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The Efficiency of Satellite Automatic Identification System (Sat-AIS) Device for Monitoring Small Scale Fisheries in Ghana

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Abstract

This study employed Satellite Automatic Identification System (Sat-AIS) to monitor the activities of artisanal tuna fishing canoes in Ghana. Class-B transponders were mounted on two wooden canoes operating from Albert Bosomtwe Sam fishing harbour, and their activities monitored over a period of six months. The canoes were mainly involved in the harvesting of tuna off the coast of Ghana. The results indicated that skipjack (*Katsuwonus pelamis*), bigeye tuna (*Thunnus obesus*), yellowfin tuna (*Thunnus albacares*) and frigate tuna (*Auxis thazard*) dominated the species landed during the study period. Based on the analysis of the speed profiles from the canoe trajectories obtained from AIS data, speeds between 2 knots to 4.3 knots was classified as fishing speeds for canoe fisheries. Findings from this study suggest that Sat-AIS, augmented by a Class-B transponder could be a useful tool in fisheries management for the small scale fishing fleet in Ghana. Based on the findings of this study, it is recommended that the Central government should legalise and make it mandatory for all small scale fishing fleets to have the device to enhance surveillance, monitoring and control of small scale fisheries in Ghana.

Keywords: Automatic Identification System, transponder, monitor, tuna, Ghana

Introduction

The marine fisheries industry of Ghana can be divided into three broad categories: industrial, semi-industrial and artisanal or small-scale fishing (Nunoo & Asiedu, 2013). The artisanal fisheries also known as small-scale marine fisheries serve as an important source of food and income for coastal communities. In Ghana, artisanal marine fleet consists of both motorized and non-motorized dugout canoes. According to Finegold et al. (2010), the artisanal fleet consists of approximately 13,500 canoes and employs over 200,000 fishermen. The artisanal fleet accounts for 70-80 % of the marine fish landings in the country (Mensah et al., 2006). This type of fishery is practiced in nearshore areas with water depth of about 40 m (Aggrey-Fynn & Sackey-Mensah, 2012). The artisanal fishery typically involves a wide variety of target species, gear types, landing areas, and distribution routes, making it virtually impossible to collect reliable and comprehensive statistics for the vast majority of fisheries (King & Lambeth, 2000; Nunoo & Asiedu, 2013).

The marine fisheries sector of Ghana is faced with enormous challenges including excessive fishing pressure, overcapacity, use of illegal fishing methods, weak compliance with fisheries controls, illegal, unreported and unregulated fishing (IUU) and dominance of foreign fleets (Ministry of Fisheries and Aquaculture Development, 2015). These challenges are partly due to lack of monitoring of fishing activities, along with ineffective law enforcement and control mechanisms (Bank of Ghana, 2008). The situation has resulted in dwindling stocks especially pelagic species which impact livelihoods. In addition to the aforementioned issues, the current management systems lack crucial information about fishing locations, which hinders effective planning, implement law enforcement initiatives, create adaptive management strategies and make policy decisions.

Currently, monitoring of fishing activities is under the mandate of Fisheries Enforcement Unit of the

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Fisheries Commission. However, patrols to monitor small scale fisheries in Ghana is ad-hoc in nature and insufficient, making fisheries regulation enforcement ineffective. The functioning of the unit have been less effective due to the alarming increases in the number of canoes, inadequate personnel and limited resources for enforcement. Thus, enforcement and control of fishing activities as well as knowledge about their fishing zones have become a daunting task for state authorities.

The Vessel Traffic Management information System (VTMIS) has been introduced to enhance continuous electronic surveillance on Ghana's maritime for industrial canoes to ensure compliance with fisheries regulations. Recently, efforts are being made to enforce monitoring of small scale fisheries using Vessel Monitoring System (VMS) and Automatic Identification System (AIS) to detect in real-time vessels that engage in illegal fishing activities especially, vessels without license to fish in Ghanaian waters.

AIS is an automatic tracking system used on ships and by Canoe Traffic Service (VTS) for identifying and locating canoes by electronically exchanging data with nearby ships, AIS base stations, and satellites (Natele et al., 2015; Wang et al., 2015). In addition to locating the vessels, other uses include identification of potential fishing zones and characterisation of fishing behaviour when at sea. Despite this new trend, few studies have been conducted in Ghana to evaluate the efficiency of the Sat-AIS in small scale marine fisheries monitoring. This study deployed Satellite Automatic Identification System (Sat-AIS) on a pilot basis as a tool to monitor fishing activities of two artisanal tuna canoes and their potential fishing grounds in the coastal waters of Ghana.

Materials and Methods

The study was conducted within the exclusive economic zone of Ghana over a period of six months. The Albert Bosomtwe Sam fishing habour in Sekondi, Ghana was used as the main sampling site. The fishing habour is located in Sekondi-Takoradi in the Western region of Ghana. The facility was built in 1995 through 13.5 million dollar Japanese grant for the provision of contemporary fish landing and handling support facilities and services for inshore boats and large canoes. The fishing habour covers an area of about 1.4 hectares of land and 12.6 hectares of sea. Two canoes fitted with 40 HP outboard meters length (m) were randomly selected with the help of local authorities at Sekondi fishing landing beach in Ghana. The fishing activities of the canoes were monitored using an AIS device; Advance Class-B Satellite Enabled AIS (ABSEA) transponder.

A transponder as shown in Fig. 1, is a radio or radar transceiver that automatically transmits a signal of its own when it receives a predetermined signal from satellite, used especially for locating and identifying objects. The device is embedded with an Automatic Identification Systems (AIS) transmitter and receiver which automatically provides the geographical position of the canoe and therefore can be monitored and tracked. The canoes for the experiment were given special numbers as ASSIF 1 and ASSIF 2 for easy identification. A recharging solar panel was the energy source for each fishing trip, which was at least 72 h with departure to arrival 5-8 fishermen on-board.

The activities of the canoes were monitored from an AIS base station at ECOWAS Coastal and Marine Resources Management Centre, University of Ghana where fishing traffic information are collected from ExactEarth^{TM} web portal. The quantity of the catch was estimated and the fish were identified to species level using identification manuals (Kwei & Ofori-Adu, 2005). Areas of repeated fishing activities were mapped and delineated as potential fishing zones of the artisanal tuna canoes from operating from Sekondi fishing habour.

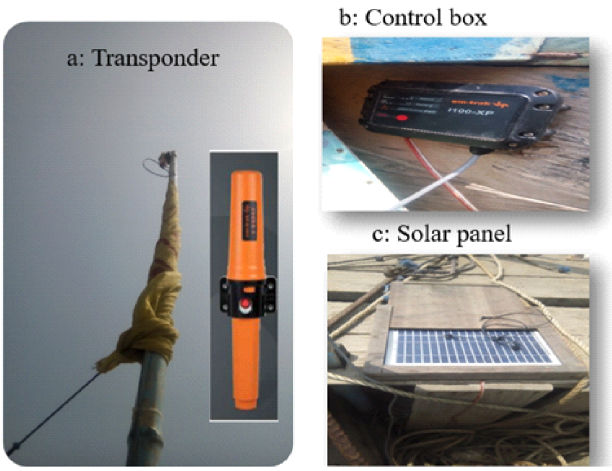

Fig. 1. Components of AIS Advance Class-B Ship Transponder attached to a motorized wooden Canoe

Results and Discussion

A total of 469 tuna were caught from the two canoes, comprising of four species viz., Skipjack (*Katsuwonus pelamis*), Bigeye tuna (*Thunnus obesus*), Yellowfin tuna (*Thunnus albacares*) and Frigate tuna (*Auxis thazard*). (Fig. 2). Skipjack was the most abundant species (50.1 %), followed by Yellowfin tuna (24 %), Frigate tuna (17 %) whilst the Bigeye tuna (9 %) was the least abundant species in the landings over the six months period.

With regards to the contribution by weight of the landings, *Katsuwonus pelamis* recorded the highest by weight (911.5 kg), followed by *Auxis thazard* (299.6 kg) and *Thunnus albacares* (437.5 kg) while *Thunnus obesus* had the least with a mean catch of 169.9 kg over the study period.

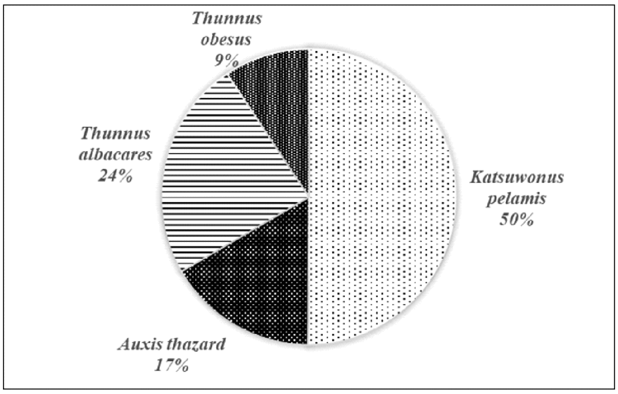

Fig. 2. Species abundance (%) of tuna landed by two canoes at ABS fishing habour, Sekondi

Fig. 3 presents the fishing route of two canoe fleets and the bathymetry of the fishing zones. Based on the canoe trajectories it was discovered that the two artisanal tuna canoes from Sekondi fishing habour mostly fished within the western corridors within the 200 nautical mile Exclusive Economic Zone of the coastal waters of Ghana. Fishing operations occurred within the grid of latitude 3.7°53′55.133′N to 4.5°54′.123′N and longitude 2.1°36′.14″W to 0.9°35′.14″ of the equator, respectively. The bathymetry information also shows that, the small scale tuna fleets mostly fished in areas beyond 100 meters.

Analysis of the histogram plots of canoe speed over ground of the two canoes revealed two bimodal peaks of the speed limits. The first modal peak showed a point where the canoes were at the port (0 knot to 1.9 knots) and the second indicate period when fishing operation occurred. From Fig. 4,

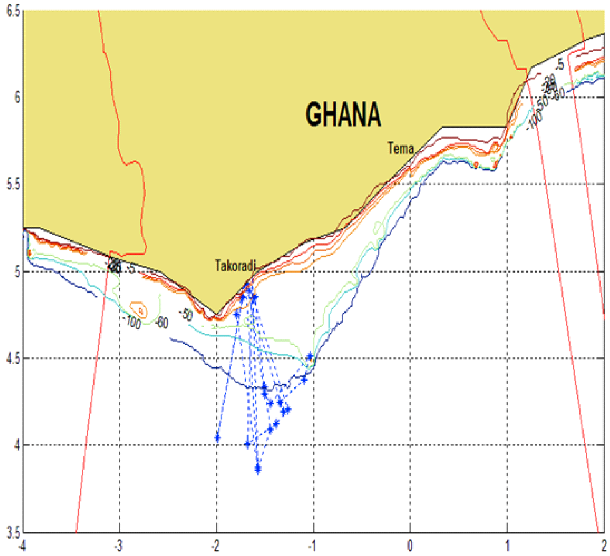

Fig. 3. Trajectories and Fishing zone of Artisanal Canoes Monitored from AIS-Satellite Transponder

fishing operation occurred between speeds of 2 knots and 4.3 knots. Inference can therefore be made that, canoes fleets with 40 hp outboard motor can be considered to be fishing when its speed over ground (SOG) is between 2 knots and 4.3 knots.

The landings by the canoes monitored was dominated by four species. The species were *K. pelamis* (50.1 %), Yellowfin tuna (*T. albacares*) (24.1 %), Frigate tuna (*A. thazard*) (16.5 %), Bigeye tuna and (*T. obesus*) (9.3 %) respectively. Skipjack tuna (*K. pelamis*) was the most dominant species with highest landings recorded. This result is consistent with findings of Addi (2014); ICCAT (2014); Miyake, et al. (2004). *K. pelamis* has dominated the tuna landings in Ghana since 1987. According to Obeng (2003), three out of the four species; *K. pelamis* and *T. albacares* are the most common tuna species found in Ghanaian coastal waters. Assessment of occurrence of tuna species in the coastal waters of Ghana also shows that all the species recorded occurs throughout the year (Kwei & Ofori-Adu, 2005). According to FAO (2014), over 300 different species of commercially important fish, 17 species of cephalopods, 25 species of crustaceans and 3 turtle species are caught from marine sources in Ghana. Tuna species form an important component of the marine landings as seen in this study. The species composition is also consistent with composition of tuna landings globally (Miyake et al., 2010).

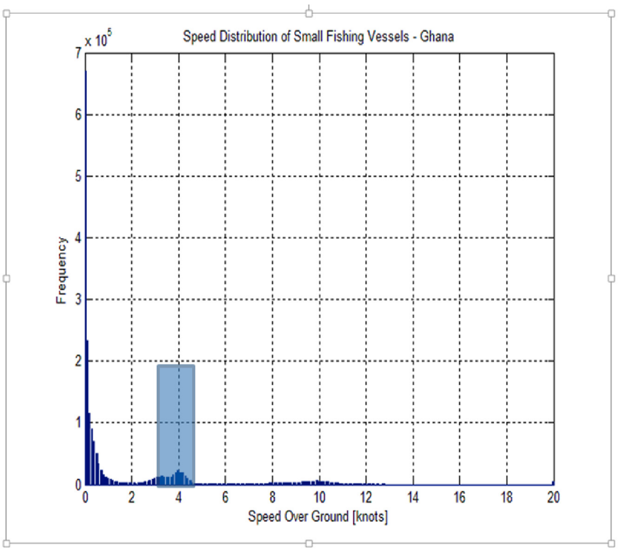

Fig. 4. Histogram Plots indicating speed over ground of canoe fleets

A study conducted by Nunoo & Asiedu (2013), on the state of marine landings in Ghana shows that the marine resources appear to be going through a phase of decline similar to most pelagic fishes worldwide. The variation in landings and under-performance of the marine fisheries is likely to have severe consequences on the fishing communities, the country and sub-region as a whole in terms of food security, employment, GDP contribution, economic insecurity, conflict and under development.

The result revealed that, fishing activities of the canoes occurred only in the coastal waters of Ghana and within the 200 nautical mile Exclusive Economic Zones (EEZ) (Fig. 3). Based on the movement pattern or the canoe track history studied in the 180 days period, the georeferenced position (latitude 3.7^{o1} to 4.5 N and longitude $2^{o}1^{1}$ to 0.9^{o} E) was delineated as the potential fishing grounds of small scale tuna canoes operating from the Sekondi fishing habour. This was further confirmed by analysis of the speed profiles of the two canoes (Fig. 4). The identification of fishing activity was based on assuming a fishing behaviour highly dependent and characterised by speed. This analysis is based on the concept that, canoes when at sea undertake three main activities; viz., stationary at port, steaming to fishing grounds and lastly steaming back to the landing beach to market their catch (Mazzarella et al., 2014; Natale et al., 2015).

Detecting changes and frequency of speed help scientists in identifying which part of the canoe track is to be considered as fishing or non-fishing (Natale et al., 2015). Analysis of fishing activities based on the speed profiles established intense fishing activities in the designated fishing zones at speed between 2 kn and 4.3 kn as shown in Fig. 4. The areas of fishing covered was found to deviate from other type of fishing fleets such as trawlers which operate closer to the shore as reported by Wang et al. (2015). Wang et al., 2015 compared the speeds of different types of fleet from VMS with corresponding logbooks, their studies revealed canoes' speeds for trawlers between 2.5 and 5.0 when fishing. According to the characteristics of trawling, when a canoe is fishing, it will go back and forth in an area frequently and will not leave for another area until the catch becomes low.

The findings further confirms to earlier studies that, canoe monitoring systems using AIS technology can indeed be used to show real time activities of any fishing fleet when at sea including whether it is fishing or not, which is a key factor to estimate fishing effort and help regulate fishers (Bastardie et al., 2010; Mazzarella et al., 2014). In the same way, long time monitoring of fishing behaviours of each fleet can provide information which are relevant to monitor IUU fishing cases at the national level. In identifying canoe activities at sea, the speed of the canoe is normally used as an indicator to classify fishing or non-fishing activity (Eastwood et al., 2007; Lee et al., 2010). Knowing the speed of different fleets can help fisheries managers to classify different canoes and also monitor illegal activities such as transhipment and pair trawling at sea.

In this study, daily fish landing data was used to monitor the behaviour of canoe. It is expected that by monitoring for long time activities of canoes or fishing canoe when at sea could be determined with AIS data. Based on the daily and monthly VMS data, fishery resource managers can simulate the canoes' track and generate fishing effort distribution map with the location and speed information. Fishing area can be determined by analysing the fishing effort map (Mazzarella et al., 2014; Natale et al., 2015), which can inturn help to estimate fishery resources and the change in stocks can be predicted (Natale et al., 2015). Further, the impact of fishing on the resource can be analysed further.

The result of this research also suggest that, the Sat-AIS system could be adopted to enhance surveillance, monitoring and control functions importantly at this period where the existing fishery management regimes methods have proven to be less effective (Nunoo et al., 2015).

Notwithstanding the importance of AIS as a new promising tool for monitoring of fisheries in Ghana as demonstrated by the findings of this study, data provided by Sat-AIS has its own shortcomings which need technical consideration before it can be used on commercial scale (Wang et al., 2015). The main challenge identified was that AIS provides no information on the catch made by the canoes. However, catch and fishing trip-related information can be obtained from daily logbooks details which usually record the times, locations, fishing types, species and catch.

In this study, logbook data was substituted with daily landings recorded at landing site. By combining these two data sources, the Satellite AIS data can be put to use in fishery stock assessment especially geographical positions where the various species of fish are hauled effectively. Most importantly, the application of canoe monitoring systems in fisheries management using the AIS systems can only be achieved in accordance with existing international and national legal frameworks for which new laws should be formulated.

Satellite Automatic Identification System (Sat-AIS) can be employed as reliable tool in fisheries management to efficiently curb IUU fishing, improve monitoring, control surveillance of small scale fisheries as well as to predict the potential fishing zones for the benefit of fishers and also enhance management of marine resources. Application of AIS as a canoe monitoring system can ensure better enforcement of fisheries laws in Ghana, especially during annual closed seasons as a management option, to revive the sector and improve socioeconomic livelihoods as well as national economy.

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