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Optimization Of Fishing Efficiency And Sustainability With AIS And Echosounder Equipped Ring Seine Operated Along Ullal Coast Off Mangaluru

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Abstract
This study evaluated the catch composition and fuel efficiency of Ring Seine fishing using AIS (Automatic Identification System) and Echosounders at a depth of 12 meters off the Ullal coast, Mangaluru. Conducted fortnightly with an Outboard Motor Engine-fitted canoe, the research recorded total catches of 37,426.9 kg with AIS and 15,964.9 kg with Echosounders. The findings highlight AIS's superiority due to its real-time location tracking, enabling faster access to productive fishing grounds and reducing search time. Over 255 days, AIS achieved a catch efficiency of 14.44%, compared to 9.58% with Echosounders over 240 days. Additionally, AIS contributed to fuel conservation, lowering operational costs while boosting productivity. These insights emphasize the economic and environmental benefits of modern fishing technology, advocating for its broader adoption. By enhancing efficiency and sustainability, such innovations empower fishermen and support responsible resource management in the fisheries sector.

Keywords: *AIS, Catch, Echosounder, Fuel, Ring seine*

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I. Introduction

The Estimated Marine fish landing was 6.04 lakh tonnes and the Motorized crafts contributed 0.71 Million tonnes to the total landings of Karnataka[1]. Fishing Technologies have evolved to address the dual challenge of maximizing catch while ensuring Marine sustainability. Karnataka Coast is historically known as the 'Mackerel Coast' and has a coastal length of 320 km that consists of Three districts viz. Dakshina Kannada, Udupi and Uttar Kannada. Karnataka sustains the livelihoods of approximately 1.7 lakh fisherfolk living in 162 coastal fishing villages[6,8]. In India, especially along the South-West coast, two primary seining methods are popularly used for capturing pelagic finfish i.e. Purse seine and Ring seine. Purse seines are a form of surrounding net in which the bottom of the net is closed by a pursuing line after encircling the fish school to prevent their escapement whereas Ring seines, otherwise known as Mini Purse seine, are a group of lightly constructed Purse seines adapted for operation in the Traditional Motorized sector. Originally confined to the South-West coast, this fishing gear has gradually extended to the North-West coast, the East coast of India, and the Andaman and Nicobar Islands in recent years[15,5]. The Ring Seine was initially developed and introduced by the Central Institute of Fisheries Technology (CIFT) as an innovative gear for traditional fishing vessels[4].

The productivity of fishing gear is influenced by its design and the physical properties of the materials used in its construction. Structural elements like the mesh can vary in chemical composition and specific gravity. Furthermore, the gear's behavior and overall performance can be influenced by factors such as mesh size, yarn thickness, and the volume of floats and ballast weights, which contribute to positive and negative buoyancy in different sections of the net[7]. Ring seine operations often rely on Outboard Engines that typically range from 10 to 40 Horse power. The speed and agility provided by Outboard Engines are essential for these operations, as they enable fishermen to react swiftly to the movements of fish schools. Besides, Outboard Engines are relatively easy to maintain and repair. The combination of the Ring seine and an Outboard Engine facilitates the rapid and efficient capture of large schools of pelagic fish. Ring seine operations, widely used for capturing pelagic species like Anchovies, Sardines, Mackerels and Shrimps have seen the integration of Technologies like AIS and Echosounders. AIS provides real-time vessel tracking and facilitates communication among vessels, whereas Echosounders locate fish shoals using Acoustic signals. This study compares the performance of these two Technologies to evaluate their impact on fishing operations along the Ullal coast.

II. Materials And Methods

Study area

The study was conducted along the Ullal coast near Mangaluru in Karnataka's Dakshina Kannada District. This location was selected due to its significance as a key hub for Ring Seine fishing in the state, featuring vessels with varying engine capacities. During the study period, the area experienced high fishing activity, making it ideal for research. Fishing operations took place between Station 1 (Lat. 12° 47.500' N, Long. 074° 49.000' E) and Station 2 (Lat. 12° 49.500' N, Long. 074° 46.000' E) at a depth of 12 meters (Figure 1). The depth of the fishing ground was assessed using an Echosounder, a hand lead line, and a GPS device installed on the canoe.

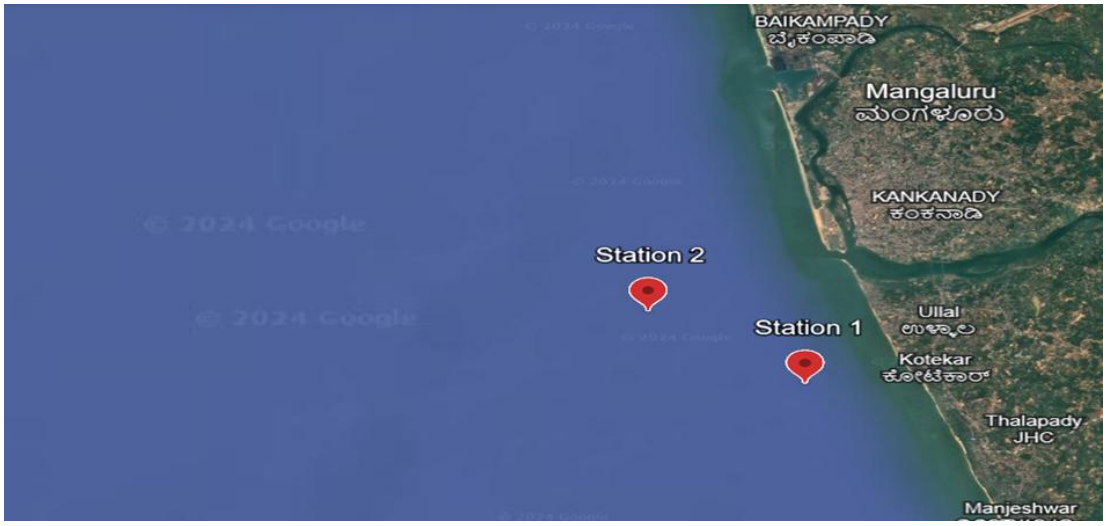

Fig. 1. Locations of fishing ground at the Ullal coast off Mangaluru

Ring seine fishing gear and vessel

Fishing operations were conducted using a 468-meter-long Ring Seine. Throughout the study, data were collected on the head rope and foot rope lengths, the number of meshes in each section, their dimensions, mesh sizes in different parts of the net, materials used, and details regarding floats, sinkers, and rings. Figure 2 illustrates the design of a standard Ring Seine used in the research area. The experimental fishing was performed using privately owned Ring Seiners, with a physical survey conducted to measure the key structural components of the fishing craft. These operations took place along the Ullal coast near Mangaluru, Karnataka.

Fig. 2. Ring seine rigged with floats and sinkers

Fig.3. Automatic identification System (AIS)

Catch analysis

The Species composition of Ring seine landings along the Ullal coast off Mangaluru was studied for both Echosounder and AIS equipped vessel (Figure 3). The samples were collected and the information on the catch by species, Fishing area, and overall catch was recorded and compared. Following each operation, the acquired catch data was separated into different groups. The most prevalent fish species were, Shrimps, Prawns Sardines and Anchovies, followed by Seer fish, white Pomfret, Needle fish and Lesser Sardines, were captured in smaller quantities (Figure 4). The total weights of the several fish groups were recorded individually.

Fig. 4 Species caught in the Ring seine during the study period

Voyage and fuel consumption

The study was conducted for a period of 9 months with 18 fishing voyages. Two experimental setups were employed: one vessel equipped with AIS and another with an Echosounder. The duration of a fishing trip refers to the number of days a vessel spends between consecutive trips. This includes time spent traveling to the fishing grounds, actual fishing activities, waiting at the grounds, returning to the harbour, unloading the catch and any delays caused by adverse weather conditions. Data on fuel consumption and operational efficiency were recorded.

To evaluate the Technological advancements represented by the Echosounder and AIS, an independent t-test was performed. This statistical analysis aimed to identify any significant differences in performance while operating at a depth of 12 meters during the study period and highlighted the Echosounder and AIS for optimization of Acoustic devices for the Fishing crafts and Gear used along the Ullal coast off Mangaluru region.

III. Results And Discusssion

Fishing gear

The study utilized a Ring seine net measuring 468 meters in length and 65 meters in depth. It was constructed from 26 vertical sections of polyamide knotless webbing with a mesh size of 18 mm. [5]observed Mini Purse seines ranging from 300 to 500 meters in length and 30 to 60 meters in depth in the Ernakulum and Alleppey regions of Kerala. According to[7], Mini Purse seines used in Ratnagiri were constructed from 25 to 32 rectangular sections. [7]observed that these nets were mainly operated at depths of less than 25 meters along the Ratnagiri coast.

Fishing operation and Voyage

In the current study, Ring seine operations lasted between 6 to 8 hours per trip, with nets being deployed to a depth of up to 12 meters. The primary fishing vessel had a crew of eighteen, while the carrier vessels had six to seven crew members each. [11]reported crew sizes of 20 to 25 for Mini Purse seine fishing, with only two to three people on the carrier boat. The three boats communicated their location and deployed their nets by shooting them with the bunt positioned between the boats, thereby encircling the fish shoal. The purse line was then hauled to close the bottom of the net. Both wings of the net were pulled simultaneously onto the boat, and the concentrated fish in the bunt were transferred to a third vessel using a scoop net, after which they were brought to shore. At Ratnagiri, [7]reported that instead of using a skiff, a master float was used to secure one end of the net while encircling the shoal. Once a shoal was located, the vessel immediately surrounded it by deploying the net, and the purse line was hauled to close the bottom with the help of an auxiliary engine. The catch was then hauled up and transferred to the carrier vessel for disposal. [2]described a similar process, in which the crew (30-35 members) split into two groups to pull each end of the purse line, thereby closing the bottom of the net and preventing the fish from escaping. This procedure, as reported by[2] is consistent with the method used in the present study.

In the present study, 45.45% of the total time was spent traveling to the fishing ground and searching for fish shoals. Returning from the fishing ground to the landing centre took up 30.3% of the time, while purse ring hauling and net hauling accounted for 15.15% of the total time. The process of encircling the shoal required only 5 to 6 minutes. Additional time was occasionally spent dodging at sea due to issues such as equipment malfunctions or staying at the shore during unfavourable weather conditions. These observations are consistent with studies conducted in other regions. For example, [14]highlighted that weather and sea conditions significantly impact fishing efficiency, with reduced fishing days during unfavourable seasons. Similarly, [9]discussed how the availability of target species and weather conditions affect the frequency and success rate of Purse seine trips.

Catch composition

The total catch and the percentage composition of different fish species caught using the Ring seine net equipped with Echosounder and AIS are detailed in Table 1 and Figure 4. According to the data, the species recorded include *Metapenaeus monoceros*, *Metapenaeus ensis*, *Litopenaeus setiferus*, *Fenneropenaeus indicus*, *Lactarius lactarius*, *Escualosa thoracata*, *Rastrelliger kanagurta*, *Pampus argenteus*, *Thryssa setirostris*, *Stolephorus waitei*, *Strongylura leiura*, *Sphyraena obtusata*, and other miscellaneous groups. Along Ullal coast, off Mangaluru, *Metapenaeus monoceros* dominated the catch, making up 40.99% of the total haul. This was followed by *Thryssa setirostris* contributing 21.73%, and *Litopenaeus setiferus*, which accounted for 15.69%. Noteworthy catches also included *Lactarius lactarius* at 6.17%, *Metapenaeus ensis* at 4.45%, *Esculosa thoracata* at 4.30%. Additionally, *Fenneropenaeus indicus* accounted for 4.21% of the total catch during the study period. Among the species, *Metapenaeus monoceros* and *Thryssa setirostris* were captured in the largest quantities. *Metapenaeus monoceros* alone contributed 40.99% of the overall catch, with a total weight of 53391.4 kg. In contrast, only 103.2 kg of *Sphyraena obtusata* were caught throughout the study period. *Thryssa setirostris* ranked second in abundance, representing 21.73% of the total catch.

Shrimp represented 61.15% of the overall landings, with *Metapenaeus monoceros* contributing the largest share at 40.99%, followed by *Litopenaeus setiferus* at 15.69% and *Metapenaeus ensis* at 4.45 %. Specifically, *Metapenaeus monoceros* recorded a total catch of 21890 Kg, making it the most plentiful Shrimp species. *Litopenaeus setiferus* yielded43 15.69 Kg, while *Metapenaeus ensis* had a total of 2380.65 Kg. The rest of the catch comprised various fish species, including *Escualosa thoracata* (4.30%), *Fenneropenaeus indicus* (4.21%), *Stolephorus waitei* (0.59%), *Strongylura leiura* (0.48%), *Rastrelliger kanagurta* (0.24%), *Pampus argenteus* (0.24%), and *Sphyraena obtusata* (0.19%). Additionally, a miscellaneous catch made up 0.65% and included rays, squid, small shark, and other species, as shown in Table 1.

In this study, the total catch was highest for AIS-equipped Ring seine operations along the Ullal coast during the months of June, July, and August. The lowest catch was recorded in December and January, contributing only 4.54% of the total catch (Figure 6). By comparison, Mohanraj *et al.* (2011) found that in Puducherry, the maximum catch occurred in April, followed by May and September. These results provide insight into the composition and distribution of fish species captured by the Ring seine, which is essential for understanding the dynamics of the local Marine ecosystem. The dominance of *Metapenaeus monoceros* in the

catches indicates that it was a key target species for fishermen during this period, underscoring its economic importance in the region (Table 1).

The average daily catch from AIS equipped Ring seine operations peaked in August, reaching 10,480.5 kg, followed by July with 8,352 kg, and June with 6,995.5 kg which was less compared to the average daily catch from Echosounder equipped Ring seine operations (Table 3, Figure 5 and 6). [2]also reported that during Mini Purse seine operations, the average daily catch was highest between June and August, ranging from 1,836 to 2,452 kg per day. This was followed by September and May, which saw average catches of 1,224 to 1,420 kg per day, and October to December, with catches between 595 and 990 kg per day. The lowest catch rates were recorded between December and April, with catches ranging from 88 to 1000 kg per day (as shown in Table 2 and 3).

Ring seine operations yielded the highest catches during the monsoon months of June to August, likely due to increased fishing activity and availability during this season. The catch rates declined significantly in April, likely due to seasonal variations in fish abundance (Table 2 and 3). These observations are consistent with the findings of[2], who also reported a similar pattern in catch rates for Mini Purse seine operations, with higher catches during the monsoon months and lower catches during the post-monsoon and pre-monsoon periods. This seasonal variation in fish availability may be influenced by various environmental factors such as water temperature, nutrient availability, and fish migration patterns, which affect the overall fishery productivity along the coast.

Overall, the study provides valuable insights into the catch composition and fishing operations along the Ullal coasts off Mangaluru, demonstrating the importance of continued monitoring and sustainable practices in maintaining the health and productivity of the fisheries industry.

Table no 1: Catch and percentage composition of various species obtained using Echosounder and AIS in Ring seine fishing operations during the study period along the Ullal coast off Mangaluru

SI NO.	Species	Total catch (kg)	Percentage composition (%)
1	*Metapenaeus monoceros*	21890	40.99
2	*Metapenaeus ensis*	2380.65	4.45
3	*Litopenaeus setiferus*	8380	15.69
4	*Fenneropenaeus indicus*	2250.5	4.21
5	*Lactarius lactarius*	3296.25	6.17
6	*Escualosa thoracata*	2300	4.30
7	*Thryssa setirostris*	11602.1	21.73
8	*Stolephorus waitei*	320	0.59
9	*Strongylura leiura*	258	0.48
10	*Rastrelliger kanagurta*	131.5	0.24
11	*Pampus argenteus*	129.25	0.24
12	*Sphyraena obtusata*	103.2	0.19
13	Miscellaneous	350	0.65
	Total	53391.4	100

Table no 2: Catch and percentage composition obtained using Echosounder in Ring seine

Days	**Depth (m)**	**Total catch (kg)**	**Percentage composition (%)**
0	12	88	0.55
15	12	125	0.78
30	12	246	1.5
45	12	640	4
60	12	690	4.32
75	12	849.5	5.32
90	12	700	4.38
105	12	950.5	5.95
120	12	725	4.54
135	12	650	4.07
150	12	990	6.2
165	12	638.5	3.9
180	12	739.4	4.63
195	12	642	4.02
210	12	1900	11.90
225	12	2645	16.56
240	12	1531	9.58
255	12	1215	7.61
	Total	15964.9	100

Table no 3: Catch and percentage composition obtained using AIS in Ring seine

Days	**Depth (m)**	**Total catch (kg)**	**Percentage composition (%)**

0	12	114	0.3
15	12	184	0.49
30	12	351	0.93
45	12	680	1.81
60	12	780	2.08
75	12	2284	6.1
90	12	800	2.13
105	12	980	2.61
120	12	855.5	2.28
135	12	985	2.63
150	12	1350	3.6
165	12	2235	5.97
180	12	3455.5	9.23
195	12	3540	9.45
210	12	4452	11.89
225	12	3900	10.42
240	12	4950.5	13.22
255	12	5530	14.77
	Total	37426.5	100

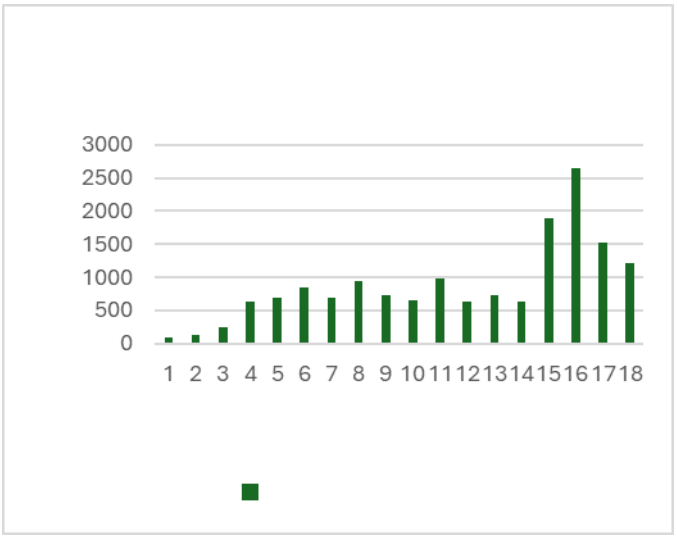

Fig. 5. Catch obtained using Echosounder in Ring seine during Fishing operations along the Ullal coast off Mangaluru

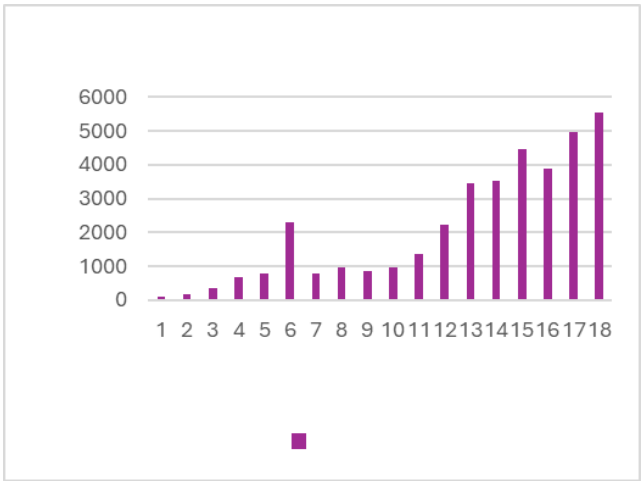

Fig. 6. Catch obtained using AIS in Ring seine during Fishing operations along the Ullal coast off Mangaluru

Fuel efficiency

In the current study, a 40 HP Outboard Engine was installed on an FRP (fibre-reinforced plastic) canoe used along the Ullal coast off Mangaluru. The AIS-equipped vessel consumed 13 liters per hour, compared to 20 liters per hour for the Echosounder-equipped vessel (Table 4 and 5). This reduced consumption is attributed to

AIS's real-time tracking capabilities, minimizing the time and distance required to locate fish shoals. It was observed that fuel consumption was lower in the AIS-equipped vessels compared to those using only an Echosounder (Table 4 and 5). The ability to receive this information allows fishermen to locate areas with higher fish density and adjust their operations, accordingly, leading to increased efficiency and catch. [11]similarly noted that technology-assisted operations, such as those using electronic tracking and navigation aids, tend to have a better catch success rate compared to traditional methods.

[7]highlighted that Mini Purse seines were operated by small-scale fishermen using FRP fishing crafts equipped with Outboard Motors (OBM). [2]described a Mini Purse seine propelled by a 25 horsepower Yamaha OBM, which started on petrol and then switched to kerosene with a running speed of about 1500 rpm. Studies have suggested that using AIS can enhance overall vessel performance, including fuel consumption. [2]also highlighted the importance of advanced technologies in improving fishing efficiency, particularly in Ring seine and Mini Purse seine operations.

For a one-hour FRP canoe Ring seine operation fitted with AIS, the OBM used 0.05 Liters of Petrol and 12.6 Liters of Kerosene. [10]reported fuel consumption for one-hour OBM operations as 7 Liters of Petrol and 12 Liters of Kerosene, stating that the current study's fuel usage was more cost-effective due to the utilisation of AIS technology. High speed is crucial for reaching the fishing grounds and returning to port quickly, ensuring the catch remains fresh. [17]noted that Outboard Motors are advantageous due to their high speed and ease of installation. [16]reported that the traditional fishing sector has been rapidly adopting motorization, with Outboard Engines ranging from 8 HP to 40 HP being widely used.

Using an Outboard Engine while considering all these factors can improve fishing efficiency. As fuel consumption is a major cost in various fishing methods, careful consideration is required for engine selection. [17]reported that Outboard Motors, with their small propeller sizes, often require more power to achieve high speeds, restricting smaller motors from venturing too far for safety reasons. Therefore, alternative propulsion systems that offer better fuel efficiency and lower maintenance costs are needed.

The independent t-test confirmed a significant difference ($p < 0.05$) in both catch composition and fuel consumption between the two technologies. These findings highlight AIS's superiority in optimizing fishing operations.

Table no 7: Average fuel consumption of a 40 HP Outboard engine fitted with Echosounder used during fishing operations along the Ullal coast off Mangaluru

Fuel	Fuel consumption liters/hour	Fuel consumption liters/trip
Petrol	0.05	0.25
Kerosene	14.4	72

Table no 8: Average fuel consumption of a 40 HP outboard engine fitted with AIS used during fishing operations along the Ullal coast off Mangaluru

Fuel	Fuel consumption liters/hour	Fuel consumption liters/trip
Petrol	0.05	0.15
Kerosene	12.6	63

Economic viability

In the current system, income distribution among the crew is based on a share system, which takes place after deducting operational costs, such as fuel expenses. Another notable cost includes hiring vehicles to transport crew members between their village and the harbour where fishing operations begin. According to[14], the share system used by small-scale fishing communities ensures income distribution that takes operational expenses into account. The catch that is landed is auctioned at harbours or landing centers by auctioneers. Once the auction is completed, approximately 7% of the auction proceeds are allocated to different fees. These include the auctioneer's commission, contributions to the cooperative society, and the share of the apex cooperative organization. Additionally, a portion is deducted as a beneficiary share that contributes to a fund, which is distributed annually to member fisher groups through the cooperative society. Economic analyses, such as those by[14], have highlighted the importance of Ring seine fishing in enhancing the income levels of small-scale fishers. This system of credit, income-sharing, and collective responsibility contributes to the socio-economic resilience of small-scale fishers relying on Ring seine operations.

The economic structure of Ring seine operations is heavily influenced by the seasonality of fishing activities. The seasonal availability of labour, particularly during the monsoon when mechanized fishing activities are paused, has also been highlighted by[12]. The number of labourers employed within the Ring seine operations changes daily and often increases during the monsoon season. During this period, workers from Mechanized Trawlers, who are temporarily without work due to the rough sea conditions, may migrate to this sector in search of employment. [3]noted that the Ring seine sector requires more labor compared to other fishing vessels in the traditional sector.

[13]analyzed the economic sustainability of traditional fishing operations in Kerala's backwaters and found that Ring nets had the highest percentage of net return on investment among fishing units. According to[10], the production cost of a 65-foot plank-built Ring seiner equipped with an Outboard Motor (OBM) unit was approximately 8.62 lakhs, while the same vessel fitted with an Inboard Motor (IBM) unit cost around 11.40 lakhs. With the catch composition being analyzed between Ring seine operations using AIS and Echosounders, the results indicate that the 46-foot Ring seine vessel equipped with AIS and powered by a 40 HP engine proved to be more economical. This setup may potentially benefit the traditional fishing community by improving their overall livelihood through more efficient fishing practices.

IV. Conclusion

In this study, the AIS device not only led to a larger catch but also reduced operational costs by cutting down on fuel consumption. This makes it a highly effective tool for enhancing both the sustainability and profitability of fishing activities. Observing these results, the use of AIS in Ring seine operations can be recommended, as it offers clear advantages in terms of catch volume, fuel efficiency, and overall economic viability for local fishing communities.

The authors declare that they have no conflicts of interest.

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