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Studies on the Impact of Ring Seiner Equipped with AIS Transponder Operated Along the Ullal Coast off Mangaluru

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ABSTRACT

The present study was conducted over a period of nine months from December, 2023 to August, 2024 along the Ullal coast off Mangaluru, Karnataka, to assess the role of Automatic Identification System (AIS) technology in enhancing the efficiency and sustainability of Ring seine fishing. The study focused on species composition, fuel efficiency, and operational performance. A 468-meter-long Ring seine net, operated with a 40 HP outboard engine, was deployed fortnightly at a depth of 12 meters, resulting in a total catch of 37,426.9 kg. The highest catches were recorded during the monsoon months (June to August), with a peak catch of 5,530 kg on the 255th day. The integration of AIS technology significantly improved fishing precision by enabling the fishers to locate the fish shoals quickly, thereby optimizing the fuel use and reducing unproductive efforts. Statistical analysis confirmed that the AIS-assisted operations yielded significantly higher catch rates and better fuel efficiency ($p < 0.05$) compared to the traditional methods. Economically, the AIS-supported system reduced operational costs and ensured equitable income distribution among the crew members through a share system. Additionally, AIS contributed to sustainable fishing by enhancing target species selectivity and minimizing bycatch. The study concluded that the adoption of AIS technology in Ring seine fishing improved productivity and cost-efficiency, while supporting small-scale fishers' livelihoods and promoting responsible marine resource management.

KEYWORDS: Ring seine, AIS, fuel efficiency, catch, sustainable fishing

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1. INTRODUCTION

The Marine fisheries sector in India has grown exponentially in both quantity wise and quality wise during the previous five decades. In 2022, the country recorded a total Marine capture production of 3.49 mt, supported by a fleet of 1,66,333 fishing vessels. By 2023, this figure had raised to 3.53 mt, reflecting a 1.2% increase compared to the previous year (Anonymous, 2023). In Karnataka alone, Marine fish landings were estimated at 6.04 Lakh Tonnes, with Motorized boats contributing around 0.71 mt to the state's total catch (Anonymous, 2023). 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 supports livelihood of 1.7 lakh fisherfolk population residing in 162 Marine fishing villages (HoFS, 2020; Kuriakose and Paul, 2017). In 2022, the average annual fish catch from seines in India is approximately 0.77 Million Tonnes, constituting approximately 22% of the Nation's total Marine fish landings. This includes catches from Purse seines (8%), Mechanised Ring seines (5%) and Outboard Ring seines (3.8%). There are about 1,189 Purse seiners and 943 Mechanised Ring seiners in operation in the country, out of which 50% of the Purse seiners are operating along the coast of Karnataka (Anonymous, 2023 Annual Report).

The Ring seine, often termed as "Mini Purse seine", which is a group of lightly constructed Purse seines adapted for operation in the Traditional motorized sector. Ring seines are similar to Purse seines but are typically smaller and operated manually or with small-scale mechanization. The net is designed to encircle a school of fish, and a Purse line is then drawn to close the bottom, trapping the fish inside. It was first designed and introduced by the Central Institute of Fisheries Technology (CIFT) as a new gear for Traditional fishing vessels (Edwin and Das, 2015) and has evolved as a preferred gear for shoaling pelagic resources like Anchovies, Sardines, Mackerels and Shrimps. Prior to the introduction of the Ring seine, the Traditional fishing sector primarily relied on less efficient and labour-intensive fishing methods. Ring seines are used mostly in Mid-water and Nearshore areas, causing minimal disturbance to seafloor habitats. However, in shallow waters, the net might touch the bottom and disturb the seabed. The targeted design of Ring seines helps avoid catching non-target species or juveniles, contributing to sustainable fishing and conserving Marine Ecosystems. Ring seine fishing often uses Outboard Engines with a power range of 10 to 40 HP because they provide the right balance of power and fuel efficiency, making it easy to move the boat and net quickly with speed being essential for encircling fish schools effectively. The Traditional fishery sector in the country has experienced considerable Structural and Technological changes over the last three to four decades (Vijayakumaran and Chittibabu, 2005).

This study focused on the application of AIS Technology which was initially developed for Vessel Traffic Safety, in enhancing fishing operations. The installation of AIS equipment on ships allows Navigators to obtain additional data about other vessels in the vicinity (Stupak, 2014). The integration of AIS with Ring seiners potentially addresses issues like fuel optimization, fishing efficiency, and species selectivity. The AIS plays a crucial role in evaluating fishing pressure within specific fishing areas (Russo et al., 2020) and in understanding the operational patterns of fishing vessels (Yan et al., 2022; James et al., 2018). As a result, it has become an essential tool for managing fisheries resources, regulating fishing activities, and safeguarding marine ecosystems. One of the first published feasibility studies on Satellite-based AIS (S-AIS) capabilities, promising long-range tracking, was conducted by the Norwegian Defence Research Establishment (FFI) (Hoye, 2004; Eriksen et al., 2006). Nowadays, many countries mandate the use of AIS for safety and cost reduction, creating opportunities for better fisheries management and enforcement. Thus the study was conducted to investigate on metrics viz., species composition, economic viability, and operational efficiency.

2. MATERIALS AND METHODS

2.1. Study area and sampling

The experiment was conducted during the month of December, 2023 to August, 2024 at the Ullal coast off Mangaluru region (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 m (Figure 1) as it is one of the most important Ring seine activity comparisons in the state, with variable HP Engines of Ring seine. The nine-month study involved fortnightly sampling aboard a 40 HP Outboard Engine equipped Ring seiner for catching the

Figure 1: Locations of fishing ground at the Ullal coast off Mangaluru

fishes. During the study period, the fishing area was known for its high efficiency. The depth of the fishing ground was evaluated with an Echosounder, a hand lead line, and a Global Positioning System (GPS).

2.2. Ring seine fishing gear and vessel

Fishing operations were conducted using a 468-meter-long Ring seine with a mesh size of 20 mm in the main body. Measurements were taken for the head rope and foot rope during the survey. Details such as the number of meshes in each section, their dimensions, mesh sizes, and materials were documented. Information about accessories like Floats, Sinkers, and Rings was also gathered. The Experimental fishing was carried out along the Ullal coast in Karnataka, off Mangaluru, using privately owned Ring seiners. These fishing boats went through a physical survey, where key structural components were carefully measured and recorded for the study.

2.3. Technology overview

The AIS system was integrated to enhance real-time tracking and selective fishing. After knowing the results of the AIS, technological impacts of the Outboard Engine were recorded for operating Ring seine in future course of study. Catch data were analyzed post-operation to identify dominant species and compare fuel consumption. 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, which were captured in smaller quantities. The total weights of the several fish groups were recorded individually.

2.4. Voyage and fuel consumption

The duration of a fishing trip includes the total time spent from the start of one trip to the next. This covered traveling to the fishing grounds, fishing activities, waiting at the site, returning to the harbor, unloading the catch, and delays due to bad weather. All these aspects were carefully recorded and analyzed. Fuel usage trip^{-1} was calculated by combining the fuel consumed during voyage to and from the fishing grounds with the amount used while fishing. Additional data, such as fuel consumption, fishing time, and sailing duration, were also collected during the operations.

2.5. Statistical analysis

The study aimed to evaluate the effectiveness of Ring seine fishing gear when equipped with an acoustic device on a 40 HP Outboard Engine. An independent t-test was used to know the significant difference with the AIS Ring seiner system in operational efficiency and catch rates.

3. RESULTS AND DISCUSSION

The Ring seine was an important fishing gear for the artisanal fishermen of the South-West coast of India and was primarily used to catch species such as Sardines, Mackerel, Anchovies, and Shrimp. According to Jadhav et al. (2011), the Mini Purse seine operated on the fundamental principle of encircling schools of fish. It was popular during both the Monsoon and Post-monsoon seasons, as it was especially effective in capturing the target species along the Karnataka coast. Sukumaran et al. (1988) reported that the Mini Purse seine (Matubale) was first introduced along the Mangaluru coast during the monsoon of 1984, and subsequent improvements in later seasons resulted in higher landings during that period. The primary contributors to the Ring seine fishery in the Dakshina Kannada and Udupi districts were the Mangaluru and Malpe Fisheries Harbours, respectively (Kuriakose, 2017). It addressed one of the main challenges fishermen faced-how to continue fishing during the monsoon season when traditional mechanized fishing was not feasible. The increased use of Ring seines allowed for uninterrupted fishing activities, which in turn supported the livelihoods of the fishing community by ensuring a steady income even during the monsoon.

In Karnataka, the Ring seine was locally known as "Rani Bale". The design and construction of the Ring seine net were influenced by several factors, making it highly versatile. These factors included the method of operation, the way the gear was handled, the depth at which it was deployed, the characteristics of the vessel, and the target species. Studies, such as those by Boopendranath and Hameed (2012), highlighted the resilience of Mini Purse seine operations during tough sea conditions, further supporting its widespread use in the region. These factors determined variations in net size, mesh size, material used, and other constructional aspects, ensuring that the Ring seine was appropriately tailored to the specific requirements of different fishing conditions. Kerala's marine fishing sector had undergone significant transformation as a result of technological changes in the design and type of fishing vessels, gear, and methods of fishing (Anonymous, 2022).

3.1. Ring seine and its operation

The study was carried out by using a Ring seine net measuring 468 meters in length. It was constructed from 26 vertical sections of polyamide knotless webbing with a mesh size of 20 mm in the main body. Edwin and Hridayanathan (2004) observed Mini Purse seines ranging from 300 to 500 m in length and 30 to 60 m in depth in the Ernakulum and Alleppey regions of Kerala. According to Jadhav et al. (2011), Mini Purse seines used in Ratnagiri were constructed from 25 to 32 rectangular sections. Similarly, Rajeswari et al. (2013) reported large-mesh Mini Purse seines of around 60 m in depth along the North Andhra Pradesh coast.

In the present study, Ring seine operations lasted between 6 to 8 hours trip^{-1}, with nets deployed to a depth of up to 12 m. Jadhav et al. (2011) observed that these nets were mainly operated at depths of less than 25 m along the Ratnagiri coast. Sukumaran et al. (1988) noted that hauls along the Mangaluru coast took between half an hour to one hour, with operations limited to near-shore areas with a depth of 10 m. However, Sivadas and Balasubramaniam (1989) found that Mini Purse seines were used up to a depth of 45 m. In this study, one boat was used for the Ring seine operation along with two carrier crafts for bringing the catch to shore. These carriers played a crucial role in the overall fishing operation by assisting in the transportation of the catch from the fishing grounds back to shore. Eighteen crew members operated the seine on the main vessel, while six crew members operated each of the two carrier crafts. According to Jadhav et al. (2011), Mini Purse seines at the Ratnagiri coast were operated by 8 to 12 crew members. Mohanraj et al. (2011) reported crew sizes of 20 to 25 for Mini Purse seine fishing, with only two to three people on the carrier boat. Boopendranath and Hameed (2012) documented Mini Purse seine operations involving 30–35 fishermen and 5–8 fishermen 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. A master float was used to hold one end of the net while encircling. 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, Jadhav et al. (2011) 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. Boopendranath and Hameed (2012) 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 Boopendranath and Hameed, was consistent with the method used in the present study. The primary vessel was equipped with Automatic Identification Systems (AIS).

3.2. Catch composition

AIS-enhanced operations yielded a diverse species composition, dominated by pelagic fishes like Sardines and Mackerel, alongside smaller catches of Shrimps and Anchovies. According to the data, the species recorded included *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. The system demonstrated better selectivity and reduced bycatch compared to conventional methods. 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 the months of December and January, contributing only 4.54% of the total catch. By comparison, Mohanraj et al. (2011) found that in Puducherry, the maximum catch occurred in April, followed by May and September. In the present investigation, 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 (Table 1). Boopendranath and Hameed (2012) 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 day^{-1}. This was followed by September and May, which saw average catches of 1,224 to 1,420 kg day^{-1}, and October to December, with catches between 595 and 990 kg day^{-1}. AIS data were pivotal in accurately

Table 1: Catch and percentage composition obtained using AIS in Ring seine during fishing operations along the Ullal coast off Mangaluru

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

characterizing fishing efforts by tracking vessel movement and fishing activities in real-time. Several studies in the past had explored the use of AIS technology to locate fishing grounds and monitor fishing activities (Natale et al., 2015; Guard, 2017; Fiorini et al., 2016; Russo et al., 2016; Vespe et al., 2016; Shepperson et al., 2018; Thoya et al., 2021). The lowest catch rates were recorded between December and April, with catches ranging from 88 to 1,000 kg day^{-1}. Among the species, *Metapenaeus monoceros* and *Thryssa setirostris* were captured in the largest quantities. The dominance of *Metapenaeus monoceros* in the catches indicated that it was a key target species for fishermen during this period, underscoring its economic importance in the region.

These results provided insight into the composition and distribution of catches, as Ring seine operations yielded the highest catches during the monsoon months of June to August, likely due to increased fish activity and availability during that season. The catch rates declined significantly in April, possibly due to seasonal variations in fish abundance (Figure 2). These observations were consistent with the findings of Boopendranath and Hameed (2012), 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 was likely influenced by various environmental factors such as water temperature, nutrient availability, and fish migration patterns, all of which affected the overall fishery productivity along the coast.

3.3. Operational cycle of ring seine fishing trips

In this study, a total of 18 fishing trips were conducted, with the highest number occurring in August and the fewest in February. According to Sathiadas et al. (1993), during 1991 to 1992, the average annual number of fishing trips for Mini Purse seine units was 178 in Puthiangadi (Calicut region) and 209 in Punnapra (Alappuzha region), with the highest number of trips recorded in April. Boopendranath and Hameed (2012) reported that the average number of fishing days per year for Mini Purse seine operations off Cochin, Kerala, was 171. This duration varied based on factors like the fishing ground's location, weather conditions, and fish availability. The fishing trip cycle included traveling to the fishing ground, actively fishing, waiting at the fishing ground, returning to the harbour, and the time spent at the harbour for unloading the catch, along with delays caused by adverse weather conditions (Figure 1).

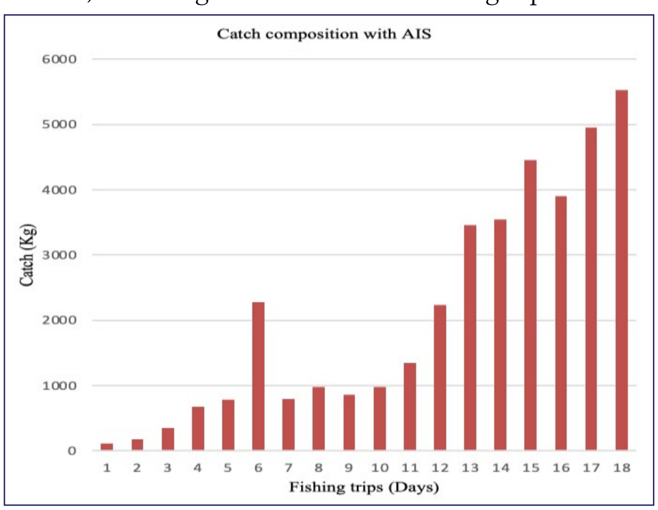

Figure 2: Catch composition obtained using AIS in Ring seine during fishing operations along the Ullal coast off Mangaluru

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 were consistent with studies conducted in other regions. For example, Sathianandan et al. (2006) highlighted that weather and sea conditions significantly impacted fishing efficiency, with reduced fishing days during unfavourable seasons. Similarly, Kurian et al. (1962) discussed how the availability of target species and weather conditions affected the frequency and success rate of Purse seine trips. Overall, the present study supported the notion that effective management of time and resources was crucial in ensuring successful fishing operations and achieving optimal yields.

The results of the independent t-test were utilized to assess the catch of the Ring seine operated with a 40 HP Outboard Engine, with the vessels fitted with an AIS at a depth of 12 m along the Ullal coast off Mangaluru. This analysis also examined the fuel consumption of the vessel when using the acoustic device. According to the findings presented, the p-value for the catch composition of the Ring seine equipped with AIS was found to be less than 0.05, indicating a significant difference in catch composition. Similarly, when comparing fuel consumption for AIS-equipped vessels with the 40 HP engine, the p-value was also below 0.05, demonstrating a significant difference in fuel usage.

3.4. Fuel efficiency and economics

In this study, AIS (Automatic Identification System) was used on an FRP canoe along the Ullal coast off Mangaluru. The vessel was powered by a 40 HP Outboard Engine. Mohite et al. (2011) highlighted that Mini Purse seines were operated by small-scale fishermen using FRP fishing crafts equipped with Outboard Motors (OBM). The findings showed that the AIS-equipped vessels consumed less fuel compared to those using only the Echosounder. AIS technology offered several benefits, including better navigation, reduced conflicts with other boats, and improved communication within fishing fleets. The ability to receive this information allowed fishermen to locate areas with higher fish density and adjust their operations accordingly, leading to increased efficiency and higher catches. Mohanraj et al. (2011) similarly noted that technology-assisted operations, such as those using electronic tracking and navigation aids, tended to have a better catch success rate compared to traditional methods. By enabling more precise targeting of fish schools and reducing the time spent on unproductive searching, AIS-equipped vessels ultimately achieved higher yields. Boopendranath and Hameed (2012) also highlighted the importance of advanced technologies in improving fishing efficiency, particularly in Ring seine and Mini Purse seine operations.

The total fuel consumed was 0.15 liters of petrol and 63 liters of kerosene for the AIS-equipped vessel. Boopendranath and Hameed (2012) 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. Average fuel consumption was detailed in Table 2 for the AIS-equipped vessel with a 40 HP Outboard Engine. For a one-hour fishing operation, the AIS-equipped vessel used only 0.05 liters of petrol and 12.6 liters of kerosene, making it more fuel-efficient than traditional operations, as illustrated in table 3. Kurup and Rajasree (2003) reported fuel consumption for one-hour OBM operations as 7 liters of petrol and 12 liters of kerosene, noting that the fuel usage in the present study was more cost-effective due to the utilization of AIS technology. The study suggested that using AIS technology, along with Outboard Engines, helped small-scale fishermen reduce operational costs while increasing fishing efficiency.

Economically, the study revealed that income from fishing was shared among the crew based on a share system, which accounted for costs like fuel and transportation. After the catch was auctioned, a portion of the proceeds went to various fees, such as auctioneer commissions and cooperative society contributions. According to Sathianandan et al. (2009), the share system used by small-scale fishing communities ensured income distribution that took operational expenses into account. Economic analyses, such as those by Sathianandan et al. (2009), 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 contributed to the socio-economic resilience of small-scale fishers relying on Ring seine operations. The economic structure of Ring seine operations was heavily influenced by the seasonality of fishing activities. The seasonal availability of labour, particularly during the monsoon when mechanized fishing activities were paused, was also highlighted by Pravin et al. (2012). The number of labourers employed within the Ring seine operations changed daily and often increased during the monsoon season. During this period, workers from mechanized trawlers, who were temporarily without work due to rough sea conditions, migrated to this sector in search of employment. Das et al. (2012) noted that the Ring seine sector required more labour compared to other fishing vessels in the traditional sector.

Table 3: Average fuel consumption of a 40 HP outboard engine fitted with AIS used during the study period along the Ullal coast off Mangaluru

Fuel	Fuel consumption liters hour^{-1}	Fuel consumption liters trip^{-1}
Petrol	0.05	0.15
Kerosene	12.6	63

Overall, the use of AIS in Ring seine operations offered significant economic and operational advantages, helping small-scale fishers improve their livelihoods and fishing efficiency while keeping costs manageable. The AIS-equipped vessel showcased lower fuel consumption, attributable to optimized navigation and reduced idle time spent searching for fish schools.

4. CONCLUSION

AIS technology enhanced fishing efficiency by tracking vessels and identifying productive spots, reducing delays and boosting catches. In Ring seine operations, the highest catch recorded was 5,530 kg on day 255, while the lowest was 114 kg on day 0 at a depth of 12 m. Fuel consumption ranged from 62.41 to 65.81 liters hour^{-1}, peaking on day 75. By optimizing routes and operations, AIS helped the fishermen increase yields, cut fuel costs, and use resources more sustainably.

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