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Trends in catch and effort in Western African coastal lagoon system fisheries and their socio-economic implications

Delagnon Assou[1,*], Jean Baptiste G Gnimassoun[1], Kossi Ahoedo[1,2], Mawoussi Yawa Charlotte Akoetey[1], Daniele Dendi[1,3], Mark Auliya[4,5], Neil D'Cruze[6,7], Guillaume Koffivi Ketoh[1], Hoinsoude Gabriel Segniagbeto[1], Luca Luiselli[1,3] and Timo Mortiz[8,9]

[1] Laboratory of Ecology and Ecotoxicology (LaEE), Department of Zoology and Animal Biology, Faculty of Sciences, University of Lomé, 01 BP 1515 Lomé, Togo
[2] Fisheries Committee for the West Central Gulf of Guinea (FCWC), Fisheries Research Institute Building, PO Box BT62, Tema, Ghana
[3] IDECC—Institute for Development Ecology Conservation and Cooperation., via G. Tomasi di Lampedusa 33, I-00144 Rome, Italy
[4] Zoological Research Museum Alexander Koenig, Adenauerallee 160, 53113 Bonn, Germany
[5] Leibniz Institute for the Analysis of Biodiversity Change (LIB), Bonn, Germany
[6] Wildlife Conservation Research Unit (WildCRU), Department of Biology, University of Oxford,Tubney House, Tubney, Oxfordshire OX13 5QL, United Kingdom
[7] Department of Natural Science, Manchester Metropolitan University, All Saints Building, All Saints, Manchester M15 6BH, United Kingdom
[8] Leibniz-Institute for the Analysis of Biodiversity Change, Hamburg, Germany
[9] Department of Ecology, Institute of Biosciences, University of Rostock, 18051 Rostock, Germany
[*] Author to whom any correspondence should be addressed.

E-mail: patricedelagnon@gmail.com

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Abstract

Coastal lagoon systems in West Africa are highly productive ecosystems that constitute a critical foundation for local subsistence and economic activity. This study draws on demographic, effort, and catch data from Togo's inland fisheries monitoring program to evaluate fishing practices and their socio-economic significance. Approximately 1000 individuals are directly engaged in the fishery, predominantly Togolese nationals, although some foreign participation occurs. Women are primarily involved in post-harvest activities such as processing and trade. A variety of fishing gear are employed, with gill nets remaining the most widespread. Over recent years, a marked transition toward smaller mesh size gear (up to 20 mm) has been observed. The catch is dominated by cichlids (*Sarotherodon melanotheron, Coptodon guineensis*), mullets (*Mugil* cf. *cephalus, Neochelon falcipinnis*), catfishes (*Clarias* spp., *Chrysichthys* spp.), and the clupeid *Ethmalosa fimbriata*, with cichlids contributing on average 34% ± 30% of annual landings. The fishery generates substantial revenues, exceeding 1 billion FCFA (≈1.67 million USD) annually. However, the increasing prevalence of small-sized individuals and declining catches of medium- and large-sized fish, indicate overexploitation of fish stocks, likely driven by the widespread use of small-mesh fishing gear that removes individuals before they reach larger size classes. These findings emphasize both the ecological and socio-economic importance of Togo's coastal lagoon fishery and underscore the necessity of implementing sustainable management measures.

1. Introduction

Lagoon ecosystems represent a natural heritage of significant value due to their multiple biological, ecological, social, and economic functions, as well as their cultural importance (Bouillon *et al* 2002, Idrus *et al* 2019, Yuliana *et al* 2019). These systems are highly productive, support complex food webs, and serve as nurseries for phyto- and zoo-plankton, including fish larvae (Issola *et al* 2008, Assou *et al* 2018, Yuliana *et al* 2019). Their biological productivity provides important fishery resources for local communities (Albaret 1994, Koranteng *et al* 1998, Baran 1999, Addo *et al* 2014).

Globally, fishery resources feed over one billion people, supplying nearly 20% of the average animal protein intake of 3.3 billion people (Ricard 2021, FAO 2022). Fish consumption has more than doubled over the past six decades, rising from 9.0 kg per capita in 1961 to 20.5 kg in 2019, highlighting the critical role of fisheries in combating hunger and malnutrition (FAO 2022). Fisheries also contribute substantially to economic and social development, particularly in coastal regions. In West Africa, fish accounts for approximately half of animal protein intake, underscoring the region's dependence on fisheries for both nutrition and income (Lam *et al* 2012, Africa Center for Strategic Studies 2016).

In Togo, the fishing sector—including inland and marine fisheries—generates approximately 5 billion FCFA (∼8.25 million USD) annually, with an added value of 10 billion FCFA (∼16.5 million USD), representing 4% of the GDP of the primary sector (FAO 2007). It employs around 22 000 individuals, including 10 000 fishermen and 12 000 traders and processors (FAO 2007, 2020). Inland artisanal fisheries in the coastal lagoon system produce roughly 1000 tons per year, providing livelihoods for about 60% of the communities along the lagoon margins and contributing to national food security (SOFRECO 2011, Djangbedja *et al* 2013). Fish are a critical source of high-quality protein, essential amino acids, omega-3 fatty acids, vitamins, and minerals, particularly for low-income households (Cochrane *et al* 2009, Lam *et al* 2012, Abdoullahi *et al* 2018, FAO 2018, 2022). Consequently, fisheries are integral to Togo's socio-economic development and to achieving the United Nations Sustainable Development Goals (1, 2, and 14) and the African Union's Agenda 2063.

However, the coastal lagoon ecosystem in Togo is severely degraded due to overexploitation, destructive fishing practices, pollution, erosion, and climate change (Ali *et al* 2013, Adjoussi and Wilson-Bahun 2020, Fiagan 2021, Konko *et al* 2023, N'Souvi *et al* 2024). Historically considered an open-access resource, fisheries are now dominated by small-sized fish, while previously abundant large specimens have become rare, as reported in similar ecosystems in West Africa (Lalèyè *et al* 2007, Montchowui *et al* 2008). Furthermore, detailed data on catch composition, sizes, and socio-economic contributions are scarce, and previous reports are often outdated or incomplete (FAO 2007, Ali *et al* 2013, Djangbedja *et al* 2013).

This study provides a comprehensive characterization of the fishing communities and activities in Togo's coastal lagoon system, analyzing trends in fishing effort, gear types and mesh sizes, catch per fishing trip, composition, landings, and revenues. Data were obtained from the Directorate of Fisheries and Aquaculture (DPA), including information on active fishing units, gear use, mesh sizes, catch volumes, and revenues. We hypothesized that: (1) total landings increase with fishing effort and average catch per trip, particularly for gill nets; (2) total landings are primarily driven by dominant species; and (3) the size distribution of captured fish is positively correlated with mesh size.

The results are intended to inform sustainable management strategies for Togo's lagoon fisheries. The recognition of this coastal lagoon system as a Ramsar site (TG 1722) and as part of the Mono Transboundary Biosphere Reserve underscores the urgent need for conservation and resource management measures to safeguard both biodiversity and local livelihoods.

2. Methodology

2.1. Description of the study area

The coastal lagoon system of Togo is a semi-closed environment (figure 1), under a subequatorial climatic regime, with two rainy seasons and a total volume of 900 mm of rainfall on average per year (Wilson-Bahun 2021, Assou 2025). The Togolese coastal lagoon system has an area of approximately 6400 hectares (ha), consisting of Lake Togo (4600 ha), the Togoville lagoon which is a 13 km channel parallel to the coast whose width varies between 150 and 900 m, Lake Zowla (655 ha), and the Aného lagoon to the southeast. The Aného lagoon is made up of a network of narrow channels, with a depth varying from 4 to 11 m (Ouro-Sama *et al* 2014). The entire system communicates with the Beninese lagoon system to the east (Vidy 2000) and with the sea through the mouth, 'la passe d'Aného', permanently open since 1989. It is fed mainly by: (i) Zio and Haho rivers, which flow respectively to the west and north into Lake Togo, (ii) Boko, the smallest, which flows into Lake Zowla, and (iii) Mono the largest, which communicates with the Gbaga channel and flows into the sea at 'Bouche du Roy' in Benin. The area is located along the coast and extends between N06°06' and N06°14' latitude and E01°11' and E01°37' longitude.

2.2. Data collection and analysis protocol

We used seven years of inland fisheries monitoring data (2016–2022) from the coastal lagoon system of Togo, collected by the DPA. Before the establishment of the inland fishing monitoring program for rivers and lagoons, including that of the coastal lagoon system of Togo, the DPA had received financial

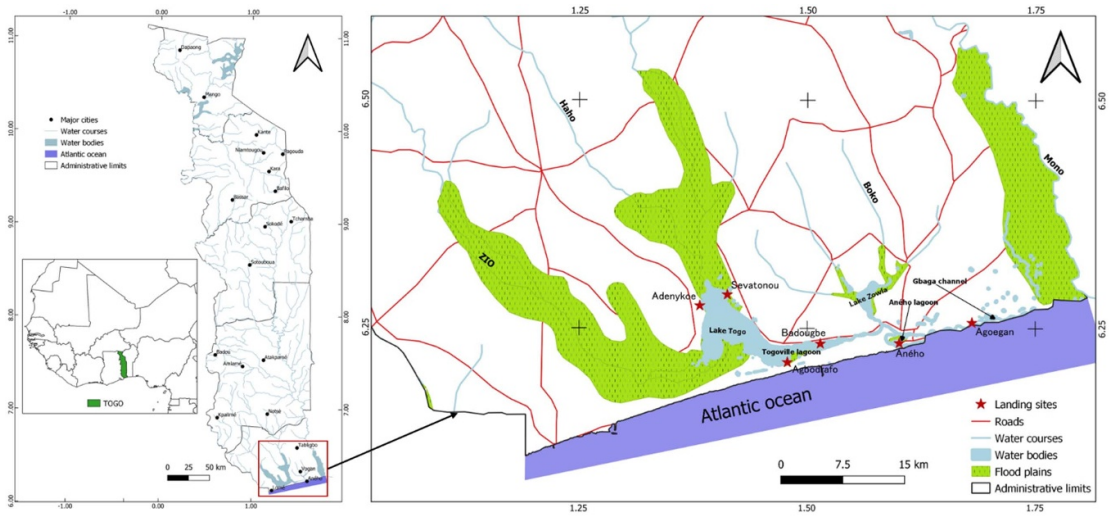

Figure 1. Map of the study area.

support from partners such as the Food and Agriculture Organization and the West African Economic and Monetary Union to conduct a baseline survey on who participates in fishing activities, the number and type of canoes, and the total number of landing sites. Following this initial census, the number of canoes and gear are monitored regularly each year in collaboration with local fisheries management committees.

The surveys were conducted at six selected fish landing sites based on the results of the baseline survey (figure 1). These sites were representative of Togo's coastal lagoon system, and the data collected were extrapolated to reflect the entire ecosystem.

For the monitoring program, the DPA used two types of questionnaires: the by-day landings observation questionnaire (DOQ) and the seasonal activities declaration questionnaire (SAQ). Surveys using the DOQ are conducted twice per week at each selected fish landing sites, while the SAQ is administered once per semester and per site.

The DOQ questionnaire essentially gathers information on the following aspects: the survey time, the duration of the fishing trip, the total number of operational canoes observed, the number of fishermen, the total landings, the overall weight of the catches, the composition of the catches (by size and species), and the average market prices of the main species.

For the SAQ survey, the investigator mainly collects the following information: the number of fishermen without canoe working on the site during the season, the number of trips per week of the fisherman during the season, the average duration of the trip, the total weight of catches and the species caught per fishing trip, the number of active processors during the season, the types of processing practiced during the season, the number of traders who buy fish from the fishermen.

The data collected are recorded in an Excel spreadsheet and processed using the R software, version 4.2.1. (R Core Team 2022). Frequencies, means and standard deviations were used to describe each recorded variable. Linear regression analyzes were performed to identify changes in canoe activity rates, the duration and number of fishing trips, average catch per trip, total landings and revenues generated over the years. The trends were assessed using the correlation coefficient (r), slope and the statistical significance level (p). Kruskal–Wallis nonparametric tests were used to assess statistical differences in the percentages of various fishing gear types and categories, as well as the catches of dominant species over the study period. Spearman's rank correlation (rs) tests were conducted to assess the relationships between total landings, fishing effort and average catch per trip (for gill net and all gear combined) on one hand, and between total landings and catches of dominant species on the other hand. Finally, Pearson's correlation (r) was performed to determine whether the proportions of the different mesh size categories were correlated with the size classes of fishes captured.

Fishing gear mesh sizes were divided into three categories: small (up to 20 mm), medium (20–40 mm) and large (more than 40 mm). Similarly, the captured fishes were classified into three categories according to their sizes: small (less than 15 cm), medium (from 15 to 25 cm) and large (more than 25 cm). The monetary values were reported in West African CFA Francs (XOF) and converted to US dollars (USD) using the average exchange rate of 1 CFA = 0.001 67 USD for the period from 2016 to 2022 (www.exchangerates.org.uk/XOF-USD-spot-exchange-rates-history-2022.html).

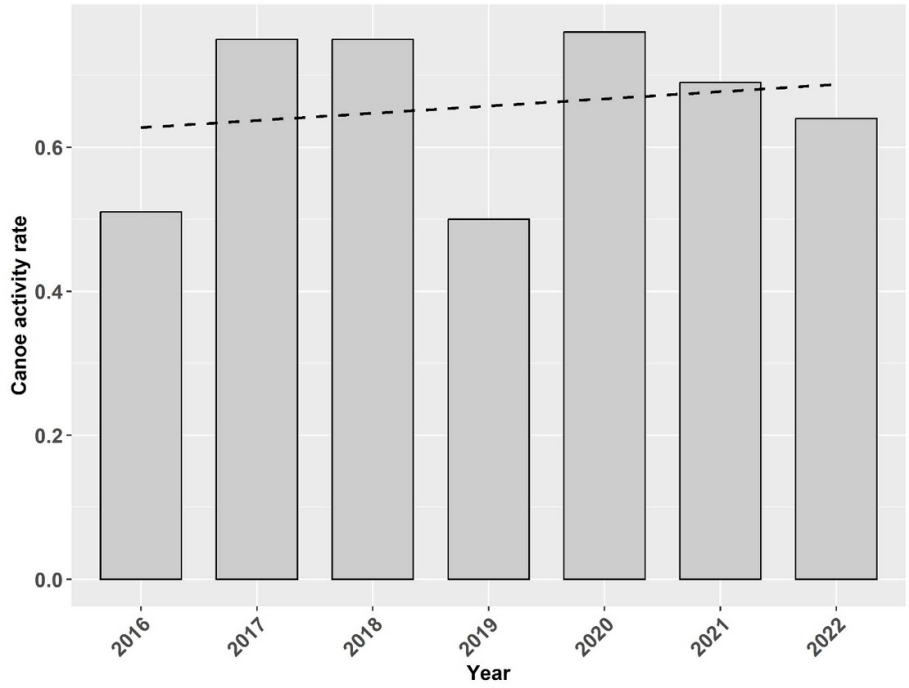

Figure 2. Canoe activity rate in the coastal lagoon system per year, where a value of 1.0 indicates that each canoe was active every day of the respective years, regardless of the total number of canoes. The dashed line represents the overall trend across the study period.

3. Results

3.1. Fishermen community

The baseline survey showed that fishing in the coastal lagoon system of Togo (considered as part of inland fisheries) employs around 1000 individuals, predominantly nationals, but also foreigners (mainly Beninese and Ghanaians). The main ethnic groups working in the fisheries of Togo's coastal lagoon system are: Guin (12.67%), Ouatchi (16.48%), Xwlà (25.79%) and Pedah (26.18%). Fishing is mainly practiced by men and less commonly by women. The processing and marketing of fishery products in the villages around the coastal lagoon system are mainly the prerogative of women. Fishery products are harvested for both commercial purposes and household consumption. They are marketed either fresh, smoked, dried or fried. However, smoking remained the main traditional way of processing fish products in the coastal lagoon system. The main products traded are fishes, crabs, shrimps and oysters.

3.2. Fishing effort

Throughout the entire coastal lagoon system, fishermen use approximately 560 canoes, of which 65.57% ($n = 367$) were dugout canoes and 34.43% ($n = 193$) were plank-built frame canoes. The daily activity rate of these canoes varied between 0.50 in 2019 and 0.76 in 2020, with an average of 0.66 ± 0.11 (figure 2). However, this variation over the study period was not significant ($r = 0.193$; slope $= 5.194 \pm 2.279$; $p = 0.679$).

The number of fishing trips throughout the coastal lagoon system of Togo showed a significant increasing trend over the study period ($r = 0.892$; slope $= 26\,974 \pm 5453.2$; $p = 0.007$), ranging from 41 497 in 2017 to 168 046 in 2022, with an average of $94\,032 \pm 58\,270$ trips per year (figure 3). The average number of trips by canoe in the coastal lagoon system varied between 74 trips in 2017 and 300 trips in both 2021 and 2022, with an annual average of 168 ± 104 trips per year. An analysis of the duration of fishing trips revealed that the average length of a trip was 5.47 ± 1.05 h per day, ranging from 3.5 h in 2020 to 6.8 h in 2022. However, this variation over time was not statistically significant ($r = 0.242$; slope $= 0.485 \pm 0.210$; $p = 0.60$).

3.3. Fishing gear, methods and techniques

In the coastal lagoon system of Togo, several fishing gear, methods and techniques are used. Among these are the gill nets, cast nets, shrimp nets, drift nets, baited and unbaited hooks, fish traps and trap dams or Xha, and shore seines (online supplementary table S1), as well as fishing using baskets or by

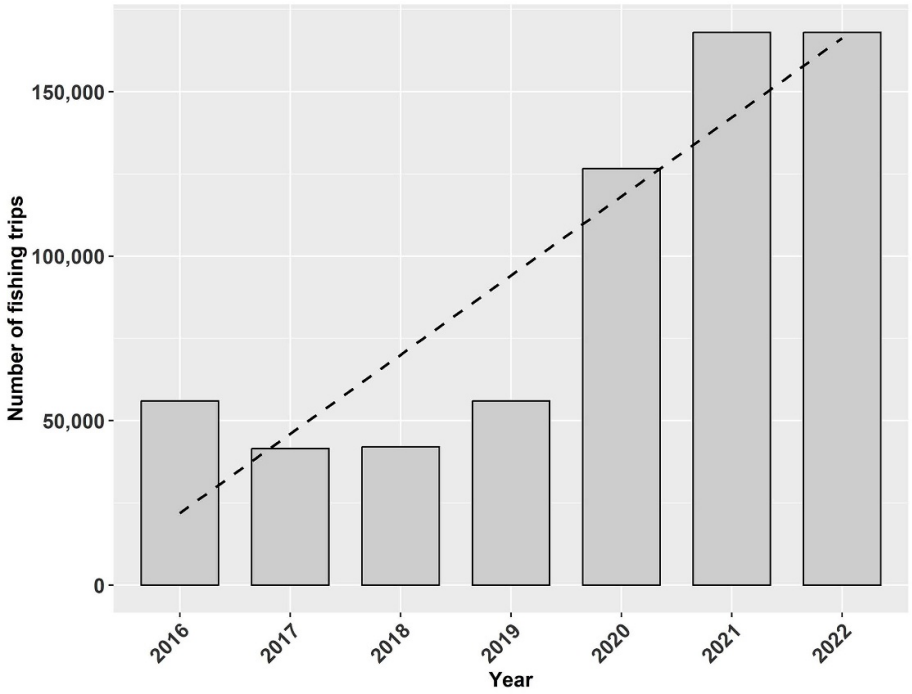

Figure 3. Number of fishing trips in the coastal lagoon system per year with the dashed line showing the overall trend over the study period.

hand (particularly practiced in floodplains during the recession). The baited and unbaited hooks are categorized as hooks, while fish traps and trap dams are classified as traps. However, it should be noted that information on fishing using basket or hand is not included in the data collected and was therefore not integrated into the analyzes. Throughout the study period and in almost all sites (figure 4), gill nets remained the most commonly used gear, with a rate varying from 19.79% in 2019 to 60.75% in 2021, and an average of 34.58% ± 16.13%. Comparison of the percentages of the various fishing gear and techniques used over the study period showed that there is no significant difference between the years (Kruskal–Wallis $\chi^2 = 2.541$, $p > 0.05$).

Over the study period, there were major changes in the percentage of use of the three mesh size categories (figure 5). The use of small mesh-sized gear has generally increased over time, from 38.27% in 2017 to 76.62% in 2021. Conversely, the use of medium mesh-sized gear decreased from 42.70% in 2016 to 20.5% in 2021, and the use of large mesh-sized gear declined from 11.30% in 2017 to 2.14% in 2021. A statistical comparison of the percentages of the different mesh size categories across the years revealed significant differences (Kruskal–Wallis $\chi^2 = 14.92$, $p < 0.001$).

3.4. Fishing yield

Overall, the total landings of Togo's coastal lagoon system have shown a downward trend, decreasing from 1211.00 tons in 2016 to 410.78 tons in 2021 (figure 6), with an annual average of 825.71 ± 296.71 tons. However, this decline was not statistically significant over time ($r = -0.30$; slope $= -137.35 \pm 58.60$; $p = 0.514$). The average yield was 129 ± 46 kg hectare^{-1} per year, ranging from 190 kg hectare^{-1} in 2016 to 60 kg hectare^{-1} in 2021, but this variation was also not significant over the study period ($r = -0.30$; slope $= -21.46 \pm 9.16$; $p = 0.514$).

Fishing in the Togolese coastal lagoon system generates an average revenue of 1002 752 267 ± 428 759 867 FCFA (∼1674 596 ± 716 028 USD) per year, fluctuating between 405 685 890 FCFA (∼677 495 USD) in 2021 and 1647 401 190 FCFA (∼2751 159 USD) in 2022. However, this variation was not statistically significant over the study period ($r = -0.031$; slope $= -1.98 \times 10\text{^}8 \pm 8.87 \times 10\text{^}7$; $p = 0.9477$). The lagoon's share in the inland fishing landings ranged from 19% in 2016 to 7% in 2021, with an annual average of 13% ± 4%, though this variation was not significant ($r = -0.324$; slope $= -0.021 \pm 0.009$; $p = 0.478$). Similarly, its contribution to national fishery landings fluctuated between 5% in 2016 and 2% in 2021, with an average annual share of 3% ± 1%, but this variation was also not statistically significant ($r = -0.30$; slope $= -0.005 \pm 0.002$; $p = 0.514$).

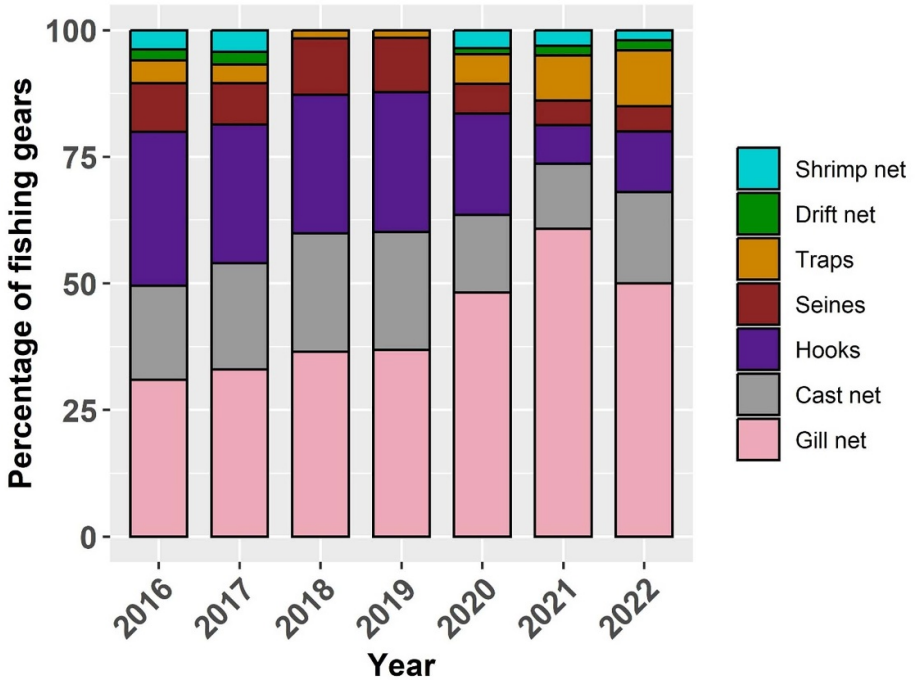

Figure 4. Percentage of fishing gear used in the coastal lagoon system per year.

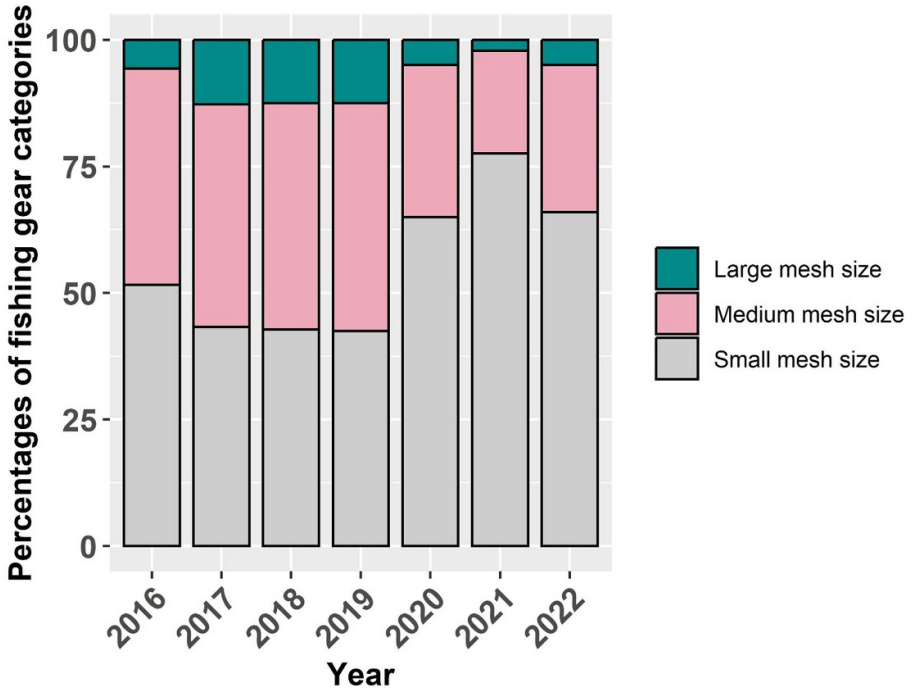

Figure 5. Percentages of categories mesh size used in the coastal lagoon system per year.

The average catch per fishing trip has decreased over the period, dropping from 11.74 kg in 2016 to 03.97 kg in 2020 for all gear combined, with an average of 05.83 $\pm$ 02.68 kg per trip (figure 7). However, this decrease was not statistically significant over the time ($r = -0.672$; slope $= -1.243 \pm 0.411$; $p = 0.097$). A similar trend was also observed particularly for the gill net, the most used gear, whose catch per trip decreased from 5.59 kg in 2016 to 2.25 kg in 2020, with an average of 2.82 $\pm$ 1.27 kg per trip ($r = -0.467$; slope $= -0.589 \pm 0.233$; $p = 0.29$). Contrary to our expectations, the Spearman's *rs* correlation test between the total landings, number of trips, average catch per

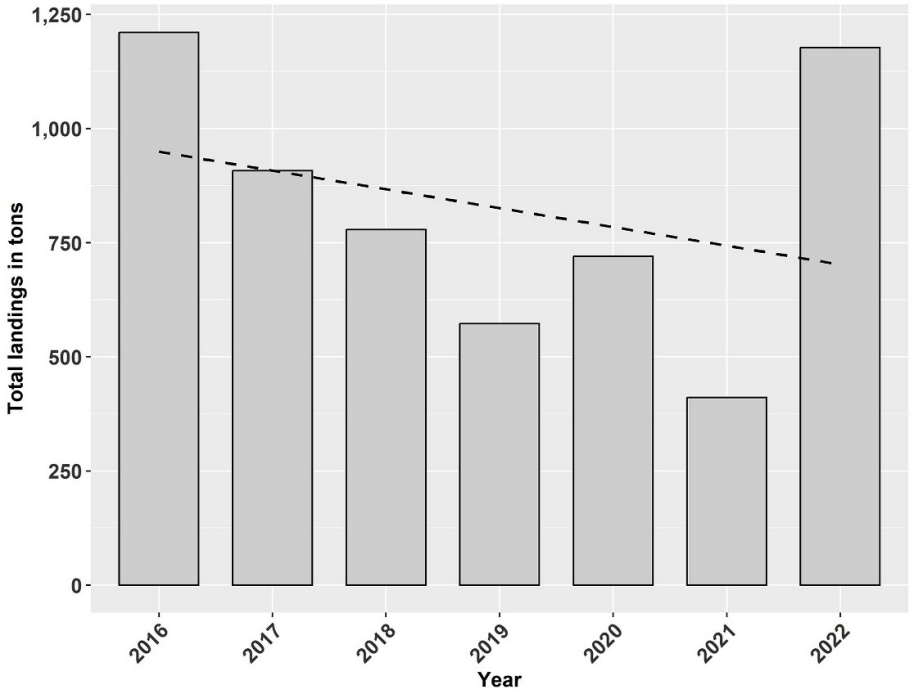

Figure 6. Total fisheries landing of the coastal lagoon system of Togo per year with the dashed line showing the trend over the study period.

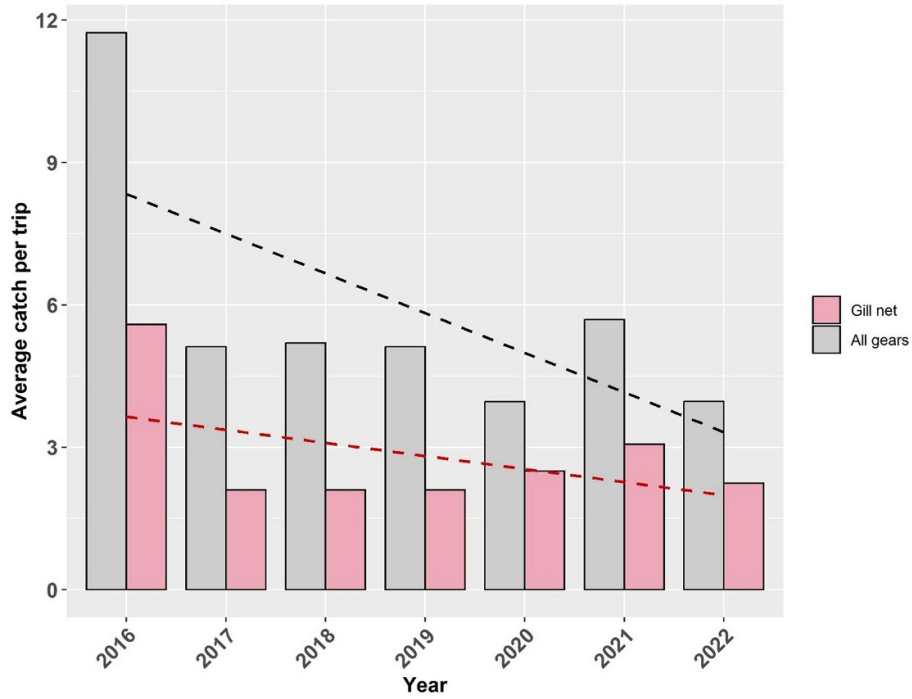

Figure 7. Average catch per fishing trip per year in the coastal lagoon system of Togo with the dashed lines showing the trends over the study period.

fishing trip of all gear combined and average catch per trip of gill net demonstrated that there is no significant correlation between these variables ($rs < 0.5$).

3.5. Dominant species in the catches

Catches in the coastal lagoon system of Togo are mainly dominated by cichlids *Sarotherodon melanotheron* and *Coptodon guineensis*, mullets *Mugil* cf. *cephalus* and *Neochelon falcipinnis*, catfishes *Clarias* spp. and *Chrysichthys* spp., and the clupeid *Ethmalosa fimbriata* (table 1). Cichlids occupied a

Table 1. Annual contribution of dominant species to total landings (%).

Taxa	2016	2017	2018	2019	2020	2021	2022
Cichlids	7.45	79.73	73.30	13.25	15.31	25.32	26.91
Mullets	18.99	1.43	2.70	8.64	15.18	2.32	6.17
Clarias spp.	19.00	2.59	2.82	16.93	1.92	2.63	12.17
Chrysichthys spp.	3.98	1.05	0.90	10.38	4.28	1.37	9.67
Ethmalosa fimbriata	6.86	0.04	0.13	15.18	4.17	0.17	5.74

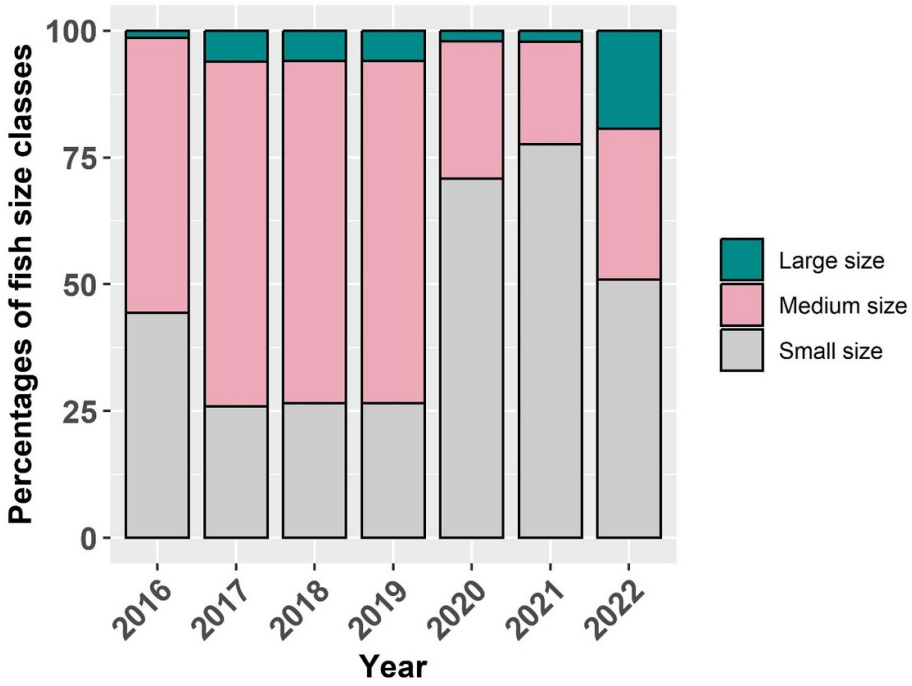

Figure 8. Percentages of fish size classes caught per year.

significant part of these catches, representing an average of 34% ± 30% of the annual fish landings. Comparative analysis of catches by species over the study period revealed significant difference between the years (Kruskal–Wallis $\chi^2 = 10.04$, $p = 0.039$). The Spearman's *rs* correlation test between the total landings and catches of dominant species showed a significant correlation between fish landings and catches of *Clarias* spp. ($rs = 0.73$), cichlids ($rs = 0.62$), *Chrysichthys* spp. ($rs = 0.55$), as well as mullets ($rs = 0.54$). However, no correlation was observed between landings and catches of *E. fimbriata* ($rs < 0.5$).

3.6. Trends in catches by size classes and their relationship with fishing gear mesh sizes

The analysis of catches by size class highlighted a significant increase in the catch of small-sized fishes, rising from 20.62% in 2017 to 76.62% in 2021. In contrast, the catch of medium-sized fishes experienced a gradual decline, decreasing from 66.90% in 2018 to 20.50% in 2021. Furthermore, the catch of large-sized fishes has decreased, dropping from 06.00% in 2018 to 02.14% in 2021 (figure 8). However, the highest share of large-sized fishes is recorded in 2022. A statistical comparison of the percentages of fish size classes over the years revealed a highly significant differences (Kruskal–Wallis $\chi^2 = 13.38$, $p = 0.001$). The Pearson correlation test between the percentages of the fish size classes and the different gear mesh size categories revealed a significant correlation ($r = 0.88$), indicating that the mesh size used significantly influenced the size classes of fishes captured.

4. Discussion

The study describes the fishermen community and the socio-economic importance of the Togo's coastal lagoon system. It documents trends in fishing effort, gear types, mesh sizes used and catch composition over a seven-year period (2016–2022), providing better temporal resolution than earlier studies (see FAO

2007, Ali *et al* 2013, Djangbedja *et al* 2013). Furthermore, it also assesses catch per fishing trip and total landings across multiple landing sites and years, thereby highlighting shifts in species composition and size structure over time. Although the selected landing sites capture the main hubs of fishing activity and most of the fishing effort and landings, they do not include every small or informal landing sites across the lagoon system. Consequently, the extrapolated estimates may not fully reflect catches from these minor sites. Despite this limitation, we believe that our findings represent valuable information for sustainable management of the ecosystem.

Togo, with an estimated internal demand of more than 70 000 tons of fishery products per year, has an annual landing of around 25 000 tons. This disparity creates a significant external dependence, forcing the country to import between 40 000 and 50 000 tons of fishery products every year (Ali *et al* 2013). National fishery landings are mainly influenced by marine fishing. However, although the contribution of inland fishing is small in terms of national annual landing, it plays a significant socio-economic role. It provides livelihoods for a rapidly growing population (Ali *et al* 2013) and contributing to the country's food security (SOFRECO 2011). For example, fishing in the Togo's coastal lagoon system represents the main source of income for around 60% of the populations living on the edge of the ecosystem (Djangbedja *et al* 2013).

Inland fishing is practiced throughout the territory, whether on rivers, dams, ponds or even in floodplains. The Mono and Oti rivers, the Nangbéto hydroelectric dam, as well as the coastal lagoon system represent important areas for inland fisheries in the country. For example, in 2022, inland fishing generated an estimated landing of 6502 tons, with a specific contribution of 1177 tons coming from the coastal lagoon system (DPA 2022). The fishery landings of the coastal lagoon system of Togo represented on average 13% $\pm$ 4% of inland fisheries and 3% $\pm$ 1% of the national fisheries landing each year. It generated on average a revenue of 1002 752 267 $\pm$ 428 759 867 FCFA ($\sim$1674 596 $\pm$ 716 028 USD) per year. However, we acknowledge that all prices were converted to USD using an average exchange rate of 1 CFA = 0.001 67 USD for the study period 2016–2022, without adjustment for inflation. As such, values across years are not fully directly comparable, and some of the observed variation in revenue may reflect inflation rather than changes in catch or fish availability. Future studies could strengthen this analysis by incorporating inflation-adjusted prices to better capture the real economic changes over time and enable more robust temporal comparisons.

Fish landings of Togo's coastal lagoon system were estimated at 825.71 $\pm$ 296.71 tons of catches per year, which, when considering the standard deviation, was not significantly different from the previous estimate of 1000 tons of annual catch (FAO 2007). However, Ali *et al* (2013) highlighted an alarming and persistent decline of fishery resources in the Togolese lagoon system. This decline, characterized by a reduction in catches and an impoverishment of fishing communities, underscores the need for the implementation of sustainable management measures. Our results also indicated a decline in the average catch per fishing trip, although this trend was not statistically significant over the time, and an increase in the number of fishing trips per year.

Over the study period, 2022 stood out as the second most productive year (figure 6), due to an increased fishing effort in terms of the number of trips per year (168 046 trips; figures 3) and (a) significant share of large-sized fishes (19.34%; figure 8) compared to other years. In general, the constant increase in the exploitation of fresh and brackish water fish populations in Africa by local communities, combined with a permanent population growth, as well as a worrying acceleration of all degradation processes of natural environments, poses a significant risk of depletion in stocks and extirpation of some species (Lalèyè *et al* 2004). Additionally, the decline in fish stocks mainly results from inadequate fishing practices, the use of gear that does not comply with regulations, as well as the increasing siltation that this ecosystem is currently experiencing (Ali *et al* 2013). Siltation of Togo's coastal lagoon system is mainly due to intense human activities in the watershed (Adjoussi and Wilson-Bahun 2020). The absence of alternative sources of income and employment means that local communities exert significant pressure on the fishery resources of the lagoon system to meet their needs (Dankwa *et al* 2004, Addo *et al* 2014). Fishermen practiced their activity as a means of last resort livelihood.

The decline in the average catch per fishing trip, though not statistically significant over the time, could also be explained by an increase in sand mining activities in the ecosystem (see Lalèyè *et al* 2022). In 2016, the ecosystem had three functional sand mining units in Sewatrikopé, Amédéhoèvé, and Dévégo. Today, this number has increased, with the addition of two new units: in Agbata and in Aného.

The yield of the coastal lagoon system of Togo averaged 129 $\pm$ 46 kg ha^{-1} per year, ranging from 190 kg ha^{-1} (in 2016) to 60 kg ha^{-1} (in 2021). In general, West African lagoons have an average yield of 290 kg ha^{-1} per year (Gnohossou 2006). This average yield of West African lagoons was much higher than the yield of the coastal lagoon system of Togo. In addition, the yield of the Togolese lagoon system was much lower than that of Lake Nokoué in Benin, the most productive lagoon in West Africa with an

annual yield of approximately one ton (or 1000 kg) per hectare (Gnohossou 2006). It should be noted that fishing in Lake Nokoué is dominated by the 'acadja' system (Niyonkuru and Lalèyè 2010), a method whose efficiency per unit area was significantly higher than that observed in open water (Welcomme 2002, Niyonkuru and Lalèyè 2010). In inland fisheries in Togo and in the lagoon system in particular, fishery resources are open access and have long been considered inexhaustible resources from which everyone could fish at will. However, this perception could lead to an overexploitation of the resources and have negative impacts on their overall yield.

During the study period, 66% ± 11% of the canoes were active every day throughout the year. The number of fishing trips experienced a general increase across the entire coastal lagoon system of Togo, rising from 41 497 (in 2017) to 168 046 (in 2022), with an average of 94 032 ± 58 270 trips per year. While the trends of both canoe activity rates and duration of fishing trips were not significant over the study period, the number of fishing trips significantly increased. Changes in fishing effort were primarily driven by the number of fishing trips per year. However, this increase in effort was not correlate with total landings. This discrepancy may be explained by other factors, such as the number and type of fishing gear used, mesh size, as well as by shifts in target species and fishing locations, that were not accounted for in this study.

Catches in the coastal lagoon system of Togo were mainly dominated by cichlids *Sarotherodon melanotheron* and *Coptodon guineensis*, mullets *Mugil* cf. *cephalus* and *Neochelon falcipinnis*, catfishes *Clarias* spp. and *Chrysichthys* spp., and the clupeid *Ethmalosa fimbriata*. Cichlids occupied a preponderant part in these catches, representing on average 34% ± 30% of annual landing. For example, in 2017, Cichlids made up around 80% of the total landing, or 723 tons of the 908 tons of fishery products caught. Similarly, in 2018, they dominated the landing with a share of 73%, or 571 tons out of a total of 779 tons of fishery products. In Lake Togo, Assou *et al* (2018) observed a predominance of *S. melanotheron* in their samples (>50%), followed by *E. fimbriata* (13%), *C. guineensis* (8.8%) and *Chrysichthys nigrodigitatus* (6%), while each of the other species represented less than 5% of the catches. In the Keta Lagoon in Ghana for example, catches were also dominated by cichlids, notably *S. melanotheron*, accounting for around 33% of the catches, closely followed by *C. guineensis*, which constituted around 14% of the catches (Dankwa *et al* 2004, Addo *et al* 2014). The Spearman's *rs* correlation test between the total landings and catches of dominant species showed that the total landings are driven by the catches of *Clarias* spp., cichlids, *Chrysichthys* spp. and mullets. However, the analysis revealed that an increase or reduction in the catches of *E. fimbriata* does not influence the total landings. This could be explained by the size and weight *E. fimbriata*, which is a small seized fish species (Paugy *et al* 2003).

Changes in species dominance, with certain species becoming predominant in catches could be related to intensive fishing effort (Albaret and Laë 2003); however, the dynamics of the lagoon ecosystem is poorly understood to distinguish here human impact from possibly natural occurring fluctuations. In any case, fishing activities in estuarine and near-shore environments significantly influence the structure and functionality of these ecosystems, although other non-fishing impacts also contribute to their dynamics (Blaber *et al* 2000). In tropical lagoons, a shift in the community trophic structure of the fish community, with an increase in phytophagous and detritivore species, and a decrease in piscivores has been observed under high fishing pressure (Albaret and Laë 2003). According to Amadi *et al* (2017), herbivores and omnivores tend to dominate fish communities in West Africa. Similar studies delving into the fish trophic categories are recommended in the coastal lagoon system to determine which category dominates the catches.

The ichthyofauna of the coastal lagoon system is quite diverse, with notable species richness (Daget 1950, Paugy and Bénech 1989, Laë 1994, Assou *et al* 2018). Despite this great diversity, observations revealed that local communities target certain fish species to which they attach particular values, whether economic, cultural or culinary. Economically, species such as *S. melanotheron, C. guineensis, Oreochromis niloticus*, and *M.* cf. *cephalus* are particularly priced. As for *E. fimbriata, Eucinostomus melanopterus, Dormitator lebretonis* and *Pellonula leonensis*, they are more valued in terms of cooking local dishes. However, *N. falcipinnis* stands out from the others for its importance in rituals and traditional beliefs. There are indications that species such as *P. leonensis* and *D. lebretonis* have been overexploited for a long time and are becoming increasingly rare in the ecosystem. The scarcity of these last two species now forces local communities to turn to *E. fimbriata, E. melanopterus*, and juvenile cichlids to meet their needs. The targeted exploitation of these species with high social or cultural value increases their vulnerability. Their gradual decline in catches could lead to a loss of both biological and cultural heritage. At this stage, defining a management mechanism for their stocks in the coastal lagoon system of Togo is therefore urgently needed to ensure their sustainable use. It should be noted that in the Togolese coastal lagoon system, the most valued species by local communities do not always correspond to those that are most abundant.

Our results showed that the use of small mesh-sized gear (down to 20 mm) has increased over the time, rising from 38.27% in 2017 to 76.62% in 2021. The high predominance of small mesh-sized gear usage in the fisheries of the coastal lagoon system of Togo has led to catches dominated by small-sized fishes (less than 15 cm). The analysis of catches highlighted a significant increase in the catch of small fishes, rising from 20.62% in 2017 to 76.62% in 2021. Similar observations have been made in the lower valley of the Ouémé River in Benin, where researchers reported a predominance of catches of small-sized and/or juvenile fishes (Montchowui *et al* 2008). Additionally, specimens of large-sized fishes, once abundant in catches of this river in Benin, have become extremely rare (Lalèyè *et al* 2007). Furthermore, our observations might be attributed to overexploitation, as highlighted by Albaret and Laë (2003), who reported that intense fishing pressure in tropical lagoons leads to a reduction in medium and large-sized fish populations. This is particularly relevant considering the findings that indicated an increase in fish capture effort within the coastal lagoon system of Togo.

Ichthyological inventories of the lagoon system, conducted between April 2022 and March 2024, identified small-sized species such as *E. melanopterus* ($TL = 6.0$–15.5 cm; $N = 556$), *D. lebretonis* ($TL = 5.2$–8.2 cm; $N = 140$), and *P. leonensis* ($TL = 6.4$–11.2 cm; $N = 106$). These species hold significant economic, cultural and culinary importance for local communities. To ensure the sustainable management of fishery resources within this ecosystem, it is crucial to implement regulations on fishing gear, particularly those targeting these species during their peak of reproduction. Such measures are essential to safeguard the renewal of their stocks and maintain the overall ecological balance.

It is also important to note that many fishermen working in the coastal lagoon system use non-selective fishing methods, such as trailing or shrimp nets, shrimp traps and trap dam or Xha, as well as 'acadja' system. Although the use of 'acadja' has been prohibited in the lagoon system since 2007 by Order No. 18 MAEP/CAB/SG/DEP of 22 July 2007, this practice continued until 2020. These practices mainly lead to the catch of juveniles, a significant post-capture loss (FAO 2020) and compromises the sustainability or renewal of stocks.

In many inland fisheries, the status of fish stocks remains poorly understood due to limited data (Welcomme *et al* 2014), which hampers an accurate assessment of the sector's actual contribution. Moreover, biases in the available information (Agapito *et al* 2019) tend to exacerbate the underestimation of resource overexploitation. However, overfishing in a fishery may not always manifest as a decline in total catch, even when species and long-term sustainability are severely threatened (Allan *et al* 2005). An in-depth analysis of the growth and exploitation parameters of fish species in the coastal lagoon system of Togo would provide a better understanding of stock exploitation levels and help define appropriate management measures. Furthermore, a proper fish stock assessment of the ecosystem is recommended. Updating the fishery management plan for Togo's coastal lagoon system, defining the suitable mesh sizes to ensure the renewal of stocks, is an essential strategy for achieving a sustainable management of this ecosystem.

5. Conclusion

Coastal lagoons play a significant role as an essential source of fishery resources, highlighting the importance of their ecological monitoring. Fishing in the coastal lagoon system of Togo employs around 1000 people, provides food and generates income for the local communities' livelihood. Over a period of seven years, monitoring of fishing activities in the coastal lagoon system of Togo indicated an annual landing of 825.71 ± 296.71 tons of catches per year. This landing generated an average revenue of 1002 752 267 $\pm$ 428 759 867 FCFA (~1674 596 $\pm$ 716 028 USD) per year. Cichlids occupied an important part of the catches, representing on average $34 \pm 30\%$ of annual landing. The data also highlighted that the average yield of the ecosystem (129 ± 46 kg ha^{-1} per year) is relatively low compared to the West African lagoons' average (290 kg ha^{-1} per year). At the same time, an increasing use of small mesh-sized gear has been observed, leading to a significant catch of small-sized fishes and/or juveniles. The increase in the use of small mesh-sized gear and fishing effort poses a significant threat to the sustainability of fish stocks. Given the critical role of fishing as a livelihood and source of income for the growing population in the Togo coastal lagoon system, there is a pressing need to ensure sustainable management of the resources. This highlights the importance of updating the fishery management plan for the ecosystem. The revised plan should clearly define the appropriate mesh sizes for fishing gear to safeguard stock renewal and specify the periods during which each type of gear may be used.

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Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

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ORCID iDs

Delagnon Assou 0000-0002-1593-1452
Neil D'Cruze 0000-0001-8006-3084

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