Investigating the Effects of Marine Debris on Coastal Navigation

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Abstract- This study investigated the effects of marine debris (Plastics Debris, Wrecked Vessels, Ghost Fishing Gears) on coastal navigation in Eastern Port Channels comprising the Calabar, Onne-Bonny, Port Harcourt and Warri waterways. The research adopted survey method and structured questionnaire designed in five Likert scales for data collection from a sample size of 320 respondents being maritime professionals. The research tested three hypotheses using quantitative analysis on the survey data collated. Multiple regression analysis showed there is strong positive relationship between the dependent and independent variables which is significant at 95% significant level confirmed in the ANOVA table. The findings reveal that marine debris factors including; Plastics Debris, Wrecked Vessels, and Ghost Fishing Gears have individual significant effects on Navigational Hazards, Safety Risks and Economic Activities which compromise navigational safety, operational safety and potential economic operations of Calabar, Onne-Bonny, Port Harcourt and Warri waterways. The results of the test of hypotheses infer that the effects of PlasDebr, WreVess, and AbaFisGea on NavHaz, SafRis, and EcoAct in Eastern Port Channels are statistically significant. The study shows that a unit increase in PlasDebr, WreVess, and AbaFisGea would bring about 10.02, 4.010, and 2.005, degrees of effects on NavHaz respectively; a unit increase in PlasDebr, WreVess, and AbaFisGea would bring about 2.261, 3.032, and 0.936 degrees of effects respectively on SafRis; also, a unit increase in PlasDebr, WreVess, and AbaFisGea would bring about 2.123, 4.030 and 2.971, degrees of effects respectively on EcoAct. The study concludes that marine debris substantially hampers Nigeria's eastern port zones, affecting port efficiency, fishing activities, livelihoods, marine safety, and coastal economic growth, however, the study recommends that the relevant authorities should implement immediate debris removal programs targeting high-traffic shipping lanes, with particular emphasis on plastic, wreckages and ghost fishing nets collection systems that address the most prevalent debris types considered in this study.

I. INTRODUCTION

1.1 Background to the Study

The eastern port channels are vital segment of the Atlantic Ocean's coastline, serves as a crucial maritime corridor for West and Central Africa. This region, encompassing the Niger Delta, is characterized by its intricate network of rivers, estuaries, and creeks, notably the Calabar, Onne-Bonny, Port Harcourt and Warri waterways (Koranteng & Price, 2010). These waterways are essential for local transportation, fishing and other commercial activities, connecting coastal communities within Nigeria and outside for commercial and social interactions. However, the increasing accumulation of marine debris poses significant challenges to the safety and efficiency of navigation in these coastal areas for inland waterways transportation.

Marine debris, particularly plastics, has become a pervasive issue in the Easter Port Channels. Studies have highlighted the seasonal variation in marine debris along the coastline, with a higher accumulation during the rainy season. For instance, a survey at Araromi seaside in Nigeria revealed that the total number of debris items collected was 29,029, with 21,671 items found in the rainy season alone (Ajayi, 2024). Plastic materials dominated the debris composition, accounting for 86% in the dry season and 91.8% in the rainy season. Such high concentrations of plastic debris not only degrade the environment but also pose direct threats to maritime activities.

The Eastern waterways, being integral to the region's maritime operations, are increasingly affected by pollution. Suspended marine debris in the Calabar/Bonny Estuary and Amadi Creek has been documented, with plastic and nylon comprising over

70% of the debris (Uche & Babatunde, 2020). The impact of marine debris on navigation is not merely theoretical but has manifested in real-life incidents. In October 2023, a commercial boat traveling from Bonny to Port Harcourt capsized after its propeller became entangled in floating plastic waste. Tragically, this incident resulted in a fatality, underscoring the lethal risks posed by submerged debris. Boat drivers have reported that plastics, often invisible beneath the water's surface, can entangle propellers and engine inlet valves, leading to accidents and fatalities.

Beyond immediate hazards, the presence of marine debris can also affect the hydrodynamics of a vessel. The research by Mac-Pepple Blessing James *et al., (2021)* demonstrates that the investigation on the hydrodynamic performance of the initial and optimized hull form of a parent ship from the resistance, power and sea keeping point of view. Based on the analytical results, it was noted that the resistance results of the optimized hull are lower than the initial hull at different speeds under the same conditions.

The ecological consequences of marine debris are equally concerning. The Easter Port Channels waterways are rich in biodiversity, including mangroves, fish, and other aquatic species (Scheren *et al.,* 2002). The accumulation of plastics and other debris can disrupt these ecosystems, leading to habitat degradation and threats to marine life. For example, the Bonny Estuary, characterized by its mangrove swamps, faces ecological challenges due to pollution, which can affect the resilience and health of these vital ecosystems.

The issue of marine debris in the eastern port channel requires a multifaceted approach. Effective waste management practices, public awareness campaigns, and stricter enforcement of environmental regulations are essential. Technological solutions such as debris collection systems and real-time monitoring can aid in mitigating the impact of pollution on navigation. Collaborative efforts between governmental agencies, local communities, and international organizations are crucial to developing and implementing strategies to reduce marine debris and protect the waterways.

The accumulation of marine debris in the eastern port channel, particularly in the Port Harcourt and Bonny waterways, presents significant challenges to safe and efficient coastal navigation. The environmental, economic, and ecological impacts underscore the urgency of addressing this issue. Through concerted efforts and comprehensive strategies, it is possible to mitigate the effects of marine debris and ensure the sustainability of the region's maritime activities.

1.2 Statement of Problem

Marine debris has become a pervasive issue in the eastern inland water channels, significantly impairing the safe and efficient navigation of coastal waters. Despite growing attention to marine pollution globally, the eastern Port Channels remains severely affected by unregulated waste disposal, poor environmental governance, and inadequate maritime waste management infrastructure (Okafor & Adewumi, 2020). One of the most critical problems is the continuous accumulation of plastic waste in navigational Port Channels, including fishing routes, port entrances, and shipping channels.

Another dimension of the problem is the lack of consistent data and documentation concerning the spatial distribution and seasonal variation of marine debris in the Eastern port channels. While sporadic studies and surveys have been conducted, they remain insufficient in scope and frequency to inform policy or real-time navigation decisions.

Physical navigational hazards and marine debris in the eastern Port Channels imposes an economic burden on coastal shipping and fishing industries. Frequent damage to vessel infrastructure leads to elevated maintenance costs and unplanned downtimes, especially for small-scale operators who lack the financial resilience to absorb such shocks. The clogging of port approaches by debris reduces the efficiency of port operations, causes delays in cargo handling, and can deter foreign shipping lines from accessing certain ports due to increased risks. This undermines the economic competitiveness of maritime sectors in the region and weakens the reliability of trade routes critical for the economic development of the Eastern Ports.

The problem is also compounded by fragmented governance and a lack of coordination by Port authorities operating within the Eastern Port Channel. While marine debris often crosses national boundaries, efforts to manage and mitigate its effects are typically limited to individual national policies, many of which are poorly enforced. There is a notable absence of standardized protocols for debris reporting and response among countries sharing maritime borders.

Ultimately, the lack of a unified and systematic approach to managing marine debris has allowed the issue to escalate, posing serious threats to navigational safety, economic viability, and environmental sustainability in the Eastern port channels. The cumulative impact of unmanaged marine waste not only threatens the integrity of shipping and fishing operations but also jeopardizes the long-term development goals of coastal communities and states that depend on maritime trade and resources.

1.3 Aim and Objectives of the Study

The aim of this research is to examine the effects of marine debris on coastal navigation in Eastern Port Channels comprising the Calabar, Onne-Bonny, Port Harcourt and Warri waterways channels with the specific objectives which included to determine if the effect of marine debris (Plastics Debris, Wrecked Vessels, Ghost Fishing Gears) on Navigational Hazard in eastern port channels (Calabar, Onne-Bonny, Port Harcourt and Warri waterways) is statistically significant, to examine if the effect of marine debris (Plastics Debris, Wrecked Vessels, Ghost Fishing Gears) on safety risk within the eastern port channels is statistically significant and to evaluate the statistically significant effect of marine debris (Plastics Debris, Wrecked Vessels, Ghost fishing gears) on economic activities within the eastern port coastal regions.

1.4 Research Questions

i. Is the effect of Marine debris (Plastics Debris, Wrecked Vessels, Ghost Fishing Gears) on Navigational Hazards in eastern port channels statistically significant?
ii. Is the effect of Marine debris on Safety Risk within the eastern port channels statistically significant?
iii. Is the effect of Marine debris on economic activities within the eastern port coastal regions statistically significant?

1.5 Research Hypotheses

i. Ho_I: The effect of Marine debris (Plastics Debris, Wrecked Vessels, Ghost Fishing Gears) on Navigational Hazards in eastern port channels (Calabar, Onne-Bonny, Port Harcourt and Warri waterways) is not statistically significant.
ii. Ho_2: The effect of Marine debris on Safety Risk within the eastern port channels is not statistically significant
iii. Ho_3: The effect of Marine debris on economic activities within the eastern port coastal regions is not statistically significant

1.6 Scope of the Study

This study explores the effect of marine debris on coastal navigation within the Eastern port channels, a region increasingly affected by maritime pollution and rising marine traffic. The study specifically investigates four main aspects:

i. The Navigational Hazards – posed the risk of collision, propeller and hull damage, navigation channel obstruction by marine debris to vessels navigating the coastal waters;
ii. The Safety Risk – crew and passenger safety, and vessel stability risks which marine debris most frequently encountered result to loss of lives, properties and damage to the vessels;
iii. The economic impacts- vessel damage and repair, delays and diversions, increase insurance cost contributed by such debris to coastal navigation in the eastern port channels;
iv. The current mitigation strategies in place to address the issue.

II. MATERIALS AND METHODS

2.1 Research Design

This investigation employs a facto quasi survey method whereby a questionnaire was used for primary data collection, descriptive research design, utilizing surveys as the primary research strategy. Survey methodology connects effectively with the deductive research approach and facilitates quantitative data collection (Saunders et al., 2019). Quantitative methods will determine the severity of marine debris impacts on navigational safety in the Eastern port channels. The research targets various maritime stakeholders including vessel operators, port authorities, coastal communities, and environmental agencies operating within the Eastern Port Channels of Nigeria.

Questionnaires will be structured using a 5-point Likert scale technique, allowing for moderately Agree responses when participants are uncertain about specific aspects of marine debris impacts. This approach quantifies subjective perceptions into objective data points that can be systematically analyzed (Joshi et al., 2015). The Likert scale will gauge respondents' agreement levels with statements assessing impacts of marine debris on navigational safety, operational challenges, and potential mitigation strategies, following established methodologies in maritime safety research (Sheavly & Register, 2007).

2.2 Population of the Study

The population of the study was estimated at 1800 respondents including personnel across organizational hierarchies: Senior managers, junior managers of vessel managing companies, vessel operators (ship crews), port officials (NPA staff), coastal community representatives (local craft operators and dwellers), and environmental officers (Government and NGOs), National Inland Waterways Authority (NIWA) staff and Nigerian Maritime Administration and Safety Agency (NIMASA) staff.

The Participants were primarily from maritime stakeholders operating within the Eastern port channels of Nigeria. Selection criteria prioritize decision-makers with minimum one-year experience in their respective organizations. The survey will encompass personnel across organizational hierarchies: Senior managers, junior managers, vessel operators, port officials, coastal community representatives, and environmental officers, National Inland Waterways Authority (NIWA) staff and Nigerian Maritime Administration and Safety Agency (NIMASA) staff. Purposive sampling was employed alongside Slovin's formula to account for confidence levels and error margins.

2.3 Determination of Sample Size

Taro Yamane formula was used to determine the population size of the study. The formula is as stated below:

$$n = \frac{N}{(1+Ne^2)} \quad (1)$$

Where,

n is the sample size

N is the total population

e is the margin of error

Hence, the sample size was calculated as 327 respondents for the study.

2.4 Instruments for Data Collection

This quantitative investigation into marine debris impacts on coastal navigation employed structured questionnaire by the researcher in Likert scales for data collection which elapsed for over 2-3 months period. The questionnaire was structured in two sections. Section one deals on respondent's demographics (age range, education, organizational role, maritime experience). Section two was based on the research questions covering navigation hazards, Vessel safety, and economic/social/ environmental costs and mitigation effectiveness of marine debris management using a 5-point Likert scale. The scale assigns numerical values: strongly agree (5), agree (4), moderately Agree (3) disagree (2), and strongly disagree (1). Questions were aggregated to address research questions with mean scores calculated from Likert responses. This approach converts subjective measures such as perceptions, attitudes, and opinions into quantifiable values for systematic analysis.

Survey questionnaires were distributed exclusively to maritime sector employees and stakeholders. No sensitive personal data (names, emails, phone numbers) were collected, ensuring complete anonymity (Kaya & Guler, 2013). Data protection measures prevent third-party access, with collected information used solely for this research purpose. Detailed descriptions ensure respondents have full knowledge of how their responses were utilized. Participants and organizations retain the right to withdraw their responses at any point. The study adhered to established guidelines ensuring data protection rights comply with European research ethics standards (Speelman & McGann, 2013). All data securely maintained during the study and destroyed upon completion.

Survey validity and reliability of participant responses were rigorously assessed. Reliability refers to measurement consistency across iterations. A research instrument is considered reliable when results can be reproduced under similar methodological conditions. Hence, having measured the tool consistent for this study, the instrument should yield similar results when repeatedly measured the same phenomenon.

2.5 Statistical Analysis

Statistical analysis of marine debris impacts on coastal navigation employed several key methodologies including descriptive and inferential analyses. Mean and standard deviation calculations provided foundational understanding of central tendencies and data dispersion for variables such as navigation hazard, vessel safety and economic cost frequencies, and rates impact on the areas. Multiple regression analysis was employed to examine effects of debris types on coastal navigation and assess statistical significance of changes in key metrics on coastal navigation.

2.5.1 Mean

The arithmetic mean serves as a fundamental measure of central tendency, providing a single representative value for data summarization (Kim, 2014). It proves particularly valuable when analyzing datasets where individual observations contribute equally to overall results. Mean calculation involves summing all observations and dividing by the total observation count:

$$\bar{X} = \frac{{}_{i-1}^{n}x_i}{n} \qquad (2)$$

Where,

$\bar{X}$ represents the mean value of the dataset,

X_i denotes individual observations,

n represents the total number of observations.

For this study, mean values will evaluate average impact severity of marine debris on navigational safety, frequency of debris encounters, and effectiveness of current removal strategies across different vessel categories and coastal locations within the Eastern port channels.

2.5.2 Standard Deviation

Standard deviation quantifies data dispersion by measuring how individual observations deviate from the mean. Higher standard deviation indicates greater variability, while lower values indicate observations clustered closely around the mean:

$$\sigma = \frac{\sqrt{{}_{i=1}^{n}(X_i - \bar{X})}}{n} \qquad (3)$$

where,

σ represents the standard deviation,

Xi represents individual observations,

$\bar{X}$ is the mean of the dataset,

n is the total number of observations.

This study will employ standard deviation to assess consistency of responses regarding marine debris impacts on navigation. It will help understand variation in debris encounter rates across different coastal locations and vessel types, determining whether certain areas exhibit higher or lower variability—critical for interpreting finding reliability.

Decision Rule:

i. Agreement Level ≥4.00: Strongly Agree
ii. Agreement Level ≥3.50 ≤ 3.90: Agree
iii. Agreement Level ≥ 2.5 ≤ 2.49: Moderately Agree
iv. Disagreement Level ≥ 1.5 ≤ 1.49: Disagree
v. Disagreement Level ≥ 0.5 ≤ 0.49: Strongly Disagree

2.5.3 Multiple Regression

Regression is a statistical tool to predict the dependent variable with the help of one or more independent variables. While running a regression analysis, the main purpose of the researcher is to find out the relationship between the dependent and independent variables and the impact of the relationship.

The Multiple Regression Analysis is the relationship between dependent and independent variables as it depicts how dependent variables will change when one

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or more independent variables change due to factors. Therefore, the formula to calculate multiple regressions is given as:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots\ldots + bnXn + E, \quad (4)$$

where

Y is the dependent variable,

X is the independent variable,

a is the intercept,

b is the slope, and

E is the residual.

Model Specification

$$Y_{NavHaz} = a + b_1X_{PlasDebr} + b_2X_{WreVess} + b_3X_{AbaFisGea} \quad (5)$$

$$Y_{SafRis} = a + b_1X_{PlasDebr} + b_2X_{WreVess} + b_3X_{AbaFisGea} \quad (6)$$

$$Y_{EcoAct} = a + b_1X_{PlasDebr} + b_2X_{WreVess} + b_3X_{AbaFisGea} \quad (7)$$

where,

a is the intercept of the graph

b1; b2; b3 = the slope of the lines

Y_{NavHaz} is the Navigational Hazard

Y_{SafRis} is the Safety Risk

Y_{EcoAct} is the Economic Activities

$X_{PlasDebr}$ is the Plastics Debris

$X_{WreVess}$ is the Wrecked Vessels

$X_{AbaFisGea}$ is the Abandoned/ Ghost Fishing Gears

III. RESULTS AND DISCUSSION

3.1 Data Presentation

The collected questionnaire data were analyzed using both descriptive and inferential statistical methods to comprehensively address the research questions and test the proposed hypotheses. Descriptive statistics will include mean scores, standard deviations, and frequency distributions for each Likert scale item, providing an overview of respondent perceptions regarding marine debris impact on coastal navigational (Navigational hazards, safety risk and economic activities). Data was presented through tables showing central tendencies and variability measures, complemented by bar charts and histograms illustrating response distributions across the 5-point scale.

For inferential analysis, Cronbach's alpha, Anova, Paired T-test were computed to examine relationships between debris density indicators and safety metrics, directly testing Hypothesis 1's proposed inverse correlation. One-way ANOVA was employed to compare mean scores across different debris types. Multiple regression analysis assessed the effect of marine debris concentration on coastal navigation validating the research Hypotheses.

Reliability analysis using Cronbach's alpha ensured internal consistency within each research question cluster. The paired T-test examined the associations between categorical variables such as debris types and coastal navigational challenges. Results were presented through correlation matrices, regression tables, and comparative charts, with significance levels set at $p < 0.05$. This comprehensive analytical approach provided a robust evidence for drawing conclusions about marine debris' impact on coastal navigation in Eastern port channels in Nigeria.

3.1.1 Analysis of Questionnaire Distribution and collation

Table 1: Questionnaire Distribution

	Questionnaire	Frequency	Percent
Valid	Total Distributed	327	100%
	Recovered	322	98..47%
	Not recovered	5	0.02%

Invalid	2	0.01%
Total used	320	97.86%

The Table 1 above provided information on the analysis of questionnaire distribution and collation for the study. It shows that a total of 327 questionnaires implying 100% were distributed to the various respondents out of which 322 (98.47%) were actually recovered and 5(0.02%) not recovered, however, 2(0,01%) were invalid. Therefore, the total questionnaire responses used for the study were 320 (97.86%).

3.1.2 Demographic of Participants

Table 2: Respondents' Education

	Qualification	Frequency	Percent
Valid	Diploma	89	27.8%
	Bachelors	156	48.75%
	Masters	62	19.3%
	Doctorate	13	4.1%
	Total	320	100%

Table 2 Respondents' Education shows the qualifications of the respondents whereby there were 89 diploma holders, 156 Bachelors (B.Sc., B.Tech. and HNDs), 62 Master degree holders and 13 Doctorates participants in the study. This implies that the study targeted mostly the educated respondents who were knowledgeable enough to provide the required information for the study.

Table 3: Respondents' Age

	Age	Frequency	Percent
Valid	18-25	42	13.13%
	26-35	118	36.88%
	36-45	95	29.7%
	46-55	48	15%
	56-65	17	5.31%
	Total	320	100%

Table 3 represents the age brackets of the Respondents informing that include workers from the ages of 18 to 65years were the age of 26-35years were the highest representing 36.88% of the total respondents.

Table 4: Respondents' Position

	Designation	Frequency	Percent
Valid	Staff (NIMASA, NIWA, NPA,)	200	55.63%
	Manager	42	30.62%
	Onboard Crews	78	13.75%
	Total	320	100%

Table 4 informs on the Respondents' Position/designation. The study covered all required and experienced personnel capable and knowledgeable to provide the need information for the study.

3.2 Descriptive Statistics

Table 5: Plastics Debris

Plastics Debris	N		Mean	Std. Deviation	Variance	Remark
	Valid	Missing				

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Plastics debris pose significant risk to coastal navigation	320	0	3.5833	0.8004	0.641	Agreed
Plastics debris can block ship propellers or steering system causing direct damage to vessels	320	0	3.8573	0.7795	0.608	Agreed
Plastics debris can potentially lead to vessel accidents or collision resulting to repair cost and cargo damage	320	0	4.8802	0.9702	0.941	Strongly Agreed
Plastics debris can entangle damage hulls, resulting in costly repairs and downtime for vessel operations	320	0	4.8568	1.0829	1.173	Strongly Agreed
Plastics debris can injure or kill crew members and passengers, especially in cases of collision or entanglement	320	0	3.7120	0.9425	0.888	Agreed

Table 5 shows the responses on plastics debris effects on coastal navigation in eastern port channels in Nigeria. The respondents have indicated the mean and standard deviation scores of 3.5833±0.8004 showing that Plastics debris pose significant risk to coastal navigation area. The mean and standard deviation scores of 3.8573±0.7795 imply that Plastics debris can block ship propellers or steering system causing direct damage to vessels. The mean and standard deviation scores of 4.8802±0.9702 indicated that Plastics debris can potentially lead to vessel accidents or collision resulting to repair cost and cargo damage. The mean and standard deviation scores of 4.8568±1.0829 indicated that Plastics debris can entangle damage hulls, resulting in costly repairs and downtime for vessel operations and the mean and standard deviation scores of 3.7120±1.9425 indicated that Plastics debris can injure or kill crew members and passengers, especially in cases of collision or entanglement.

Table 6: Wrecked Vessels

Wrecked Vessels	N		Mean	Std. Deviation	Variance	Remark
	Valid	Missing				
Wrecked vessel can have significant effects on coastal navigation	320	0	3.8776	.8869	0.787	Agreed
Wrecked vessel can obstruct navigational channels posing a risk to other vessels and cause accidents and collision	320	0	3.9375	1.0277	1.056	Agreed
Wreckages can be difficult to detect increasing the risk of collisions or grounding	320	2	3.5304	0.8958	0.802	Agreed
Wrecked vessel can result in significant economic losses including costs associated with salvage, removal and environmental cleanup	320	0	3.6354	0.9735	0.948	Agreed
Wrecked vessels can pose risk to rescue operations including the potential for further accidents or injury	320	0	3.5313	1.1073	1.226	Agreed

The information in Table 6 above, are responses on Wrecked Vessels effects on coastal navigation in eastern port channels in Nigeria. The respondents have indicated the mean and standard deviation scores of 3.8776±0.8869 showing that wrecked vessel can obstruct navigational channels posing a risk to other vessels and cause accidents and collision. The mean and standard deviation scores of 3.9375±1.0277 imply that Wrecked vessel can obstruct navigational channels posing a risk to other vessels and cause accidents and collision. The mean and standard deviation scores of 3.5304±.8958 indicated that Wreckages can be difficult to detect increasing the risk of collisions or grounding. The mean and standard deviation scores of 3.6354±0.9735indicated that Wrecked vessel can result in significant economic losses including costs associated with salvage, removal and environmental cleanup and the mean and standard deviation scores of 3.5313±1.1073 indicated that Wrecked vessels can pose risk to rescue operations including the potential for further accidents or injury.

Table 7: Abandoned Fishing Gears

Ghost / Abandoned Fishing Gears	N		Mean	Std. Deviation	Variance	Remark
	Valid	Missing				
Abandoned Fishing Gears or ghost fishing gears and lines can entangle propellers, rudders or hulls of vessels causing damage or loss of control	320	0	3.7474	1.1036	1.218	Agreed
Large amount of Abandoned Fishing Gears can accumulate and pose a collision risk to vessels particularly in areas with high fishing activity	320	0	3.8594	.9887	.978	Agreed
Abandoned Fishing Gears can damage vessels resulting in costly repairs and downtime in ship operations	320	0	3.8385	.9112	.830	Agreed
Abandoned Fishing Gears can pose a risk to navigation particularly if it is not properly marked or removed	320	0	3.7474	1.0072	1.014	Agreed
Abandoned Fishing Gears can pose a risk to marine life including entanglement and suffocation	320	0	3.8880	.9884	.977	Agreed

The information in Table 7 above, are responses on Abandoned Fishing Gears effects on coastal navigation in eastern port channels in Nigeria. The respondents have indicated the mean and standard deviation scores of 3.7474±1.1036 informing that Abandoned Fishing Gears or ghost fishing gears and lines can entangle propellers, rudders or hulls of vessels causing damage or loss of control. The mean and standard deviation scores of 3.8594±0.9887 imply Abandoned Fishing Gears can pose a risk to navigation particularly if it is not properly marked or removed. The mean and standard deviation scores of 3.8385±0.9112 indicated that Abandoned Fishing Gears can damage vessels resulting in costly repairs and downtime in ship operations. The mean and standard deviation scores of 3.7474±1.0072 indicated that Wrecked vessel can result in significant economic losses including costs associated with salvage, removal and environmental cleanup and the mean and standard deviation scores of 3.8880±0.9884 indicated that Abandoned Fishing Gears can pose a risk to marine life including entanglement and suffocation.

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Table 8: Navigational Hazards

Navigational Hazards	N		Mean	Std. Deviation	Variance	Remark
	Valid	Missing				
Navigational hazards caused by marine debris may include propellers, rudders and hull damages	320	2	3.5335	2.3634	5.586	Agree
Marine debris results to increasing accidents on coastal navigation such as grounding	320	2	3.4817	0.9678	0.937	Moderately Agree
Marine debris can entangle propellers causing loss of propulsion and control	320	0	3.4844	0.9253	0.856	Moderately Agree
Debris can also entangle hulls causing damage and potentially leading to flooding or sinking	320	1	3.6172	0.9340	0.872	Agree
Large size debris items can block navigation channels requiring vessels to take detours or navigate through treacherous waters	320	1	3.5979	1.0830	1.173	Agree

The information in Table 8 above, are responses on Abandoned Fishing Gears effects on coastal navigation in eastern port channels in Nigeria. The respondents have indicated the mean and standard deviation scores of 3.5335±2.3634 informing that Navigational hazards caused by marine debris may include propellers, rudders and hull damages. The mean and standard deviation scores of 3.4817±0.9678 imply Marine debris results to increasing accidents on coastal navigation such as grounding. The mean and standard deviation scores of 3.4844±0.9253 indicated that Marine debris can entangle propellers causing loss of propulsion and control. The mean and standard deviation scores of 3.6172±0.9340 indicated that Debris can also entangle hulls causing damage and potentially leading to flooding or sinking and environmental cleanup and the mean and standard deviation scores of 3.5979±1.0830 indicated that Large size debris items can block navigation channels requiring vessels to take detours or navigate through treacherous waters.

Table 9: Safety Risk

Safety Risk	N		Mean	Std. Deviation	Variance	Remark
	Valid	Missing				
Marine debris can cause vessel to collide with other vessels, structures or the seafloor	320	0	3.7599	0.8666	0.751	Agreed
Marine debris can cause injury or fatalities to crew members and passengers, particularly in cases of collisions or entanglements	320	0	3.9010	0.8824	0.779	Agreed
Debris can entangle or trap crews and passengers making it difficult to rescue them	320	0	3.8313	0.8452	0.714	Agreed

Damage vessels and containers can leak oil or hazardous materials posing environmental and health risks	320	0	3.7208	0.8486	0.720	Agreed
Debris can pose safety risk to responders including entanglements cuts and other injuries	320	0	3.6391	0.8738	0.763	Agreed

The information in Table 9 above, are responses on Abandoned Fishing Gears effects on coastal navigation in eastern port channels in Nigeria. The respondents have indicated the mean and standard deviation scores of 3.7599±0.8666 informing that Marine debris can cause vessel to collide with other vessels, structures or the seafloor. The mean and standard deviation scores of 3.9010±0.8824 imply Marine debris can cause injury or fatalities to crew members and passengers, particularly in cases of collisions or entanglements. The mean and standard deviation scores of 3.8313±0.8452 indicated that Debris can entangle or trap crews and passengers making it difficult to rescue them. The mean and standard deviation scores of 3.7208±0.8486 indicated that Damage vessels and containers can leak oil or hazardous materials posing environmental and health risks and standard deviation scores of 3.6391±.8738 indicated that Debris can pose safety risk to responders including entanglements cuts and other injuries.

Table 10: Economic Activities

Economic Activities	N		Mean	Std. Deviation	Variance	Remark
	Valid	Missing				
Marine debris can damage fishing gears leading to costly repairs and replacement	320	0	3.5729	0.7647	0.585	Agreed
Debris can entangle and kill fishes reducing fish stocks and impacting the livelihoods of fishermen	320	0	3.8391	0.8403	0.706	Agreed
Marine debris can require costly beach cleanup which can be a burden on local communities	320	0	3.7417	0.8165	0.667	Agreed
Debris-littered beach and coastal areas can deter tourists leading to lost revenue for local business	320	0	3.9505	0.8822	0.778	Agreed
Debris can increase fuel consumption by requiring vessels to take longer route or maneuver to avoid debris	320	0	3.6417	0.7938	0.630	Agreed

The information in Table 10 above, are responses on Abandoned Fishing Gears effects on coastal navigation in eastern port channels in Nigeria. The respondents have indicated the mean and standard deviation scores of 3.5729±0.7647 informing that Marine debris can damage fishing gears leading to costly repairs and replacement. The mean and standard deviation scores of 3.8391±0.8403 imply Debris can entangle and kill fishes reducing fish stocks and impacting the livelihoods of fishermen. The mean and standard deviation scores of 3.7417±0.8165 indicated that Marine debris can require costly beach cleanup which can be a burden on local communities. The mean and standard deviation scores of 3.9505±0.8822 indicated that Debris-littered beach and coastal areas can deter tourists leading to lost revenue for local business and standard deviation scores of 3.6417±0.7938 indicated that Debris can increase fuel consumption by requiring vessels to take longer route or maneuver to avoid debris.

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3.3 Data Analysis

Table 11: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.677[a]	0.458	0.456	2.76032

a. Predictors: (Constant), PlasDebr WreVess AbaFisGea

The Table 11 above shows the regression model summary which informs on the variables' correlation or influence. From the result, the table shows there is a strong positive correlation/influence between the dependent and independent variables given that R = 0. .677. This infers that the correlation/influence is strong at 67.8%. Furthermore, the R square value is given as 0.458 which indicates that about 46% of the variance in the dependent variable is predictable from the independent variables which show a good fit for the model. Similarly, the Adjusted R square is given as 0.456 which is 45.6% of goodness of fit of the regression model.

Table 12: ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1722.253	5	344.451	45.209	0.000[b]
	Residual	2880.119	378	7.619		
	Total	2897.372	383			

a. Dependent Variable: NavHaz
b. Predictors: (Constant), PlasDebr WreVess AbaFisGea

The Table 12 above is the ANOVA table which provided the F-value and significance of the relationship/influence between the dependent and independent variables of the study. The F-value of 45.2 indicates that the regression model explains a significant amount of variance in the dependent variable which also shows significant at 95% significant level. This suggest that the strong positive relationship/influence between the data variables identified in the model summary table is significant at 95% significant level given that (0.000<0.05) p-value. Therefore, the study accepts that the influence/relationship between the dependent and independent variables are statistically significant at 95%.

Table 13: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	20.912	1.521		13.749	0.000	17.922	23.903
	PlasDebr	10.029	0.088	0.564	113.966	0.000	0.144	11.201
	WreVes	4.010	0.058	0.229	69.138	0.000	0.103	5.124
	AbaFisGea	2.005	0.041	0.340	48.902	0.000	0.086	3.075

a. Dependent Variable: NavHaz

Table 13 explains degree of the significance influence the independent variables exert on the dependent variable of the study. The degree of the influence can be best explains using the model equation as given below:

$$Y_{NavHaz} = 20.912 + 10.029X_{PlasDebr} + 4.010X_{WreVess} + 2.005X_{AbaFisGea} \quad (8)$$

The model explains on a general note that marine debris (plastics litters, ghost fishing gears, wreckages) at a constant value of 20.912 affect the coastal navigation causing navigational hazards, and notwithstanding, the model provided the individual effects of each factors of marine debris impacts on navigational hazards, informing that a unit increase in any of the independent variables would have great impacts on the Navigational Hazards. The equation shows that a unit increase in plastic debris, wreckages, and ghost fishing gears would result in 10.02, 4.010, and 2.005 degrees of Navigational hazard suffered due to marine debris in the Eastern port channels of Nigeria. Therefore, the study rejects the Null hypothesis ($H0_1$) and accept that the effect of Marine debris (Plastics Debris, Wrecked Vessels, Ghost Fishing Gears) on Navigational Hazards in eastern port channels (Calabar, Onne-Bonny, Port Harcourt and Warri waterways) is statistically significant.

Table 14: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.717[a]	0.514	0.512	4.26165

a. Predictors: (Constant), PlasDebr WreVess AbaFisGea

The Table 14 above shows the regression model summary which informs on the variables' correlation or influence. From the result, the table shows there is a strong positive correlation/influence between the dependent and independent variables given that R = 0. 717. This infers that the relationship is very strong at 71.7%. Again, the R square value is given as 0. 514 which indicates that about 51.4% of the variance in the dependent variable is predictable from the independent variables which shows a good fit for the model. Similarly, the Adjusted R square is given as 0.512 which is 51.2% of goodness of fit of the regression model.

Table 15: ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	995.314	5	199.063	10.960	0.000[b]
	Residual	6865.100	378	18.162		
	Total	6960.414	383			

a. Dependent Variable: SafRis

b. Predictors: (Constant), PlasDebr WreVess AbaFisGea

The Table 15 the above ANOVA table provided the F-value and significance of the relationship between the dependent and independent variables of the study. The F-value of 10.960 indicates that the regression model explains a significant amount of variance in the dependent variable which also shows significant at 95% significant level. This suggest that the strong positive relationship between the data variables identified in the model summary table is significant at 95% significant level given that (0.000<0.05) p-value. Therefore, the study accepts that the relationship between the dependent and independent variables are statistically significant at 95%.

Table 16: Coefficients[a]

Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	T	Sig.	95.0% Confidence Interval for B Lower Bound	Upper Bound
1 (Constant)	21.807	2.348		9.287	0.000	17.190	26.425
PlasDebr	2.261	0.135	0.381	16.748	0.000	-.527	3.005
WreVes	3.032	0.089	0.619	34.067	0.000	-.207	4.143
AbaFisGea	0.936	0.063	0.332	14.857	0.000	-.088	2.160

a. Dependent Variable: SafRis

Table 16 explains the impact of independent variables on the dependent variable and the significance relationship between the dependent and independent variables of the study. The impact of the relationship can be best explained using the model equation as given below:

$$Y_{SafRis} = 21.807 + 2.261X_{PlasDebr} + 3.032X_{WreVess} + .936X_{AbaFisGea} \quad (9)$$

The model explains on a general note that marine debris (plastics litters, ghost fishing gears, wreckages) at a constant value of 20.912 affects the coastal navigation causing safety risk. The model also provided the individual effects of each factors of marine debris impacts on safety risk, informing that a unit increase in any of the independent variables would have great impacts on the safety risk. The equation shows that a unit increase in plastic debris, wreckages, and ghost fishing gears would result in 2.261, 3.032, and 0.936 degrees of safety risk suffered due to marine debris in the Eastern port channels. Therefore, this study reject the Null hypothesis ($H0_2$) and accept that the effect of Marine debris (Plastics Debris, Wrecked Vessels, Abandoned Fishing Gears) on Safety Risk within the eastern port channels

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(Calabar, Onne-Bonny, Port Harcourt and Warri waterways) is statistically significant.

Table 17: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.587[a]	0.344	0.342	3.93520

a. Predictors: (Constant), PlasDebr WreVess AbaFisGea

The Table 17 above shows the regression model summary which informs on the variables' correlation or influence. From the result, the table shows there is a strong positive correlation/influence between the dependent and independent variables given that R value is equal to 0.587. This infers that the strength of the relationship is estimated at 58.7% between dependent and independent variables. Furthermore, the R square value is given as 0. 344 which is far less than 1, i.e. about 34.4% of the variance in the dependent variable is predictable from the independent variables which is not a good fit for the model. Similarly, the Adjusted R square is given as 0.342 which is 34.2% of goodness of fit of the regression model. However, the researcher observed the missing predictors.

Table 18: ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	484.847	5	96.969	6.262	0.000[b]
	Residual	5853.642	378	15.486		
	Total	5898.490	383			

a. Dependent Variable: EcoAct

b. Predictors: (Constant), PlasDebr WreVess AbaFisGea

The Table 18 above is the ANOVA table which provided the F-value and significance of the relationship between the dependent and independent variables of the study. The F-value of 6.262 indicates that the regression model explains a significant amount of variance in the dependent variable which also shows significant at 95% significant level. This suggest that the positive relationship between the data variables identified in the model summary table is significant at 95% significant level given that (0.000<0.05) p-value. Therefore, the study accepts that the relationship between the dependent and independent variables are statistically significant at 95%.

Table 19: Coefficients[a]

Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	T	Sig.	95.0% Confidence Interval for B Lower Bound	95.0% Confidence Interval for B Upper Bound
1 (Constant)	20.887	2.168		9.632	0.000	16.623	25.150
PlasDebr	2.123	.125	.393	16.984	0.000	.122	3.369
WreVess	4.030	.082	.520	49.146	0.000	.192	5.131
AbaFisGea	2.971	.058	.113	51.224	0.000	.115	3.115

a. Dependent Variable: EcoAct

Table 19 explains that impact of the significance relationship between the dependent and independent variables of the study. The impact of the relationship can be best explain using the model equation as given below:

$$Y_{EcoAct} = 20.887 + 2.123X_{PlasDebr} + 4.030X_{WreVess} + 2.971X_{AbaFisGea} \quad (10)$$

The model explains on a general note that marine debris (plastics litters, ghost fishing gears, wreckages) at a constant value of 20.887 affects the coastal navigation causing economic loss. The model also provided the individual effects of each factors of marine debris impacts on economic activities, informing that a unit increase in any of the independent variables would have great impacts on the coastal navigation. The equation shows that a unit increase in plastic debris, wreckages, and ghost fishing gears would result in 2.261, 3.032, and 0.936 degrees of economic loss suffered due to marine debris in the Eastern port channels. Therefore, the study reject the Null hypothesis ($H0_3$) and accept that the effect of Marine debris (Plastics Debris, Wrecked Vessels, Abandoned Fishing Gears) on economic activities within the eastern port coastal regions (Calabar, Onne-Bonny, Port Harcourt and Warri waterways) is statistically significant.

3.4 DISCUSSION

3.4.1 Effect of Marine Debris (Plastics Debris, Wrecked Vessels, Ghost Fishing Gears) on Navigational Hazard in Eastern Port Channels (Calabar, Onne-Bonny, Port Harcourt and Warri Waterways)

The statistical analysis of navigational Hazard data reveals compelling evidence supporting the hypothesis that marine debris (Plastics Debris, Wrecked Vessels, and Ghost Fishing Gears) positively correlated/influence navigational hazards in the Eastern port channels. The comprehensive examination of three key debris factors demonstrated consistent patterns of concern among maritime professionals operating in these waters through their responses on the questionnaire data collected addressing whether marine debris significantly compromises navigational safety, yielded the most decisive response pattern with a mean score of ≥ 3.00 and P-value < 0.050. This overwhelming outcome indicates that the maritime professionals directly experience Navigational safety compromises due to marine debris presence in Calabar, Onne-Bonny, Port Harcourt and Warri waterways. The significant value of 0.000 suggests high precision in this measurement, while the relatively low standard deviation indicates consistent agreement across the sample population.

The operational impact becomes more pronounced in the coefficient table of the regression which addresses the individual effect of each factor of marine debris encounters. The findings of the study agreed that the effects of debris (Plastics Debris, Wrecked Vessels, Ghost Fishing Gears) on Navigational Hazard in eastern port channels (Calabar, Onne-Bonny, Port Harcourt and Warri waterways) is statistically significant.

Many other studies supported the findings of this study such as; a field study by the Nigerian Institute of Oceanography and Marine Research assessing marine debris on Nigeria's coastline noted plastics as the most prevalent debris causing navigational safety issues, including capsizing and hull punctures in coastal towns such as Calabar (Anozie, 2025). The Nigerian Ports Authority (NPA) and maritime stakeholders have called for stronger policy frameworks to combat these threats, which impair navigation and port efficiency. Stakeholder reports from maritime summits highlight challenges posed by marine debris to vessel navigation and port operations on the Bonny, Port Harcourt, and Calabar waterways. These debris elements include plastics and ghost fishing gear, which cause navigation hazards and vessel damage (Faith, 2024). Studies note ghost gear (abandoned fishing equipment) as a notable marine debris threatening marine biodiversity and creating navigation hazards in Nigerian and global waters. Ghost gear entangles marine life, damages habitats, and interferes with vessel propulsion and maneuverability. Regional studies and reports specifically examining Onne and Port Harcourt ports discuss marine pollution effects on shipping terminals and the maritime environment, highlighting how marine debris poses a risk to navigation and marine ecosystems in these areas. Recent maritime stakeholder calls stress the need for continued cleanup efforts, stronger regulation, and national policy to reduce marine debris and protect navigation channels in Nigeria's ports including Eastern ports like Calabar, Onne-Bonny, Port Harcourt, and Warri (AARON, 2020)

3.4.2 Effect of Marine Debris (Plastics Debris, Wrecked Vessels, Ghost Fishing Gears) on Safety Risk in the Eastern Port Channels (Calabar, Onne-Bonny, Port Harcourt And Warri Waterways)

The examination of marine debris types and their associated Safety Risks provides substantial evidence supporting the hypothesis that Plastics Debris, Wrecked Vessels, and Ghost Fishing Gears constitute the most prevalent type of marine debris in the Eastern port channels and directly increases the safety risk of vessel. The questionnaire responses reveal distinct patterns in debris encountered and their subsequent operational impacts on maritime safety.

Marine debris (Plastics Debris, Wrecked Vessels, and Ghost Fishing Gears), recorded the high mean scores of ≥ 3.80. The respondents strongly agreed that Marine debris (Plastics Debris, Wrecked Vessels, and Ghost Fishing Gears) represents the most commonly encountered types with detrimental impacts of operational risk in the Eastern Port Channels (Calabar, Onne-Bonny, Port Harcourt And Warri Waterways). The hypothesis test results showed the effects of each factors on safety risk which proved significant with the P-values less than 0.05 at 95% significant level.

Many studies have recorded significant impacts of marine debris on safety risk in the eastern ports' channels and waterways in support of the findings of this study. According to Aaron (2020), on the study "Marine Pollution and Maritime Terminals in Onne Port, Rivers State, Nigeria", examines marine pollution effects on navigation and safety at shipping terminals in Onne/Port Harcourt, identifying oily water and marine debris as significant factors impacting maritime safety and recommending pollution control measures. Arinze and Babatunde (2020), A study on suspended marine litter in the New Calabar and Bonny estuary systems documented the presence and categories of marine debris, highlighting its prevalence and implications for navigation and environmental risk in Nigerian coastal waters. Scientific reviews on abandoned, lost, or discarded fishing gear (ghost gear) underline their role in causing ghost fishing and navigational hazards, affecting marine biodiversity and safety of vessel operations (Koelmans et al., 2014). Reports on wrecked vessels note their dual threat as sources of pollution (including oil and hazardous cargo) and as physical obstructions that compromise navigation safety in Nigerian coastal and port waters. Besseling et al. (2013) study on Broader assessments of marine debris effects on Nigerian coastal communities document navigational risks including hull damage, vessel accidents, and safety threats to small crafts caused by plastics, wrecks, and ghost gear in major waterways including those around Calabar and Bonny and found significant effects of marine debris on safety risk around Calabar and Bonny channels.

3.4.3 Effect of Marine Debris (Plastics Debris, Wrecked Vessels, Ghost Fishing Gears) on Economic Activities in Eastern Port Coastal Regions (Calabar, Onne-Bonny, Port Harcourt and Warri Waterways)

The analysis of marine debris accumulation effects on economic activities provides comprehensive evidence supporting the hypothesis that higher debris presence in high-traffic Port Channels significantly reduces potency of economic activities. The statistical examination of Marine debris (Plastics Debris, Wrecked Vessels, and Ghost Fishing Gears) effects on economic activities reveals substantial impacts on voyage time, fuel consumption, loss of aquatic lives and overall vessel performance within the Eastern port channels. The descriptive analysis established the concentration of marine debris in high-traffic shipping areas of Calabar, Onne-Bonny, Port Harcourt and Warri Waterways, recorded mean scores of greater than or equal to 3.57 agreed that marine debris in the high-traffic areas are detrimental and reduces efficiency of economic activities. This overwhelming consensus establishes the foundational premise that debris accumulation correlates directly with economic loss. The relatively low standard deviations indicate consistent observations across economic activities. The operational efficiency impacts become evident on coefficient table regression analysis which examined the individual debris factors impacts on economic activities, the finding shows a p-value < 0.05, affirming statistically significant effects at 95% significant level.

Notwithstanding other research findings aligned with the results of this study showing significant effects of marine debris on the economic operations in the Eastern ports and waterways, such include; an analysis published in 2024 highlights that marine pollution causes extensive harm to Nigeria's maritime economy, affecting activities like fishing, shipping, and tourism, informing that Marine debris significantly disrupts port operations, damages vessels through collision and hull punctures, and hampers the productivity of coastal fisheries, which are vital to local livelihoods (Chiemezie et al., 2024). Another research on Nigerian coasts shows that plastics and other debris pose direct hazards to artisanal and commercial fishing activities, leading to vessel damage, entanglement, and accidents, which reduce fish catch and increase operational costs. Also, the study of Sule (2021) on wrecked vessels and ghost gear as Sources of Pollution and Safety Risks. the multiple reports document the proliferation of wrecked ships and abandoned fishing gear which block navigational channels, cause physical damage to vessels, and lead to economic losses in port regions like Calabar and Bonny. The coastal communities along Calabar, Onne, and Warri experience economic setbacks due to debris-related accidents, reduced fish stocks, and port inefficiencies caused by obstructive marine debris, which also threatens tourism and peripheral industries.

IV. CONCLUSION AND CONTRIBUTION TO KNOWLEDGE

4.1 Conclusion

The comprehensive statistical analysis of marine debris impacts in the Eastern port channels provides compelling evidence supporting significant effects in all the three research hypotheses. Stakeholders including the Nigerian Ports Authority have emphasized the importance of stronger policies to reduce debris and manage waste effectively to protect maritime trade and coastal economies. Initiatives include port reception facilities and legislative frameworks aimed at controlling marine litters.

In summary, marine debris substantially hampers Nigeria's eastern port zones, affecting port efficiency, fishing livelihoods, marine safety, and coastal economic growth. Formal studies and policy reviews from 2024-2025 support these findings, emphasizing the need for integrated waste management and strengthened regulatory measures.

4.2 Contribution to Knowledge

i. This study has made significant impact to knowledge in that it evaluated the effects of marine debris on coastal navigation in eastern port channels highlighting coordinated responses to mitigate marine pollution particularly within coastal waters.

ii. The study estimated the contributory effects of Plastic Debris, wrecked vessels, and Ghost Fishing Gears on Navigational Hazards, safety risks and economic activities which compromise navigational safety, operational safety and potential economic operations of Calabar, Onne-Bonny, Port Harcourt and Warri waterways.

iii. The results of the test of hypotheses infers that the effects of plastic debris, wrecked vessel, and ghost fishing nets on navigation hazard is 10.02, 4.010 and 2.002, degrees respectively;

iv. The effects plastic debris, wrecked vessels and ghost net on safety risks is 2.262, 3.032, and 0,936 degrees respectively; and the effects of plastic debris, wrecked and ghost nets on economic activities are 2.123, 4.030 and .971 degrees respectively.

v. The contribution is significant in the sense that no known study has evaluated the effects by analyzing the individual impacts of the debris factors on navigational hazards, safety risk and economic activities of Calabar, Onne-Bonny, Port Harcourt and Warri coastal waters and ports.

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