REDUCTION OF ECOLOGICAL FOOTPRINTS OF DRIFTING FISH AGGREGATING DEVICES (DFADS) USING DRONE TECHNOLOGY IN NIGERIAN OFFSHORE WATERS

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ABSTRACT

Drifting Fish Aggregating Devices (dFADs), which are used intensively in industrial tuna fisheries, have become widespread in West African waters. While effective in aggregating pelagic species such as tuna, dFADs have serious environmental consequences in the form of ghost fishing, marine pollution and disruption of ocean ecosystem processes. These challenges are further added to by dFADs drifting into Nigerian offshore waters from neighboring countries, increasing the difficulty of fisheries management and undermining conservation efforts. Existing mitigation efforts are limited by high cost, technology deficits, and weak enforcement capacity. This research examined the possibility of employing drone technology as an affordable and environmentally friendly means of mitigating the environmental impact of dFADs in Nigerian waters. Drone-assisted reconnaissance missions were conducted at three offshore locations — Brass, Escravos and Lagos — augmented by two locally adapted fishery boats. Utilization of drones enabled real-time identification, geolocation, and recovery of errant dFADs, which was more efficient and cost-effective compared to traditional retrieval. The results indicated that drone utilization reduced time and the impacts of uncontrolled dFAD drift, saving marine ecosystems. The research highlighted the need for regional cooperation among ECOWAS member states in the regulation of utilization, traceability and disposal of dFADs through shared surveillance platforms. The outcomes offer actionable suggestions to policymakers, fisheries stakeholders, and conservationists responsible for protecting the marine ecosystem in the Gulf of Guinea, in addition to promoting responsible fishing habits.

Keywords: Fisheries, Drone-assisted technology, Responsible fishing habits

INTRODUCTION

Drifting Fish Aggregating Devices (dFADs) are becoming a ubiquitous vehicle in global tuna fisheries, catching almost half of all the tuna caught (Fonteneau *et al.*, 2000; Miyake *et al.*, 2010). The strategy relies on the capacity to mimic natural floating refuse - such as seaweed and driftwood, which draw pelagic species like tuna into aggregations, and thus make them more catchable (Fromentin and Fonteneau, 2001). But extensive and unregulated use has transmitted ecological challenges such as ghost fishing, ocean pollution through use of man-made material and disruption of marine biodiversity (Dempster and Taquet, 2004; Fulton *et al.*, 2011).

Research also indicates that discarded or abandoned dFADs are among the principal sources of marine litter, which can drift outside national jurisdiction and affect distant ecosystems from where they were deployed (Supta *et al.*, 2020). West African countries such as Ghana have been actively using dFADs for commercial tuna fishing, whereas others, such as Nigeria, have banned them (Federal Department of Fisheries, Nigeria pers. comm.). Even so, dFADs continue to be found in Nigerian waters, likely due to drift currents and local pressure on fisheries.

Existing measures of mitigation such as onboard observer schemes, satellite FAD tracking and biodegradable material mandates have failed to a significant extent; due to loopholes in enforcement and operational costs (Bharam, 2004; Floch *et al*., 2012). Technologies such as GPS buoys and software models such as Ocean Control Real-time Acquisition (OCRA) have improved monitoring but are usually underutilized in most developing nations.

Recent studies have focused on the use of drones for fishery monitoring, and recognize their potential for real-time surveillance, affordability, and minimal environmental disturbance (Escalle *et al*., 2019). This study is timely, as it evaluates the use of drone technology for dFAD identification and recovery in Nigerian offshore waters. Through the organized integration of drone surveillance with traditional vessel-based fisheries, this study augments literature on innovative tools for ecologically friendly fisheries. It also emphasizes the need for transboundary cooperation in ECOWAS in the management and regulation of dFAD utilization in Exclusive Economic Zones (EEZs) for ecological consistency with long-term fishery productivity.

MATERIALS AND METHODS

The survey was conducted across a width of approximately 6,000 km^2, situated 70 km offshore along the southern coast of Nigeria. There were 118 pre-plotted sail lines across the survey area, with an average length of 66.3 km and spaced at an interval of 750 m. The combined length of all planned sail lines amounted to 7,817 km. Bathymetric conditions in the area were extremely varied, ranging from around 50 m in the southeast corner to over 2,000 m in the west.

To map and monitor offshore dFADs in the study area, DJI Pro 3 Unmanned Aerial Vehicle (UAV) was deployed. This model comes with an Integrated Zenmuse X9-8k Air gimbal camera that provides high imaging resolution critical for detailed video capture stability. Detailed flight plans were created in Speed, Navigation aids, Approach briefing and Pre-landing (SNAP) checklist using Waypoint Pro’s altitude, heading, speed and camera tilt features, while simulating all mission paths for accuracy checked safety. Three DJI Pro 3 UAVs were used interchangeably during the survey. Drones were deployed from the source vessel's helideck at an altitude of 14.35 m, above sea level at 14:35 UTC. The flights were carried out between 6 am to 7 pm UTC. Each UAV had an operational range diameter of 1.5 km and flew as high as 65 m above sea level for up to one hour, and was rotated on four-hour schedules across three drones. Over eight months (splitting wet and dry seasons evenly), a total of 293 flights, capturing 89 hours and 17 minutes of footage over a distance of 2197 km, were conducted.

Assessment of RTK calibration, battery levels alongside alignment checks on gimbals was done preflight, ensuring dual operators would manage navigation alongside camera controls using the raw footage recorded in 8k/25fps pro-res format stored on DJI PROSSD drives configured to RAID-5 system.

Table 1. Coordinates of surveyed area along the Nigerian coastline

Point ID	Easting (m)	Northing (m)
1	977795.5	424982.1
2	978322.2	337276.6
3	939197.4	337180.3
4	864977.1	334071.6
5	709241.9	333701.6
6	588823.4	333553.2
7	588756.6	414611.6
8	588367.2	525151.9
9	612672.9	525179.5
10	649642.8	527085.5
11	721755.1	527260.7
12	745715.2	527341.3
13	745703.8	516272.9
14	827308.4	424355.3
15	977795.5	424982.1

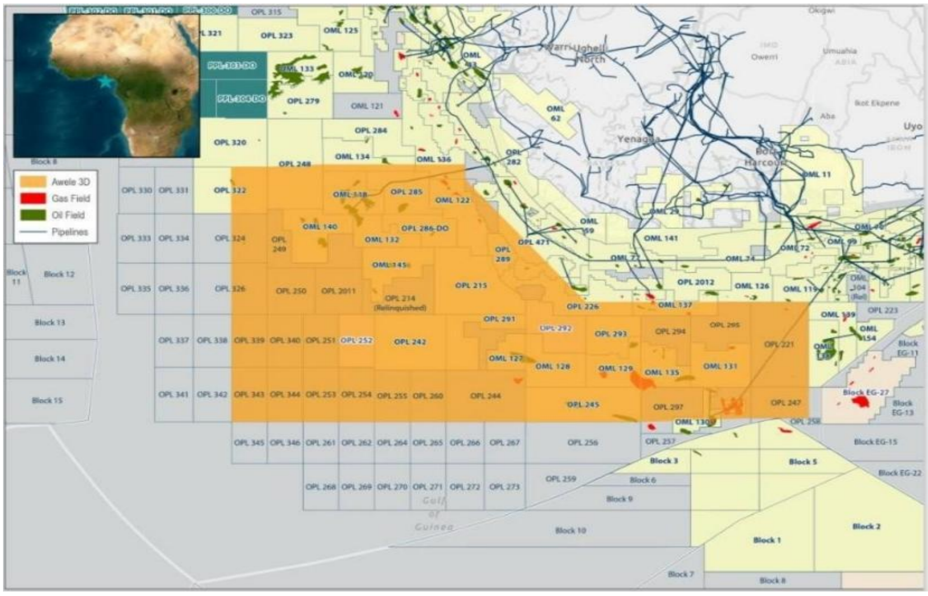

Figure 1: Sampled area along the coastline of Nigeria (delineated in orange colour)

Supporting metadata like GPS coordinates log timestamps were used alongside GIS software for spatial-temporal analysis. Workboats were employed to recover dFADs, photograph and classify them based on their transmitters. Real-time monitoring of several units equipped with GPS trackers was conducted using OCRA software, drawing data streams from Zunibal, Global Marine, and Satlink for streamlined retrieval.

RESULTS

The drone flights had aggregated effective hours of effort of 89 hours and 17 minutes flying a distance of 2,197 km. This was achieved during 293 flights at a height of 37.5 m. During this time, 63 dFADs were recovered with a total weight of 2,631 kg. This recovery occurred over seven months

Table 2: Classification of retrieved dFADs from the Nigerian coastline, based on GPS

Month	Zunibal	Global Marine	Satlink	Unidentified	Total
July	4	0	0	3	7
Aug.	4	0	0	4	8
Sept.	2	0	0	10	12
Oct.	1	1	1	2	5
Nov.	0	0	0	12	12
Dec.	1	1	0	7	9
Jan.	0	0	2	2	4
Feb.	2	1	1	2	6
Sub-total	**14**	**3**	**4**	**42**	**63**

Figure 2. Drifting Fish Aggregating Devices retrieved from the Nigerian coastline

from July 2023 to February 2024.

Three GPS locator transmitter models attached to the dFADs were recovered, with manufacturer-specific serial codes: T8E (Zunibal), MGiGO (Global Marine), and SLX (Satlink). Among the 63 recovered dFADs, 42 were unidentified because they lacked indented codes, 14 had Zunibal codes, 4 had Satlink codes, and 3 had Global Marine codes (Table 2).

The highest number of dFADs occurred in September (12), while the lowest number (4) occurred in January (Table 2). Comparing the numbers and weights of dFADs, seasonally between the wet season (July to October) and the dry season (November to February) did not show a significant difference.

DISCUSSION

The use of drone technology for detection and retrieval of drifting Fish Aggregating Devices (dFADs) in Nigerian offshore waters was feasible and highly effective. Over seven months, 63 dFADs were recovered within an operational effort of 89 hours across nearly 2,200 km of flight. This demonstrates a substantial improvement in efficiency compared to traditional, vessel-only methods, which are often limited by visibility, weather conditions, and slower search-and-retrieval capabilities.

There was no seasonal difference in the number or weight of recovered dFADs, suggesting a consistent presence and threat all year-round. The predominance of unidentified dFADs (42 out of 63) and the presence of GPS-tagged devices from foreign manufacturers highlight the transboundary nature of the problem and reinforce the need for regional collaboration under ECOWAS frameworks. Escalle *et al.* (2019) emphasized the potential of drone surveillance in improving real-time monitoring of dFADs in the Pacific ocean. This study is pioneering in its application within African waters, particularly Nigeria. Nevertheless, the adoption of technologies like GPS buoys and satellite-linked software (e.g., OCRA) have been limited in developing countries, due to cost and infrastructure gaps (Bharam, 2004; Floch *et al.,* 2012).

This study addresses that gap directly by demonstrating the integration of OCRA with drone operations in a resource-constrained context. The environmental concerns such as ghost fishing and marine debris, could be practically tackled using dFADs (e.g. Dempster and Taquet, 2004; Fulton *et al*., 2011). By retrieving over 2.6 tonnes of dFAD-related material, the ecological benefit is evident. This study offers a localized and implementable approach for West African fisheries, making a strong case for further investment in drone technology and inter-country regulatory cooperation.

CONCLUSION

This study underscores the importance of developing methods for retrieving drifting Fish Aggregating Devices (dFADs) from the Exclusive Economic Zones of coastal states like Nigeria. The use of drone technology was effective in the detection, tracking, and retrieval of dFADs. Additionally, identification of GPS transmitters through unique codes and serial numbers provided the potential for tracing the origin of these devices. The incorporation of this identification in future research will significantly enhance tracking, accountability, and overall management of dFAD deployment within regional waters.

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