

An evaluation of the port of Fremantle as a tropical cyclone haven

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The Fremantle area has been evaluated as a tropical cyclone haven and provides safe shelter in the inner harbour or in Cockburn Sound from tropical cyclones. Large ships anchoring in Gage Roads would be more vulnerable to strong winds and seas associated with intense tropical cyclones.

Introduction

Severe tropical cyclones, also known as hurricanes or typhoons, are among the most destructive weather phenomena a ship may encounter whether the ship be in port or at sea. When faced with an approaching tropical cyclone, a timely decision regarding the necessity and method of evasion must be reached. Basically, the questions are . . . Should the ship remain in port, evade at sea, or if at sea, should it seek the shelter offered by the harbour? This study evaluates the port of Fremantle as to its potential as a tropical cyclone haven and should provide useful guidance to ships' captains, harbour officials, or meteorological personnel in answering the above questions.

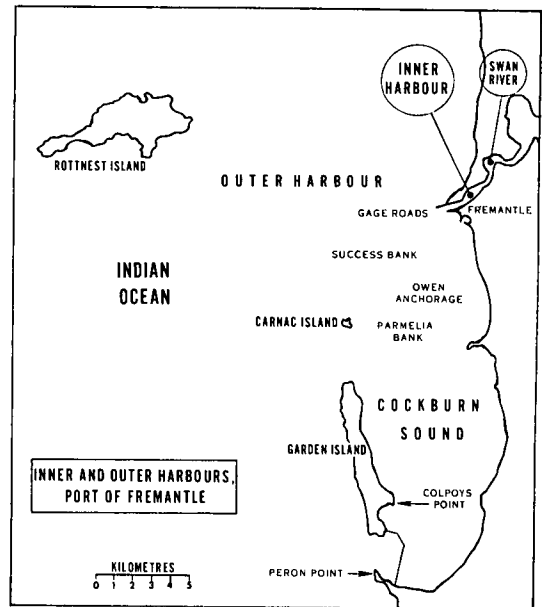
In general it is an oversimplification to label a harbour as merely good or bad. Consequently, an attempt is made to present enough information about the harbour to aid a decision maker in reaching a sound decision with respect to a ship. The decision should not be based on the expected weather conditions alone, but also on the ship itself and the characteristics of the harbour. These characteristics include port congestion and availability of support facilities and natural shelter (Brand and Bleloch 1976).

Fremantle harbour

Cockburn Sound is the most sheltered of the three anchorage areas (Gage Roads, Owen Anchorage, and Cockburn Sound) in Fremantle's expansive outer harbour (Fig. 1). The inner harbour extends a short distance up to the Swan River to the northeast.

The northern end of Cockburn Sound is approximately 9 km south of the entrance to the Fremantle inner harbour. Transit into Cockburn Sound must be made from the north via single channels through two very shoal banks, Success Bank and Parmelia Bank, which separate the three anchorage areas. Cockburn Sound, a spacious anchorage area approximately 7 km wide by 15 km long, is situated between Garden Island to the west and the mainland to the east and south.

Fig. 1 Port of Fremantle.



Garden Island protects the U-shaped embayment from the west. Its irregular terrain is broken by several hills roughly 50 m in height. A causeway at the southwestern end of the sound connects Garden Island with Peron Point across a very shoal strand of sandy and rocky reefs and only small boats can pass west.

As an anchorage area, Cockburn Sound is quite versatile and affords secure anchorages at almost all points. Most of the area provides depths ranging from 9 to 32 m. It is well protected from most winds and the holding ground is generally a stiff blue clay that provides an excellent setting.

Tropical cyclones affecting Fremantle harbour

Tropical cyclone climatology for Fremantle harbour

Tropical cyclones that pose a threat to Fremantle — and any tropical cyclone approaching within approximately 340 km is defined a ‘threat’ in this study — are usually weakening at the time of passage. The maximum sustained winds of the tropical cyclones are typically less than 28 m s^{-1} at the closest point of approach (CPA). The majority of those that pose a threat to Fremantle occur during the period January through April.

Figure 2 is a December-May monthly summary of threat situations based on data for the 28 years 1949-76. The maximum number of threat situations have occurred in February and March. Figure 3 depicts these threat tropical cyclones according to the compass octant from which they approached Fremantle; their tracks are shown in Fig. 4. Figure 5 shows the percentages of tropical cyclones that have passed within approximately 340 km of Fremantle during the months of December through April; these data can be interpreted as indicating probability of threat. The dashed lines in Fig. 5 represent approximate approach times to Fremantle based on typical speeds of tropical cyclones affecting this port — for example, a tropical cyclone located at 24°S , 111°E has a 50 per cent probability of passing within 340 km of Fremantle and will typically reach it in approximately 1.5 to 2 days.

Fig. 2 Frequency distribution of the number of tropical cyclones (18) that passed within approximately 340 km of Fremantle during the period 1949-76.

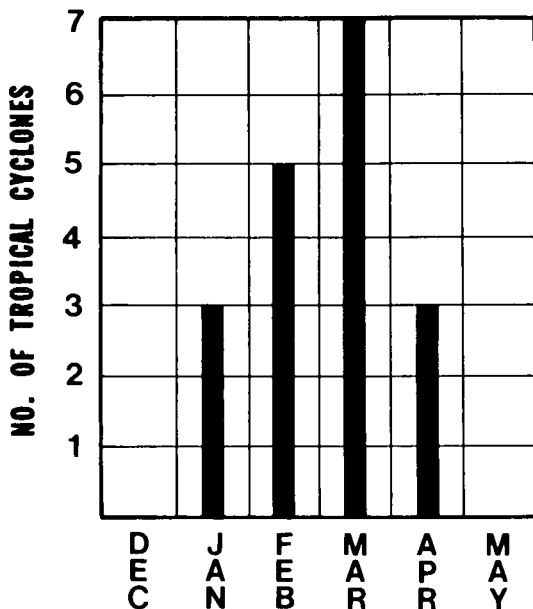


Fig. 3 Direction of approach to Fremantle of tropical cyclones (1949-76) that passed within approximately 340 km of Fremantle. Circled numbers indicate the number that approached from each octant. Percentages indicate the total sample of 18 that approached from each octant.

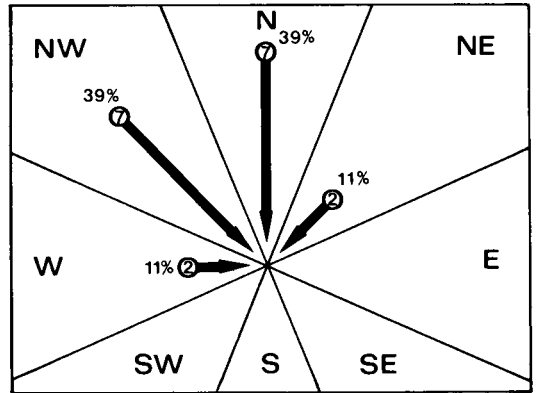
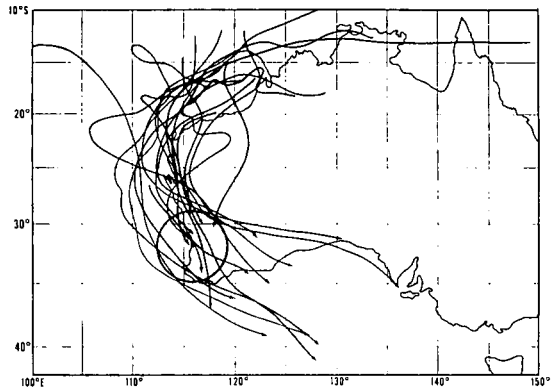


Fig. 4 Tracks of tropical cyclones (1949-76) that passed within approximately 340 km of Fremantle (circled area).



Winds and seas due to tropical cyclones

Of the 18 tropical cyclones that posed a threat to Fremantle during the 28-year period 1949-76, only two or three contributed to sustained winds (10-min average) of gale force or greater*. Gusts from 20 to 30 m s^{-1} , generally from the northwest or northeast, were common from these tropical cyclones.

The tropical cyclones that threaten the Fremantle area are usually those that have become extratropical and have weakened. Some of these storms move very rapidly, with forward movement at 10 to 15 m s^{-1} at CPA to Fremantle, so the time of occurrence of strong winds associated with the storms is brief. It should be kept in mind, however, that as these storms become extratropical in character, the area of gale force winds sometimes expands. Gales therefore may occur in Fremantle with the storm centre about 500 to 600 km away and winds may not

* The wind records examined were from the Perth City anemometer and the Fremantle area winds could be higher for certain strong wind conditions.

necessarily increase as the centre approaches. They may even decrease as the cyclone centre loses intensity or begins to be absorbed in an oncoming trough of low pressure in the westerlies.

The most dangerous situation for the Fremantle area would be a close 20 to 40 km passage just to the west. In addition, the storm would have to be intense at CPA ($> 30 \text{ m s}^{-1}$ maximum wind at this latitude could be considered intense). The rarity of occurrence of such a combination of close passage and intensity leads to the conclusion that the Fremantle area is a good tropical cyclone haven. This is particularly true in the sheltered areas of Cockburn Sound (the wharves of Colpoys Point or anchorages to the east of Garden Island, for example) or in the inner harbour. The only exception would be for a large ship anchoring in Gage Roads, an area more exposed to the north and west. Gage Roads could also experience 3 to 5 m seas, whereas Cockburn Sound would never have seas greater than 3 m under the worst possible conditions. It should also be noted that while Gage Roads might be having 3 to 5 m seas, the open sea to the west could be experiencing 6 to 9 m seas.

Storm surge does not appear to be a problem in the Fremantle area.

The decision to evade or remain in port

Remaining in port

Remaining in Fremantle is the recommended course of action for all ships except those large ships anchoring in Gage Roads*. The Cockburn Sound area, as well as the security of the inner harbour, provides excellent shelter from the effects of tropical cyclones affecting Fremantle.

Figure 6 shows the highest probabilities of Fig. 5 depicted as a tropical cyclone threat axis for Fremantle. The following timetable incorporating Fig. 6 provides guidance for assessing the threat posed by an approaching tropical cyclone.

1. Existing tropical cyclone moves into, or potential development occurs in, Area A with forecast movement toward Fremantle:
 - (a) Review material condition of ship.
 - (b) Reconsider all maintenance activities scheduled to exceed 24 hours.
 - (c) Plot tropical cyclone warnings. Be aware of local warnings issued at Perth.
 - (d) Large ships should begin planning course of action should sortie be ordered.
2. Tropical cyclone enters Area B with forecast movement toward Fremantle:
 - (a) Reconsider all maintenance activities scheduled to exceed 12 hours.
 - (b) Prepare ship for heavy weather. Move to secure anchorages or wharves in Cockburn Sound, or to inner harbour.

* Large ships with their large sail areas would find the narrow channel leading to the protected area of Cockburn Sound hazardous to transit in moderate or high winds.

Fig. 5 Probability that a tropical cyclone will pass within approximately 340 km of Fremantle for the months, December through April. The broken lines indicate approximate approach times to Fremantle based on typical speeds of movement of tropical cyclones affecting Fremantle. (Based on data from 1949-76.)

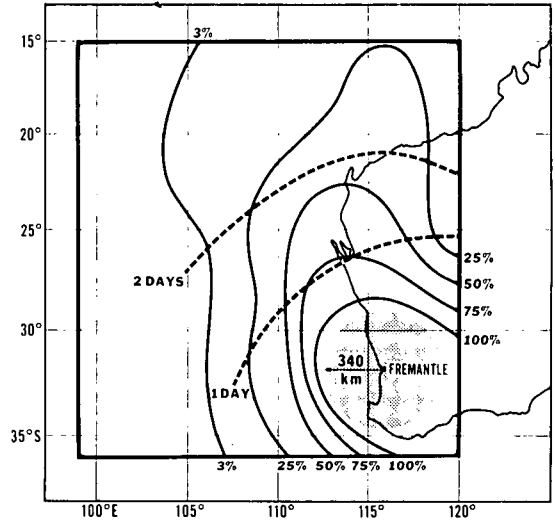
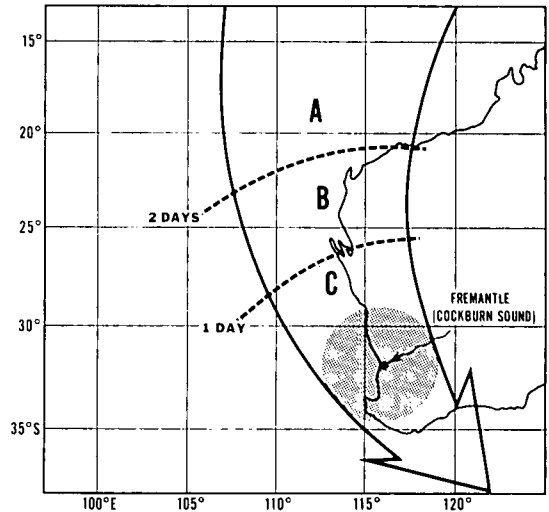


Fig. 6 Tropical cyclone threat axis for Fremantle. Approach times are based on typical speeds of movement for tropical cyclones affecting Fremantle harbour.



- (c) Plot tropical cyclone warnings. Be aware of local warnings.
- (d) If an intense tropical cyclone is forecast to pass within 340 km and has maximum winds of $> 30 \text{ m s}^{-1}$ at CPA, evasive action is recommended to west-southwest if anchored in Gage Roads.
3. Tropical cyclone enters Area C with forecast movement toward Fremantle:
 - (a) Ensure sufficient power available to counter high winds and seas by steaming to anchor.
 - (b) Monitor tropical cyclone and local warnings.

Evasion at sea

Evasion at sea is not the recommended course of action. The only exception would be for large ships anchored in Gage Roads and with the expected arrival of an intense tropical cyclone ($> 30 \text{ m s}^{-1}$ maximum wind at CPA). Such an occurrence is rare in the Fremantle area, but as is the case with many ports, the Fremantle area has never been truly tested in recent times by the close passage of a severe tropical cyclone.

The evasion route to the west-southwest is short and direct with following sea and wind for almost all tropical cyclone threat situations.

Summary

The Fremantle area provides safe shelter in the inner harbour or in Cockburn Sound from tropical cyclones. Large ships anchoring in Gage Roads would be more vulnerable to strong winds and seas associated with intense tropical cyclones. These conclusions are based on the following:

1. Tropical cyclones passing near Fremantle will be weakening and, based on history, will generally contribute to less than 20 to 25 m s^{-1} sustained winds (10-min average).
2. Garden Island to the west of Cockburn Sound significantly reduces westerly winds and seas in Cockburn Sound, and the inner harbour is well protected from winds and seas.
3. The blue clay anchor holding ground is excellent in Cockburn Sound and is considered good in Gage Roads.
4. The present channel from Gage Roads to Cockburn Sound might be too restrictive for some large ships; therefore, they would tend to anchor in Gage Roads which is potentially more susceptible to an intense tropical cyclone.

Acknowledgments

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References

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