WEATHER AND SEA CONDITIONS OF WELLINGTON HARBOUR AND SOUTH COAST

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Weather and Sea Conditions of Wellington Harbour and South Coast

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PREFACE

Certain parts of New Zealand's coastline, as well as having considerable commercial traffic, are utilised by large numbers of small craft. These craft have special requirements for weather forecasts.

As a result, detailed studies of weather and sea conditions in these areas are being made, firstly to provide background information for forecasters and secondly to give those people who use the areas a better understanding of the weather and sea conditions they are likely to encounter.

This, the first of the series, deals with the Wellington Harbour and south coast. Subsequent publications in the series will be similar in style.

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A.M. QUAYLE

ABSTRACT

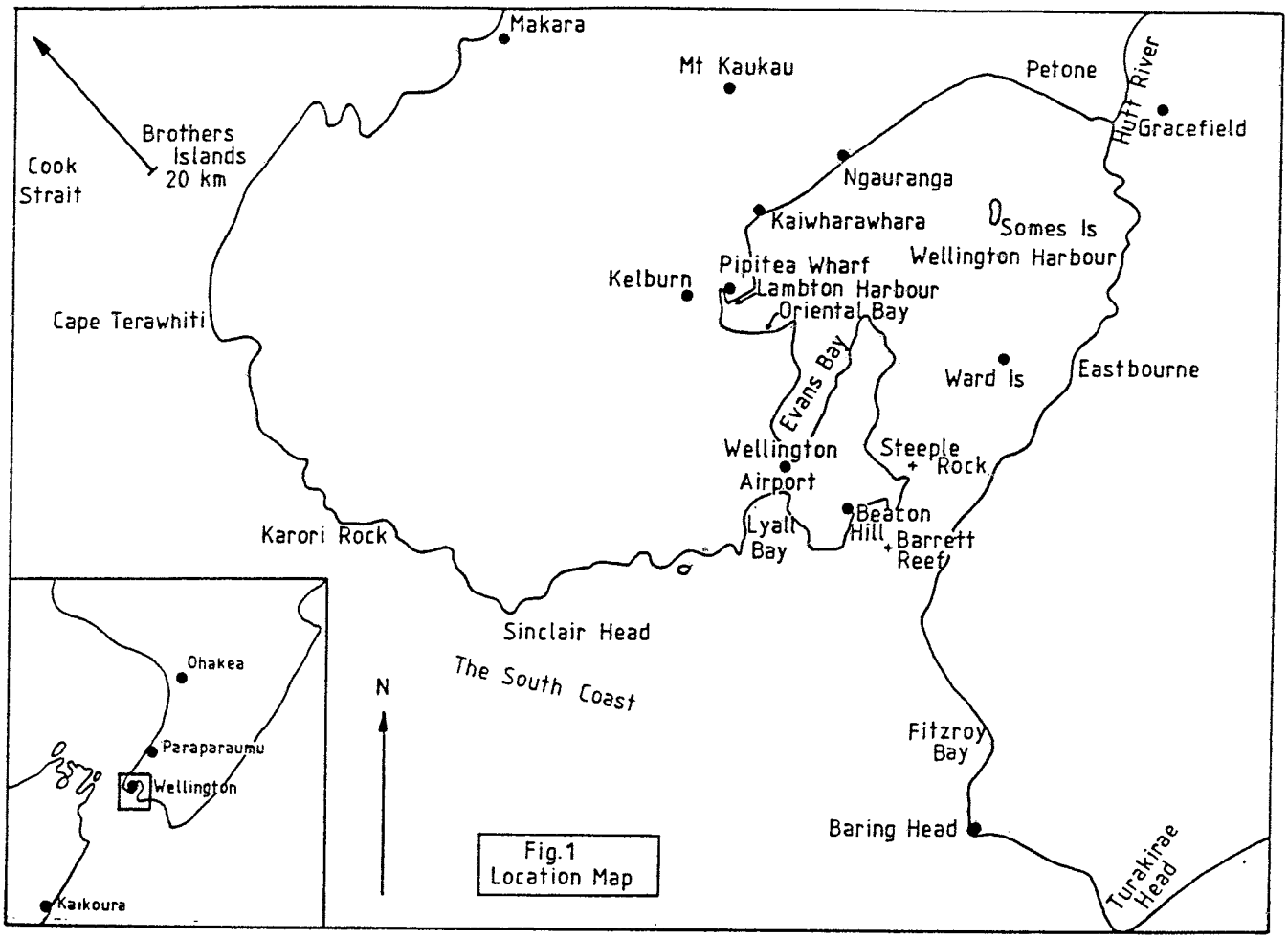
Over the past few years, since the formation of a specialist marine forecasting group at the National Weather Forecasting Centre, a wealth of information and experience in forecasting for the seas around New Zealand has been accumulated. This information has been supplemented greatly by the feedback of information from forecast users, especially in the Cook Strait area where the rail ferries provide regular observations and numerous commercial fishermen are in regular communication with the forecasters. Information from all available sources has been used in order to produce this report, which describes the weather and sea conditions of the area.

1. INTRODUCTION.

Wellington Harbour covers an area of some 76 sq.km adjacent to Wellington City. Steep hills rise to around 400m above the western and eastern shores of the harbour, with lower hills, rising to around 150m, immediatly west of the harbour entrance. The valley of the Hutt River leads into the northern end of the harbour and the harbour entrance (2-3km wide) leads out to the south. Very steep hills rise to heights of around 500m above the south coast. The main basin of the harbour is some 22m deep, although the sea floor shelves up to around 12m in the entrance. As well as being an important commercial port, with some 7000 arrivals and departures per annum, Wellington Harbour is an important recreational area. The harbour itself is used by large numbers of yachts, water skiers and swimmers while the south coast is popular with fishermen, surfers, divers and swimmers.

Because of its location, close to Cook Strait, Wellington experiences a high frequency of strong winds, mostly from the north and south.

The locations of places referred to in the text are shown in Fig. 1.



2. OBSERVATIONS.

Hourly wind observations are available from Mt Kaukau, Kelburn and Wellington Airport, supplemented by synoptic observations from Beacon Hill at 0600hrs, 1200hrs and 1800hrs (local time). Occasional reports received from ships and from various harbour users can also be used to supplement the regular observations.

Winds reported at Wellington Airport give an excellent indication of likely winds over much of the harbour, as do those from Beacon Hill. Because of its somewhat sheltered location, Kelburn's winds only rarely provide a good guide to winds on the

harbour. Winds recorded on Mt Kaukau are almost invariably stronger than those experienced on the harbour, but are a useful indication of likely gust speeds and for estimating wind speeds on the south coast.

Statistical wind information from various other sites around the harbour (e.g. Pipitea Wharf, Gracefield and Somes Island) has also been used in this study. Unfortunatly no real-time information is available from these places.

Regular reports of sea and swell conditions are received from Beacon Hill and from the Cook Strait ferries (normally at the mid-strait reporting point, west of Cape Terawhiti), and may be supplemented at times with reports from surfers, fishermen and others.

The Forecasting Centre at Kelburn commands an excellent view of Wellington Harbour, enabling forecasters to keep wind and sea conditions under constant surveillance.

3. WINDS.

3.1. General.

Winds on Wellington Harbour and the south coast are strongly influenced by the area's proximity to Cook Strait. As a result of its being a narrow gap between the mountainous North and South Islands, winds through the strait are subject to strong channelling and strengthening influences. The resulting winds through Cook Strait are predominantly from the north and south. Fig. 2 shows wind roses for various sites aroound Wellington Harbour, and serves to illustrate the effects of channelling in the area. Note that while Kelburn has a high frequency of northwesterlies, observations from other sites suggest that northerlies are the prevailing wind. The Mt Kaukau anenometer (elev. 425m) probably gives the best estimate of wind directions in the Wellington area, being situated on a high mast above localised channelling influences. It appears likely that winds at Kelburn are modified by the local topography, while those recorded at the other sites are more representative of the general flow over the area. This is confirmed by the inset wind rose in Fig. 2, constructed from winds reported by ships in Cook Strait. The pattern with southerlies is quite consistent, with the exception of observations at Baring Head where the representation of southerly winds probably differs from what is actually experienced over the adjacent sea.

Information received from harbour users suggests that there is little spatial variation of wind on the harbour, apart from some small scale localised sheltering and strengthening (e.g., sheltering of inshore parts of Oriental Bay during a southerly and local strengthening near the Ngauranga Gorge under northwesterly conditions). Much greater variability exists on

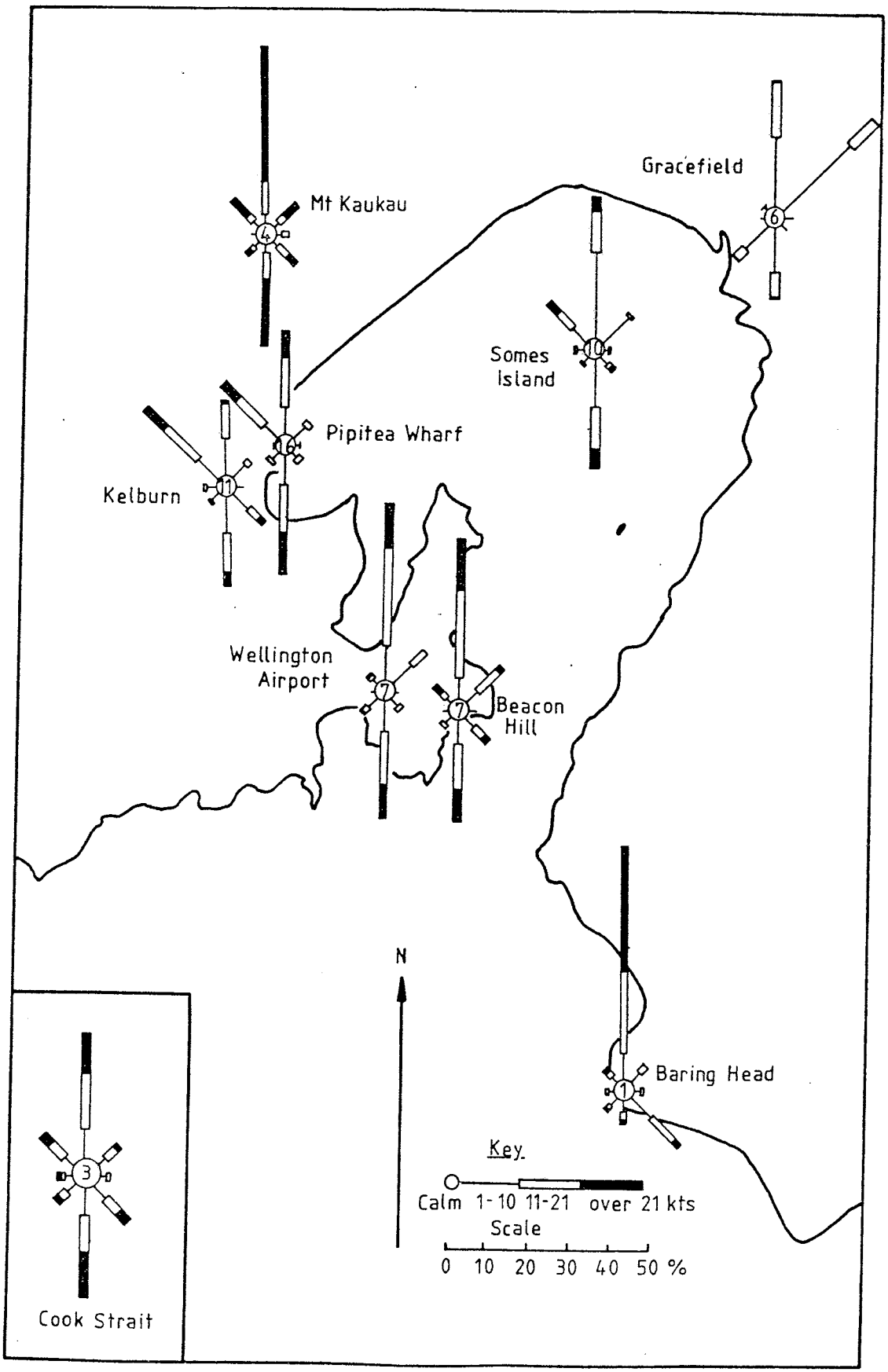


Fig. 2 Wind Roses for sites around Wellington and (inset) for Cook Strait (based on Ship Reports, from Reid and Collen, 1983).

the south coast and is dealt with (where possible) in the following sections.

Seasonal variations of wind speed and direction at Wellington Airport are shown in Table 1.

Table 1: Seasonal Variations of Wind Speed and Direction (%) (Wellington Airport)

	Spring	Summer	Autumn	Winter
Northerly	60	57	52	48
Southerly	31	34	35	38
0 - 10kt	29	30	38	39
20kt and above	34	30	27	28

3.2. Northerly Winds

Northerlies (from 320 to 040 degrees) are the prevailing winds in the Wellington area, accounting for 50 to 60% of all winds. Under most conditions the winds are in the range 340 to 020 degrees and tend northwesterly only when strong or when the air is unstable. Northerlies are most frequent during the period October to January and least frequent between May and August.

Winds from the north occur in the Wellington area when pressures are lower over the South Island than over the North Island, with the wind strength being roughly proportional to the magnitude of the pressure differences. Parts of the south coast are known to sometimes experience northerlies with speeds much higher than elsewhere in the region. This effect is pronounced in the Karori Rock to Sinclair Head area and has been the subject of at least one study (Stainer, 1983). Very similar effects are known to occur in the Turakirae Head area but a lack of observations has prevented any detailed study being made. Following a period of southerlies or light winds, northerlies usually increase rapidly, often reaching their maximum strength on the first day with subsequent days having similar (and sometimes lower) wind speeds.

Situations producing northerlies through Cook Strait have been classified into five main types (Revell, 1982), each producing characteristic flow patterns. These situation types are illustrated in Fig. 3.

A. Anticyclonic Northerlies.

This type of situation occurs frequently, especially in

summer and is characterised by anticyclones centred east of New Zealand. The air is normally stable and channelling influences are marked. Wind speeds on the harbour are typically about 80% of those on Kaukau and winds in the Karori Rock to Sinclair Head area are about 110% of the Kaukau speeds.

B. Strong Northwesterlies.

This type of situation commonly occurs when a front is advancing onto and over the South Island. Northerlies begin to freshen in the Wellington area as pressures fall over the South Island ahead of the front. The strongest winds are often experienced when the front is lying across Otago and Southland. As the front moves north of about Westport and Christchurch there is sometimes a gradual moderation of the winds about Cook Strait. However, this is not always the case, especially if there is a marked pressure trough with the front. An important charcteristic of this type of situation is the formation of a wind maximum on parts of the south coast, sometimes with wind speeds in the order of 150 to 200% of those recorded on Mt Kaukau. This phenomenon is not fully understood but appears to be associated with the formation of a small orographic low off the coast (Stainer, 1983) and is most likely to occur when the wind direction at Mt Kaukau is in the range 350 to 020 degrees and the air is stable. Under these conditions strong "downslope" winds develop as the stable air accelerates down off the ridges above the coast. There is some evidence that the position of the wind maximum alters as the wind direction changes; however, this aspect is not well documented.

C. Strong Westerly.

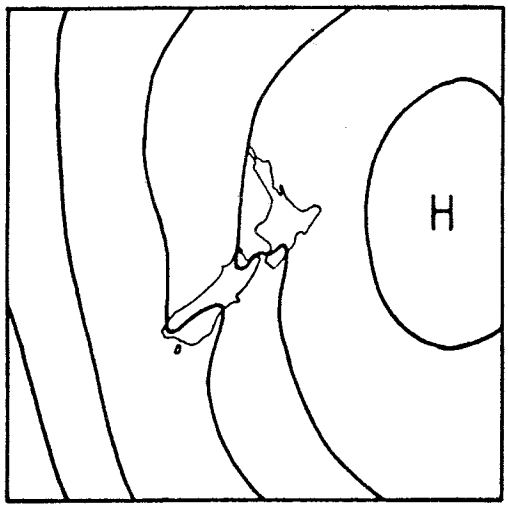
This situation type, often associated with post frontal conditions, produces gusty northwesterlies on the harbour and south coast. As a general rule the strongest winds occur in the northern parts of Cook Strait - from the outer Sounds to Mana Island. However, wind speeds similar to those recorded on Mt Kaukau are sometimes experienced on the South Coast and occasionally on the harbour.

D. Anticyclonic West to Southwesterly.

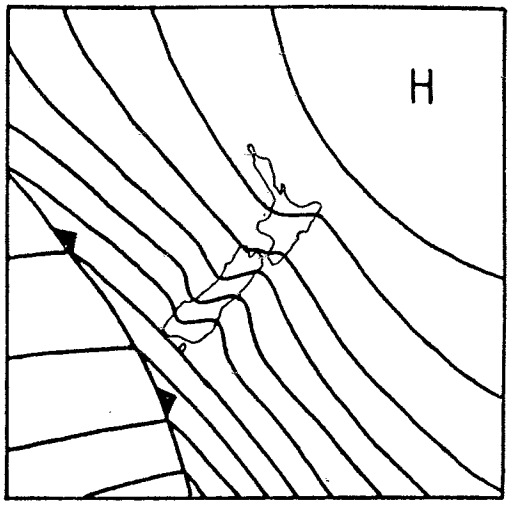
This is a common situation, occurring with an anticyclone in the Tasman Sea. The air over the region is usually stable, with strong channelling effects resulting in predominantly north to northeast winds on the harbour and south coast. The strongest winds are normally experienced in the area from Karori Rock westwards, where speeds are typically 120% of those recorded on Mt Kaukau.

E. Cyclonic Southwesterly.

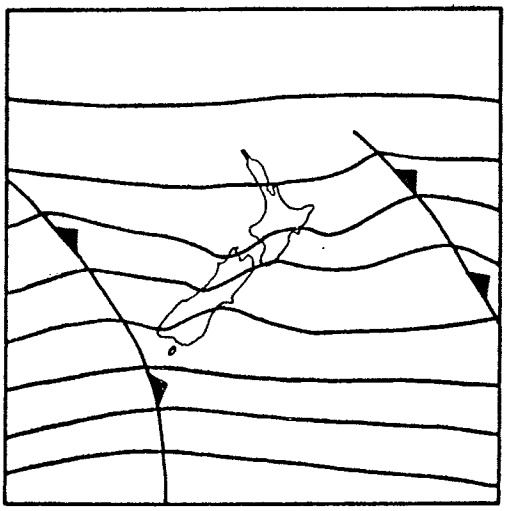
These situations are characterised by unstable air and the



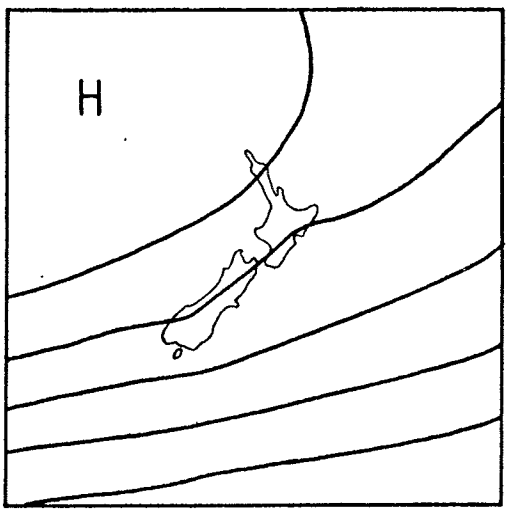
a) Anticyclonic Northerly



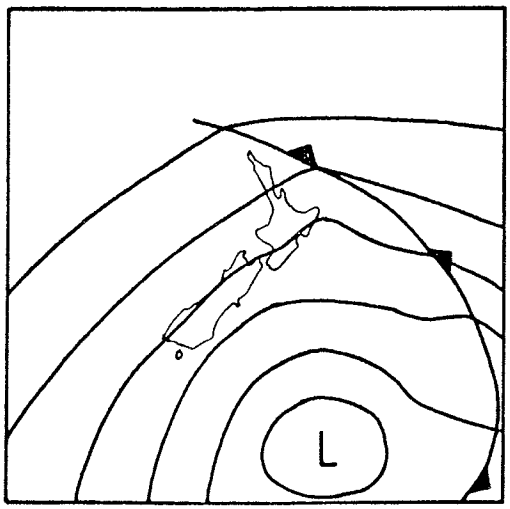
b) Strong Northwesterly



c) Strong Westerly



d) Anticyclonic West-Southwesterly



e) Cyclonic Southwesterly

Fig. 3 Situations producing Northerlies in the Wellington Area

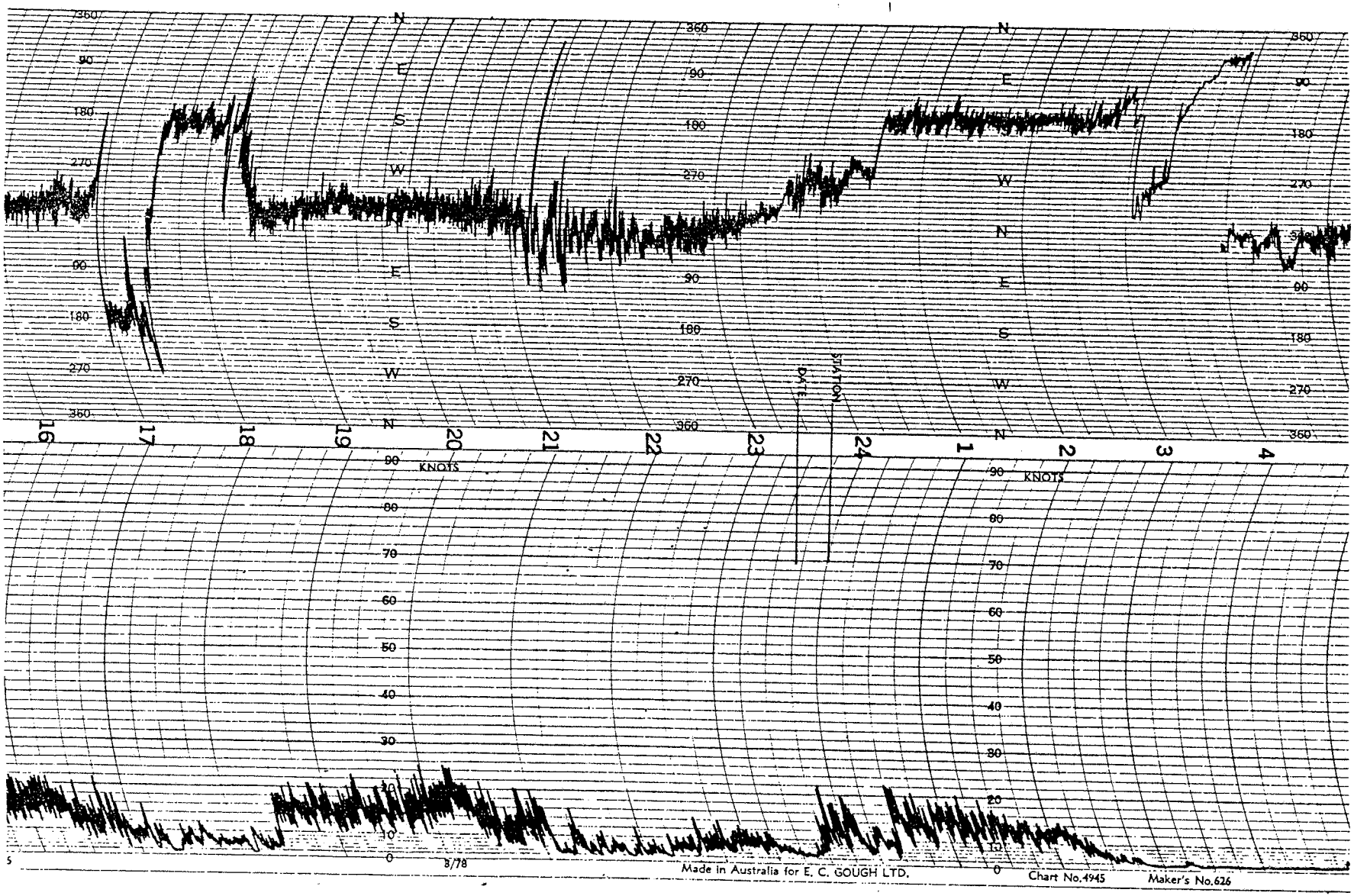


Fig. 4: Anemograph Chart for 28-29 January 1979.

resulting winds have a marked westerly component. Forecasting winds in Cook Strait under these conditions can be extremely difficult as there is often considerable spatial and temporal variability. It is not uncommon for winds in the order of 20kt from the north, south and west to be recorded simultaneously at various locations in the Wellington area. Generally however, the winds can be expected to be from between west and northwest, with considerable variation in strength. The highly variable nature of winds at Wellington under these conditions can be clearly seen on the anemograph (Fig. 4) from Wellington Airport on 28-29th January 1979.

3.2.1 Forecasting Rules for Northerlies. Various empirical methods have been developed for forecasting the strength of northerly winds in the Wellington/Cook Strait area. Van den Assum (1975) has developed a method which relates the magnitude of the pressure difference Paraparaumu minus Wellington to the wind speed at Wellington Airport (Fig. 5.). Beswick (personal communication) found that when the pressure difference Ohakea minus Christchurch reaches 10hPa (positive) winds of about 35kt are likely in Cook Strait (and probably 20 to 25kts on Wellington Harbour). When this pressure difference reaches 15hPa, winds of 50kt are likely in the Straits and 30 to 35kt with gusts 50kt on the harbour.

3.3. Southerly Winds.

Southerly winds, mostly in the range 140 to 200 degrees occur most frequently during the months May to August and least frequently between October and January. They account for about 30% of all winds at Wellington and are likely whenever pressures are higher over the South Island than over the North Island.

The arrival of a southerly at Wellington can be difficult to predict as can its strength. Such changes are normally easily traced as they advance northwards along the east coast of the South Island, but speeds recorded there often give little indication of the speeds that will be experienced in Cook Strait. While one southerly may give 25kt at Kaikoura and 50kt at Wellington another may produce the opposite; 50kt at Kaikoura and 25kt at Wellington. Because of their unpredictable nature and the fact that they are capable of producing such severe conditions, each potential southerly change should be treated with caution, by mariners and forecasters alike.

As in the case of northerlies it has been possible to divide southerly situations into five categories (see Fig. 6.) which can be summarised as follows.

A. Cyclonic South to Southwest.

When a depression lies east of Wellington strong south to

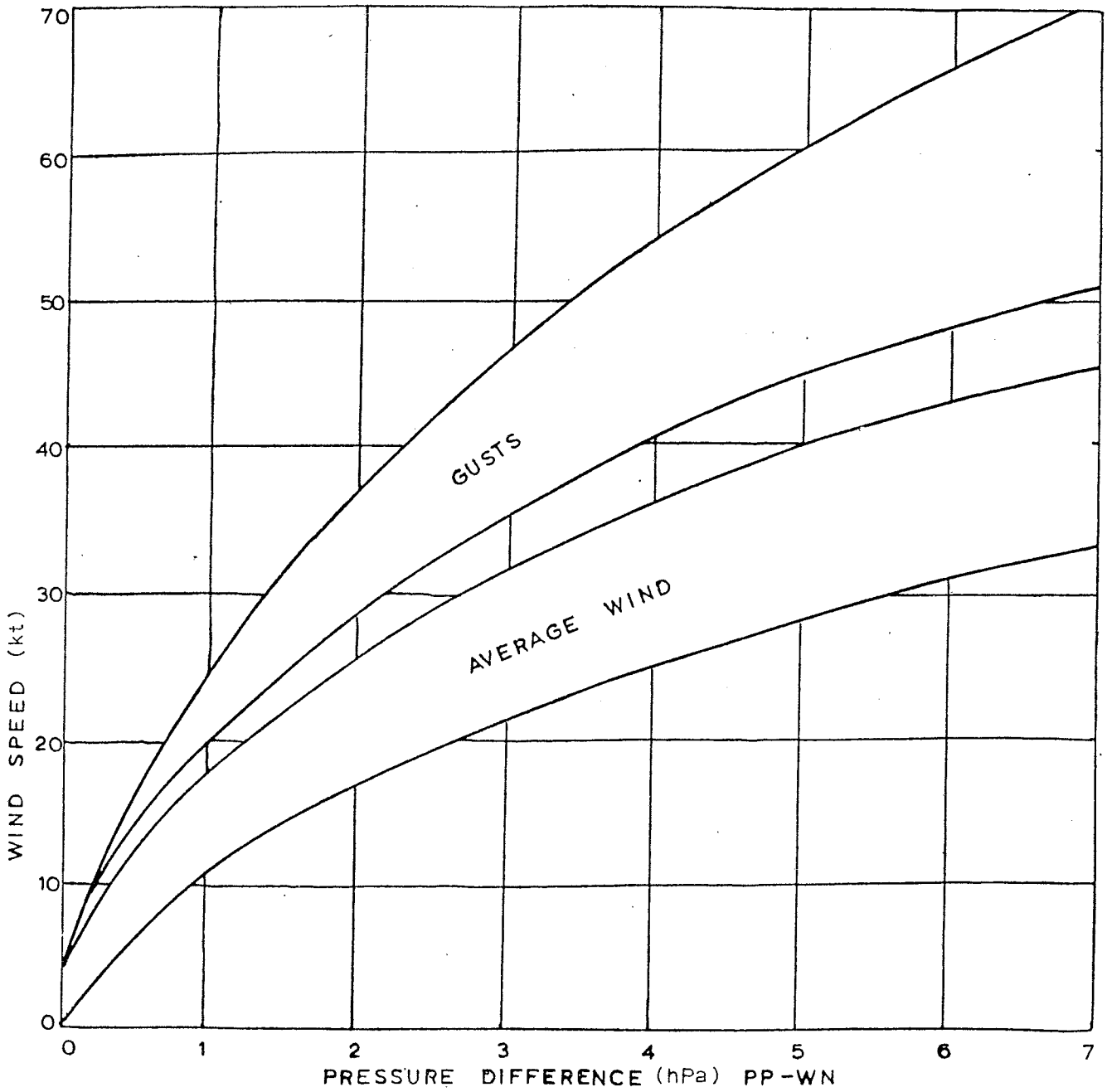
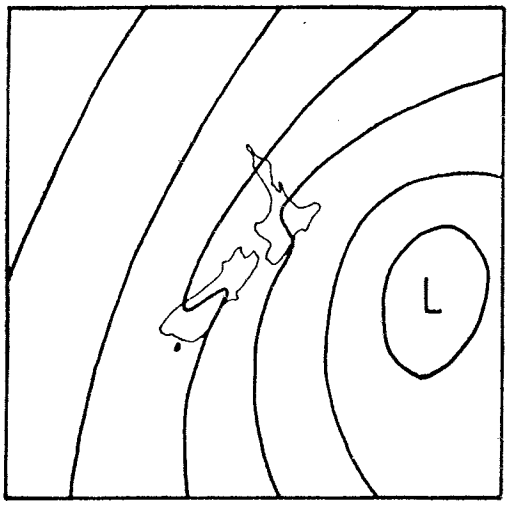
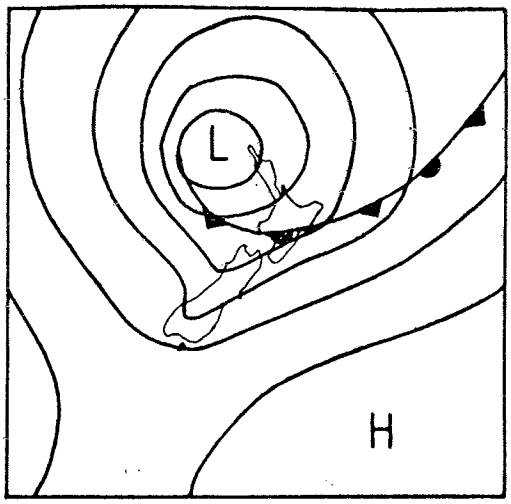


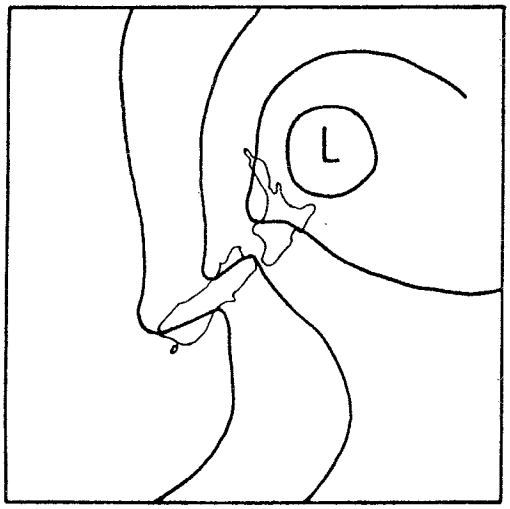
Fig. 5: Relationship between northerly winds at Wellington Airport, at the time of maximum diurnal heating, and the pressure difference Paraparaumu minus Wellington (from Van den Assum, 1975).



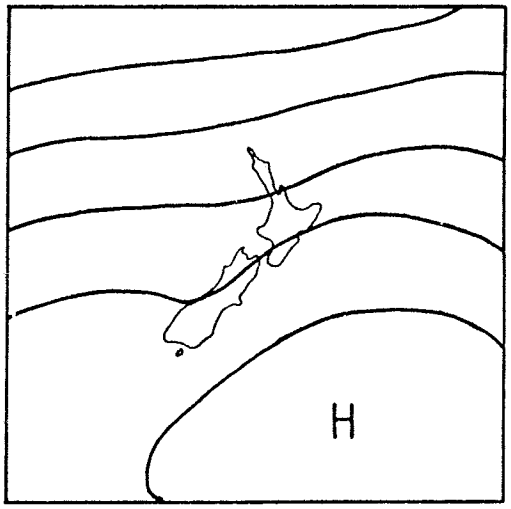
a) Cyclonic South-Southwest



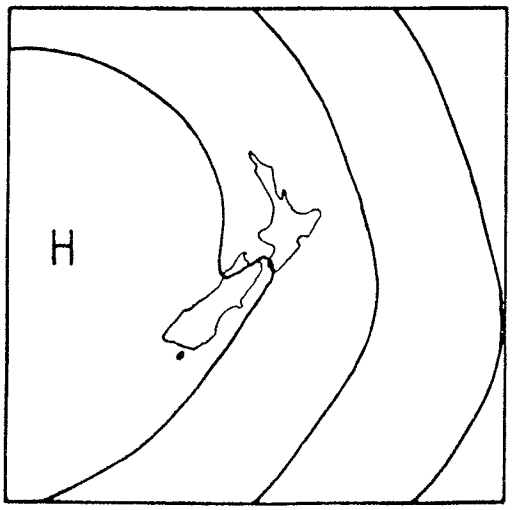
c) Cyclonic East-Northeast



b) Cyclonic ESE-SE



d) Anticyclonic Easterlies



e) Anticyclonic S-SW

Fig. 6 Situations Producing Southerlies at Wellington

southwest flows often occur. Severe southerly gales often develop in the Wellington area and may last for several days. There is reported to be a wind maximum in the harbour entrance and wind speeds reported by ships and at Wellington Airport often equal those recorded on Mt Kaukau. The direction of the southwest flow over New Zealand is very critical as slight changes in direction may result in very significant changes to the winds around Wellington (see also Section 3.2.E and Fig. 4).

B. Cyclonic Eastsoutheast to Southeast.

This type of situation occurs when pressures are relatively high over the South Island and a depression lies in the Bay of Plenty to East Cape area. The flow over the North Island is generally from between eastsoutheast and southeast but winds in the Wellington/Cook Strait area are strongly influenced by the local topography. In general, wind directions are southerly with speeds typically 80 to 90% of the Kaukau value, but with a maximum (about 120% of the Kaukau speed) extending from near Karori Rock to the Brothers Islands.

C. Cyclonic Northeast to East.

When a low lies over or immediatly west of Northland a northeast or east flow develops over the North Island. As in type (B) winds through Cook Strait and about Wellington are channelled into southerly or southeasterly directions. Speeds are generally less than with type (B) but a relative maximum often develops in the Karori Rock to Brothers Islands area, with speeds typically about 90% of those on Kaukau.

D. Anticyclonic Easterlies

Quite frequently large anticyclones lie east of the South Island, with relatively low pressures over the north of the North Island (but without a depression). These situations produce a similar pattern to type (C) but with lighter winds.

E. Anticyclonic South to Southwest.

When large anticyclones in the Tasman Sea spread ridges across the South Island a southerly flow tends to develop over the North Island and strong southerlies often occur in Cook Strait. Wind speeds on the harbour are generally about 70% of those on Mt Kaukau and the coast from Sinclair Head to Karori Rock experiences winds approximatly equivelent to those on Kaukau.

3.3.1 Forecasting Rules for Southerlies. The importance of being able to accurately predict the arrival and strength of southerlies has led to several

forecasters investigating the use of pressure differences as a forecasting tool. Van den Assum (1975) found that a southerly change at Wellington becomes very likely when the pressure at Christchurch rises above that at Wellington, with the change occurring on average four to six hours after the pressure difference Wellington minus Christchurch becomes negative. This timing, however, is rather variable, and relates to such other elements as the 500hPa wind direction at Invercargill (the change is likely to occur earlier if the 500hPa wind at Invercargill is southerly) and the pressure pattern over the North Island (the change is likely to be delayed if pressures over the North Island are high, and may arrive earlier if the flow over the North Island is already southwesterly). Beswick (personal communication) has found that the strength of the southerly (in kt) in Cook Strait is approximatly ten times the pressure difference Wellington minus Christchurch (in hPa), when this difference is negative. This rule can only be used when the flow over New Zealand is southerly as opposed to southeasterly, i.e. it can only be used with situation types (A) and (E).

3.4. Other Wind Directions.

Because of the strong channelling influences already discussed, and because Wellington is sheltered by ranges to the east and west, winds from directions other than north and south are comparatively rare. Winds from the west and from the east do occasionally occur but only rarely do speeds exceed 15kt, and in most cases these winds blow only for short periods.

3.5. Sea Breezes.

During the months October to April a sea breeze may develop in the Wellington area when pressure gradients are weak and the skies are clear. The sea breeze at Wellington Airport is southsouthwesterly at about 10kt and a similar sea breeze affects the south coast and harbour. There is, however, a marked onshore component to the winds around the harbour and although the general flow is southsouthwesterly, winds tend to be southeasterly along the western shores from Kaiwharawhara to the west end of Petone Beach and southwesterly along the Eastbourne coast. During sea breeze conditions winds are normally light and variable, or even northeasterly, in Oriental Bay and Lambton Harbour. It is not uncommon for a sea breeze to develop on the south coast while winds remain northerly over the harbour.

On some occasions, after the sea breeze has developed, a pressure gradient favourable to northerly winds forms, so that winds above the surface turn northerly. Sometimes further increases in the pressure gradient will be sufficient to produce a rapid change from sea breeze southerlies to northerlies on the harbour and south coast.

Generally the sea breeze develops late in the morning, but

in midsummer it may be as early as 9.30am. By early evening it has normally died away.

On a larger scale, when pressure gradients over the country are weak during the summer, winds in the Wellington area are often strongly influenced by the development of heat lows over the central North Island and over the north and east of the South Island. Predicting which heat low will dominate is a difficult task for forecasters. However, it appears that when the general flow over the country is southwesterly the North Island heat low will dominate, producing fresh southerlies at Wellington. Conversely, when the general flow over New Zealand is northwesterly the South Island heat low tends to be dominant, producing fresh northerlies in the Wellington area.

3.6. Katabatic Winds.

When pressure gradients are weak the predominant early morning winds on Wellington Harbour are northeasterly, due to the drainage of cool air from the Hutt Valley onto the harbour. This is a very shallow wind and although it does sometimes affect the airport it is never experienced at Kelburn.

3.7 Calms.

Calms occur on Wellington Harbour between 7 and 10% of the time and, along with light winds, are most frequent during autumn and winter (see Table 1.).

Although relatively infrequent they are important, as recreational usage of the harbour and south coast can be very high on such days. Situations producing calms on Wellington Harbour can be divided into two main types, which are illustrated in Fig. 7.

A. Ridges (often narrow) which move across New Zealand following a period of southerly winds. The main anticyclone centre is usually centred north of Wellington's latititude and the ridge moves fairly quickly east giving a brief calm period before the northerlies begin to freshen.

B. Large anticyclones which spread aross the country. These situations are frequently associated with blocking patterns and, if the axis of the ridge lies across Wellington, prolonged calm periods may occur (sometimes lasting two or three days). Typically with this type of situation the high divides in two, with centres east and west of central New Zealand. The eastern centre produces a northeasterly flow along the east coast while the western centre gives a southwesterly flow along the west coast, leaving Wellington in a col with very little wind.

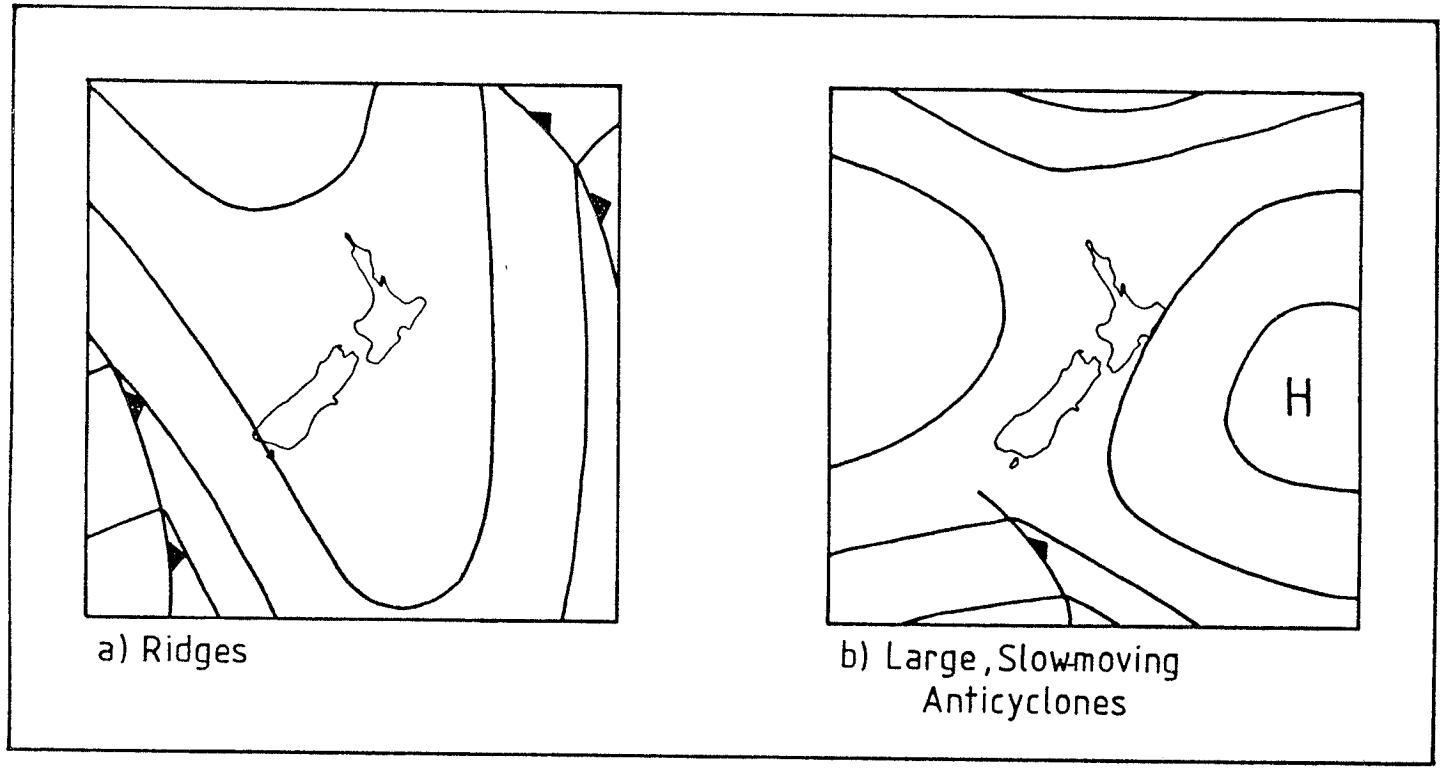


Fig. 7
Situations which Produce Calms
at Wellington

4. SEA CONDITIONS.

4.1. General.

Although Wellington Harbour experiences a high frequency of strong winds, the limited fetches available restrict the growth of sea waves. The area is also sheltered from the prevailing west to southwest swells of these latitudes.

The descriptive terms normally used when forecasting sea and swell waves were designed primaraly for shipping and they are less meaningful for small pleasure craft. For example the term "slight sea" implies waves up to 1.25 metres high, producing decidedly uncomfortable conditions for most small craft. Similarly, a "low swell" may be up to 2 metres high in the open sea, and probably higher when breaking - a good sized wave by any surfer's standards and capable of making the launching of small boats from the shore hazardous. The wave heights given in Table 2 and Fig. 8 may be used to give a more detailed description of the sea conditions.

4.2. Sea Waves.

With a maximum width of about 10km and a length of 14km Wellington Harbour provides only short fetches for the development of sea waves, but the harbour entrance and south coast are exceptions with a substantial fetch available to the south. Southerlies produce waves on the south coast which relate well to those which can be predicted using Fig. 8. Inside the harbour, however, this method has been found to be of only limited value and the wave heights given in Table 2 are probably more meaningful.

Table 2: Approximate fetch lengths and wind speeds required for the development of waves of:

	0.25	0.50	0.75	1.00	1.50	2.00	2.50	3.00
				(metres)				
15kt	2.5km	5.0km	10km	-	-	-	-	-
25kt	0.8km	1.6km	3km	5km	8km	14km	-	-
35kt	0.4km	0.8km	1.2km	1.6km	3km	5km	8km	15km

This table has been developed from the results of intensive observations made with wind speeds of 25kt, supplemented by limited observations at other wind speeds. The figures in the

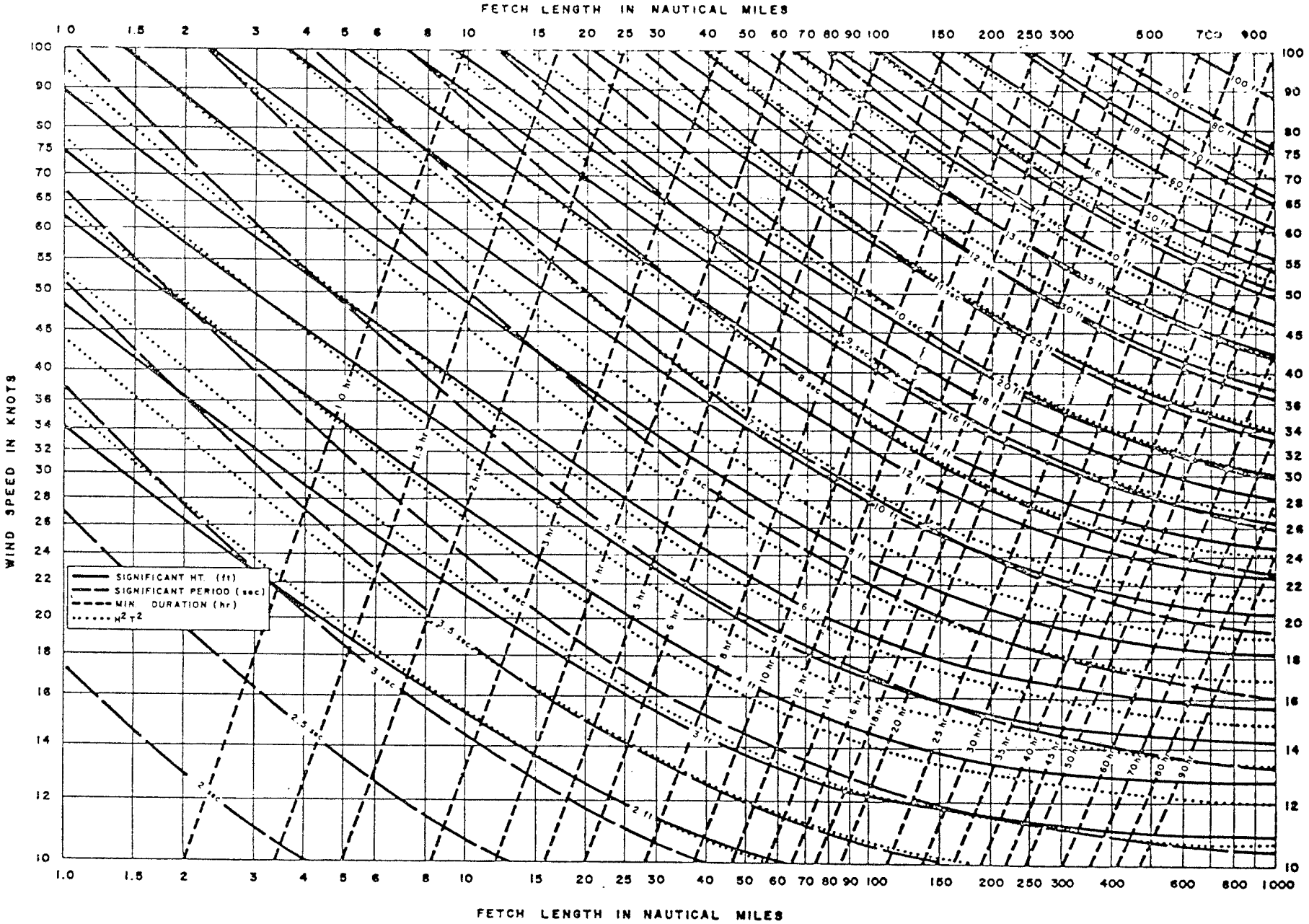


Fig. 8: Deep water wave forecasting curves as a function of wind speed, fetch length and wind duration.

table are intended to be used as a guide and the wave heights obtained from it should be modified whenever additional information indicates that this is necessary.

4.3. Swell Waves.

The south coast of the North Island is exposed to southerly swells, generated either by strong south to southwest airstreams between the South Island and the Chatham Islands or by strong southwesterlies on the western side of deep depressions moving across the Southern Ocean. Commercial fishermen use a simple but effective rule for forecasting southerly swells on the south coast:

> As long as the wind at the Chatham Islands is south westerly then southerly swells are likely on the south coast, and the onset of the southerly swell is about 12 hours after southwesterlies develop at the Chatham Islands.

Southerly swells, like southerly winds, are most frequent in winter and least frequent in summer. Occasionally, when a strong east to northeast flow covers the area east of the North Island a small amount of the swell generated by the easterlies is refracted into the Wellington area, giving a low south to southeast swell on the south coast.

While southerly swells may produce difficult or hazardous conditions in the harbour entrance and on the south coast, little swell is reported to penetrate into the harbour, north of about Steeple Rock.

4.4. The Influence of Tides.

The influence of tides on wave patterns is not included in forecasts. However, where strong tidal flows occur, such as in the harbour entrance and the "Terawhiti Rip", they have considerable effect. When the tidal flow is running in the opposite direction to the wind, effectively increasing the wind speed across the water, higher waves can be expected. Similarly when the tidal flow is in the same direction as the wind the waves will be lower. Strong tidal flows running in the opposite direction to the wind and/or swell may cause the waves to steepen considerably.

5. VISIBILITY.

5.1. General.

As a rule visibility is not a problem on Wellington Harbour, with fogs being uncommon and periods of heavy rain or drizzle relatively brief. Visibilities below 3000m occur about 12% of the time and are below 1000m about 3% of the time (frequencies obtained from Wellington Airport data).

5.2. Fog.

Fog is reported at Wellington Airport on an average of 6 days per year. Sea fog is the most common type, and is advected onto the harbour by light southerly winds when a moist easterly or northeasterly flow covers the New Zealand area. As a general rule, whenever sea fog is present in the area east of Cook Strait, and southerly winds (including sea breezes) are likely at Wellington, fog can be expected to affect the harbour and/or the south coast. Because of the local topography sea fogs move north through the harbour entrance and across the low lying isthmus where Wellington Airport is situated, to affect a large part of the harbour. The inner harbour - Oriental Bay area is sheltered by higher and more extensive land to the south and is much less prone to sea fog. Sea fogs are most frequent during the months January to April and may occur at any time of the day. They occasionally persist for several days.

Occasionally, radiation fogs which have formed in the Hutt Valley drift onto Wellington Harbour. These are invariably short-lived and cause few problems.

5.3. Rain and Drizzle.

Rain and drizzle are the most frequent causes of reduced visibility on Wellington Harbour. Rain generally occurs with the passage of fronts and the period of seriously reduced visibility is brief. Drizzle, associated with moist airstreams from either the north or south, often lasts for longer periods but only infrequently is the visibility reduced enough to cause serious difficulties to shipping movements.

5.4. Spray.

Occasionally when the winds are very strong (above about 50kt) spray may cause significant visibility reductions. While this effect is not often reported on the harbour, parts of the south coast are very prone to extensive spray when strong north to northwest winds are being experienced in the lee of the Wellington hills.

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