480>

---

<sup>105</sup> William Beinart and Lotte Hughes, *Environment and Empire* (Oxford: Oxford University Press, 2007), ch. 12; Ross, *Ecology*, pp. 359-361, 374-379

<sup>106</sup> Ross, *Ecology*, pp. 352-353.

<sup>107</sup> See Joshua Grace, *African Motors: Technology, Gender, and the History of Development* (Durham and London: Duke University Press, 2021), pp. 10-11.

<sup>108</sup> TNA, CO 625/7. Fisheries Ordinance 1949; Lowe, *Report*, p. 77.

<sup>109</sup> Such limitations are mentioned frequently throughout GFTC reports. Nyasaland Protectorate, *Annual Report of Department of Game, Fish and Tsetse Control* (Zomba: The Government Printer, 1949-1963) [hereafter GFTC], 1949-1963.

<sup>110</sup> GFTC, 1949, 1950, 1960; TNA, CO 910/5. Report on a visit to Nyasaland, June 1960.

<sup>111</sup> While provision was made to permit established African concerns to export, the overwhelming proportion of exports came from the non-African firms. GFTC 1958, 1959. Please visit our project website to view statistical fisheries data extracted from GFTC reports, <https://www.colonialfisheries.com>. See also Malawi National Archives, C.O.M. 9-3-1. Commission of Inquiry into the Fishing Industry (1956), also available via <https://www.colonialfisheries.com>.

<sup>112</sup> GFTC, 1958-1962.

<sup>113</sup> *Ibid.* Please visit our project website to view statistical fisheries data extracted from GFTC reports, <https://www.colonialfisheries.com>.

<sup>114</sup> *Ibid.*, 1959.

<sup>115</sup> *Ibid.*, 1949.

<sup>116</sup> *Ibid.*, 1958. Please visit our project website to view statistical fisheries data extracted from GFTC reports, <https://www.colonialfisheries.com>.

<sup>117</sup> These calculations were later approved by John Allan Guland of Lowestoft Laboratory. *Ibid.*, 1961.

<sup>118</sup> *Ibid.*, 1961.

<sup>119</sup> *Ibid.*, 1949-1962.

<sup>120</sup> *Ibid.*, 1949-1962.

<sup>121</sup> *Ibid.*, 1952-1953.

<sup>122</sup> *Ibid.*, 1960.

<sup>123</sup> *Ibid.*, 1962.

<sup>124</sup> *Ibid.*, 1962; Hara, "Early development," pp. 19, 30; McCracken, "Fishing," pp. 426-7; Nakayama, "Waterscape."

<sup>125</sup> GFTC, 1949-1962; McCracken, "Fishing," pp. 426-427; Mavhunga, *Workspaces*, pp. 7-16; Nakayama, "Waterscape."

<sup>126</sup> TNA, CO 1015/389, No. 6. Nield to Footman, July 1953.

<sup>127</sup> *Ibid.*; GFTC, 1951, 1961.

<sup>128</sup> GFTC, 1951-1962.

<sup>129</sup> Hodge, *Triumph*, pp. 238-239; Ross, *Ecology*, p. 361.

<sup>130</sup> TNA, CO 1015/389, No. 7. Letter to Williams, 7 October 1953; GFTC, 1956-1962.

<sup>131</sup> GFTC, 1961.

<sup>132</sup> Chirwa, "Fishing," p. 10; GFTC, 1953, 1954, 1960.

<sup>133</sup> GFTC, 1961-1962; Nakayama, "Waterscape," pp. 807-808.

<sup>134</sup> Robyn d'Avignon, *A Ritual Geology: Gold and Subterranean Knowledge in Savanna West Africa* (Durham and London: Duke University Press, 2022); James Fairhead and Melissa Leach, *Misreading the African Landscape: Society and ecology in a forest-savanna mosaic* (Cambridge: Cambridge University Press, 1996); Clapperton Chakanetsa Mavhunga, *Transient Workspaces: Technologies of Everyday Innovation in Zimbabwe* (Cambridge and London: The MIT Press, 2014); Clapperton Chakanetsa Mavhunga, *The Mobile Workshop: The Tsetse Fly and African Knowledge Production* (Cambridge and London: The MIT Press, 2018); Laura Ann Twagira, "Introduction: Africanizing the History of Technology," *Technology and Culture*, 2020, 61:2, S1-S19, <https://doi.org/10.1353/tech.2020.0068>; Laura Ann Twagira, *Embodied Engineering: Gendered Labor, Food Security and Taste in Twentieth Century Mali* (Athens, Ohio: Ohio University Press, 2021).

<sup>135</sup> Clarke, *Science*, p. 11; Hodge, *Triumph*, pp. 250-253.

<sup>136</sup> Hara et al., "Lessons"; Russell et al., "Fisheries".