



**NEW ZEALAND
MINISTRY OF AGRICULTURE AND FISHERIES**

**FISHERIES TECHNICAL REPORT
No. 98**

**ANALYSIS OF WIND DIRECTION, WIND SPEED
AND WAVE HEIGHT FROM 6 SELECTED
NEW ZEALAND METEOROLOGICAL STATIONS
1967 TO 1969 INCLUSIVE**

B. F. WEBB

**WELLINGTON, NEW ZEALAND
1972**

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ABSTRACT

Three Meteorological criteria were analysed for six stations: Beacon Hill, Cape Campbell, Brothers Island, Nelson and Westport. Strong directional air flows were found in four of these stations.

Wind speeds were analysed by chi-square and showed that 1969 had a more moderate climate when compared to the two previous years.

Wave height recordings showed human bias since no significant variation in heights occurred throughout the three year period. Such bias was thought caused by the elevation of all stations above sea level, and to their moderating coastal locations.

Correlation was made of these three weather criterion with purse seining operations using a 28m and 40m vessels. Best suited fishing areas were found to be in Tasman Bay and the region north of the Marlborough Sounds.

INTRODUCTION

The fishing industry is one of the few professional enterprises dependent on climatic conditions (Hela & Laevastu, 1970). In New Zealand meteorological data has been used on occasions in conjunction with oceanographic results, e.g., Brodie (1960, Paul (1968), and Heath (1969). However, correlation of weather and the defining of climatic limitations to fishing over a specific region has not been attempted.

In the account below three meteorological criterion have been analysed and discussed from 6 selected weather stations over a period of three years: these stations were Westport, Nelson, Stephens Island, Brothers Island, Beacon Hill, and Cape Campbell. Farewell Spit, although within the region covered, was not included as the collected data was incomplete. The meteorological criteria used were wind direction, wind speed and wave height, the latter being excluded from Nelson as the data from this station was collected from aerodrome

readings. The purpose of the analysis was to find the percent number of days suitable for purse seining north of the South Island; record the general climatic conditions in the region for future comparison; and briefly suggest further elaboration in future work of this type.

METHOD

All wind speed, wind direction and wave height data are 0900 hours readings from the Meteorological Office records in Wellington. These data best reflected weather conditions most likely to affect fishing. Cloud cover, air pressure, rainfall, and visibility, although useful in a detailed analysis of weather relationships, were not considered in this report.

Chi-square analyses were used to compare the percent frequency of wind speed between years and seasons. December for each year was excluded since data for December 1969 was not available. Seasonal divisions were based on meteorological patterns as summer (December, January, February), autumn (March, April, May), winter (June, July, August), and spring (September, October, November).

Percentage distribution of wind direction and wave height was calculated for each season. Although no records were available for a number of days for Cape Campbell, Brothers Island and Stephens Island, these were not considered to significantly alter the calculations.

The Beaufort scale was used for wave height (Marine Department 1972).

	<u>Feet</u>	<u>Metres</u>
0 Calm (glassy)	0	0
1 Calm (rippled)	0-1/3	0-0.1
2 Smooth (wavelets)	1/3-1 2/3	0.1-0.5
3 Slight	1 2/3-4	0.5-1.25
4 Moderate	4-8	1.25-2.5
5 Rough	8-13	2.5-4
6 Very rough	13-20	4-6
7 High	20-30	6-9
8 Very high	30-45	9-14
9 Phenomenal	Over 45	Over 14

Wind direction was divided into $22\frac{1}{2}^{\circ}$ sectors, all directions recorded being confined to the nearest compass bearing: such recording was standard procedure. Wind speeds were all recorded in knots.

RESULTS

Wind Direction

The percentage wind directions were plotted per month over the three year period (Fig. 1a-f) with the exception of December 1969.

1. Beacon Hill (Wellington) showed strong directional air streams for all three years, 40-70% from the north and 15-30% from the southerly quarter. Little difference occurred in the percent wind direction between the yearly totals. Calm and variable weather ranged from 0-12% for any one month, but over the whole year was insignificant.
2. At Cape Campbell the predominant northerly and southerly flow was continued, to a lesser degree. Wind from the easterly and westerly quarters was still significant. Such changeable air flow was the result of peculiar wind circulation in the low pressure

troughs which converged through Cook Strait. There were few calm and variable days although they were more common than at Beacon Hill.

3. Strong influence from north-westerly and southerly air currents (Brodie, 1960) were seen at the Brothers Island. In most months, 70-90% of the directional flow was from these quarters. There was no significant difference between the yearly totals. The lowest number of calm days were recorded during the equinoxial period of late summer and autumn.
4. In the region of Stephens Island most winds blew from the southeasterly (mainly summer and autumn) and westerly quarters. A greater proportion of calm and variable days were experienced during 1969 than in the other two years.
5. Westport showed a variation of wind direction between the three years; although the prevailing winds were all from the easterly and southerly quarters, 1967 had a predominance of southerly winds. The summer season in all three years had a larger percentage of calm days than the rest of the year.
6. Meteorological data for Nelson was recorded at the inland aerodrome. Some influence from surrounding topography was expected explaining the high proportion of calm days through each year. No strong directional pattern was evident although most winds were from the northerly or southerly quarters.

Although it is generally recognised that no two years have the same wind pattern, there did occur broad patterns in this central New Zealand region. With approaching low pressure systems air flows were found to shift from westerlies and north-westerlies into northerlies, and then to southerlies as they passed over the country. The westerly flows tended to concentrate in spring and early summer. The nature of the topography, in conjunction with the constricting north-south location

of Cook Strait, intensified these air flows as well as orientated their direction. Thus four areas exhibited a strong directional pattern, these being Beacon Hill, Brothers Island, Cape Campbell and Stephens Island, the other stations, while having preferential wind quarters, showed regular variations distributed around the compass.

Wind Speeds

Wind velocity was analysed by the chi-square (X^2) method for comparison of percent samples per season and between years (Fig. 2a and 2b).

- A. Beacon Hill - Although season difference between the three years was noticed during summer (in 1969 wind speeds appeared to be less intense than for the other two years) total X^2 gave 13.4 (18d.f.) having $p = .75$, indicating no significant difference between the three years.
- B. Brothers Island - Chi-square analysis within seasons showed differences in spring and summer, but not for autumn or winter. The total X^2 gave 27.7, $p = .1-.05$ (18d.f.), indicating significant difference between the years. Winds were more moderate in 1969 (between 10-30 Kts) than the previous two years as noted by the less number of days having extreme conditions (calm or rough).
- C. Stephens Island - Between the years all seasons were found to vary significantly with 1969 having a greater number of days with 0-19 knot winds. This difference was further noted in the total comparisons, $X^2 = 54.5$ (18d.f) giving $p < .005$ of being similar. This moderating influence in 1969 was evident in the wind directions when there occurred a large number of calm days.
- D. Cape Campbell - This region showed (between season X^2) that the exposed areas to the north were more sensitive to possible weather abnormalities, since very few days at Cape Campbell had wind speeds greater than 35 knots. The X^2 illustrated that 1969 differed from the previous

2 years having a more moderate wind force: the total X^2 between years gave 23.8, $p = .1$ (18d.f.).

- E. Westport - Between seasons gave X^2 differences for spring and summer but not for autumn and winter. Total X^2 gave 17.3 (12d.f.), $p = .1$, indicating difference in the percentage occurrence of the wind speeds. A greater concentration during 1969 occurred in the 5-9 knot range than for 1967 or 1968, while for 14 knots and below little difference between the years occurred (1969 = 96.7%; 1968 = 93.4%; 1967 = 94.3%). Few days having 30 knots or above were recorded at Westport.
- F. Nelson - With the high percent of wind speeds below 10 knots and the large number of calm days recorded, Nelson aerodrome evidently received protection from the surrounding topography and its inland position, factors also noted for the directional air flow. While 1969 appeared to have less extremes than the previous two years no significant differences were noted within seasons except for the summer months. Only during 1968 were winds of over 30 knots recorded.

Since purse seining operations and success depended to a large part on wind strength, the percent number of days (Table 1) was important. The 20 knot division line was for a 90 ft (27.4m) vessel the size of the r.v. "W.J. Scott", and represents the maximum wind strength permissible both for safety and fishing practicability when purse seining with a dory.

TABLE 1 Wind strength for the six stations analysed;
percent number of days below 20 knots per season.

	1967 <20	1968 <20	1969 <20
<u>Beacon Hill</u>			
summer	45.7	46.6	71.7
autumn	55.4	60.8	56.5
winter	63.0	52.1	57.6
spring	51.6	54.9	60.4
<u>Brothers Island</u>			
summer	42.1	33.3	52.6
autumn	37.0	40.2	41.1
winter	39.5	39.3	48.3
spring	37.2	36.6	41.7
<u>Stephens Island</u>			
summer	86.2	67.7	84.7
autumn	80.8	78.0	84.7
winter	67.7	76.9	85.8
spring	65.1	74.7	67.7
<u>Cape Campbell</u>			
summer	67.7	65.0	69.4
autumn	68.4	73.6	72.8
winter	77.1	75.8	78.2
spring	71.4	51.6	75.8
<u>Nelson</u>			
summer	98.3	88.1	96.6
autumn	98.9	94.5	97.8
winter	96.7	97.8	98.9
spring	97.8	95.6	98.9
<u>Westport</u>			
summer	100.0	98.3	98.3
autumn	98.9	97.8	100.0
winter	97.8	97.8	98.9
spring	98.9	95.6	100.0

From Table 1 it was evident that a gradation occurred in possible fishable areas. Taking into account the time involved for fishing and unloading catch, plus any unsuccessful attempts at purse seining, a lower limit of 75% fishable days below 20 knots was set by the author. Nelson (which indicated fishing in lower Tasman Bay) had the best record, followed by Westport (sea areas within 5-10 miles of the shoreline), Stephens Island, and Cape Campbell (for the region of Clifford and Cloudy Bays, western Cook Strait). The Brothers Island - Beacon Hill region (northern, central and eastern Cook Strait) was definitely unsuitable for purse seining. As wind direction for Westport and Cape Campbell (Fig. 1d and 1e) showed a southeast to southwest predominance in air flow, caution must be exercised in relating fishable number of days to wind force: the actual percent would be much lower than indicated as both areas were in exposed locations. Analysis of wind force did not take into account the areas of sheltered or protected waters, e.g., north of the Marlborough Sounds.

Wave Height

As was noted above wave heights were recorded according to a standard code from 0-9. The percentage incident of wave heights for 1967-1969 for each of 5 stations is given in Table 2. Data for Nelson was not recorded. Chi-square analyses were computed for this table, and showed that there were no significant annual differences at any of the stations.

	<u>χ^2</u>	<u>d.f.</u>	<u>p.</u>
Beacon Hill	7.9	16	.95
Brothers Island	5.6	16	.99
Stephens Island	14.9	14	.5 - .25
Cape Campbell	9.5	12	.75 - .5
Westport	12.2	14	.75 - .5

TABLE 2. % INCIDENCE OF WAVE HEIGHT RELATED PER YEAR FOR 5 WEATHER STATIONS, M = % number of days missing from the calculations. Refer to wave height code in text.

		WAVE CODE											total %	
		0	1	2	3	4	5	6	7	8	9	M	<3	>3
BEACON HILL														
	1967	.5	1.08	22.1	56.1	10.4	9.3	-	.2	-	-	-	79.7	19.9
	1968	.2	2.43	20.2	54.9	15.5	5.7	.8	-	-	-	-	77.7	22.0
	1969	.2	4.1	17.9	58.6	12.2	4.7	1.1	-	-	.5	-	80.8	18.5
CAPE CAMPBELL														
	1967	-	1.3	22.4	51.2	20.8	4.1	-	-	-	-	-	74.9	24.9
	1968	-	3.5	21.8	50.0	21.3	2.4	-	-	.2	-	.5	75.3	23.9
	1969	-	.5	12.2	61.3	23.9	1.7	-	-	-	-	-	74.0	25.6
BROTHERS ISLAND														
	1967	-	1.0	16.1	38.6	27.1	12.3	1.6	-	-	-	3.0	55.7	41.0
	1968	.2	.5	10.1	41.2	32.2	9.2	2.7	.2	-	-	2.9	52.0	44.3
	1969	-	1.1	16.4	40.3	28.7	9.5	.5	-	-	-	2.0	57.8	40.7
STEPHENS ISLAND														
	1967	-	1.3	16.4	35.5	34.8	9.8	.5	-	-	-	1.3	53.2	46.4
	1968	.5	1.0	23.4	44.8	22.8	6.2	.2	-	-	-	-	69.9	29.2
	1969	.8	5.0	18.8	43.7	25.4	5.6	-	-	-	-	.2	68.3	31.2
WESTPORT														
	1967	.2	.2	23.5	48.2	20.5	7.1	-	-	-	-	-	72.1	27.6
	1968	-	.2	21.3	46.1	22.1	10.1	-	-	-	-	-	67.6	32.2
	1969	.2	-	34.1	44.3	13.7	7.1	.2	-	-	-	-	78.6	21.0

TABLE 3.	%	WAVE HEIGHT,	BELOW	AND	ABOVE	CODE	3,	FOR	EACH	STATION	A	number	of	PER	MONTH	OVER	THE	3	YEAR	PERIOD,	NB.	days																																							
																						were excluded from % through data being unavailable,																																							
																							January	February	March	April	May	June	July	August	September	October	November	December	< 3	> 3	< 3	> 3	< 3	> 3	< 3	> 3	< 3	> 3	< 3	> 3															
																							BEACON HILL												1967	70.9	29.1	85.7	14.3	87.0	13.0	66.6	33.3	90.3	9.7	83.3	16.7	77.4	22.6	80.6	19.4	80.6	19.4	74.1	25.9	73.3	26.7	87.0	13.0		
																							BEACON HILL												1968	70.9	29.1	82.7	17.3	96.8	3.2	73.3	26.6	80.6	19.4	53.3	46.7	67.7	32.3	80.6	19.4	80.6	19.4	67.7	32.3	83.3	16.7	93.5	6.5		
																							BEACON HILL												1969	93.5	6.5	85.7	14.3	96.8	3.2	70.0	30.0	83.8	14.2	86.6	13.4	74.4	25.9	70.9	29.1	93.3	6.7	61.2	38.8	76.6	23.4	-	-	-	-
																							CAPE CAMPBELL												1967	61.2	38.8	85.7	14.3	87.0	13.0	66.6	33.3	77.4	22.6	70.0	30.0	67.7	32.3	77.4	22.6	90.0	10.0	100.0	-	53.3	46.7	64.6	35.4		
																							CAPE CAMPBELL												1968	74.1	25.9	65.5	34.5	83.8	16.2	76.6	23.4	74.1	25.9	76.6	23.4	87.0	13.0	58.0	42.0	76.6	23.4	70.9	29.1	66.6	33.3	93.5	6.5		
																							CAPE CAMPBELL												1969	83.8	16.2	71.4	28.6	83.8	16.2	63.3	36.7	70.9	29.1	66.6	33.3	58.1	41.9	80.6	19.4	70.0	30.0	80.6	19.4	90.0	10.0	-	-	-	-
																							BROTHERS ISLAND												1967	80.6	16.1	57.1	39.4	67.7	32.3	43.3	50.0	56.6	48.4	70.0	30.0	48.3	51.7	35.4	61.4	54.8	45.2	51.6	42.0	36.6	50.0	70.9	29.1		
																							BROTHERS ISLAND												1968	42.0	58.0	51.6	48.4	70.9	16.1	60.0	36.6	35.4	61.4	36.6	63.4	61.2	38.8	54.8	64.4	54.8	38.7	48.3	51.7	50.0	50.0	64.6	35.4		
																							BROTHERS ISLAND												1969	77.4	19.3	71.4	25.1	64.5	32.3	60.0	36.6	41.9	58.1	56.6	40.1	61.2	38.8	45.1	48.3	60.0	40.0	51.6	48.3	60.0	40.0	-	-	-	-
																							STEPHENS ISLAND												1967	67.7	32.3	64.2	35.8	41.9	58.1	43.3	56.7	64.5	25.6	63.3	33.3	48.3	51.7	25.8	74.2	41.9	58.1	41.8	58.1	40.0	56.7	70.9	29.1		
																							STEPHENS ISLAND												1968	67.7	32.3	68.6	31.4	90.3	9.7	83.3	16.7	64.5	35.5	70.0	30.0	74.1	25.9	67.7	32.3	64.5	35.5	67.7	32.3	63.3	36.7	87.0	13.0		
																							STEPHENS ISLAND												1969	83.8	16.2	53.5	46.5	83.8	16.2	66.6	33.3	54.8	45.2	73.3	24.7	77.4	22.5	77.4	22.5	43.3	53.3	67.7	32.3	76.6	23.3	-	-	-	-
																							WESTPORT												1967	70.9	29.1	85.7	14.3	77.4	22.6	73.3	26.7	70.9	29.1	86.6	13.4	70.9	29.1	54.8	45.2	77.4	22.6	83.8	16.2	33.3	66.6	80.6	19.4		
																							WESTPORT												1968	83.8	16.2	82.1	17.9	74.1	25.9	66.6	32.4	38.7	61.3	73.3	26.7	74.1	25.9	54.8	45.2	64.5	35.5	48.3	51.7	53.3	46.7	100.0	-		
																							WESTPORT												1969	93.5	6.5	89.2	10.8	90.3	9.7	66.6	33.4	83.8	16.2	66.6	33.4	74.1	25.9	74.1	25.9	46.6	53.3	87.0	13.0	93.3	6.7	-	-	-	-

Such a result suggested that the recorded meteorological data was inaccurate (i.e. human bias) or that wave height was not a very good criterion since the waves became modified close inshore, and so nullified any true extremes that may have existed. With wind direction and wind speed taken into account, the author suspects the latter reason since with 1969 displaying less extremes of weather, some variation in wave height should have been discernable. These inaccurate wave heights further reflected the height of each recording station which ranged from 65 ft (19.8m) at Westport to 600 ft (182.8m) at Stephens Island. As was expected the largest waves occurred in Cook Strait with waves of 6 to 14+metres.

Allowing for bias, however, Table 3 was included to show the percent wave heights above and below force 3 (see wave code), since 1.25m approximates the maximum for practical fishing on the r.v. "W.J. Scott" when using a dory in purse seining. For vessels of larger size or fishing without a dory, maximum wind speed and wave height would be higher: for a 40m purse seine vessel = 30 knot winds and 3m waves. The author considered any month having less than 20% wave height above 3 was good for purse seining, between 20-40% average with fishing still possible, while above 40% as unprofitable. When wind speed is considered it appears that the region west of the Brothers Island and in Tasman Bay is best, with about 70-80% chance of fishing. The other areas could be fished at some stage during the summer-autumn period depending on daily variation of wind direction and wind speed.

DISCUSSION

Annual weather conditions fluctuate within a region, the variations taking place over a number of years, being part of a general fluctuating climatic pattern extending, over decades, into cycles, and incorporating within themselves normal year to year variations. Thus it was found for the 1967-1969 period that although wind direction and wind speed showed annual variations, general patterns did arise, such as the predominant northerlies of Beacon Hill, the north-westerlies

and southerlies at the Brothers Island, and the large proportion of calm weather at Nelson. Within sheltered regions, e.g., lower Tasman Bay and the Marlborough Sounds, no relationship existed between wind speed and wave height owing to the short fetch of water available. These regions would provide workable purse seine areas in times of high winds. Purse seining is not possible in winds above 35-40 knots since the recovery of the net through the power block, and subsequent re-setting of the gear, becomes difficult.

Further elaboration of weather data

The use of computers, both as a storage place for fish and weather information and for oceanographic predictions, has been in service in other parts of the world for a number of years, (Japan, Russia). This service codes and records the boats position, gale warnings, wind force, low pressure centres, wave heights and direction, surface temperatures, water colour, all fishing information, and oceanographic data, for use in weather forecasting and indicating the availability of fishable grounds. Iselin (1969) advocates the setting up of a world-wide computer service, over a 10 year period, to correlate such information as an international co-operation plan for the benefit of mankind. The development of a similar computer system is overdue in New Zealand, especially with the imminent development of the World Weather Watch under the guidance of the World Meteorological Organisation, for oceanic forecasting (Schaefer, 1969). The author advocates:

- (a) The setting up of permanent weather ships in the South Pacific - Antarctic regions for continuous logging of meteorological and oceanographic data;
- (b) making use of FAX recorders compulsory on all fishing vessels built after 1974; and
- (c) the setting up of a computer system for continuous data storage and extended forecasting to cover the antarctic region. Although initially costly for this country the benefits in forecasting oceanographic and fishing conditions, as well as the possible saving of lives would justify the expenditure.

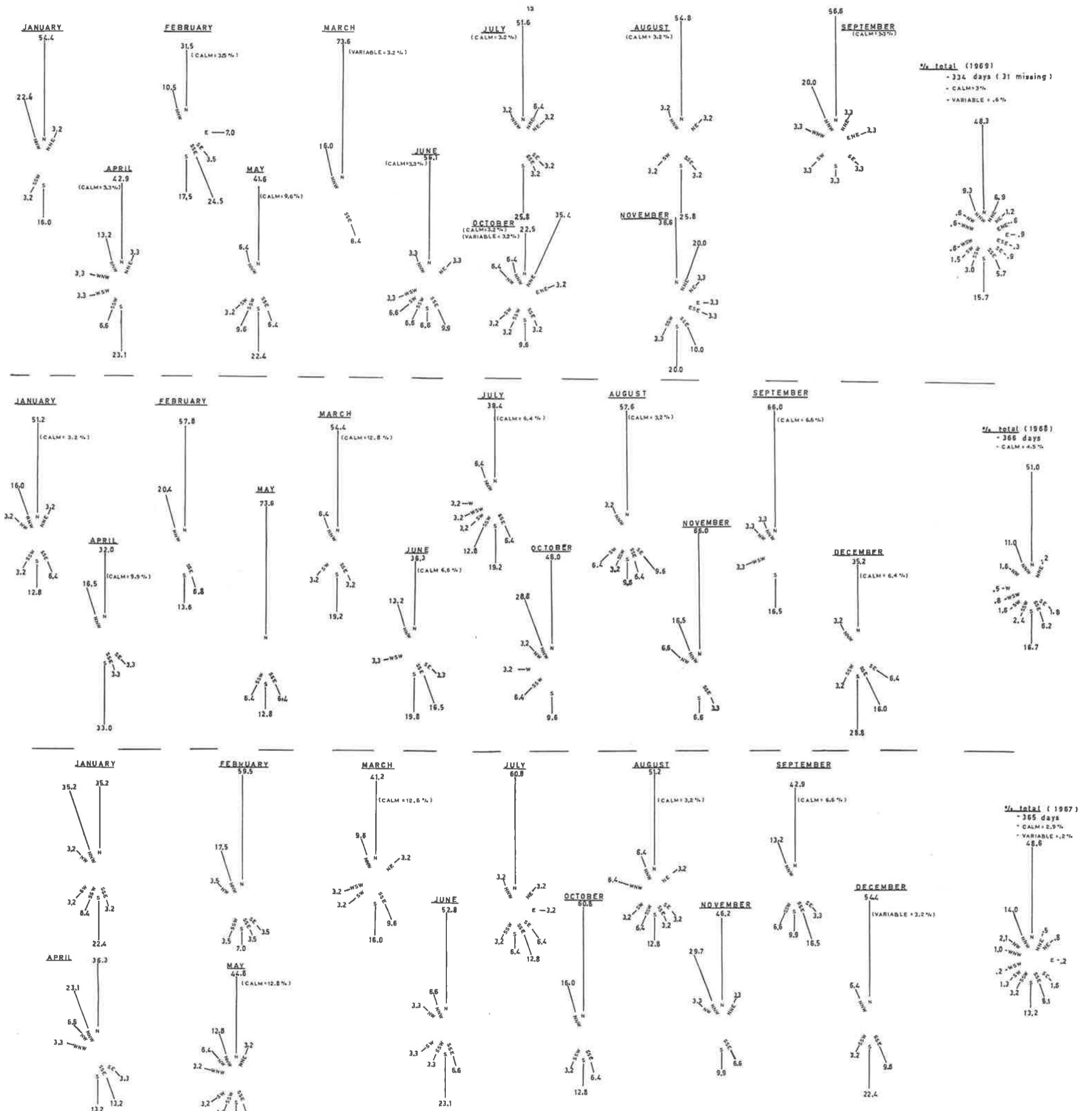


FIGURE 1a Beacon Hill - showing % wind direction plotted per month for the years 1967, 1968, to November 1969. Recordings taken 0900 hrs - METEOROLOGICAL OFFICE.

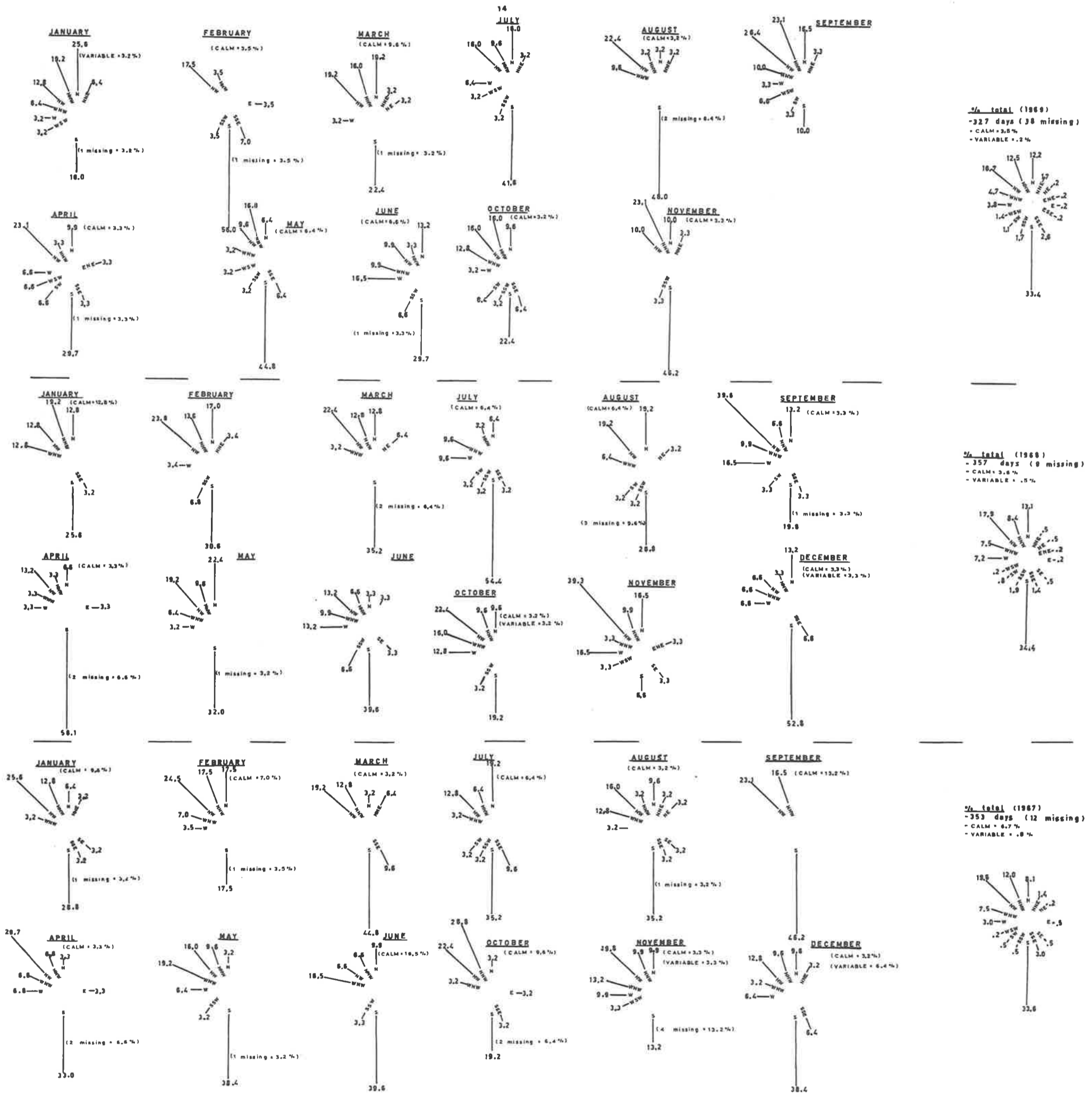


FIGURE 1b Brothers Island - showing % wind direction plotted per month for the years 1967, 1968, to November 1969. Recordings taken 0900 hrs.

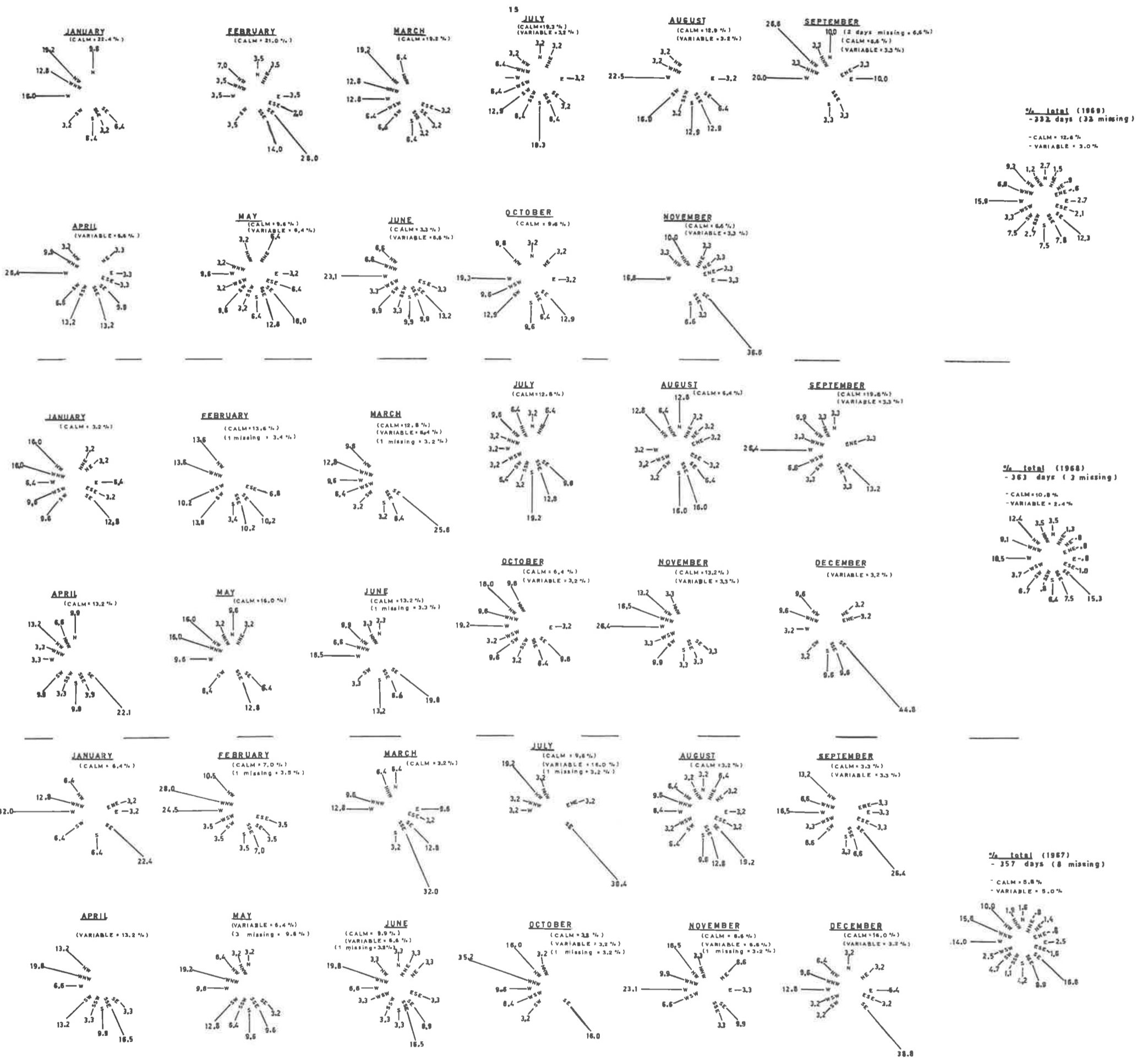


FIGURE 1c Stephens Island - showing % wind direction plotted per month for the years 1967, 1968, to November 1969. Recordings from 0900 hrs.

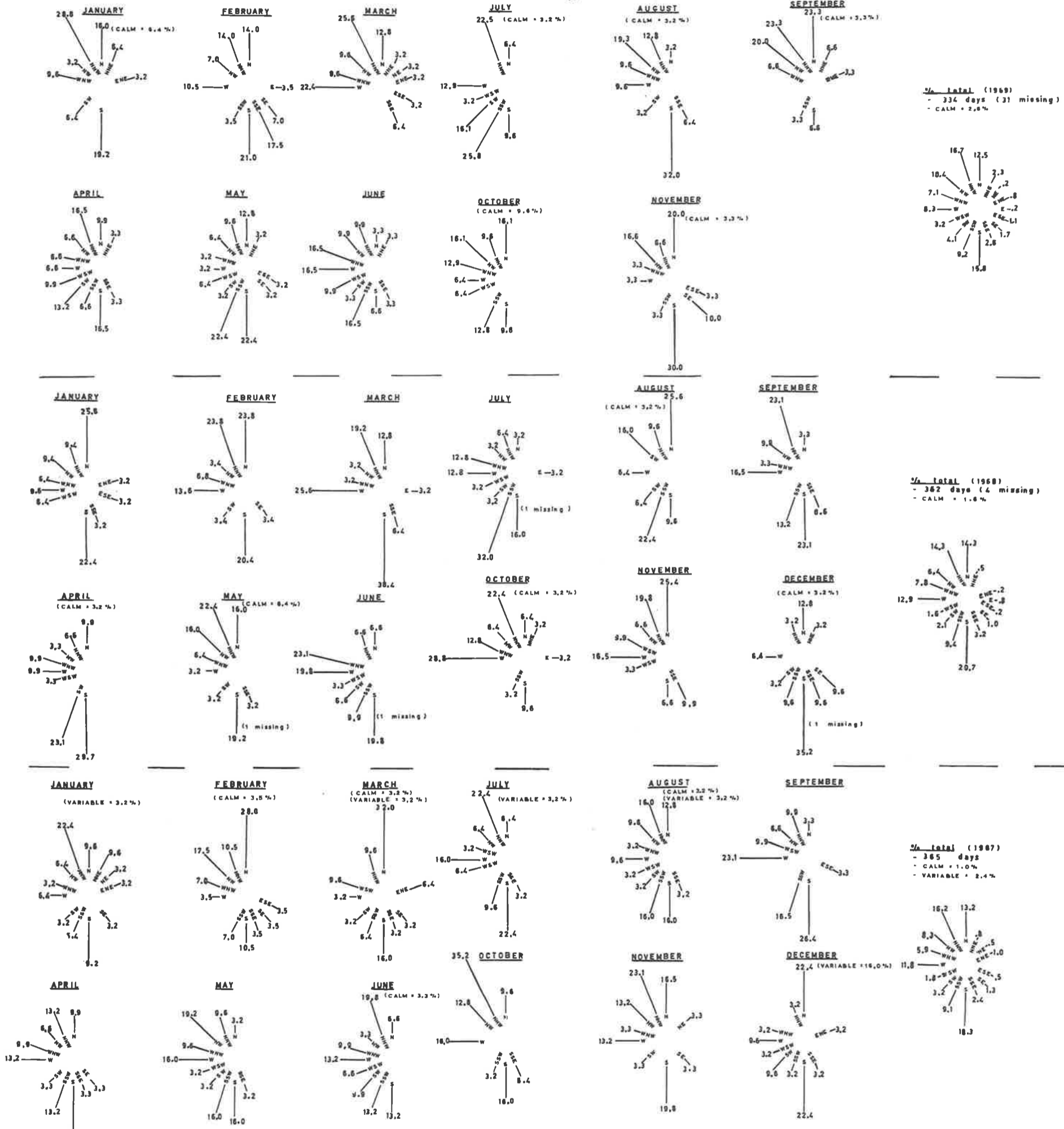


FIGURE 1d Cape Campbell - showing % wind direction plotted per month for the years 1967, 1968, to November 1969. Recordings from 0900hrs.

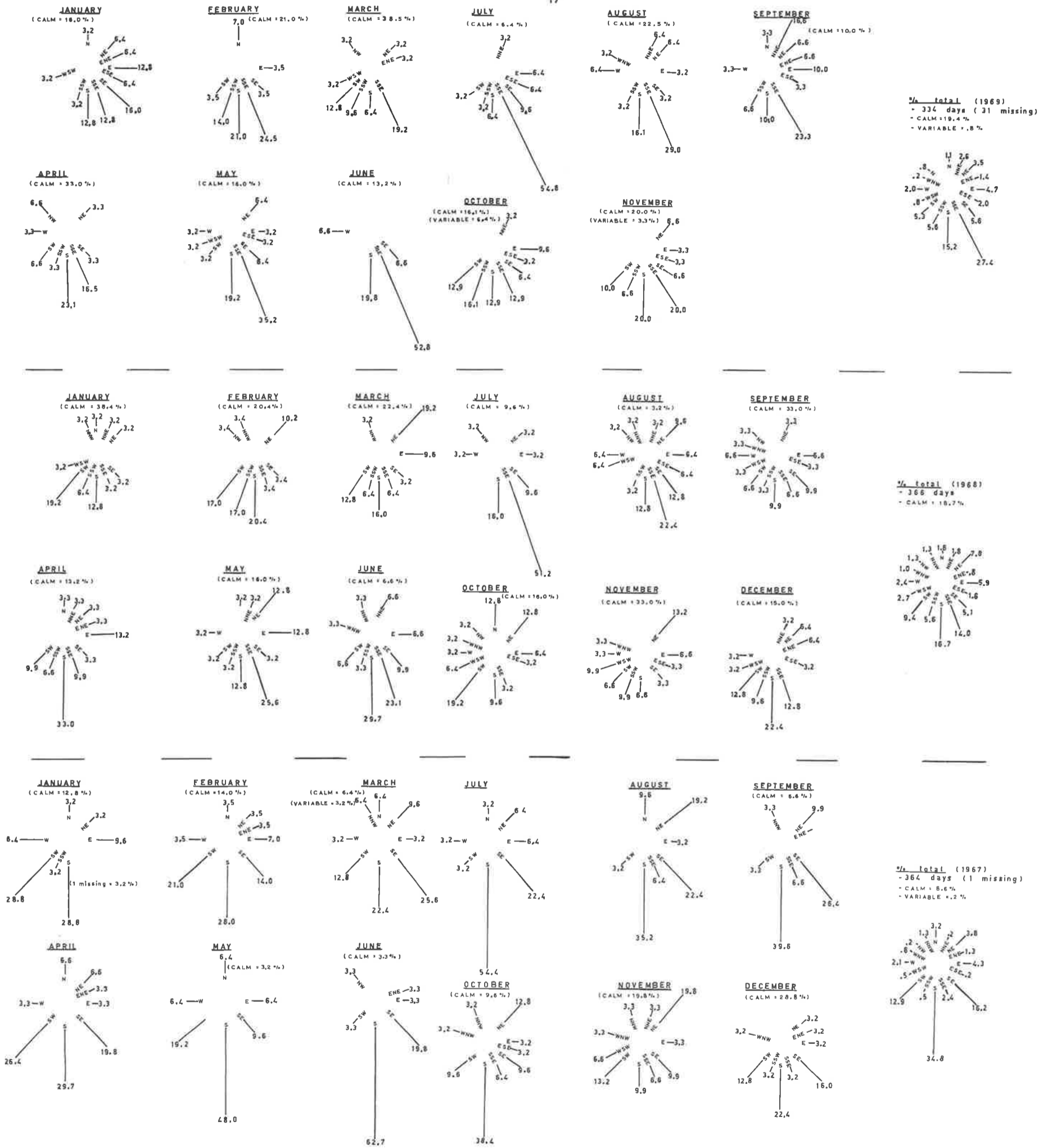


FIGURE 1e Westport - showing % wind direction plotted per month for the years 1967, 1968, to November 1969. Recordings from 0900hrs.

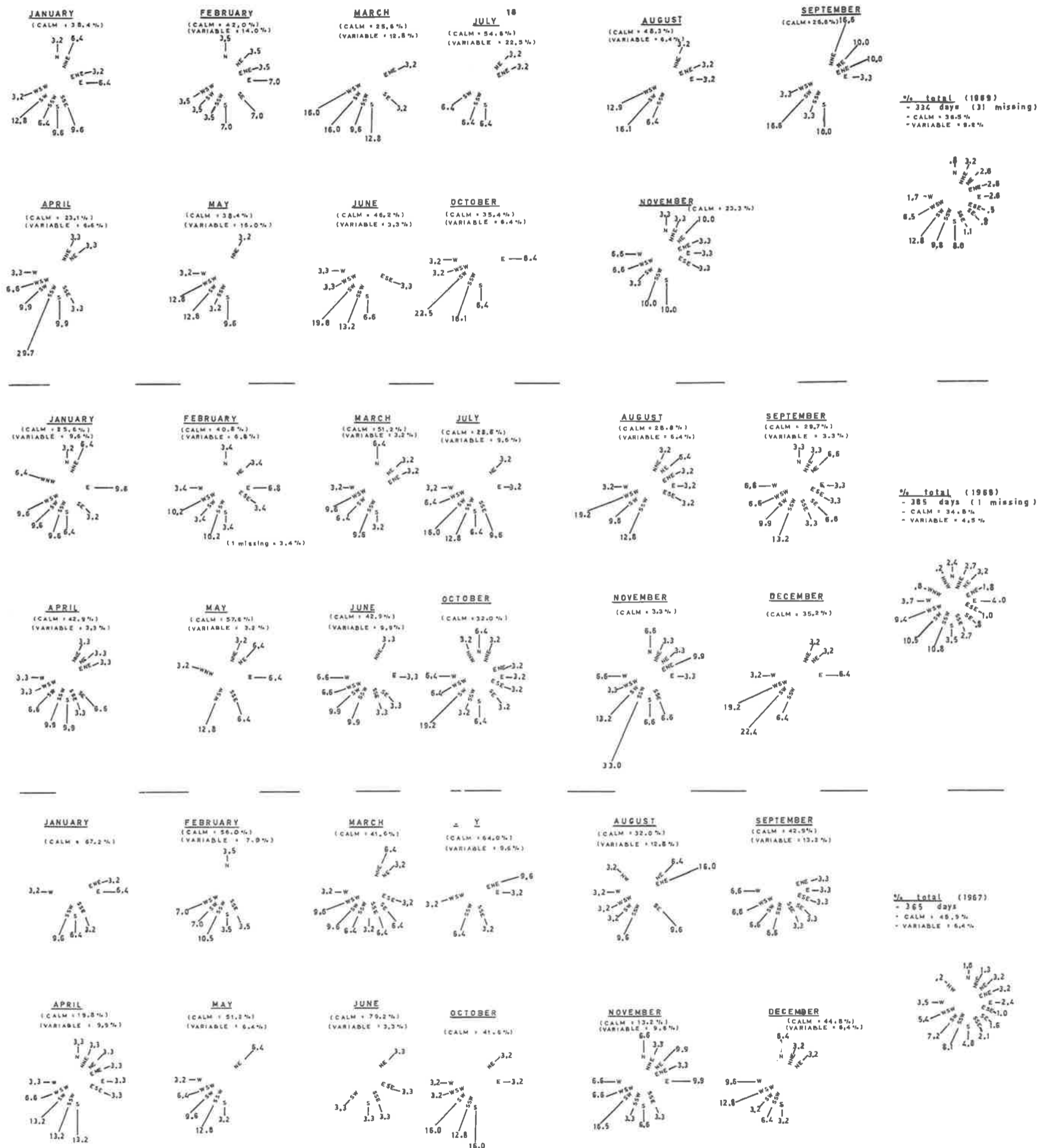


FIGURE 1f Nelson - showing % wind direction plotted per month for the years 1967, 1968, to November 1969. Recordings from 0900 hrs.

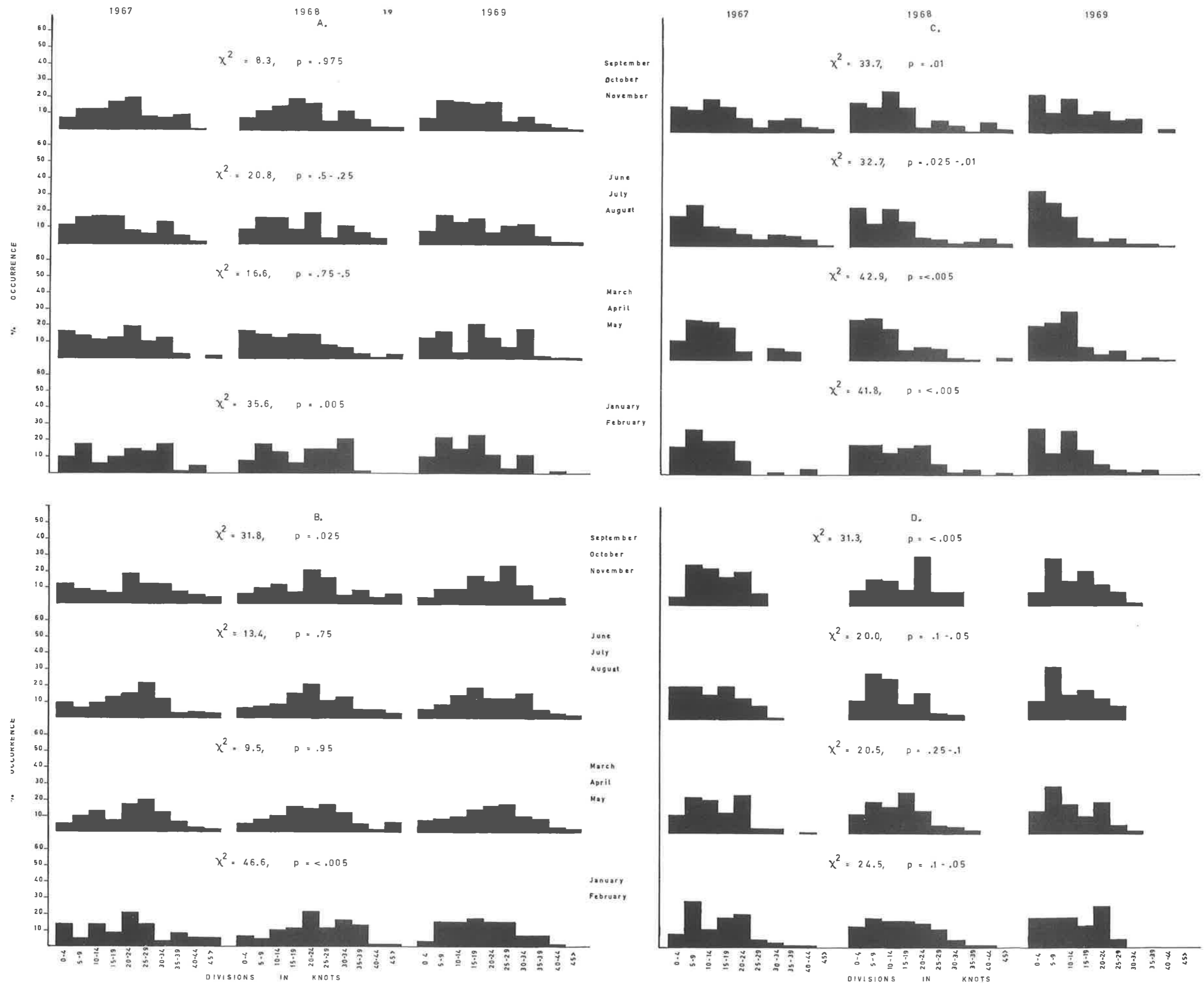


FIGURE 2 a Wind speed expressed as a % per season over a 3 year period; December for each year was excluded from the calculations. A. = Beacon Hill; B. = Brothers Island; C. = Stephens Island; D. = Cape Campbell, χ^2 = chi-square, giving the probability that the seasons were similar between years.

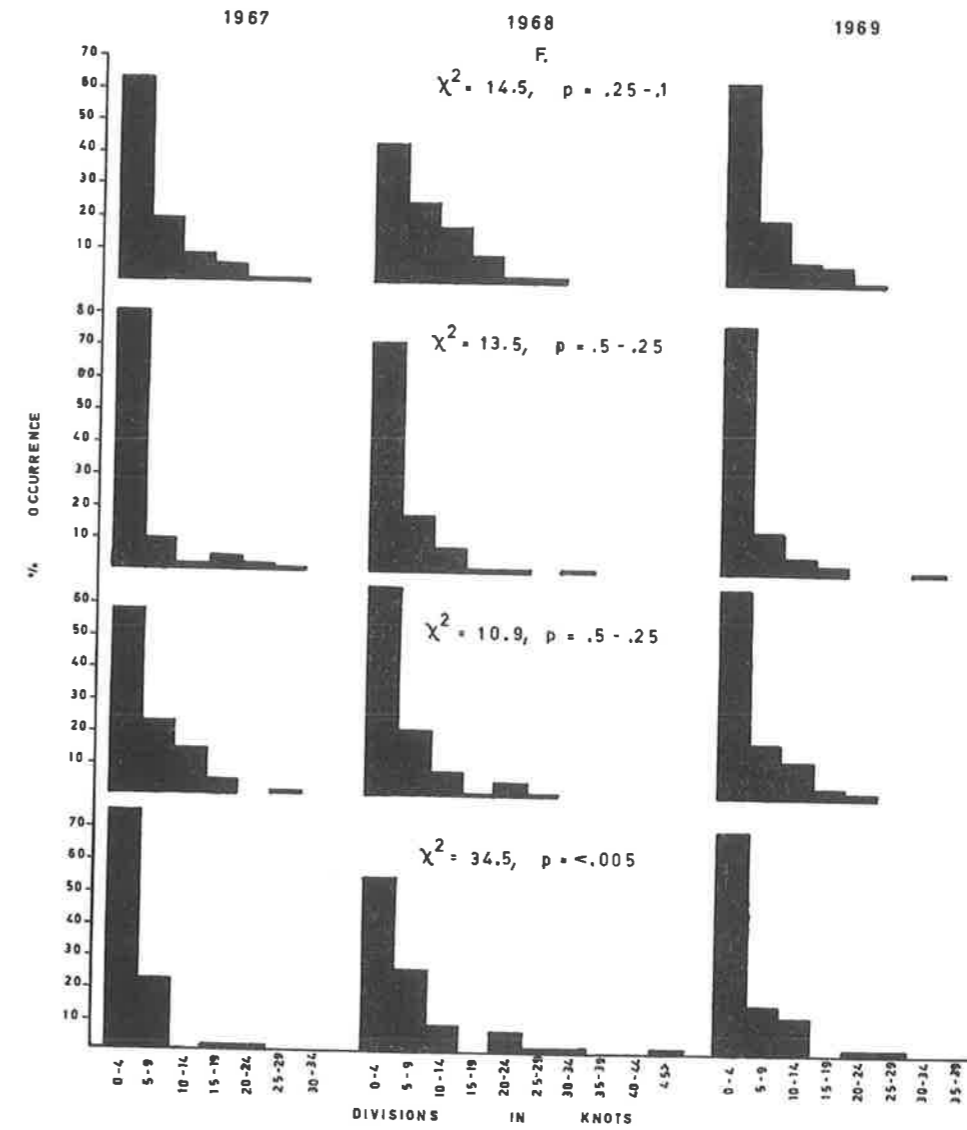
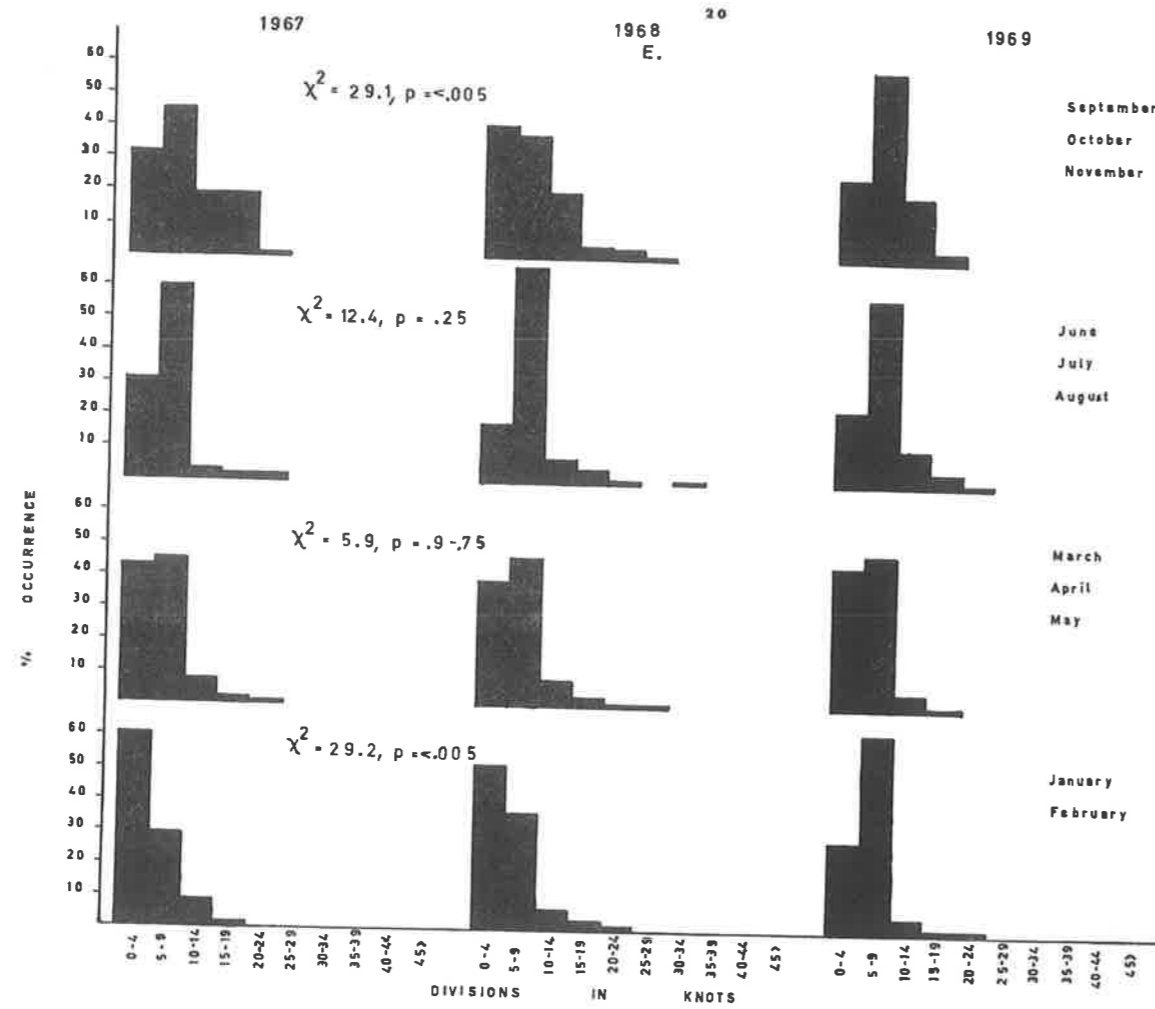


FIGURE 2b Wind speed expressed as a % per season over a 3 year period: December for each year was excluded from the calculations. E. = Westport; F. = Nelson. χ^2 = chi-square, giving the probability that the seasons were similar between years.

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LITERATURE CITED

- Brodie, J.W., 1960 Coastal surface currents around New Zealand. N.Z.J. Geol. Geophys. 3: 235-252
- Heath, R.A., 1969 Drift card observations of currents in the central New Zealand region. N.Z.Jl. Mar. Freshwat. Res. 3: 3-12
- Hela, I. & T. Laevastu, 1970 "Fisheries Oceanography", publ. Fishing News (Books) Ltd., London. 238pp. 122 fig.
- Iselin, C. O'D. 1969 Ocean: Potential resources. pp. 453-445. in "The Encyclopedia of Marine Resources", ed. Frank E. Firth, van Nostrand Reinhold Co., London, 740 pp.
- Marine Department 1972 New Zealand Nautical Almanac and Tide Tables for the year 1972. Govt. Printer, Wellington.
- Paul, L.J. 1968 Some seasonal water temperature patterns in the Hauraki Gulf, New Zealand. N.Z.Jl Mar. Freshwat. Res. 2: 535-538
- Schaefer, M.B. 1969 Oceanography and marine fisheries. pp. 464-469 in "The Encyclopedia of Marine Resources" ed. Frank E. Firth, van Nostrand Reinhold Co. London, 740 pp.
- Webb, B.F. 1971 Survey of pelagic fish in the Nelson area (1968-1969) by spotter-plane. N.Z.Mar. Dept. Tech. Rep. 69: 29 pp.



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1967 TO 1969 INCLUSIVE**

B. F. WEBB

WELLINGTON, NEW ZEALAND
1972