




Contraventions of MPA regulations by the South African demersal trawl fisheries: Evidence from loss and damage of scientific instruments

Fannie W. Shabangu^{a,b,*} , Trevor A. Branch^c, Kuhle Hlati^{d,e}, Flore Samaran^f, Imtiyaaz Malick^g, Sean T. Fennessy^h, Bernadine I. Everett^h, Marcel A. van den Berg^d, Dawit Yemane^a

^a Fisheries Management Branch, Department of Forestry, Fisheries and the Environment, Foreshore, Cape Town, South Africa

^b Mammal Research Institute Whale Unit, University of Pretoria, Private Bag X20, Hatfield, Pretoria 0028, South Africa

^c School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98195, USA

^d Oceans and Coasts Research Branch, Department of Forestry, Fisheries and the Environment, Foreshore, Cape Town, South Africa

^e Department of Botany and Zoology, Stellenbosch University, Cape Town, South Africa

^f Lab-STICC CNRS UMR 6285, ENSTA - IP Paris, Brest 29802, France

^g South African Environmental Observation Network, Gqeberha 6031, South Africa

^h Oceanographic Research Institute and University of KwaZulu-Natal, Durban, South Africa

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ABSTRACT

Marine protected areas (MPAs) are generally considered safe havens for marine organisms and resources by virtue of being able to exclude threats from within their boundaries. However, the benefits of MPAs depend on compliance to MPA regulations, and there is little known globally about the amount of illegal fishing that happens within MPAs. We used the damage and loss of passive acoustic moorings within MPAs on the west coast (Child's Bank) and east coast (Aliwal Shoal) of South Africa as evidence for illegal fishing in MPAs and to initiate investigation on the intensity of fishing activity within MPAs. These moorings were deployed to study regional soundscapes and the seasonal acoustic occurrence and behaviour of some of the critically endangered marine mammals in the Southern Hemisphere. Scientific instruments were deployed within MPAs as these areas were perceived safe and excluded trawling. Surprisingly, both moorings were trawled up, with part of the east coast mooring brought up in October 2023 and the entire other mooring brought up in January 2024. Vessel tracking data also confirm illegal fishing within MPAs. These incidents provide a novel approach on the use of loss and damage of scientific instruments as evidence for illegal fishing in MPAs and highlight the need for more monitoring and patrolling of these areas to ensure proper compliance and management in South Africa and likely the rest of Africa. To conclude, it is gravely concerning that MPA regulations are contravened without any consequences, undermining the conservation, socioeconomic and research-related objectives of MPAs.

1. Introduction

Globally, marine protected areas (MPAs) are established as a tool to protect and conserve the ocean from anthropogenic activities. MPAs can be either no-take or multiple-use, which determines their success and effectiveness (Gill et al., 2024; Hilborn, 2017; Kirkman et al., 2021). South Africa has established both types of MPAs to protect marine biodiversity, sensitive seabeds, corals, spawning grounds, important habitats, and fish recruitment areas; to promote eco-tourism, education, and research; and to encourage the recovery of depleted fish stocks and

reduce at-sea human activities (Attwood et al., 1997; Republic of South Africa 2019a, b; Kirkman et al., 2021). About 5 % (or ~15 % when including the remote Prince Edward Islands) of the South African exclusive economic zone (EEZ) was declared MPAs (Fig. 1) in 2019 with the aim to fulfil the Aichi Biodiversity Targets set for member states of the Convention on Biological Diversity (Thomas et al., 2014; Kirkman et al., 2019, 2023).

One example of a multiple-use MPA in South African waters relevant to this study is the Aliwal Shoal MPA that has multiple zones that have specific regulations, that are split into offshore and inshore components

* Correspondence to: Fisheries Management Branch, Department of Forestry, Fisheries and the Environment, Private Bag X2, Vlaeberg, 8018, South Africa.
E-mail address: fannie.shabangu@yahoo.com (F.W. Shabangu).

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(Republic of South Africa 2019a). Offshore MPA zones (Fig. 1) are designed for boat-based activities and consist of four restricted or no-take areas, two controlled areas which permit demersal (bottom) fishing, and one controlled pelagic line-fishing area that only permits fishing for pelagic gamefish (Republic of South Africa 2019a). Inshore MPA zones are meant for shore-based activities and consist of two controlled zones that permit most shore-based activities, and two small, restricted zones that are no-take regions (Republic of South Africa 2019a).

Scientific instruments are often deployed in MPAs because they

should provide benchmark information from undisturbed habitats, and to also avoid damage and/or loss by anthropogenic activities at sea. Scientific instruments such as acoustic recorders attached to oceanographic or standalone acoustic moorings can be deployed in MPAs to study the acoustic ecology of marine mammals and other organisms that produce species- and region-specific sounds (e.g. Shabangu et al., 2024a, b) and soundscape of the area (Shabangu et al., 2022). A variety of oceanographic instruments for observing temporal environmental changes are also deployed on moorings. For this study, scientific instruments were deployed in MPAs to investigate the seasonal acoustic

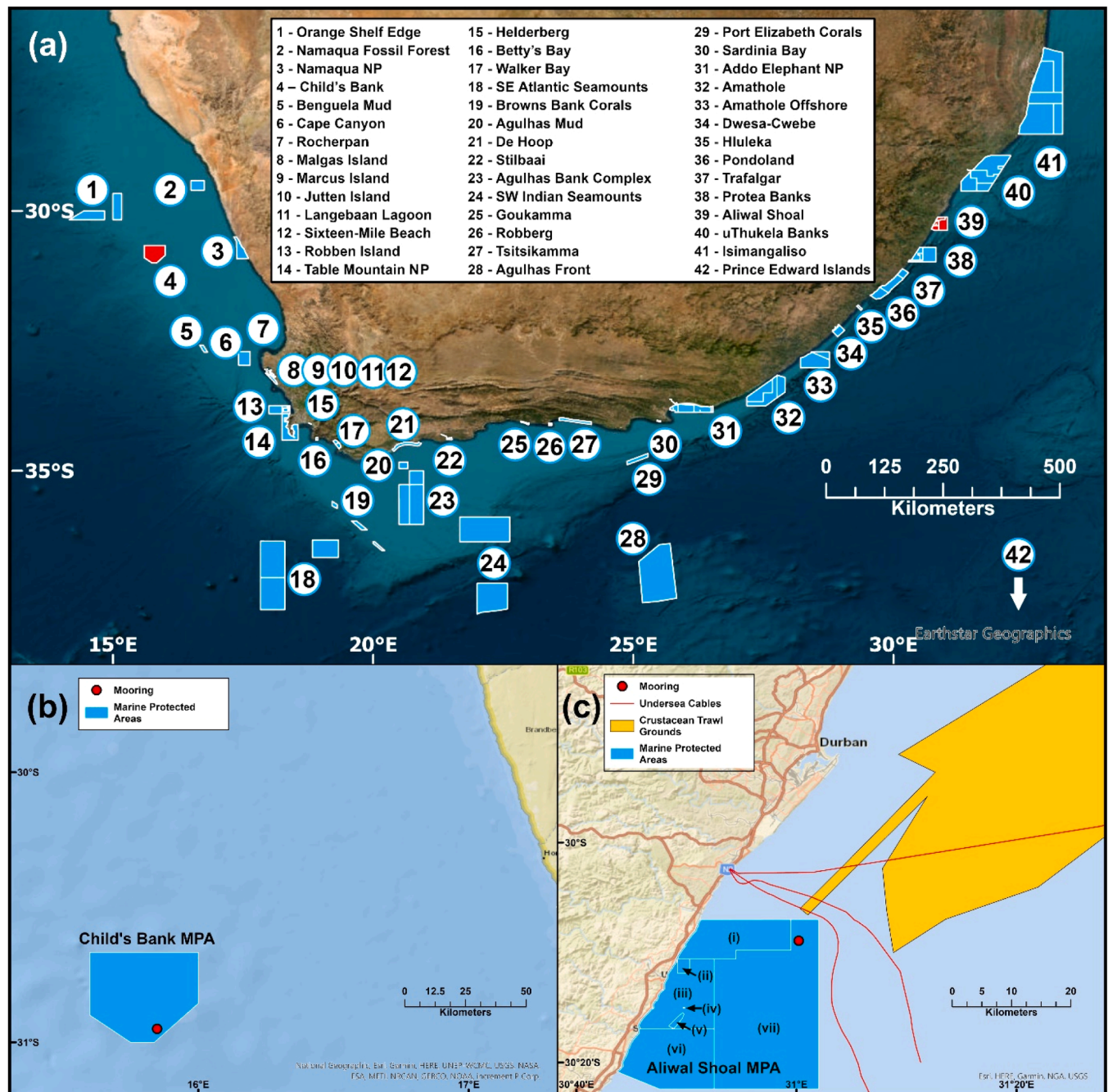


Fig. 1. (a) Map showing all 42 MPAs within the South African EEZ, (b) location of the acoustic mooring within Child's Bank MPA, and (c) locations of the acoustic mooring within Aliwal Shoal MPA; southwestern end of the crustacean trawl grounds based on logbook trawl localities; and undersea cables. (a) The two focal MPAs are shaded in red whereas other MPAs are shaded in blue and numbers next to MPA locations represent the MPA names in the plot legend. Roman numerals represent different offshore zones of the Aliwal Shoal MPA: (i) Illovo Offshore Controlled Zone, (ii) Ngene Offshore Controlled Zone, (iii) Aliwal Shoal Offshore Controlled-Pelagic Linefish Zone, (iv) Produce Offshore Restricted Zone, (v) Crown Offshore Restricted Zone, (vi) Park Rynie Offshore Controlled Zone, and (vii) Aliwal Shoal Offshore Restricted Zone (Republic of South Africa 2019a). The Aliwal Shoal MPA inshore zones are not labelled here since they are not the focal area of this study.

occurrence and behaviour of marine mammals and study effects of anthropogenic underwater noise on marine organisms—marine mammals specifically.

Marine mammals are important natural indicators of ecosystem health given their responses to ecosystem change, and the crucial role they play in transporting and transferring nutrients between different food webs and different zones of the water column that in turn benefit the whole ecosystem including fisheries (Gerber et al., 2009; Roman et al., 2014). Additionally, marine mammals contribute to South Africa’s economy through eco-tourism (Geldenhuys et al., 2019). However, the distribution, seasonality, important habitats and population abundance of marine mammals are still largely unknown due to a paucity of research (Best, 2007). These knowledge gaps make conservation and management strategies associated with MPAs ineffective at protecting most marine mammals although there are signs of increased protection for some species through MPAs (Purdon et al., 2020).

The objective of this study is to provide up-to-date accounts and

evidence for illegal fishing from the damage and loss of scientific instruments within two MPAs in South African waters. Vessel tracking data are used to confirm illegal fishing activities within MPAs.

2. Material and methods

2.1. Aliwal Shoal MPA mooring

On the east coast of South Africa (Fig. 1), an acoustic mooring (Fig. 2) equipped with one Autonomous Underwater Recorder for Acoustic Listening-Model 2 (AURAL-M2) version 04.1.3 (Multi-Electronique Inc., Canada) was deployed at a water depth of 284 m on 7 February 2022 within the Aliwal Shoal Offshore Restricted Zone of the Aliwal Shoal MPA, off the former Durban whaling grounds. The AURAL-M2 acoustic recorder was programmed to record for 13 months until March 2023. This mooring was 2.9 km from the eastern boundary of the MPA and 3.6 km from the northern boundary (Fig. 1c). The Aliwal Shoal MPA was

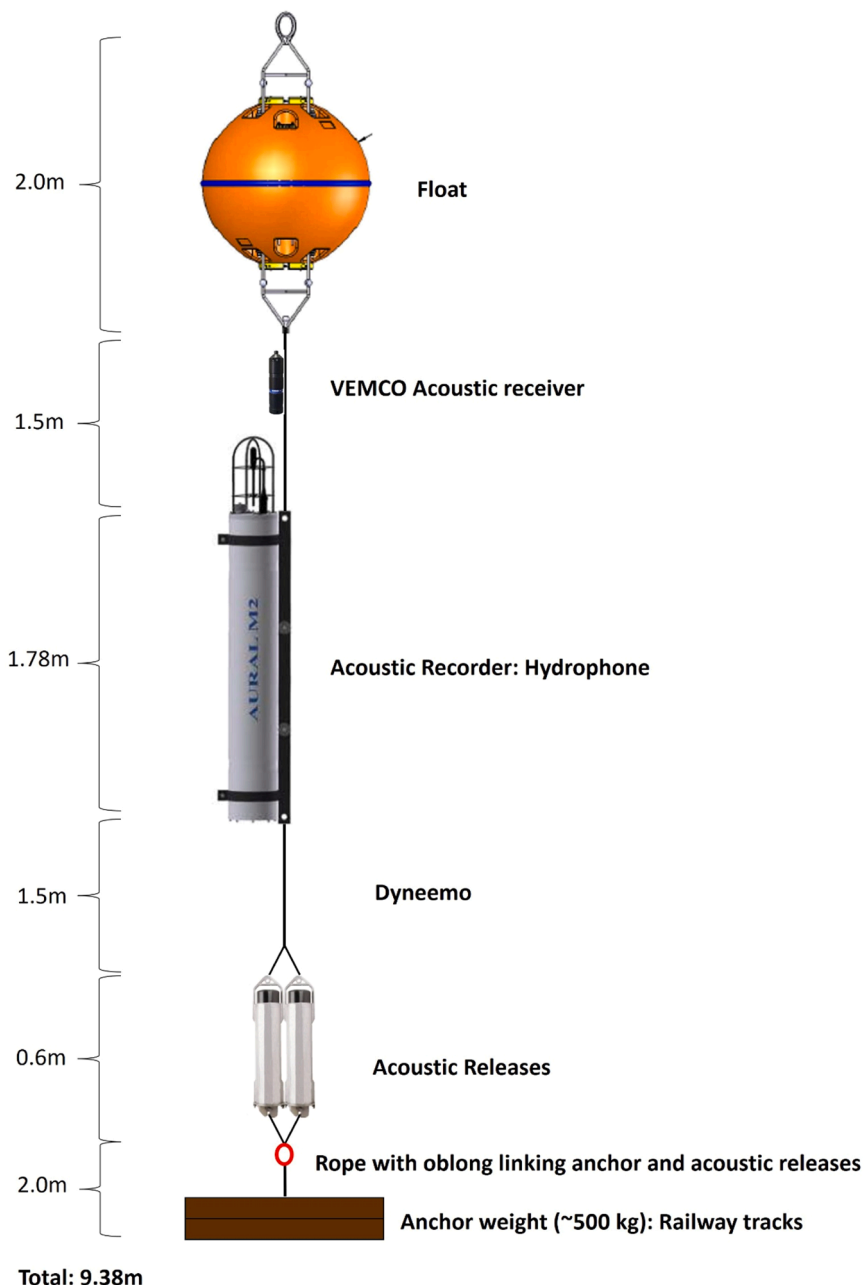


Fig. 2. Set-up of the Aliwal Shoal MPA acoustic mooring with all components including a fish tracking device (VEMCO acoustic receiver). Figure is not to scale.

established in 2004 and extended in 2019 from 125 to 670 km² (Republic of South Africa 2019a). This MPA extends from the coast outwards to about 34 km offshore. It is managed by the provincial government conservation agency Ezemvelo KwaZulu-Natal Wildlife on behalf the national Department of Forestry, Fisheries and the Environment.

2.2. Child's Bank MPA mooring

The second acoustic mooring (with a similar set-up as the Aliwal Shoal MPA mooring) equipped with one SoundTrap ST600 HF (Ocean Instruments, New Zealand) was deployed at a water depth of 281 m on 15 January 2024 off the west coast of South Africa, within the Child's Bank MPA (Fig. 1) which is a benthic protection MPA where only controlled tuna pole and large pelagic longline fishing are permitted (Republic of South Africa 2019b; Kirkman et al., 2021). The SoundTrap acoustic recorder was set up to record for eight months (to September 2024). The mooring was 3.1 km from its nearest MPA boundary to the southeast (Fig. 1b). This MPA (1335 km²) is an offshore MPA located ~125 km from the nearest landmark (Hondekliip Bay). It was established in 2019 (Republic of South Africa 2019b) and is managed by the South African government through Oceans and Coasts Research Branch of the Department of Forestry, Fisheries and the Environment.

2.3. Fishing vessel activity data

Merged satellite imagery, automatic identification system (AIS) data, vessel monitoring system (VMS) data, vessel global positioning system (GPS) data and machine learning monitored vessel localities within the whole South African EEZ were obtained on an hourly temporal resolution and 0.01° spatial resolution from Global Fishing Watch database using the package *gfwr* (Clavelle et al., 2024) in R (R Core Team, 2023). Both AIS and VMS are satellite vessel tracking techniques, and the difference between the two is that AIS is required by international law for vessels over 300 gross tons to avoid collision at-sea whereas VMS is a national and regional fisheries requirement tool for vessels less than or equal to 300 tons. AIS data has higher temporal resolution than VMS data (e.g. Shepperson et al., 2018). The minimum vessel size to be equipped with a VMS device and the temporal resolution of VMS data are specific to a region or fishery and decided by governing bodies. We focussed on Global Fishing Watch vessel localities from 7 February 2022 to 31 October 2023 occurring in Aliwal Shoal MPA and from 15 to 21 January 2024 for vessel localities occurring in Child's Bank MPA.

Information on latitude, longitude, date and time stamp, country flag, gear type, vessel identifiers (IDs), apparent fishing hours, entry and exit time stamp, and Maritime Mobile Service Identity (MMSI) numbers of vessels were extracted from Global Fishing Watch. Apparent fishing hours represent the time vessels apparently spent fishing, derived from changes in vessel speed and direction of known or possible commercial fishing vessels as classified by the Global Fishing Watch fishing detection algorithm. Furthermore, also using Global Fishing Watch data, we investigated the trend of bottom trawling around and within the MPAs in 2018 before MPAs were declared and from 2019 when MPAs were declared to July 2024—more than four years after declaration. We considered vessels that used a single gear type within a given year to avoid uncertainty about when multiple-gear vessels switched between gears. We could not obtain VMS data from the Department of Forestry, Fisheries and the Environment since their data storage system crashed in December 2023, losing all stored historic data; and their VMS server was down in January and February 2024.

3. Results

3.1. Aliwal Shoal MPA mooring loss

Three attempts were made on board RV *Phakisa* between April and

October 2023 to recover the acoustic mooring, but these were unsuccessful as there was no definitive communication from the acoustic releases. It was later confirmed on 6 November 2023 that the acoustic releases used on this mooring (Fig. 3a) were trawled up by a crustacean trawler. The target crustaceans for this fishery (comprising four active fishing vessels at the time of this study) are African lobsters, known locally as langoustines (*Metanephrops mozambicus*); knife/pink prawns (*Haliporoides triarthrus*); pink geryon/red crabs (*Chaceon macphersoni*) and Natal spiny/deep-water lobster (*Palinurus delagoae*). The owner of the vessel indicated that the releases had been trawled up in late October, outside the MPA, but the skipper had no idea what they were; no instruments or the float were attached to the releases when it was trawled up, only some ropes which were not retained. The only reason the releases were recovered was because one of us (STF) approached the owner of the company to enquire whether he would be able to assist in finding the mooring – acting on the assumption that the releases had failed when attempts were made to retrieve the mooring.

The AURAL-M2 acoustic recorder and other mooring components (Fig. 2) are still missing to date, and messages have been sent out to the fishing industry to assist in finding or reporting if the instruments are found.

3.2. Child's Bank MPA mooring damages

The acoustic mooring deployed in the Child's Bank MPA was trawled up (Fig. 3b) seven days (21 January 2024) after deployment as determined from the recorded acoustic data in which voices of the fishing vessel crew could be heard once the instrument was on deck. The demersal trawler kindly reported this untimely retrieval of the mooring and delivered it to us on the first week of February 2024. The demersal trawling industry (consisting of 60 fishing vessels) on the west coast of South Africa targets mainly deep-water Cape hake (*Merluccius paradoxus*) and shallow-water Cape hake (*M. capensis*), also catching retained secondary species - kingklip (*Genypterus capensis*), Agulhas sole (*Austroglossus pectoralis*), monk (*Lophius vomerinus*), and Cape horse mackerel (*Trachurus capensis*). The float, acoustic releases and Sound-Trap acoustic recorder were damaged (Fig. 3c-e) due to demersal trawling.

3.3. Fishing evidence from vessel localities within MPAs

Within the period of acoustic mooring deployment from 7 February 2022 to 31 October 2023, Global Fishing Watch data revealed that only one vessel crossed the Aliwal Shoal MPA boundaries in June 2023 and September 2023 (Fig. 2). Based on vessel MMSI number, the vessel that crossed the Aliwal shoal MPA boundaries was a demersal trawler, and this vessel initially fished in the Illovo Offshore Controlled Zone and Aliwal Shoal Offshore Restricted Zone close to the mooring location in June 2023 (Fig. 4a). The same trawler fished in the Aliwal Shoal Offshore Restricted Zone in September 2023 but far from the mooring location this time (Fig. 4b).

Based on these apparent fishing hours, the Aliwal Shoal MPA acoustic mooring was likely trawled up between 27 and 28 June 2023 by a KwaZulu-Natal (Durban) crustacean trawler (identified by its MMSI number) whose tracks with one apparent fishing hour were very close to the acoustic mooring location (Fig. 4a). The company managing this vessel was contacted, and they said that captain of the vessel denied fishing in the MPA but stated that the vessel was “dodging” bad weather and eventually drifted into the MPA which is allowed. Interestingly, the trawler which entered the MPA is not the one which reported having trawled up the acoustic releases; it is not even from the same company, suggesting that the former trawler may have displaced the mooring, or discarded it following its being trawled, and part of it was then subsequently trawled up by the other trawler outside the MPA.

A total of 11 demersal trawlers (based on their MMSI numbers) were found to cross the Child's Bank MPA boundaries between 15 and 21



Fig. 3. (a) Trawled up acoustic releases from the Aliwal Shoal MPA acoustic mooring; (b-e) all trawled up components of the Child's Bank MPA acoustic mooring showing (c) damage on mooring float, (d) scrapped and scratched acoustic releases, and (e) damages on acoustic recorder.

January 2024 when the acoustic mooring was deployed (Fig. 4c). On 21 January 2024, tracks of a demersal/bottom trawler (with two apparent fishing hours) passed right over the acoustic mooring deployment location (Fig. 4d) and “caught” our mooring. Tracks of another trawler are also visible going through the MPA on 21 January (Fig. 4d). The MMSI number of the vessel that fished over the acoustic mooring location on 21 January 2024 indicates that the fishing vessel belongs to the same fishing company that brought the mooring back to our possession. The fishing company denied that the vessel trawled within the MPA, but did state that they caught the mooring in the vicinity of Child's Bank MPA.

3.4. Temporal fishing trend around and within MPAs

Higher numbers of trawlers and higher apparent fishing hours were found within the more offshore Child's Bank MPA compared to the more

inshore Aliwal Shoal MPA (Supplementary Figure S1-S13). No demersal trawlers were found within the Aliwal Shoal MPA from January to July 2024. There is virtually no difference in apparent trawl fishing hours within Child's Bank MPA before the MPA declaration in 2018 and up to more than four years after the MPA declaration in 2019 (Supplementary Figure S7-S13), and a similar observation is seen for the Aliwal Shoal MPA (Supplementary Figure S1-S6). The 2020 lockdown due to coronavirus disease 2019 (COVID-19) in South Africa did not affect fishing off Child's Bank MPA since the fishing industry was given an exception to work during that period; indeed, there seems to be far more fishing effort in the MPA in 2020 than in other years (Supplementary Figure S7-S13). Vessel tracks in January and February 2022 in the Aliwal Shoal MPA occurred before the acoustic mooring was deployed (i.e. 7 February 2024) (Supplementary Figure S5). Based on the MMSI number of the vessel tracks in Supplementary Figure S1-S6, one particular vessel was fishing illegally within Aliwal Shoal MPA since 2018 to date, and

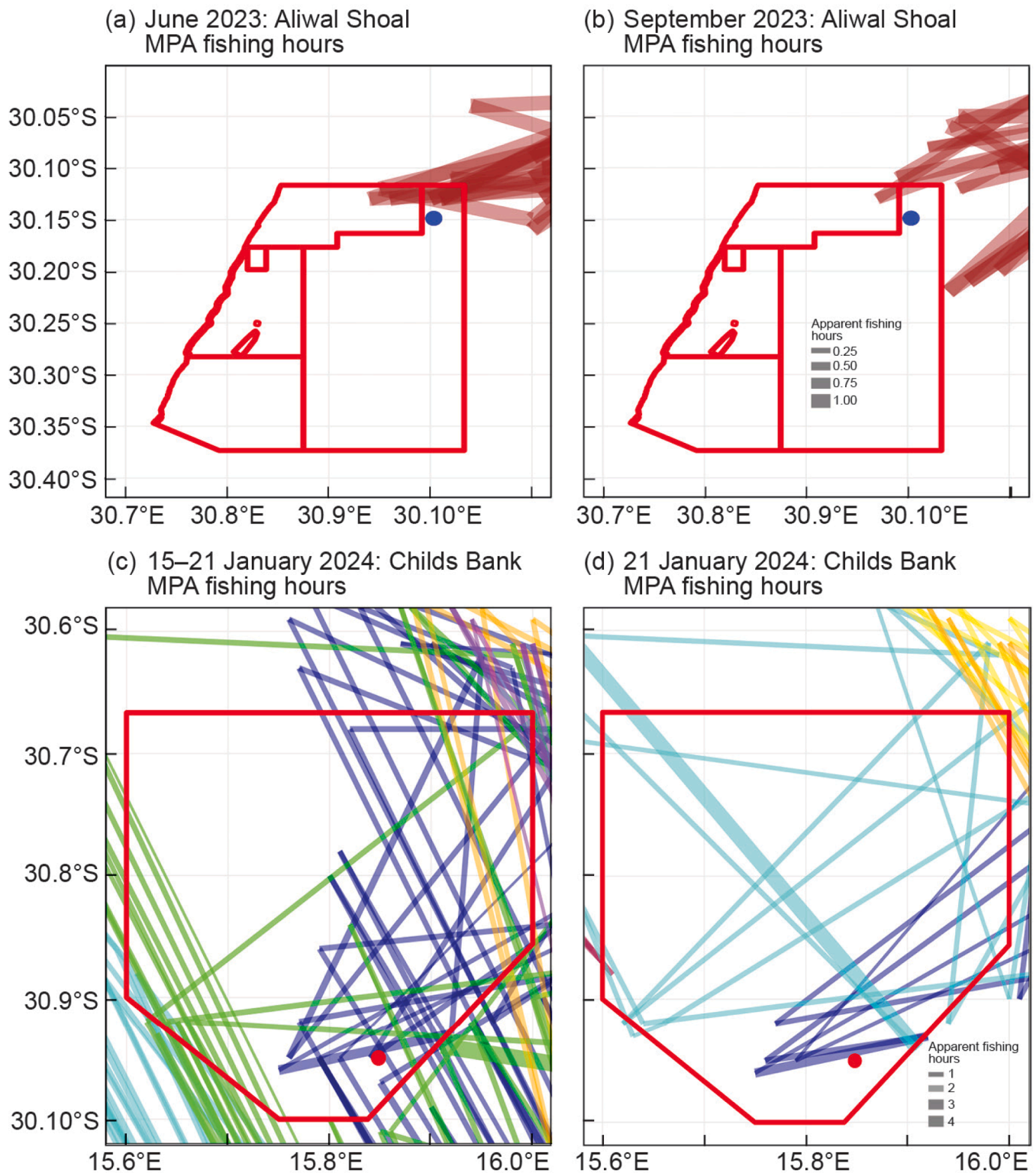


Fig. 4. Vessel tracks showing apparent fishing hours of a demersal trawler within Aliwal Shoal MPA boundaries (open red polygon) in (a) June 2023 and (b) September 2023, and (c) tracks of 11 demersal trawlers within Child's Bank MPA boundaries (open red hexagon) from 15 to 21 January 2024 and (d) tracks of five demersal trawlers on only 21 January 2024. Track colours represent individual fishing vessels based on MMSI numbers (that are omitted for confidentiality purposes). Blue and red circles represent the location of the acoustic mooring within each MPA. Width of vessel paths/tracks represents the amount of fishing hours as per keys. Only tracks of bottom trawlers are displayed here as these were more capable of retrieving the bottom acoustic mooring.

that is the same vessel that is likely to have trawled our acoustic mooring in June 2023.

4. Discussion

This study demonstrates that further protection and better management are needed for MPAs to be fully effective at fulfilling their aims and

planned uses within the South African EEZ. Furthermore, the untimely disruptions of data collection, scientific instrument loss and damage in multiple-use and controlled MPAs have negatively impacted the progress and success of our marine bioacoustics research important for the conservation and management strategies of marine mammals with wide-ranging distributions. Timelines set for fulfilling milestones of projects agreed with project funders and academic studies of students which are based on these data are also affected by these illegal activities as precious time is lost due to these disruptions in data collection. This kind of scientific instrument loss and damage is expensive to replace and repair (ca. ZAR 1 000 000, equivalent to ca. USD 55 000) because most of the scientific instruments used here were bought from overseas companies, and instruments were either not recovered or could not be reused. Moreover, funds used for preparing, deploying and at-sea attempts to retrieve moorings using costly research vessels were rendered fruitless by these illegal fishing activities. Nonetheless, these incidents provide indications of compromised effectiveness of MPAs to managing bodies, stakeholders, society, and policy and decision makers.

Vessel tracking data obtained from Global Fishing Watch further support that demersal trawling vessels fished illegally within restricted, exclusion zones of MPAs. However, this vessel tracking system is subject to limitations and caveats such as 1) vessel tracking data capture a small fraction of the fishing vessel fleet (records approximately 70 000 of the world's estimated 2.8 million fishing vessels); 2) some of the AIS and VMS messages are missed when the satellite is not overhead to receive AIS/VMS signals or when vessels are too far offshore for terrestrial receivers to detect signals depending on broadcast strength and frequency; 3) AIS/VMS signals from some vessels are missed when there is a high vessel density in an area due to signal interference; 4) skippers turning off or interfering with VMS signals (e.g. [González-Santana et al., 2023](#); [Paolo et al., 2024](#)). These limitations make it difficult for Global Fishing Watch's machine learning models to detect apparent fishing effort in certain parts of the world. The coarse temporal resolution of the VMS data of one signal every four or so hours for certain vessels means that some fishing activities may be missed during periods of no transmission. As a result, the presented trawling effort in Aliwal Shoal and Child's Bank MPA provides conservative indications of this activity in MPAs. On the other hand, penalties should be levied should it be determined that vessels are purposefully turning off their VMS while fishing as stated in fishing permit conditions. In this regard, in an unrelated incident, for the third time in South Africa, the State has prosecuted a vessel (under Regulation 75 of the Marine Living Resources Act and Section 49 A(1)(f) of the National Environmental Management Act) for fishing illegally within an MPA, which will set precedence for current and future transgressions ([DFFE Department of Forestry, Fisheries and the Environment, 2024](#)).

The conferring of only partial protection through permitting multiple-use zones in the Aliwal Shoal MPA has exposed the MPA to anthropogenic activities and rendered protection less effective when compared to MPAs with full protection in South Africa (e.g. [Kirkman et al., 2021](#)). This is also true for the far offshore Child's Bank MPA that is beyond land-based visibility range and there are limited resources to patrol those areas. Denial of fishing within MPAs by fishing companies that trawled up the acoustic mooring in Child's Bank and Aliwal Shoal MPAs is concerning and potentially indicates disregard of MPA regulations by some members of the fishing industry. This is further highlighted by the unchanging trawling trend in both MPAs before the MPA declaration and subsequent to expansion and declaration in 2019 ([Supplementary Figure S1–13](#)). It is concerning that illegal fishing is continuing to occur in these MPAs even after our acoustic moorings were trawled up, which necessitates urgent and strong management actions to stop illegal fishing. The management authority of the Aliwal Shoal MPA (Ezemvelo KwaZulu-Natal Wildlife), has been alerted of this transgression, but there has been no response to date. This transgression has now been reported to the Fisheries Management Branch of the Department of Forestry, Fisheries and the Environment for further

investigation and hopefully prosecution. The illegal fishing in Child's Bank MPA has been reported to management at the Oceans and Coasts Research and Fisheries Management Branches of the Department of Forestry, Fisheries and the Environment, and internal investigations are ongoing to penalize and curb these kinds of events from happening in the future.

Compliance by the offshore fishing industry with MPA regulations as set by Regulations for the Management of MPAs in terms of sections 48 A (2) and 86(1)(a), (b), (c) and (d) of the South African National Environmental Management: Protected Areas Act, 2003 (Act No. 57 of 2003), is expected even in the absence of patrolling, which is currently limited by compliance vessel budget cuts and other constraints. Instead, vessel compliance is monitored using satellite tracking (VMS), and thus it is gravely concerning that VMS data are not available from the Department of Forestry, Fisheries and the Environment for periods that correspond to the period of acoustic instrument damage/loss in Child's Bank and Aliwal Shoal MPAs. Robust backup plans should be devised by the Department of Forestry, Fisheries and the Environment to prevent future loss of these precious data.

Failure of acoustic releases for the Aliwal Shoal MPA acoustic mooring was initially conceived as a possible reason for components of the mooring to have ended up on the crustacean trawl ground, which is possible if the mooring was accidentally released and was swept northward by the inshore north-flowing Agulhas Counter-Current in this region ([Lutjeharms, 2009](#)). However, if this was the case, the float of the mooring would have allowed the mooring together with acoustic releases to drift with the fast Agulhas Current further away than to the nearby crustacean trawl ground; thus, this is an unlikely cause for the acoustic releases to have ended up in the crustacean trawl ground. Failure of acoustic releases for the Child's Bank MPA mooring is not a possibility since the whole mooring was still linked to the anchor weight after being trawled up ([Fig. 3b](#)). Similar acoustic releases to those used on the Aliwal Shoal MPA mooring were successfully used previously on other moorings to collect long-term (15 or so months) data off the west coast of South Africa in areas without bottom trawling at water depths greater than 850 m with strong ocean current (e.g. [Shabangu et al., 2019, 2020, 2022](#); [Letsheleha et al., 2022](#)), and also in shallow waters of ~165 m depth at the Prince Edward Islands MPA ([Shabangu et al., 2024a, b](#)). Thus, acoustic release issues are discounted as a possible cause of mooring loss or displacement given previous success with these instruments.

First descriptions of the acoustic seasonal occurrence of marine mammals ([Shabangu et al., 2019, 2020](#); [Shabangu et al., 2021](#); [Shabangu and Andrew, 2020](#); [Shabangu and Kowarski, 2022](#); [Letsheleha et al., 2022](#)), and the marine soundscape ([Shabangu et al., 2022](#)) off the west coast of South Africa, were provided using passive acoustic monitoring data collected from this kind of mooring deployment system. It is therefore important for this type of research to continue collaboratively with the cooperation of the fishing industry, policy makers, MPA managing bodies and other interested or involved stakeholders. Non-compliance with MPA regulations needs to be addressed with the understanding of the fishers' perspective of benefits, perceived conflicts, socio-economic impacts, political and ecological appropriateness, and use of conservation strategies of these MPAs ([Francolini et al., 2023](#); [Kirkman et al., 2023](#); [Field et al., 2025](#)).

Incidents reported here of scientific instrument loss and damage due to illegal fishing by two commercial demersal trawling vessels in MPAs are conceivably a small fraction of all cases of illegal fishing within MPAs in South African waters. Nonetheless, our observations provide novel evidence of illegal fishing in multiple-use and controlled MPAs, and can be used to improve the monitoring, patrolling, stakeholder engagement, negotiations, management and conservation strategies, and policies of different MPAs in South African waters. The apparent lack of MPA regulation compliance and consequences thereof raise concerns about the general effectiveness of MPA surveillance and enforcement (i.e. management), and ultimately the effectiveness of

these MPAs.

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CRedit authorship contribution statement

Malick Imtiyaz: Writing – review & editing, Project administration, Methodology, Funding acquisition. **Samaran Flore:** Writing – review & editing, Resources, Funding acquisition. **Fennesy Sean:** Writing – review & editing, Investigation. **Shabangu Fannie:** Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Hlathi Kuhle:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Branch Trevor:** Writing – review & editing, Writing – original draft, Investigation, Funding acquisition, Conceptualization. **Yemane Dawit:** Writing – review & editing, Visualization, Software, Formal analysis. **van den Berg Marcel:** Writing – review & editing, Methodology. **Everett Bernadine:** Writing – review & editing, Visualization, Software.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Fannie W. Shabangu, Kuhle Hlathi, Marcel van den Berg, and Dawit Yemane reports financial support was provided by Republic of South Africa Department of Forestry, Fisheries and the Environment; and statements made in this article do not represent those of the Department. Fannie W. Shabangu, Kuhle Hlathi, Marcel A. van den Berg, and Dawit Yemane reports a relationship with Republic of South Africa Department of Forestry, Fisheries and the Environment that includes: employment. Other authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.risma.2025.104141](https://doi.org/10.1016/j.risma.2025.104141).

Data availability

Global Fishing Watch vessel localities data is freely available from

<https://globalfishingwatch.org/our-apis/>.

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