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# A Study on the Minimum Safe Distance Index of Filipino Navigators in the Vicinity of Obstacles and in Adverse Weather Conditions

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Abstract : *This paper investigates minimum safe distances relative to a ship's four cardinal sides, as perceived by Filipino navigators when encountering dangerous elements and in adverse weather conditions when maneuvering in and around harbors. It uses a descriptive research method in the form of a questionnaire survey for experienced Filipino navigators of various ranks. During the course of research, 71 responses were colleted and the resulting data is presented in graphical and tabulated forms. Statistical methods including Pearson-product moment correlations, Cronbach's Alpha and ANOVA were used to identify internal associations, consistencies and significances, respectively. It has been proven that there are no significant differences in minimum safe distances relative to a ship's four cardinal sides, whether maneuvering while approaching a port or within an inner harbor. This study has been deemed significant for training future navigators, managing traffic in fairways, and designing harbors and maneuvering areas in the approaches to ports, among other applications. This work can also be used as a preliminary study for comparison with the well known safe domains presently in use.*

Key Words : *Navigational hazards, Survey questionnaire, Minimum safe distance, Perception of danger, Four cardinal sides*

## 1. Introduction

According to a BIMCO report, the Philippines is the leading supplier of seafarers globally (BIMCO, 2015). The country has held this standing for more than a decade as part of the global maritime human resource sector. The Philippine Overseas Employment Administration, the agency charged with overseeing Filipino overseas workers, processed 519,977 overseas sea-based contracts and deployed 406,531 sea-based workers in 2015, an increase of 0.39% and 1.17% respectively from the previous year. Out of these deployed sea-based workers, 93,992 are categorized as "Officers." In a 2015 domestic shipping report, the agency in charge, the Maritime Industry Authority, issued about 10,499 Seafarers Identification and Record Books (SIRB) for deck officers alone. It registered 12,021 merchant ships of various types and 13,042 crafts engaged in domestic fishing operations (Maritime Industry Authority, 2015).

This data shows the vibrant role and global reach of Filipino navigators aboard various types of ships in different capacities, plying the coastal waters and high seas around the world.

### 1.1 Purpose and Significance

The aim of this paper is to develop a safety index for minimum safe distances relative to a ship's four cardinal sides based on Filipino navigators' perception of risks when maneuvering in the vicinity of port approaches with adverse weather effects.

This study is significant because the results can be applied to improve navigation in the approaches and vicinity of harbors, for management of vessel traffic both onboard and ashore. This research is likewise relevant to the design of training modules and educational curricula for future navigators and, more importantly, in the design, development, or upgrading of local waterways, fairways and approaches to ports.

### 1.2 Theory of Study

This study proves the perennial concerns of navigators regarding the minimum safe distance domain and theorizes whether previously-known and well-used safety indices still hold true in contemporary times. This paper focuses on Filipino navigators because of their dominant role in the navigation of ships with particular emphasis on their perceived minimum safe distance index when faced with obstacles and inclement weather conditions.

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### 1.3 Methodology, Scope and Limitations

This study uses a descriptive research method in the from of a survey questionnaire. It targeted experienced Filipino navigators of different ranks. Although, a holistic maritime spectrum of navigators was intended, no responses were received from local marine pilots or from the fishing fleet. The survey data gathered is presented in graphical and tabulated forms in Section 2. Pearson-product correlation coefficients were applied to measure relationships among the variables, particularly among grouped types of vessels; Cronbach's alpha was used to determine internal consistencies under different conditions and visibility scenarios; and ANOVA was used to test the means of variances given adverse weather effects on visibility, current and wind. These are all presented in Section 3, and Section 4 concludes the study.

### 1.4 Related Models

There are well-known assessment models for marine traffic risk already in use in the industry today. Table 1 summarizes some of the models in use since the end of the 1960's (PIANC, 2014).

Table 1. Summary of Traffic Safety Evaluation Models

| | |
|---|---|
| Transportation Phenomena Evaluation Models | Ship encounter frequency |
| | Frequency analysis model |
| | Route congestion assessment model |
| Maneuverability Difficulty Evaluation Models | SJ model |
| | BC model |
| | ES model |
| | US unsafe shiphandling |
| IMO (IALA) Evaluation Models | PAWSA model |
| | IWRAP model |
| | Formal safety assessment models |
| | - Marine Traffic Risk Assessment (MARA) |
| | - Port Marine Safety Code (PMSC) |

Fig. 1 describes the different safety domains for vessels of approximately 100 meters in length (PIANC, 2014).

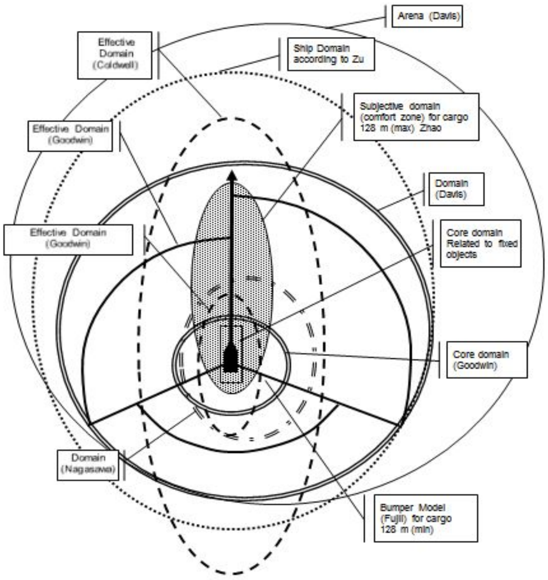


Fig. 1. Vessel safety domains for vessels with a length of approximately 100 m (PIANC, 2014).

## 2. Survey Data

### 2.1 Respondents

For this study, 71 responses were gathered from experienced Filipino navigators of various ages, serving aboard differing types of ships, from various ranks, and with different lengths of experience. Fig. 2 shows the ages of respondents grouped by decade. There were 2 navigators in their 60s, 10 in their 20s and 59 between 30 to 59. Fig. 3 shows the types of ships on which these navigators served, indicating that a majority of 24 worked on board tankers. In the last graph, Fig. 4, it is indicated that 27 navigators were masters; 2 classified themselves as fourth officers and declared they had manned the bridge unassisted; and 42 were chief, second or third officers.

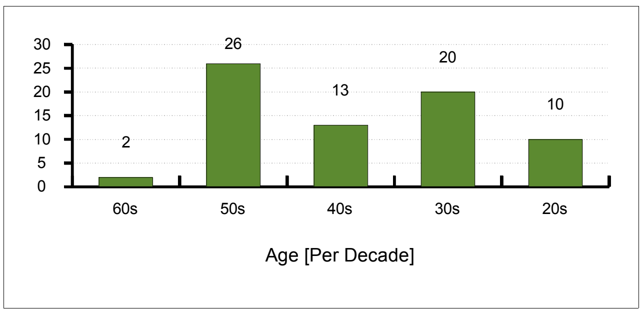


Fig. 2. Respondent ages.

There were 20 respondents with 5 years or less of sea experience; most were junior officers. There were 4 with more than 30 years at sea. Among the respondents, 34 had 6 to 20 years' experience, and 13 had 20 to 30 years. These results are graphed in Fig. 5.

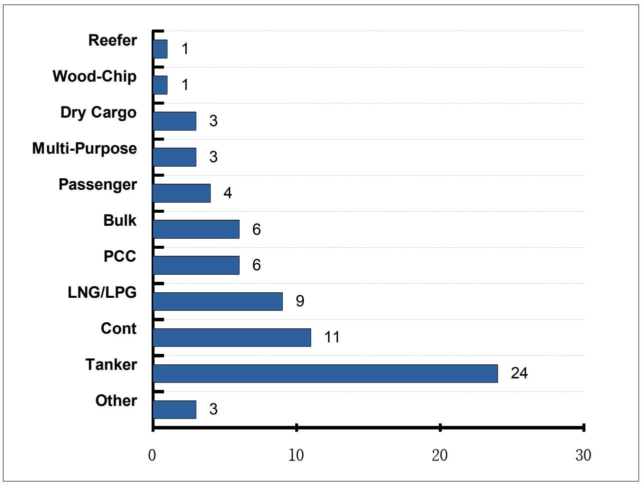


Fig. 3. Types of vessels.

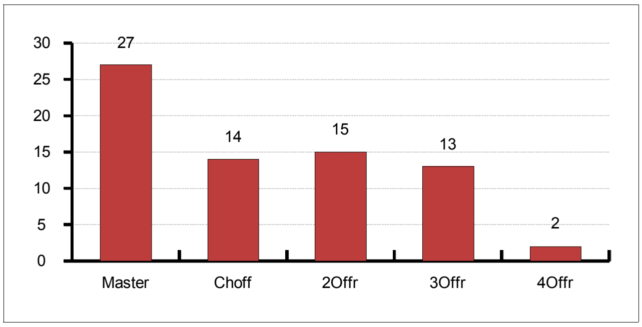


Fig. 4. Last rank held by respondents.

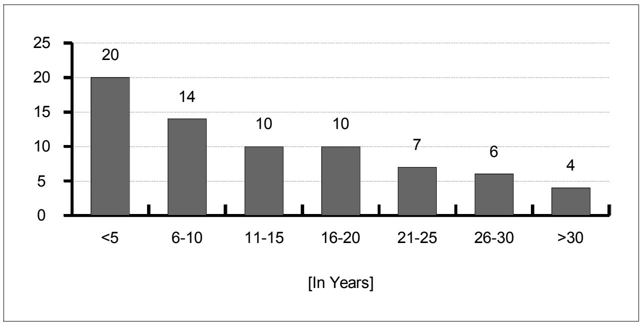


Fig. 5. Respondents' sea experience.

## 2.2 Perceived risks and weather hazards

When vessels are maneuvering at and in the approaches to the fairways of inner or outer harbors, they often encounter ships and other hazards. These obstacles normally bring a certain degree of uneasiness, and, at times, adversely affect situational awareness. These difficulties also include maneuvering near sea AtoN. Prudent navigation requires keen shiphandling around these hazards to avoid risks and mitigate accidents.

This section deals with the risks encountered by navigators while navigating the approaches of harbors. Perceived hazards include other vessels in the approaches, which are the most dangerous elements in the maneuvering areas, and natural phenomena affecting visibility, winds and current.

Fig. 6 depicts the criteria for measuring minimum safe distances from obstacles, ships or land hazards, with respect to the four cardinal sides of a ship as perceived by the respondents relative to the ship's total length (LOA).

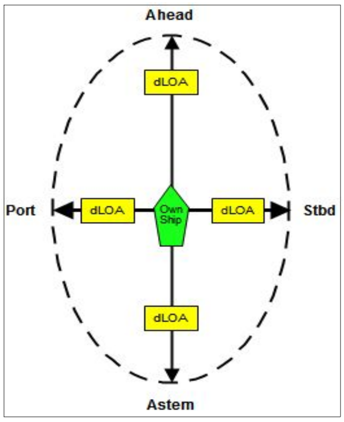


Fig. 6. Diagram of Ship Distance Relative to Other Vessels / Land Obstacles Based on LOA.

### 2.2.1 Most Bothersome Elements

Respondents were asked to rate the types of vessels deemed most bothersome when gauging distance from a ship. Most answered smaller types of ships (small G/T). Fig. 7 shows that fishing vessels were considered the most bothersome (41/49), followed by tug/tow boats (16/10) both in inner and outer harbors, respectively. Bigger ships caused the least concern.

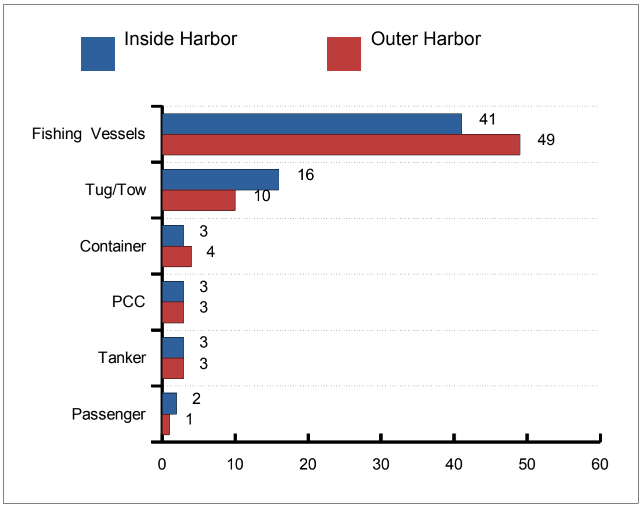


Fig. 7. Most bothersome type of ship based on area of operation.

However, concern about proximity to other ships ranked only third among options including "distance to another vessel" (1st) and "distance to shore/land" (2nd) in the most dangerous element category of hazards as shown in Fig. 8. Other bothersome elements according to navigators are shown in Table 2.

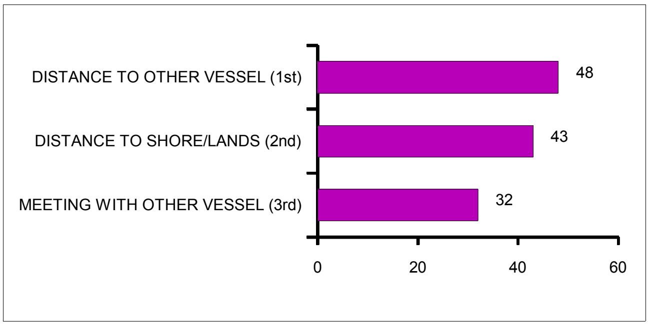


Fig. 8. Most dangerous elements hierarch.

Table 2. Other bothersome elements according to navigators

| Number | Elements |
|---|---|
| 29 | Rate of approach with a target ship |
| 20 | Relative distance from a target ship |
| 16 | Target ship's speed |
| 12 | Length of target ship |
| 12 | Length of own ship |
| 11 | Own ship's speed |
| 7 | Others |

### 2.2.2 Causal Effects of Visibility

Hazards caused by natural phenomena include the effects of visibility, currents and strong winds on a ship. In this section, good visibility conditions when reduced to 2NM are measured. Eight different visibility scenarios are summarized in Table 3. The distances listed are the ratio of distance to the present ship's LOA.

Table 3. Visibility summary

| Scenarios - Location | Ahead | Port | Stbd | Astern |
|---|---|---|---|---|
| Good vis (day-inner harbor) | 5.29 | 3.43 | 3.57 | 4.05 |
| Good vis (day-outer harbor) | 6.76 | 4.91 | 5.03 | 4.88 |
| Good vis (night-inner harbor) | 6.09 | 4.49 | 4.46 | 4.75 |
| Good vis (night-outer harbor) | 7.03 | 5.54 | 5.44 | 5.54 |
| Poor vis (day-inner harbor) | 6.90 | 4.87 | 4.97 | 6.00 |
| Poor vis (day-outer harbor) | 7.56 | 6.03 | 6.03 | 5.86 |
| Poor vis (night-inner harbor) | 8.08 | 6.08 | 6.18 | 6.41 |
| Poor vis (night-outer harbor) | 8.81 | 6.90 | 7.03 | 6.97 |
| Total Mean | 7.07 | 5.28 | 5.34 | 5.56 |

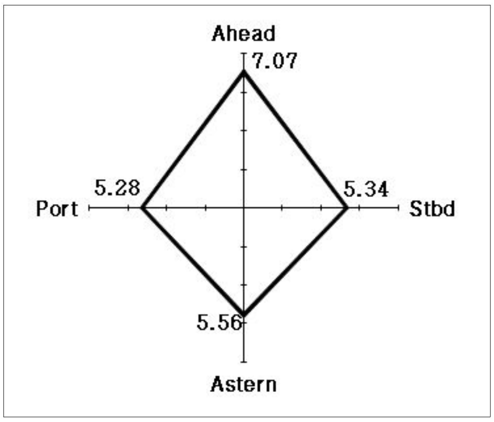


Fig. 9. Mean minimum safe distances based on visibility effects.

The values from the summary of total mean distances in Table 3 are graphed in Fig. 9, according to a ship's cardinal sides.

### 2.2.3 Causal Effects of Currents and Winds

Currents with a force greater than 3 knots and wind with a force greater than 15 knots can have adverse effects, causing a vessel to drift towards danger, i.e., other ships or land, when navigating inner and outer harbors, as summarized in Table 4.

Table 4. Wind and Current Summary

| Scenario and Location | Ahead | Port | Stbd | Astern |
|---|---|---|---|---|
| Current >3knots– Inner Harbor | 7.03L | 5.75L | 5.50L | 6.19L |
| Current >3knots– Outer Harbor | 7.55L | 6.55L | 6.71L | 6.68L |
| Wind >15knots– Inner Harbor | 7.28L | 5.94L | 5.88L | 6.19L |
| Wind >15knots– Outer Harbor | 8.00L | 6.91L | 6.88L | 7.06L |
| Total Mean | 7.47 | 6.29 | 6.24 | 6.53 |

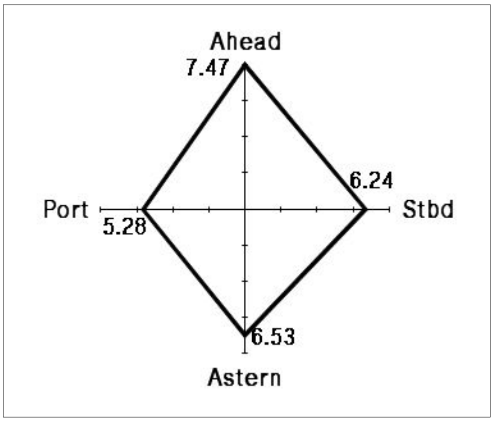


Fig. 10. Mean minimum safe distances based on current and winds effects.

Fig. 10 shows the mean values for scenarios affected by strong wind or currents, causing difficulty for maneuvering ships. The distances are relative to the present ship's LOA; for example 7.47 (Ahead) times the ship's LOA (150 meters) gives a minimum safe distance of 1,120.5 meters, 6 cables or 0.605 nautical miles.

## 3. Statistical Analysis

### 3.1 Analysis of the "Most Bothersome Ship"

This section statistically analyzes the data presented in the previous section.

For "most bothersome type of ship," respondents are grouped according to the types of ships on which they served. Tankers including LNG and LPG are coded as (A), passenger ships as (B), and dry cargo ships as (C) (including bulkers, boxed-ships or containers, general cargo, PCC, wood chip carriers, and reefer ships). Table 5 shows the calculation process used with Pearson-product correlation coefficients for identifying associations between different types of vessels and partial relationships between only two variables, excluding the third variable and partial relationships between the two variables in question when the third variable is fixed.

Table 5. Partial correlations between types of vessels by Pearson-Product Correlation Coefficient

| | Tankers (A) | | Passenger (B) | | Dry Cargo (C) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Type | A | $A^2$ | B | $B^2$ | C | $C^2$ | AB | AC | BC |
| Fishing | 20 | 400 | 3 | 9 | 18 | 324 | 60 | 360 | 54 |
| Container | 3 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PCC | 0 | 0 | 0 | 0 | 3 | 9 | 0 | 0 | 0 |
| Tanker | 1 | 1 | 0 | 0 | 2 | 4 | 0 | 2 | 0 |
| LNG/LPG | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 0 |
| Passenger | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| Tug/Tow | 8 | 64 | 1 | 1 | 5 | 25 | 8 | 40 | 5 |
| Total | 33 | 475 | 4 | 10 | 31 | 367 | 68 | 403 | 59 |

A. Partial relationship between 2 variables:

$$r_{AB} = \frac{N\sum AB - (\sum A)(\sum B)}{\sqrt{[N\sum A^2 - (\sum A)^2]\,[N\sum B^2 - (\sum B)^2]}}$$

B. Partial relationship between 2 variables when 1 variable is fixed:

$$r_{AB.C} = \frac{r_{AB} - r_{AC}\, r_{BC}}{\sqrt{(1 - r_{AC}^2)\,(1 - r_{BC}^2)}}$$

Table 6 summarizes the relationships between each of the three grouped types of vessels. To classify r-values, this study uses the standard correlation interpretation of Pearson's coefficient.

Table 6. Summary of association between and among types of vessels

| | Correlations Between Ships | Associations |
|---|---|---|
| 1 | Tankers (A) & Passenger (B) | Very Strong-Positive |
| 2 | Tankers (A) & Dry Cargo (C) | Very Strong-Positive |
| 3 | Passenger (B) & Dry Cargo (C) | Very Strong-Positive |
| 4 | Tankers (A) & Passenger (B) - Dry Cargo (C) is fixed | Very Strong-Positive |
| 5 | Tankers (A) & Dry Cargo (C) - Passenger (B) is fixed | High-Negative |
| 6 | Passenger (B) & Dry Cargo (C) - Tankers (A) is fixed | Very Strong-Positive |

### 3.2 Analysis of Visibility Conditions

Table 7 calculates variances for different visibility scenarios, depicting locations (inner/outer harbors), conditions (good/bad visibilities) and periods of the day (day/night) in relation to a ship's four cardinal sides: ahead, portside, starboard side (stbdside), and astern. Using Cronbach's Alpha to calculate the internal consistency of item results with 0.9899, the alpha (α) value denoted excellent consistency.

Table 7. Visibility variances for the four cardinal sides calculated using Cronbach's alpha

| Scenarios | - Location | Ahead | Port | Stbd | Astern | Σ |
|---|---|---|---|---|---|---|
| Good Visibility | Day-Inner Harbor | 5.29 | 3.43 | 3.57 | 4.05 | 16.34 |
| | Day-Outer Harbor | 6.76 | 4.91 | 5.03 | 4.88 | 21.58 |
| | Night-Inner Harbor | 6.09 | 4.49 | 4.46 | 4.75 | 19.79 |
| | Night-Outer Harbor | 7.03 | 5.54 | 5.44 | 5.54 | 23.55 |
| Poor Visibility | Day-Inner Harbor | 6.90 | 4.87 | 4.97 | 6.00 | 22.74 |
| | Day-Outer Harbor | 7.56 | 6.03 | 6.03 | 5.86 | 25.48 |
| | Night-Inner Harbor | 8.08 | 6.08 | 6.18 | 6.41 | 26.75 |
| | Night-Outer Harbor | 8.81 | 6.90 | 7.03 | 6.97 | 29.71 |
| | Summation | 56.52 | 42.25 | 42.71 | 44.46 | 185.9 |
| | Variance | 1.06 | 1.03 | 1.02 | 0.79 | 3.92 |

| | | |
|---|---|---|
| Columns = | $k$ | 4 |
| Σvar = | Σvar | 3.92 |
| Variance = | $\sigma^2$ | 15.22 |
| Alpha = | α | 0.989 |

An ANOVA test of Table 8 showed a P-value < 0.05 or F-value > F-critical (for both columns and rows), which implies a 95% level of confidence. There were significant differences between the minimum safe distances for inner/outer harbors and the four cardinal sides of a ship in good visibility for daytime maneuvers.

Table 8. Good visibility, Day-time, Inner/Outer harbors (near the coast)

| | Inner Harbor | Outer Harbor | Diff % |
|---|---|---|---|
| Stbd | 3.57 | 5.03 | -0.007% |
| Ahead | 5.29 | 6.76 | -0.008% |
| Port | 3.43 | 4.91 | -0.007% |
| Astern | 4.05 | 4.88 | -0.008% |

ANOVA Two-Factor Without Replication

| *Source of Variation* | *SS* | *df* | *MS* | *F-value* | *P-value* | *F-crit* |
|---|---|---|---|---|---|---|
| Rows | 4.49 | 3 | 1.49 | 29.22 | 0.01 | 9.27 |
| Columns | 3.43 | 1 | 3.43 | 66.99 | 0.004 | 10.12 |
| Error | 0.15 | 3 | | | | |
| Total | 8.07 | 7 | Level of significance | | | 0.05 |

The ANOVA test shown in Table 9 returned a P-value < 0.05 or F-value > F-critical, which indicates a 95% level of confidence. There was a significant difference between the columns and rows for good visibility, nighttime transits.

Table 9. Good visibility, Night-time, Inner/Outer harbors (near the coast)

| | Inner Harbor | Outer Harbor | Diff % |
|---|---|---|---|
| Stbd | 4.46 | 5.44 | -0.008% |
| Ahead | 6.09 | 7.03 | -0.008% |
| Port | 4.49 | 5.54 | -0.008% |
| Astern | 4.75 | 5.54 | -0.009% |

ANOVA- Two-Factor Without Replication

| *Source of Variation* | *SS* | *df* | *MS* | *F-value* | *P-value* | *F-crit* |
|---|---|---|---|---|---|---|
| Rows | 3.52 | 3 | 1.17 | 194.49 | 0.001 | 9.276 |
| Columns | 1.76 | 1 | 1.76 | 292.90 | 0.000 | 10.127 |
| Error | 0.02 | 3 | | | | |
| Total | 5.30 | 7 | Level of significance | | | 0.05 |

The ANOVA test shown in Table 10 for poor visibility, daytime maneuvers indicated a different significance: a P-value > 0.05 or

F-value less than F-critical. Therefore, with a 95% level of confidence, this test implied that there was no significant difference between the columns and rows.

Table 10. Poor visibility, Day-time, Inner/Outer harbors (near the coast)

| | Inner Harbor | Outer Harbor | Diff % |
|---|---|---|---|
| Stbd | 4.97 | 6.03 | -0.008% |
| Ahead | 6.90 | 7.56 | -0.009% |
| Port | 4.87 | 6.03 | -0.008% |
| Astern | 6.00 | 5.86 | +0.010% |

ANOVA Two-Factor Without Replication

| *Source of Variation* | *SS* | *df* | *MS* | *F-value* | *P-value* | *F-crit* |
|---|---|---|---|---|---|---|
| Rows | 4.13 | 3 | 1.37 | 7.89 | 0.06 | 9.27 |
| Columns | 0.93 | 1 | 0.93 | 5.37 | 0.10 | 10.12 |
| Error | 0.52 | 3 | 0.17 | | | |
| Total | 5.59 | 7 | Level of significance | | | 0.05 |

Table 11 holds the results from another ANOVA test, which shows P-values (all zeroes) less than 0.05 or F-values with a large difference from F-critical values. This means that with a 95% level of confidence, there was significant difference between the columns and rows for poor visibility, nighttime transits.

Table 11. Poor visibility, Night-time, Inner/Outer harbors (near the coast)

| | Inner Harbor | Outer Harbor | Difference % |
|---|---|---|---|
| Stbd | 6.18 | 7.03 | -0.009% |
| Ahead | 8.08 | 8.81 | -0.009% |
| Port | 6.08 | 6.90 | -0.009% |
| Astern | 6.41 | 6.97 | -0.009% |

ANOVA Two-Factor Without Replication

| *Source of Variation* | *SS* | *df* | *MS* | *F-value* | *P-value* | *F-crit* |
|---|---|---|---|---|---|---|
| Rows | 5.17 | 3 | 1.72 | 202.90 | 0.00 | 9.27 |
| Columns | 1.09 | 1 | 1.09 | 128.84 | 0.00 | 10.12 |
| Error | 0.02 | 3 | 0.01 | | | |
| Total | 6.29 | 7 | Level of significance | | | 0.05 |

## 3.3 Analysis of Currents and Winds

The combined effects of winds (>15 Knots) and currents (>3 Knots) on a vessel when navigating inner and outer harbors have also been tested for significant differences. Tables 12 and 13 show ANOVA calculations that resulted in P-values less than the 0.05 alpha, except for some columns in Table 12, where the P-Value is greater than 0.05, which implies significant differences among the variables. This is caused by a zero value which can be interpreted to mean that for inner harbor piloting the combined effects of currents >3 knots and winds of 15 knots, vessel crews perceive the same minimum safe distance.

Table 12. Currents / Winds: Inner Harbor

| | Current >3 Knots | Wind >15 Knots | % diff |
|---|---|---|---|
| Stbd | 5.50 ×LOA | 5.58 ×LOA | 1.4% |
| Ahead | 7.03 ×LOA | 7.28 ×LOA | 3.4% |
| Port | 5.75 ×LOA | 5.94 ×LOA | 3.2% |
| Astern | 6.19 ×LOA | 6.19 ×LOA | 0% |

ANOVA: Two-Factor Without Replication

| *Source of Variation* | *SS* | *df* | *MS* | *F-value* | *P-value* | *F-crit* |
|---|---|---|---|---|---|---|
| Rows | 2.59 | 3 | 0.86 | 69.24 | 0.002 | 9.27 |
| Columns | 0.08 | 1 | 0.08 | 6.73 | 0.080 | 10.12 |
| Error | 0.03 | 3 | 0.01 | | | |
| Total | 2.71 | 7 | Level of significance | | | 0.05 |

Table 13. Outer harbor: Currents / Winds

| | Current >3 Knots | Wind >15 Knots | % diff |
|---|---|---|---|
| Stbd | 6.71 ×LOA | 6.88 ×LOA | -0.010% |
| Ahead | 7.55 ×LOA | 8.00 ×LOA | -0.009% |
| Port | 6.55 ×LOA | 6.91 ×LOA | -0.009% |
| Astern | 6.68 ×LOA | 7.06 ×LOA | -0.009% |

ANOVA: Two-Factor Without Replication

| *Source of Variation* | *SS* | *df* | *MS* | *F-value* | *P-value* | *F-crit* |
|---|---|---|---|---|---|---|
| Rows | 1.45 | 3 | 0.48 | 67.46 | 0.003 | 9.27 |
| Columns | 0.23 | 1 | 0.23 | 32.26 | 0.011 | 10.12 |
| Error | 0.02 | 3 | 0.01 | | | |
| Total | 1.70 | 7 | Level of significance | | | 0.05 |

As shown in Tables 14 and 15, the mean results for safe minimum distances in all conditions, scenarios and locations with reference to visibility, currents and winds pass the significance test with P-value < 0.05 and a 95% level of confidence. The F-critical values, likewise, are much less than the F-values for both rows and columns.

Table 14. General average minimum safe distances according to visibility, currents and winds

| | Visibility | Currents | Winds | General Mean |
|---|---|---|---|---|
| Ahead | 7.07 | 7.29 | 7.64 | 7.33 L |
| Stbd | 5.34 | 6.11 | 6.38 | 5.94 L |
| Port | 5.28 | 6.15 | 6.43 | 5.95 L |
| Astern | 5.56 | 6.44 | 6.63 | 6.21 L |

Table 15. ANOVA test for significant differences with respect to visibility, current and winds

| Sum | Count | Sum | Ave | Var | | |
|---|---|---|---|---|---|---|
| Ahead | 3 | 21.99 | 7.33 | 0.08 | | |
| Stbd | 3 | 17.82 | 5.94 | 0.29 | | |
| Port | 3 | 17.85 | 5.95 | 0.35 | | |
| Astern | 3 | 18.61 | 6.20 | 0.32 | | |
| Visibility | 4 | 23.24 | 5.81 | 0.71 | | |
| Currents | 4 | 25.98 | 6.49 | 0.30 | | |
| Winds | 4 | 27.07 | 6.76 | 0.35 | | |
| *Source of Variation* | *SS* | *df* | *MS* | *F-value* | *P-value* | *F-crit* |
| Rows | 3.93 | 3 | 1.30 | 46.96 | 0.00 | 4.75 |
| Columns | 1.94 | 2 | 0.97 | 34.86 | 0.00 | 5.14 |
| Error | 0.16 | 6 | 0.03 | | | |
| Total | 6.04 | 11 | | | | |

## 4. Conclusion

This study gauged minimum perceived safe distances with reference to certain factors to create a safety domain, focusing on Filipino navigators' perception of danger when navigating in and around the vicinity of harbors. Thus, the following were proven:

- Smaller G/Ts (fishing boats, tug and tow boats, collectively) are the most bothersome type of vessel encountered.
- The most dangerous navigational elements are relative distances from ships (1st), land obstacles (2nd), and encounters with other ships (3rd). These findings are presented in Sub-section 2.2.1.
- Results for minimum safe distances relative to a ship's LOA in relation to its four cardinal sides (ahead, stbdside, astern and portside) with regard to natural phenomena including visibility, winds and currents are shown in Table 14 and graphed in Fig. 11.

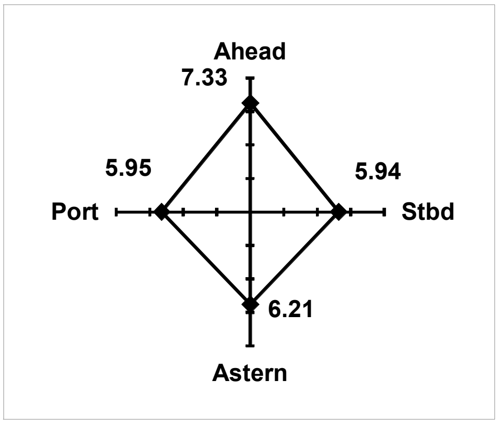


Fig. 11. General average means for visibility, currents and winds.

These findings prove that the effects of adverse weather (visibility, currents and winds) on minimum relative safe distances relative to a ship's cardinal sides do not cause significant differences whether maneuvering in inner or outer approaches of harbors.

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