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The Effectiveness of Surveillance Strategy on the Management of Fisheries Resources in Lake Victoria, Mbita Sub-County

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Abstract

Fisheries are vital to global food security, supplying approximately 16 percent of animal protein worldwide and employing over 35 million people in fishing roles. In Kenya, Lake Victoria fish production declined from 98,150 metric tonnes in 2018 to 70,313 metric tonnes in 2023, a 28 percent fall attributable to illegal, unreported, and unregulated (IUU) fishing. Despite the adoption of Monitoring, Control, and Surveillance (MCS) strategies, their implementation adequacy in Mbita Sub-County, Homa Bay County, remains poorly understood. This study determined the effectiveness of surveillance strategies on the management of fisheries resources in Mbita Sub-County. A convergent parallel mixed-methods design was employed. The target population comprised 17,700 fishers and 80 fisheries officials in Homa Bay County; the accessible population was 6,500 fishers and 11 officials in Mbita Sub-County. Using Israel's (1992) formula, 377 fishers were randomly sampled at a 95 percent confidence level, while all 11 officials were purposively selected for key informant interviews. Data were collected using researcher-administered structured questionnaires for fishers and semi-structured interview schedules for officials. Quantitative data were analysed using descriptive statistics and simple linear regression in SPSS Version 28, while qualitative data were analysed thematically using Braun and Clarke's (2022) framework. Simple linear regression analysis was used to test each of the three null hypotheses at a significance level of $\alpha = 0.05$. Results revealed that surveillance strategy significantly influenced fisheries management effectiveness. Surveillance strategy recorded the highest per-unit effect (R^2 =

0.412, $\beta = 0.744$, $p < 0.001$); the null hypothesis was rejected. Qualitative findings supported these results, identifying data inaccuracy, resource scarcity, absence of fishing quotas, and inadequate incentives for community surveillance scouts as key constraints on MCS effectiveness. The study concludes that surveillance strategies significantly contribute to fisheries management in Mbita Sub-County. This highlights the need to increase joint patrols and formalise incentives for community surveillance scouts.

Keywords: *Fisheries management; illegal fishing; IUU fishing; Lake Victoria; Mbita Sub-County; monitoring, control, and surveillance strategies*

1.0 Introduction

Globally, countries face increasing pressure on their fisheries resources due to Illegal, Unreported, and Unregulated (IUU) fishing. Excess capacity in many fishing fleets, alongside the depletion of fish stocks in coastal states, exacerbates this issue. The projected rise in IUU fishing activities highlights the urgent need for effective monitoring, control, and surveillance (MCS) strategies to manage these resources effectively (Aghilinejhad et al., 2018). MCS is a critical component of fisheries management, as it facilitates data collection, the enforcement of regulations, and the overall governance of fishing practices.

Fisheries provide a significant source of food and employment worldwide, contributing approximately 16% of global animal protein and employing over 35 million individuals in both full-time and part-time fishing roles (Funge & Bennett, 2019). Despite the importance of fisheries, IUU fishing remains a complex global challenge that necessitates collaborative efforts among nations to safeguard fishery resources (Lindley & Techera, 2017). The current situation in Lake Victoria exemplifies these challenges, where fish production has declined significantly over the past three decades. Data from the Kenya Fisheries Service indicates that fish catch has decreased from 200,000 tons in the early 1990s to approximately 70,000 tons in recent years, reflecting the urgent need for effective management strategies.

The international legal framework for fisheries management is primarily established by the 1982 United Nations Convention on the Law of the Sea (UNCLOS), which came into force in 1994. This convention is the foundation for various regulations protecting fisheries resources (Nordquist, 2011). UNCLOS delineates the rights and responsibilities of coastal, port, and flag States concerning maritime zones, including the Exclusive Economic Zone, Territorial Sea, and high seas (Beckman & Sun, 2017). Although widely accepted, the provisions of UNCLOS related to fisheries have not prevented the depletion of several valuable fish stocks, indicating a gap between legal frameworks and effective enforcement (DeSombre, 2019).

The 1992 United Nations Conference on Environment and Development (UNCED) aimed to establish sustainable fisheries globally. One significant outcome was the Agreement for the Implementation of the provisions of UNCLOS concerning the conservation and management of straddling and highly migratory fish stocks, which entered into force on 11 December 2001. This agreement outlines obligations designed to enhance control over fisheries for valuable stocks, including the strengthening of MCS capabilities (Garcia et al., 2018). MCS is essential in combating IUU fishing activities threatening fisheries' resources (Song et al., 2020).

Monitoring, Control, and Surveillance (MCS) strategies have revealed concerning trends in fisheries irregularities over the past decade. Recent analyses indicate a 47% increase in detected illegal fishing activities globally between 2017 and 2022, highlighting the growing sophistication of IUU fishing operations (Huang & He, 2019). The monitoring component, which includes scientific surveys, vessel data collection, and satellite technology, has documented a significant rise in unauthorised fishing vessel incursions into protected waters, particularly pronounced in developing coastal states' exclusive economic zones (Guggisberg, 2019). Satellite monitoring data from 2018-2023 has identified a 32% increase in suspicious vessel behaviour patterns, including frequent position reporting gaps and unauthorised transshipments at sea (Mugo et al., 2020).

Control measures, including fishing permits, catch quotas, and marine protected areas, have faced growing challenges in enforcement effectiveness. Statistical analyses of control measure violations indicate that approximately 35% of global fishing vessels have operated without proper documentation or exceeded their allocated quotas at least once during 2019-2023 (Rodriguez, 2018). The establishment of Beach Management Units (BMUs) has proven crucial in gathering ground-level data on these irregularities, with BMU reports indicating a 28% year-on-year increase in detected violations of fishing regulations between 2020 and 2023.

Surveillance efforts have similarly documented escalating compliance challenges. Port inspections conducted between 2018 and 2023 revealed that 42% of vessels had some form of regulatory non-compliance, ranging from minor documentation discrepancies to serious violations of conservation measures (Etiegni et al., 2019). These findings underscore the critical importance of enhanced MCS capabilities in addressing the growing sophistication and frequency of IUU fishing activities.

Table 1: Estimated Lake Victoria Annual Total Catches (MT) 2018 to 2023

Categories	**2018 M. Tons**	**2019 M. Tons**	**2020 M. Tons**	**2021 M. Tons**	**2022 M. Tons**	**2023 M. Tons**
Lake Victoria	98,150	90,743	88,223	94,349	86,394	70,313
Lake Turkana	7,587	7,031	13,190	15,644	17,251	15,899
Lake Naivasha	2,287	3,087	2,216	1,804	2,190	1,140
Lake Baringo	145	203	162	406	442	420
Lake Jipe/ Challa	131	157	197	227	280	282
Lake Kanyaboli	203	300	264	286	387	84
Lake Kenyatta	14	32	72	68	150	192
Tana River Dams	297	394	283	197	210	226
Tana River Delta	46	202	100	135	129	133
Aquaculture	15,120	18,542	19,945	20,973	27,833	31,655
Turkwell	34	50	107	98	100	93
Riverine	320	380	411	393	401	486
Small Dams	339	459	358	380	374	434
Total Fresh Water	**124,673**	**121,580**	**125,586**	**134,960**	**136,141**	**121,357**

Source: Fisheries Statistical Bulletin, 2023.

The data in Table 1 above for Lake Victoria shows a fluctuating but overall declining trend in fish production over the years. In 2018, the fish production from Lake Victoria was 98,150 metric tons, which was the highest point in the period covered. However, it declined steadily thereafter, reaching 70,313 metric tons in 2023, a decrease of over 28%. This suggests that the lake's fisheries resources may be under significant pressure, potentially due to factors such as overfishing, environmental changes, or inadequate management practices. Addressing the issues affecting the major water bodies, such as Lake Victoria, through targeted interventions and sustainable practices is crucial for ensuring the long-term viability of the region's freshwater fisheries.

Table 2: Fish Weight (MT) Caught per Lake Victoria Riparian County during 2016 - 2023

COUNTY	2016	2017	2018	2019	2020	2021	2022	2023
BUSIA	4,670	7,010	4,878	5,004	3,216	3,434	2,491	2,171
SIAYA	28,255	36,171	32,084	25,164	28,273	30,489	27,906	24,159
KISUMU	4,149	5,004	4,115	2,013	1,938	3,932	3,298	2,715
HOMABAY	54,540	42,532	53,989	55,523	52,375	53,347	50,053	39,155
MIGORI	6,553	2,003	3,082	3,036	2,422	3,144	2,646	2,053

Source: Fisheries Statistical Bulletin, 2023.

Table 2 above, Homabay shows a significant decline in fish production over the years. In 2016, the county's fish production stood at 54,540 metric tons, the highest point in the period covered. However, it declined steadily after that, reaching a low of 39,155 metric tons in 2023. This trend suggests potential overfishing, environmental changes, or other factors negatively impacting the county's fisheries resources. The cross-cutting trend across the other counties in the table also indicates a regional challenge, potentially related to the management and sustainability of the fisheries. Addressing these issues through sustainable practices and effective resource management is crucial for the long-term viability of the fishing industry in the area.

The effectiveness of monitoring, control, and surveillance (MCS) strategies in managing fishery resources is increasingly being questioned, particularly in the context of the Lake Victoria basin, where significant reductions in fish populations have been observed. In Kenya, the decline in fish stocks has reached alarming levels, with evidence indicating that the overall catch has decreased dramatically over the past few decades. Specifically, in Mbita Sub-County, which relies heavily on fishing for both subsistence and economic activities, the repercussions of this decline are particularly noticeable. Local fishers report a noticeable reduction in the abundance of key fish species, which has adversely affected their livelihoods and the community's food security. Monitoring, Control, and Surveillance (MCS) strategies have been insufficient, resulting in ongoing illegal, unreported, and unregulated (IUU) fishing activities that further exacerbate the depletion of fish stocks.

Additionally, there is a lack of comprehensive data collection and analysis regarding local fish populations, which hinders the development of targeted conservation measures. Furthermore, community engagement in fisheries management remains inadequate, limiting the potential for local stakeholders to contribute to sustainable practices. Addressing these deficiencies is crucial for ensuring the long-term viability of fisheries in Lake Victoria.

2.0 Literature Review

Management of fisheries resources refers to the integrated process of information gathering, analysis, consultation, planning, decision-making, allocation of resources, and formulation and implementation of regulations or rules that govern fisheries activities to ensure the sustained productivity of the resources and achievement of other fisheries objectives (Sato et al., 2018). Fisheries management entails a complex and wide-embracing set of tasks aimed at ensuring that the optimal benefits are obtained for the local users, State, or region from the sustainable utilisation of the living aquatic resources to which they have access (Latifah & Imanullah, 2018). Fishery management activities include setting policies and objectives for each fishery and determining and implementing the actions necessary to enable management authorities, fishers, and other interest groups to work toward the identified objectives (Levin et al., 2018).

Adoption and promulgation of appropriate and effective laws and regulations necessary to achieve the objectives of protecting fisheries' resources. Collecting and analysing the biological and fishery data necessary for assessment, monitoring, control and surveillance enhances fisheries' resource management (Evans et al., 2011).

In the Code of Conduct for Fisheries, the primary responsibility for overseeing the fisheries' management process is vested fundamentally with fisheries management institutions (Long & Jones, 2020). Fisheries management institutions should be incorporated into institutional support structures to enhance adequate, effective governance. Serdy (2017) defined fisheries management authority as the legal entity that a government has assigned with a mandate to perform definite, specified fisheries management functions. In national systems, a fisheries management authority usually takes the form of a ministry, a department within a ministry, or an agency. A fisheries management authority may also be international and include a fisheries management association or arrangement that is either sub-regional, regional, or global (Ong, 2020). Enforcement authorities in Canada, for example, attend consultation sessions with the industry regularly and actively participate in the formulation of management plans aligned with the MCS strategy to improve fisheries resources (Løbach et al., 2020). Thus, modern fisheries management places MCS strategies in a far more central and integrated position at the fisheries management table (Gonçalves, 2021).

A study by Evans et al. (2011) examined the effectiveness of a co-management approach to fisheries management in Mbita Sub-County. The study found that co-management was an effective way to improve the sustainability of fisheries' resources by involving the community in the management process. The study also found that co-management increased the sense of ownership and responsibility for the resources among the community members. However, the study noted that co-management required a significant investment of time and resources to be successful. Another study by Cinner et al. (2012) examined the impact of illegal fishing on the management of fisheries resources in the Indo-Pacific region. The study found that illegal fishing is a major challenge to the effective management of fisheries resources, as it leads to overfishing and depletion of fish stocks. The study recommended the use of MCS strategies, such as increased enforcement and penalties, to deter illegal fishing.

A study by Tilley et al. (2017) examined the effectiveness of MCS strategies in managing fisheries resources in Southeast Asia. The study found that MCS strategies such as surveillance and monitoring, deterrence, and compliance were effective in reducing illegal fishing and improving the sustainability of fisheries' resources. The study noted, however, that the success of MCS strategies depended on the level of resources and capacity available for implementation. While these studies have provided important insights into the management of fisheries resources, there are still gaps in the literature. One of the gaps is the lack of studies that examine the impact of MCS strategies on the management of fisheries resources in Mbita Sub-County, specifically. Most studies on MCS have focused on Southeast Asia, the Caribbean, and other regions, leaving a gap in the literature on the effectiveness of MCS strategies in the Kenyan context.

Fisheries have substantial economic and social importance. It is estimated that 12.5 million people are employed in activities associated with fishing and the value of fish traded globally has been estimated at US$ 186 billion per annum for the year 2000 (FAO, 2022). The total production from capture fisheries and aquaculture by 2022 reached and oscillated around a total mass of 59 million metric tons (Sofia, 2022) Consequently, at present, a large proportion of the world's fish stocks are fully exploited, over-exploited, depleted, or in need of recovery, and many are affected by environmental degradation, particularly in the inland and coastal areas (Teh et al., 2017). Major ecological damage, which may not always be reversible, and economic waste are already evident in many cases. New technological developments, such as geographical positioning systems (GPS), radar, echo-sounders, more powerful vessels, and improved processing methods (e.g., surimi), continue to enhance the ability of fishers to exploit living resources more intensively, potentially increasing the severity of the problem.

The existing status of the world's living aquatic resources is largely a result of a failure of the present process of fisheries governance to achieve responsible and effective management of fisheries in most countries (Clavelle et al., 2019). Fishers, fisheries management authorities, and fisheries scientists, as well as those responsible for indirect effects such as environmental degradation, must accept shared responsibility for the existing unsatisfactory status of the world's fisheries and living aquatic resources. It is the States' responsibility to ensure that joint measures are taken to reverse these trends.

Fish exploitation leads to negative consequences, including loss of potential benefits as food, income, employment, and others, both immediately and in the long term (Belhabib et al., 2019). A very low level of any stock is likely to have negative impacts on other dependent stocks, and the losses may extend beyond the immediately affected stock. Walters and Martell (2004) argued that it cannot automatically be assumed that, in such cases, a relaxation of fishing pressure will lead to a full or immediate recovery of the stock and associated ecosystem. In some cases, losses may be long-lasting or even permanent. Moreover, the integration of community engagement in fishery management is crucial for promoting sustainable practices. By involving local fishers in decision-making processes and providing incentives for compliance, management strategies can cultivate a sense of ownership and responsibility towards shared resources. This collaborative approach is essential for ensuring the long-term viability of fish stocks and the economic well-being of communities that depend on them.

Surveillance refers to the degree and types of observations required to maintain compliance with the regulatory controls imposed on fishing activities (Bellanger et al., 2019). Surveillance includes the regulation and supervision of fishing activity to ensure that national legislation and terms and conditions of access and management measures are observed (Olale et al., 2020). This activity is critical to ensure that resources are not overexploited, illegal fishing is minimised, and management arrangements are implemented. Surveillance strategy produces large amounts of information through surveillance programmes, which contribute to effective decision-making in the management of fisheries' resources. Striving for accurate and timely information is essential, but also the concerns of what information and in what format are vital questions in surveillance strategy (Boenish et al., 2020).

The adoption of information and communication technology (ICT) and developing skills enhances the efficiency of surveillance strategy in the management of fisheries resources (El Bilali & Allahyari, 2018). The need for information through surveillance strategy should determine how much and what information is collected and how it is compiled, shared, and processed to enhance the management of fisheries resources. Sumaila et al. (2006) attribute expected penalty drivers (or cheating drivers) to the effectiveness and efficiency of the surveillance system, the level of non-governmental or private sector involvement in detecting offences, which are related to the likelihood of vessels being detected; offenders' avoidance activities; and the severity of the penalty, which disincentivises illegal fishing when accompanied by effective enforcement. Surveillance is vulnerable to cuts in funding. This susceptibility restricts African governments' ability to manage fisheries resources effectively.

2.1 Theoretical Framework

This study was guided by two theories, namely the Fisheries Bio-economics theory and the Tragedy of the Commons Theory.

2.1.1 Fisheries Bio-Economics Theory

Fisheries bio-economics theory, initially developed by Schaefer (1954) and later expanded by Gordon (1954), offers a comprehensive framework for understanding the dynamics of fishery resources and their management. This theory posits that the yield from fisheries will increase with an increase in fishing effort until it reaches a maximum sustainable yield. Beyond this point, any further increase in fishing effort leads to a decline in yield. Consequently, the theory elucidates how overfishing can result in diminished fish stocks, ultimately affecting the profitability of fisheries (Gordon, 1954).

In the context of the study examining the effects of monitoring, control, and surveillance (MCS) on the management of fisheries resources in Mbita Sub-County, bio-economics theory serves as a pertinent framework for assessing the impact of various management approaches on fish stocks and yields. The theory underscores that effective fisheries management should strive to achieve maximum sustainable yield by balancing fishing efforts with fish stock levels. The implementation of MCS represents a strategic approach to maintaining this balance by regulating fishing efforts and curtailing overfishing.

Furthermore, the theory highlights the significance of understanding the technological production conditions within the fishing industry. It is essential to explore various technological factors, including species transformation, substitution between fishing inputs, economies of scope and scale, and industrial organisation. These elements are vital for comprehending the economic viability of fisheries and the implications of different management strategies on profitability.

Understanding the technological production conditions of the fishing industry is crucial for identifying the challenges that may impede the effectiveness of MCS. For instance, if the costs associated with adopting MCS are prohibitively high, compliance among fishers may be deterred, perpetuating overfishing and the depletion of fish stocks (Schaefer, 1954). Conversely, if economies of scale and scope exist in the implementation of MCS, this may incentivise more fishers to adopt sustainable practices, thereby fostering a more resilient fishing industry. Additionally, scholars, including Clark (1990) and Hannesson (1993), have further refined the bio-economic model by incorporating dynamic optimisation and fleet behaviour analysis, reinforcing its continued relevance to contemporary fisheries governance.

2.1.2 Tragedy of the Commons Theory

According to Hardin (1968), the tragedy of the commons theory elucidates the detrimental consequences associated with treating resources as freely accessible. This theory posits that overuse and depletion of resources occur when individuals prioritise personal gain without considering the long-term sustainability of the resource. In the context of fisheries, this phenomenon becomes evident when fishers operate without adequate regulations and enforcement mechanisms to guide their activities. The absence of proper management can lead to increased fishing efforts, resulting in overfishing and the depletion of fish stocks, which ultimately incurs significant economic and social losses (Grafton et al., 2006).

The tragedy of the commons theory underscores the necessity for effective management strategies to ensure the sustainable utilisation of fisheries resources. One such strategy involves the implementation of Marine Protected Areas (MPAs), which serve as a tool for managing fisheries. MPAs can regulate fishing activities within designated zones, allowing fish stocks to recover and replenish. Additionally, these areas can provide alternative income sources for local communities through ecotourism while also serving as a buffer against the impacts of climate change on marine ecosystems (Mora et al., 2006).

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The success of MPAs and similar management strategies hinges on the presence of robust enforcement mechanisms. The introduction of monitoring, control, and surveillance (MCS) strategies can facilitate the enforcement of regulations, thereby preventing illegal and unsustainable fishing practices. Enhanced compliance with such regulations can lead to a reduction in overfishing, ultimately promoting the sustainable use of fisheries' resources and improving economic and social outcomes for local communities (Jacquet et al., 2010).

In this context, when fishers engage in excessive fishing without a sustainability mindset, the levels of fish resources may decline, potentially leading to crises, conflicts with authorities, and unhealthy competition among fishers. The social costs associated with the tragedy of the commons, as articulated by Hardin (1968), arise when joint ownership and use of environmental resources incentivise users to exploit these resources, imposing costs on their neighbours. This dynamic can also manifest in pollution issues.

The theory highlights the adverse effects of joint ownership and the utilisation of environmental resources. In the case of Mbita Sub-County's fisheries, the implications of MCS on resource management can be examined through the lens of this theory. The study of MCS can illuminate how joint ownership and use of fisheries resources contribute to abuse and overexploitation, resulting in social costs that affect other users and the environment. In the same way as pollution scenarios, the utilisation of common resources encompasses both positive gains and negative costs. In fisheries, the positive gain pertains to the increased revenue from capturing more fish. In contrast, the negative costs encompass the depletion of fish stocks and the detrimental impacts on aquatic ecosystems.

MCS can mitigate the negative consequences of individual user behaviour on the environment and other stakeholders, thereby alleviating the social costs associated with overuse and abuse. By establishing limits on catch sizes and fishing methods, MCS can ensure that resource users do not exploit fisheries beyond the point where private marginal costs exceed marginal revenue. In this manner, an MCS can assist users in maximising their net gains while minimising adverse impacts on the ecosystem and fellow resource users.

2.2 Conceptual Framework

This study was guided by the conceptual framework (Figure 1), which postulates that surveillance strategy directly influences the management of fisheries resources in the Mbita Sub-County. This framework is guided by the assumption that an effective surveillance strategy can enhance the sustainability and productivity of fisheries resources by addressing challenges such as illegal, unreported, and unregulated (IUU) fishing.

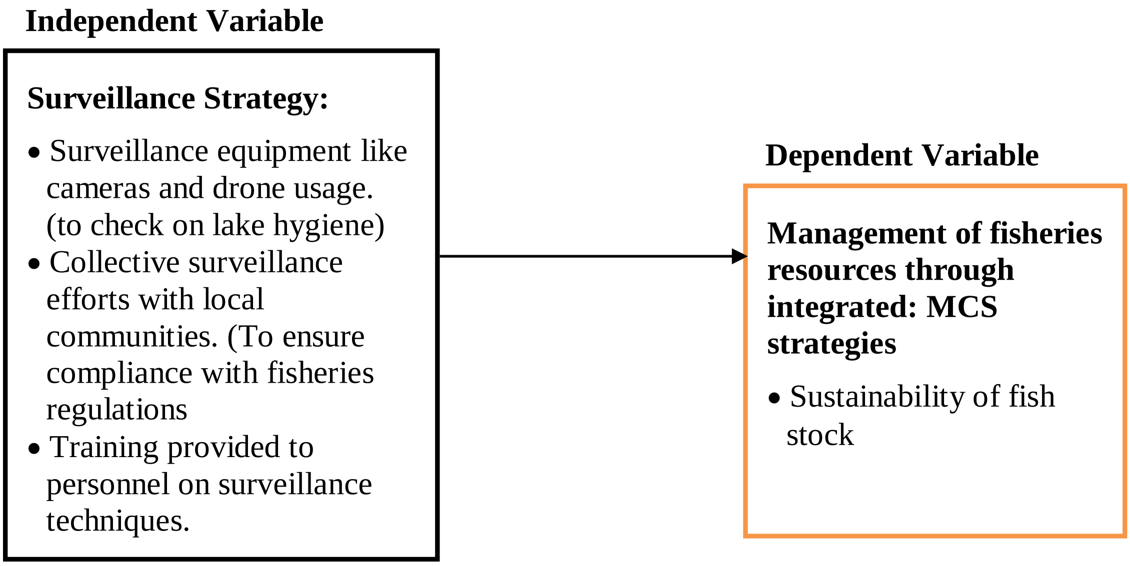

Figure 1: *Conceptual Framework on MCS strategies and management of fisheries resources*

3.0 Methodology

This study adopted a primary data collection approach, as outlined by Kara (2020), employing a convergent parallel mixed-methods research design. This design integrates both qualitative and quantitative research methodologies to provide a comprehensive understanding of the research problem. The justification for using a mixed-methods approach lies in its ability to draw on the strengths of both qualitative and quantitative data, thereby offering a more holistic view of the complexities surrounding fisheries management. Using a mixed-methods approach, the study aims to triangulate findings from both qualitative and quantitative data, thereby enhancing the validity and reliability of the results.

The proposed study was conducted in Mbita Sub-County, Kenya. Mbita Sub-County is located on the shores of Lake Victoria in Homa Bay County, one of 47 Counties in Kenya. It is a primarily rural area found between latitudes 0° 21' and 0° 32' South and longitudes 34° 04' and 34° 24' East. It is about 400 km west of Nairobi, the capital city of Kenya and it covers 163.28 km^2. The economy of Mbita Sub-County in Homa Bay County is mainly anchored on fisheries resources, which are the primary source of income and employment in the area.

The study area was selected since it is an important fishery trade Centre with numerous Beach Management Units. The County has 151 landing beaches managed by 133 beach management units (BMUs). Of these BMUs, 61 are in Mbita, 33 are in Suba, 30 are in Rachuonyo North, and four are in Homa Bay (Homa Bay County Integrated Development Plan 2013-2017).

The study focused on a target population of 17,700 registered fishers and 80 fisheries officials in Homa Bay County, as reported by the Homa Bay County Fisheries Department (2023). The accessible population for this study consists of 11 fisheries officials and 6,500 registered f fishers affiliated with the BMUs in Mbita Sub-County. The sample was derived from the government officials and the registered fishers.

The study employed a stratified random sampling technique, which is particularly effective in ensuring that various subgroups within the population are adequately represented. The 61 Beach Management Units (BMUs) in Mbita Sub-County were grouped into five wards, which served as the strata for sampling. From each stratum, BMUs were randomly selected using simple random sampling, and within each selected BMU, registered fishers were then randomly selected from the BMU membership register. This approach ensured that fishers from all five

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wards were proportionally represented in the final sample of 377, thereby enhancing the representativeness of the findings across the sub-county.

The sample size for this study was determined using a formula developed by Israel (1992), which is suitable for estimating sample sizes in survey research. For a population of 6,500 fishers, a sample size of 377 was selected to ensure statistical significance. This calculation considers a confidence level of 95% and a margin of error of 5%. By adhering to this sample size, the study aims to balance representativeness and practicality, ensuring that the data collected is robust enough to support meaningful analysis and conclusions regarding the effectiveness of MCS strategies in fisheries management. Random sampling was then used to arrive at the specific sample category for the fishers. For the Fisheries officials, a Purposive sampling technique was used to select all 11 fisheries officials who were targeted for Key Informant Interviews, since they have specific characteristics or criteria relevant to the study's purpose. For instance, the individuals who have knowledge, experience, or traits that align with the research objectives.

After the collection of the primary data, the data was processed and analysed to answer the set research objectives. This was done using both descriptive and inferential statistics. The data was then coded, and the coding involved assigning numerical values to the qualitative data. It was then entered into a computer and analysed using a statistical package for the social sciences (SPSS version 28). Descriptive statistics were used in data analysis. Descriptive statistics: frequencies, means, percentages and standard deviation (SD) were generated to explain various attributes of the variables under study. Inferential statistics, such as linear regression, were used to examine relationships among variables and to draw conclusions about the entire population.

In this study, the linear regression model was applied to examine the influence of surveillance strategy on fisheries resource management in Lake Victoria. Linear regression is appropriate because the management of fisheries resources is treated as a continuous outcome, and the independent variables are derived from Likert-scale responses. To ensure comparability and reduce measurement error, the continuous data for both independent and dependent variables were obtained by calculating the mean score of the responses per variable.

Linear regression analysis was used to test the hypotheses at a significance level of $\alpha = 0.05$. The model assumes a linear relationship between the dependent variable and the explanatory variables, with normally distributed residuals, constant variance (homoscedasticity), and no perfect multicollinearity among predictors.

The general form of the linear regression model is expressed as:

$Y = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \ldots + \beta nXn + \varepsilon$……………………………………..………3.2

Where Y = Management of fisheries resources

α = Constant

β_1- β_n = Régression coefficients

X_1 - X_n = Independent variables

ε = error term

Objective three

$Y = \alpha + \beta_3X_3 + \varepsilon$………………...…………...……………………………………...….……3.5

Where Y = Management of fisheries resources

α = Constant

β_3 = Régression coefficient

X_3 = Surveillance

ε = error term

4.0 Findings and Discussion

The study targeted 377 registered fishers affiliated with Beach Management Units (BMUs) in Mbita Sub-County. All 377 researcher-administered questionnaire schedules were completed during face-to-face interviews and found to be fully usable, representing a response rate of 100 percent. In addition, of the 11 fisheries officials targeted for key informant interviews, seven participated fully in the key informant interviews, providing complete responses to all scheduled questions. This response rate is regarded as excellent. Holtom et al. (2022) stipulate that a response rate of 70 percent and above is sufficient for survey research, whilst rates at or near 100 percent enhance the representativeness and generalisability of findings. The high participation rate was facilitated using the Open Data Kit (ODK) platform for questionnaire administration, prior engagement with BMU leaders, and the researcher's presence throughout the data collection period.

The demographic profile of the respondents was examined to provide context for the study findings. The characteristics investigated included gender, age, level of education, and years of experience in fishing. These factors are relevant because they influence fishers' awareness of fisheries regulations, their compliance behaviour, and their perceptions of MCS effectiveness. Demographic results revealed that, male fishers constituted the majority, with 267 respondents (70.8%), whilst 110 respondents (29.2%) were female. This male dominance is consistent with the character of artisanal fishing communities around Lake Victoria, where women's involvement in the fishery is concentrated in fish trading and processing at the beach rather than active fishing on the lake. The largest proportion, 172 respondents (45.6%), fell within the 29–38 years age bracket, followed by the 39–48 years group at 22.0 percent (83 respondents). Those aged 49–58 years accounted for 12.7 percent (48 respondents), whilst the youngest category of 18–28 years comprised 11.1 percent (42 respondents).

The study found out that, majority, 229 respondents (60.7%), had attained primary-level education, whilst 110 respondents (29.2%) had secondary education. Certificate and diploma holders represented 2.1 percent (8 respondents) and 3.7 percent (14 respondents) respectively. Only 3 respondents (0.8%) held a bachelor's degree, and 11 respondents (2.9%) reported no formal education. These findings confirm that the fishing community in Mbita Sub-County has a predominantly basic level of formal education, with nearly 90 percent having attained only primary or secondary schooling. Low educational attainment has significant implications for MCS implementation. The largest group, 127 respondents (33.7%), had been fishing for 5–10 years, followed closely by 118 respondents (31.3%) with 11–20 years of experience. Those with more than 20 years accounted for 22.3 percent (84 respondents), and those with less than 5 years represented 12.7 percent (48 respondents).

4.1 Descriptive Statistics

This section presents the descriptive statistics for the three independent variables, monitoring strategy, control strategy, and surveillance strategy, and the dependent variable, management of fisheries resources. Frequencies, percentages, mean ranks, and Kendall's Coefficient of Concordance are reported for each variable to assess respondents' perceptions of MCS implementation and fisheries management effectiveness in Mbita Sub-County.

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4.1.1 Descriptive Statistics Surveillance

Surveillance strategy was assessed using seven statements on the five-point Likert scale (Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree). Table 3 presents the frequency distribution of responses.

Table 3: Distribution of Responses to Surveillance Statements

Statement	SD f(%)	D f(%)	N f(%)	A f(%)	SA f(%)	Total
Surveillance officers conduct market surveys to determine the species of fish in the market.	45 (11.9%)	46 (12.2%)	9 (2.4%)	220 (58.4%)	57 (15.1%)	377 (100.0%)
Observer schemes for fisheries have been implemented to enhance the Surveillance strategy.	46 (12.2%)	80 (21.2%)	7 (1.9%)	198 (52.5%)	46 (12.2%)	377 (100.0%)
Surveillance officers patrol the lake regularly for enforcement and ensure legal compliance.	25 (6.6%)	38 (10.1%)	11 (2.9%)	222 (58.9%)	81 (21.5%)	377 (100.0%)
There is a regulated use of technology and gear size to regulate the size of catch for fisheries operations.	60 (15.9%)	98 (26.0%)	19 (5.0%)	191 (50.7%)	9 (2.4%)	377 (100.0%)
There are limited fishing units and a number of licenses and permits issued by authorities.	46 (12.2%)	68 (18.0%)	10 (2.7%)	212 (56.2%)	41 (10.9%)	377 (100.0%)
There are appropriate, limited efforts placed on fisheries operations.	30 (8.0%)	87 (23.1%)	15 (4.0%)	217 (57.6%)	28 (7.4%)	377 (100.0%)
Each fishing unit has a designated extent of effort based on the size of the vessels, technology utilised, gear quality, and size.	42 (11.1%)	82 (21.8%)	17 (4.5%)	222 (58.9%)	14 (3.7%)	377 (100.0%)

Note: Sample size = 377 respondents. SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree.

The frequency results for surveillance strategy (Table 3) reveal that human-based enforcement activities are more widely recognised than technology-assisted surveillance mechanisms. The statement on regular lake patrols for enforcement and legal compliance received the highest combined positive response, with 80.4 percent of respondents agreeing or strongly agreeing (58.9% Agree; 21.5% Strongly Agree). Market surveys by surveillance officers to determine fish species in the market attracted 73.5 percent positive responses. These findings are consistent with the visible presence of Kenya Fisheries Service officers and BMU beach scouts at landing sites in the sub-county. In contrast, statements on technology use and effort management attracted lower positive responses. Only 53.1 percent agreed that technology and gear size are regulated to control catch size, whilst 41.9 percent disagreed or strongly disagreed. The statement on limited fishing units and licences attracted 67.1 percent agreement, and observer scheme implementation received 64.7 percent positive ratings. Table 4 presents the mean rank scores for the surveillance strategy statements.

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Table 4: Ranked Mean Scores of Surveillance Statements

	Mean Rank
Surveillance officers patrol the lake regularly for enforcement and ensure legal compliance.	4.65
Surveillance officers conduct market surveys to determine the species of fish in the market.	4.21
There are limited fishing units and a number of licenses and permits issued by authorities.	4.06
There are appropriate, limited efforts placed on fisheries operations.	3.92
Observer schemes for fisheries have been implemented to enhance the Surveillance strategy.	3.91
Each fishing unit has a designated extent of effort based on the size of the vessels, technology utilised, gear quality, and size.	3.77
There is a regulated use of technology and gear size to regulate the size of catch for fisheries operations.	3.48

Regular lake patrols for enforcement and legal compliance received the highest mean rank (4.65), consistent with the high agreement rates in the frequency distribution. Market surveys by surveillance officers ranked second (4.21), followed by fishing unit and licence limitation (4.06), limited effort placed on fishing operations (3.92), and observer scheme implementation (3.91). The statement on each fishing unit having a designated effort allocation received a mean rank of 3.77, whilst the use of technology and gear size to regulate catch recorded the lowest mean rank of 3.48. Table 5 presents the Kendall's Coefficient of Concordance for the surveillance strategy statements.

Table 5: Statistical Test Results for Agreement on Surveillance - Kendall's Coefficient of Concordance

Test Statistics	
N	377
Kendall's W[a]	0.057
Chi-Square	128.018
df	6
Asymp. Sig.	0.000

a. Kendall's Coefficient of Concordance

The test yielded a Kendall's W of 0.057, a Chi-Square of 128.018 with 6 degrees of freedom, and an asymptotic significance of $p = 0.000$. The significant result confirms group-level consistency in respondents' ranking of the surveillance statements.

4.1.2 Descriptive Statistics of Management of Fisheries Resources

The dependent variable, management of fisheries resources, was assessed using six statements covering key management dimensions: information gathering, data analysis, BMU consultation, resource allocation planning, fishers training, and community sensitisation. Table 6 presents the frequency distribution of responses.

Table 6: Distribution of Responses to Management of Fisheries Resources

Statement	SD f(%)	D f(%)	N f(%)	A f(%)	SA f(%)	Total
There are guidelines for information gathering.	32 (8.5%)	53 (14.1%)	7 (1.9%)	195 (51.7%)	90 (23.9%)	377 (100.0%)
Analysis of data from the gathered information is done quarterly.	39 (10.3%)	72 (19.1%)	7 (1.9%)	179 (47.5%)	80 (21.2%)	377 (100.0%)
The management periodically holds consultative meetings with the BMU administration.	26 (6.9%)	9 (2.4%)	7 (1.9%)	186 (49.3%)	149 (39.5%)	377 (100.0%)
The resulting quarterly analysis data informs the planning and resource allocation for optimum productivity.	65 (17.2%)	57 (15.1%)	10 (2.7%)	175 (46.4%)	70 (18.6%)	377 (100.0%)
The management trains fishers on the importance of managing fish resources.	21 (5.6%)	42 (11.1%)	15 (4.0%)	192 (50.9%)	107 (28.4%)	377 (100.0%)
The management authorities sensitise the community on compliance with fishing regulations.	31 (8.2%)	28 (7.4%)	12 (3.2%)	206 (54.6%)	100 (26.5%)	377 (100.0%)

Note: Sample size = 377 respondents. SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree.

The results indicate that fisheries management activities are viewed positively by many respondents, though with notable variation across the six statements. The statement that management periodically holds consultative meetings with the BMU administration attracted the highest positive response at 88.8 percent (49.3% Agree; 39.5% Strongly Agree), pointing to regular formal consultation between fisheries authorities and BMU leadership as a well-functioning aspect of the management system. Community sensitisation on compliance with fishing regulations received 81.1 percent positive ratings, and the training of fishers on fish resource management attracted 79.3 percent agreement. These results suggest that the communicative and participatory dimensions of fisheries management are relatively well-established in Mbita Sub-County. More technical management functions attracted lower positive responses. The statement that quarterly analysed data informs planning and resource allocation was agreed with by only 65.0 percent of respondents, whilst 32.3 percent disagreed or strongly disagreed. Information-gathering guidelines attracted 75.6 percent agreement, with 22.6 percent disagreeing. Table 7 presents the mean rank scores for the management of fisheries resources statements.

Table 7: Ranked Mean Scores of Management of Fisheries Resources

	Mean Rank
There are guidelines for information gathering.	3.47
Analysis of data from the gathered information is done quarterly.	3.3
The management periodically holds consultative meetings with the BMU administration.	4.05
The resulting quarterly analysis data informs the planning and resource allocation for optimum productivity.	3.02
The management trains fishers on the importance of managing fish resources.	3.62
The management authorities sensitise the community on compliance with fishing regulations.	3.55

Consultative meetings with BMU administration received the highest mean rank (4.05), reinforcing the frequency data showing strong endorsement of this management activity. Training of fishers on fish resource management ranked second (3.62), followed by community sensitisation on regulatory compliance (3.55), information-gathering guidelines (3.47), and quarterly data analysis (3.30). The statement on data-informed planning and resource allocation for optimum productivity recorded the lowest mean rank of 3.02. Table 8 presents the Kendall's Coefficient of Concordance for the management of fisheries resources statements.

Table 8: Statistical Test Results for Agreement on Resilience

Test Statistics	
N	377
Kendall's W[a]	.081
Chi-Square	153.573
df	5
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

The test produced a Kendall's W of 0.081, a Chi-Square of 153.573 with 5 degrees of freedom, and an asymptotic significance of $p = 0.000$. The statistically significant result confirms group-level consistency in respondents' ranking of management statements.

4.1.3 Correlation between Surveillance Strategy and Management of Fisheries Resources

A Pearson correlation analysis was conducted to examine the strength and direction of the relationships between Surveillance Strategy and the management of fisheries resources. Table 9 presents the results of the correlation between surveillance strategy and management of fisheries resources.

Table 9: Correlation between Surveillance Strategy and Management of Fisheries Resources

		Management of fisheries resources
	Pearson Correlation	.642**
	Sig. (2-tailed)	.000
Surveillance Strategy	N	377

**. Correlation is significant at the 0.05 level (2-tailed).

The results show statistically significant positive correlations between surveillance strategy and the management of fisheries resources. Surveillance strategy showed a moderately strong positive correlation ($r = 0.642$, $p < 0.05$).

4.1.4 Effectiveness of Surveillance Strategy on the Management of Fisheries Resources in Mbita Sub-County

The null hypothesis tested was H_{03}: surveillance strategy has no statistically significant effectiveness on the management of fisheries resources in Mbita Sub-County. A linear regression was conducted with surveillance strategy as the predictor variable. Table 10 presents the results.

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Table 10: Linear Regression Results: Effect of Surveillance on Management of Fisheries Resources in Mbita Sub-County (N = 377)

Component	Statistic	Value
Model Fit	R	0.642
	R^2	0.412
	Adjusted R^2	0.410
	Std. Error of the Estimate	0.71438
ANOVA	Regression Sum of Squares	133.973
	Regression df	1
	Regression Mean Square	133.973
	Residual Sum of Squares	191.376
	Residual df	375
	Residual Mean Square	0.510
	Total Sum of Squares	325.348
	Total df	376
	F	262.519
	Sig. (p)	0.000
Coefficients	**(Constant)**	
	Unstandardised B	1.225
	Std. Error	0.159
	t	7.726
	Sig. (p)	0.000
	95% CI Lower Bound	0.913
	95% CI Upper Bound	1.536
	Surveillance (predictor)	
	Unstandardised B	0.744
	Std. Error	0.046
	Standardised Beta	0.642
	t	16.202
	Sig. (p)	0.000
	95% CI Lower Bound	0.654
	95% CI Upper Bound	0.834

Predictor: Surveillance Strategy. Dependent Variable: Management of Fisheries Resources.

The regression model for surveillance strategy yielded an R value of 0.642 and an R^2 of 0.412, indicating that surveillance strategy accounts for 41.2 percent of the variance in the management of fisheries resources. The adjusted R^2 of 0.410 confirms this explanatory power, and the standard error of the estimate is 0.714.

The ANOVA results confirm statistical significance: $F(1, 375) = 262.519$, $p = 0.000$. The null hypothesis H_{03} is rejected. Surveillance strategy has a statistically significant and positive effect on the management of fisheries resources in Mbita Sub-County.

The constant is 1.225 (SE = 0.159; t = 7.726; p = 0.000; 95% CI [0.913, 1.536]). The unstandardised regression coefficient for surveillance strategy is B = 0.744 (SE = 0.046; standardised Beta = 0.642; t = 16.202; p = 0.000; 95% CI [0.654, 0.834]). A one-unit increase in the mean score of surveillance strategy is associated with a 0.744-unit increase in the mean score of management of fisheries resources.

The KII data provided rich qualitative evidence on how surveillance is operationalised, the tools and technologies in use, the frequency of patrols, and the barriers that limit surveillance effectiveness. Four themes emerged from the KII data on surveillance: surveillance methods and tools, patrol frequency and geographic coverage, community involvement in surveillance, and resource and motivation gaps as structural barriers.

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Theme 1: Surveillance Methods and Tools

All seven respondents confirmed that physical patrols on the lake and at landing beaches constitute the primary surveillance method in Mbita Sub-County. Lake patrols were consistently described as the cornerstone of the surveillance system, corroborating the quantitative finding that regular lake patrols received the highest mean rank among surveillance strategy statements (mean rank = 4.65; 80.4% agreement).

> *"By conducting regular patrols."* (Respondent A, 3+ years' experience)
>
> *"By regularly patrolling the beaches and the fishing zones."* (Respondent C, 10 years' experience)
>
> *"Conducting both lake and land patrols."* (Respondent G, 11 years' experience)

The tools and technologies reported for surveillance were predominantly basic and low-cost, reflecting the resource constraints that pervade the sub-county's fisheries management system. Patrol boats, torches, and paper-based data recording (including Excel datasheets) were the most commonly reported surveillance tools:

> *"A boat, an autoboard engine, torch, armed soldiers."* (Respondent A, 3+ years' experience)
>
> *"Patrol boats, Excel datasheet."* (Respondents B and E)
>
> *"Use of engine boats."* (Respondent G, 11 years' experience)
>
> Only one respondent mentioned more advanced surveillance technology:
>
> *"Enhanced speed boats, well-developed tracking devices, and tools such as electronic devices."* (Respondent C, 10 years' experience)

The absence of digital monitoring tools such as vessel monitoring systems, satellite tracking, or mobile phone-based reporting applications from the responses of six out of seven officials confirms the quantitative finding that technology-based surveillance received the lowest mean rank (3.48) and the lowest positive response rate (53.1%) among all surveillance strategy statements.

Theme 2: Patrol Frequency and Geographic Coverage.

A dominant and concerning finding across the KII data was the infrequency of surveillance patrols in much of the sub-county. Five of the seven respondents described patrol operations as rare or irregular, driven by reactive rather than planned scheduling:

> *"Patrols are conducted monthly and breeding areas are prioritised."* (Respondent A, 3 years' experience)
>
> *"Not often. No identified areas."* (Respondent B, 10 years' experience)
>
> *"Rarely."* (Respondents E and G)
>
> *"Very rarely. No prioritised areas."* (Respondent D, 5 years' experience)

Respondent G explained that patrol scheduling is not planned systematically but is demand-driven, responding to community alarms or specific intelligence rather than following a regular patrol calendar:

> *"There are no specific areas, but it is demand-driven depending on the need."* (Respondent G, 11 years' experience)

The respondent with the most experience (16 years) described patrol operations as being triggered primarily by departmental decisions and breeding zone considerations, rather than based on risk mapping or MCS planning cycles:

> *"By department specifically, whenever it's considered a breeding zone."* (Respondent F, 16 years' experience)

The significant exception was Respondent C, who described daily, round-the-clock patrols including night operations and emergency responses. This respondent's station appears to be better resourced than those of the other respondents, and the contrast highlights the inequitable distribution of surveillance capacity across the sub-county's 61 BMU beaches.

Theme 3: Actions and Protocols When Illegal Fishing Is Detected.

The actions taken when illegal fishing activities are detected during surveillance operations reflect both the enforcement capacity of the sub-county and the formal procedures in place. Gear confiscation and destruction emerged as the most consistent enforcement response across respondents:

> *"Confiscated gears are destroyed."* (Respondents D and E)
>
> *"Fining the culprits, deregistration of offenders, delicensing."* (Respondent C, 10 years' experience)
>
> *"Patrol done, hence confiscated gears are destroyed."* (Respondent G, 11 years' experience)
>
> Formal prosecution and court referral are used in more serious cases:
>
> *"The matter is reported to the fisheries office."* (Respondent A, 3 years' experience)
>
> *"The in-charge fisheries officer sought authority to confiscate and destroy illegal gear."* (Respondent F, 16 years' experience)
>
> *"Arrest is conducted."* (Respondent F, 16 years' experience)

The use of operation patrol forms requiring authorisation, as described by one respondent, indicates that a formal protocol for surveillance operations exists in principle. However, the practical implementation of these protocols varies considerably across the sub-county, with some officials describing fully structured enforcement cascades (fine, arrest, deregistration) and others indicating that no specific protocols are followed. This variation reflects the capacity differences between BMU stations and the inconsistency in enforcement that the quantitative data also captures in the divergent agreement rates across surveillance statements.

Theme 4: Community Involvement, Motivation Gaps, and Structural Barriers.

All respondents acknowledged community involvement in surveillance through BMU beach scouts and community volunteers as an important component of the surveillance system. Beach scouts perform watching, patrolling, and reporting functions, and several respondents noted that the BMU structure has helped to extend surveillance reach beyond what official staffing alone could provide:

> *"By engaging the community in the co-management."* (Respondent A, 3 years' experience)
>
> *"They patrol and report to the officers in charge. They are awarded cash rewards and special recognition."* (Respondent C, 10 years' experience)

> *"Most beaches do reporting, given that regulators pushed patrols to the BMU network level."* (Respondent G, 11 years' experience)

However, a critical and recurrent theme across the KII data was the lack of rewards, recognition, and incentives for community volunteers and beach scouts, which respondents identified as the central barrier to sustained community participation in surveillance:

> *"No reward for motivation."* (Respondents B and D, independently)

> *"No reward for motivation."* (Respondent D, 5 years' experience)

> *"Leakage of information to those with illegalities. No reward for motivation."* (Respondent E, 13 years' experience)

> *"No, remove for motivation."* (Respondent of the fourth transcript)

The information leakage problem was particularly highlighted as a serious barrier to surveillance effectiveness. When community scouts are not adequately compensated or protected, they may be susceptible to pressure from fishers to leak patrol schedules in advance, negating the deterrent effect of surveillance:

> *"They pull early warnings to their members before any patrol is conducted to avoid being arrested."* (Respondent F, 16 years' experience)

This finding is directly aligned with Sumaila et al. (2022) observation that non-governmental and community involvement in detecting offences increases the likelihood of detection, which in turn enhances the deterrent effect of the entire MCS system. Conversely, when community surveillance networks are demotivated and susceptible to capture by vested interests, their contribution to enforcement effectiveness is undermined.

The cross-cutting structural barrier of resource inadequacy was explicitly named by six of the seven Key informants as the overarching constraint on surveillance effectiveness. Insufficient patrol boats, limited fuel funding, inadequate staffing, and the non-operational status of departmental vessels were all cited:

> *"Department to have its patrol boat operational."* (Respondent G, 11 years' experience)

> *"Lack of financing sub-entities to help effectively do surveillance."* (Respondent G, 11 years' experience)

The convergence of qualitative and quantitative findings on surveillance strategy is particularly strong. The quantitative regression shows that surveillance produces a large per-unit improvement in fisheries management outcomes (B = 0.744, R^2 = 0.412, p = 0.000). The qualitative data explain why this potential is currently under-realised: inadequate patrol frequency, reliance on basic tools, absence of technology-based surveillance, unmotivated community scouts, and patrol schedule leakage all prevent the surveillance system from operating at the intensity needed to achieve durable compliance across the sub-county's 61 BMU beaches.

5.0 Conclusion

The study concludes that surveillance strategy significantly influences fisheries resource management in Mbita Sub-County. Regular lake patrols, market surveys, and observer schemes are the most consistently practised activities and they link strongly to better management outcomes. But technology-based surveillance is barely used. That's untapped potential.

The qualitative side of the research points to real problems. Patrols happen infrequently. The tools are basic. Community scouts get no proper incentives, and information leaks about patrol schedules undermine enforcement. Among the three MCS strategies, surveillance shows the most promise for improving fisheries management. So, it deserves targeted investment. Addressing the resource constraints, motivating the scouts properly, and bringing in low-cost tech tools that could make a real difference for Lake Victoria's fisheries.

6.0 Recommendations

Given that surveillance strategy produced the largest per-unit effect on fisheries management outcomes among the three MCS strategies, targeted investment in surveillance capacity is the most high-impact intervention available to fisheries managers in Mbita Sub-County. The Kenya Fisheries Service should increase the frequency of joint patrol operations between fisheries officers, BMU beach scouts, and county enforcement units, particularly during peak fishing periods and at night when illegal activity is most prevalent. Observer schemes should be formalised within all 61 BMUs, with trained community observers receiving standardised logbooks for recording compliance violations, catch data, and gear inspections; these records should be submitted monthly to the sub-county fisheries office and used to guide patrol scheduling. Low-cost technology-based surveillance tools such as vessel tracking systems for motorised boats, mobile phone-based reporting applications for BMU scouts, and sonar equipment for lake patrols should be piloted in partnership with research institutions. Weekly market surveys at all major fish markets in the sub-county should be conducted to detect undersized fish, illegal species, and fish from closed areas, with results publicly displayed at landing beaches to promote community accountability.

This study was confined to Mbita Sub-County and collected data at a single point in time through a cross-sectional research design. Several areas merit further investigation. Thus, longitudinal studies tracking changes in fish catch volumes, species diversity indices, and IUU incidences before and after targeted MCS interventions would provide stronger causal evidence of MCS management impact than the cross-sectional research design used in this study.

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