M.O.655 AIR MINISTRY

METEOROLOGICAL OFFICE

QUARTERLY SURFACE CURRENT CHARTS

OF THE

EASTERN NORTH PACIFIC OCEAN

Eastward of Longitude 160° W.

Prepared in the Marine Division of the Meteorological Office

LONDON: HER MAJESTY'S STATIONERY OFFICE

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OF THE

EASTERN NORTH PACIFIC OCEAN

Eastward of Longitude 160° W.

CONTENTS

EXPLANATION OF THE CHARTS

THESE CHARTS are compiled from observations of surface current sent to the Meteorological Office by Voluntary Marine Observers in British Merchant Ships, and from observations made in H.M. Ships forwarded by the Hydrographer of the Navy. The observations cover the period 1855–1952.

BASIC COMPUTATION AREAS

For the computation of the charts of predominant current and those of vector mean current the ocean is divided into rectangles, each covering an area of 2° of latitude by 4° of longitude. For each of these basic areas, where the number of current observations is sufficient, the vector mean direction and rate of current and the predominant direction and average rate of current have been computed. On the charts of current roses the larger areas used for the computation of roses contain an integral number of the basic areas.

CHARTS OF CURRENT ROSES

Each rose summarises all the current observations available within the blue pecked line area to which it refers. These areas have been chosen to separate the different current trends of the general circulation as far as possible, and therefore vary in size and shape. Each area is numbered with a blue figure and the rose areas and numbers are also shown on the predominant current and vector mean charts. By this means comparison of the different kinds of information given on the three types of chart may readily be made.

The function of the roses is to indicate the degree of current variability in any region. Each rose is divided into sixteen directions, the total length of the arrow in any direction giving the percentage frequency of current setting in that direction. Each arrow is subdivided into sections which give the percentage frequency of currents of different rates setting in its direction. In the regions of most constant current there is a marked preponderance of length in two or three adjacent arrows. Where the current is most variable the arrow lengths are much the same in all directions. Even in regions of most constant current, a certain number of currents flow in directions other than the preponderating arrows, in some cases including currents in direct opposition to these.

CHARTS OF PREDOMINANT DIRECTIONS AND AVERAGE RATES

The function of these charts is to show the predominant direction in which the current flows in all parts of the ocean and to give average rates of current in miles per day. The predominant direction and rate for each basic area are derived as follows:— The current observations within each basic area are totalled for successive 90° sectors round the whole compass, each sector being displaced 15° from its predecessor. The mid-direction of the sector containing the largest number of observations is the predominant direction of current in the basic area. The rate of current in the area is the average rate in miles per day of all currents in the predominant sector, i.e. of all currents flowing in the predominant direction and up to 45° on each side of it, irrespective of their differences of direction within the sector. In each basic area the constancy of the predominant current is the percentage ratio of the number of currents in the predominant sector to the total number of currents setting in all directions.

A preliminary chart is drawn showing the predominant direction, rate and constancy for each of the basic areas. From this the published chart is prepared, with longer arrows (flowlines of current), for which purpose some degree of smoothing is necessary.

In regions from which no regular current observations have been received, broken arrows are inserted to indicate the generally accepted knowledge of the flow of current.

CHARTS OF VECTOR MEANS

These charts show the mean resultant direction and rate of current, that is the overall movement of water over the period of three months to which the chart refers. An arrow is given for each of the basic areas for which information is sufficient. Within each of these areas the current observations are more or less variable in both direction and rate, according to the degree of constancy of the general circulation in the region. However variable the observed currents are in any area they never cancel each other out exactly in the vector mean computation so there remains a resultant water movement out of each area. If, for example, in one area the arrow shows a vector mean current of six miles per day in a west direction, this water movement continued daily for the three months of the chart would be exactly equivalent in effect to that of all the various water movements comprising the currents observed within the area.

The overall water movement shown by these charts constitutes what is known as the general circulation. The accuracy of the representation of this circulation depends on the number of observations available in each basic area. Besides their use in establishing the details of the direction and mean rate of movement of the general circulation, these charts are of value for oceanographical purposes where the mean net transport of surface water is required.

The representation of the direction of the oceanic circulation on the predominant charts, which has been obtained through the use of flowlines, is a fairly close approximation to the general circulation. It is not always identical with the latter in detail, since the flowlines are derived only from the currents in the predominant sector, while all observed currents are taken into account in computing the vector mean charts. Furthermore, as has been stated, the representation by flowlines necessitates some degree of smoothing of the direction.

The vector mean direction and rate are derived, for each basic area, from the difference of the totals of the north and south components of all the available currents and from the differences of the totals of the east and west components. It is obvious that in the more variable current regions, where there is much cancelling out of opposite components, the vector mean rates will be low in proportion to the average actual rates of currents experienced, and may be as little as from one to three miles per day, while actual currents of up to about one knot might be experienced. In regions of more constant current this disparity of rate is much less, but the vector mean rate is always lower than the average one. It is for this reason that the average rate of actual currents is given on the predominant chart.

USE OF THE CHARTS IN NAVIGATION

In day-to-day navigation the predominant chart and the rose chart should invariably be used in conjunction. The former shows the predominant direction of current and average rate, but it is equally important to know the extent to which the current experienced on any occasion may differ from the predominant current and this is found by reference to the appropriate rose.

In using the predominant chart the following points should be borne in mind:

1. The predominant direction of current is not only the one shown on the chart but includes all directions up to 45° on either side of it.

2. Where the constancy shown by the different thicknesses of the arrows exceeds 50%, the predominant direction, as defined in 1 above, is the one most likely to be experienced on any given occasion, i.e. it will more probably be experienced than a current in any other direction. If the constancy exceeds 74% this probability is still higher. The constancy of current very rarely exceeds about 85%, and nowhere reaches 100%, so that no current direction can be predicted with certainty.

3. When the constancy shown is in the lowest category, 25–50%, the degree of variability is such that no direction can be singled out as the most likely one on any given occasion. Since in these regions the total number of currents round the compass outside the predominant sector exceeds that within the predominant sector, the chances on any given occasion are more or less against experiencing the predominant direction. It is still worth while to show a predominant current in such a region since over a period more currents will flow in the direction specified than in any other single direction and the predominant direction completes the general picture of the circulation.

The vector mean chart should be used for calculating the drifts of boats or derelicts over considerable periods, say from two or three weeks up to three months. The longer the period the more likely the drift is to approximate to the vector mean drift. If the drift exceeds three months the chart for the subsequent quarter should be used for the later part of the drift. Discretion must be exercised in regard to the vector means used for this purpose. If based on only a few observations a particular vector mean value should not be used unless it conforms in general direction with neighbouring arrows based on larger numbers of observations. If, on the other hand, there is a region of arrows based on small numbers of observations which indicate a reasonable conformity of flow, these could be made use of.

Drifts lasting only a few days cannot be estimated in regions where the predominant chart shows a constancy of only 25–50%. In regions of greater constancy an estimation could be made on the basis of the direction and average rate shown by the predominant chart, but this direction, though the most likely one, is not necessarily the direction in which the current will flow on the days in question.

EFFECT OF LOCAL WIND ON CURRENT

The effect of local wind in producing a current is gradual, not immediate, but if it is known that a moderate or strong wind has been blowing in the region for a day or more, with reasonable steadiness of direction, some modification of the current to be expected may be made with due discretion.

If the wind has been blowing fairly steadily in direction for not less than 24 hours the rate of current so produced is about 2% of the wind speed in knots in high latitudes and 4% in low latitudes. The direction of the current will be 30° or more to the right of the wind in deep water in the northern hemisphere and to the left of the wind in the southern hemisphere. For a few degrees of latitude on either side of the equator the current direction is downwind.

The effect of local wind on the actual current experienced by a ship varies in different parts of the general circulation. A local wind current, established as above stated, is likely to be that actually met with in regions where the roses show the current to be most variable. The same remark applies to the temperate regions of predominant westerly winds, where the various current directions shown on the roses are mainly due to the varying local winds. Thus in the region of the North Pacific Current, the local wind might have a marked effect on the current at the time. Many of the winds associated with the passage of depressions, however, do not blow from essentially the same direction for a sufficient time to establish fully the current they would otherwise produce. The occurrence of strong winds or gales in the surrounding neighbourhood during the previous day or two, if known, must also be taken into consideration. Thus, though the wind may have fallen light in the region of the ship, a current may still be running in a direction produced by recent gales there or elsewhere. Just as the onset of wind does not produce an immediate fully developed current, so a fall of wind or a marked change in its direction does not result in the immediate cessation of a current.

In a region where the current is relatively constant, such as that of the South Equatorial Current north of the equator, an established current due to local wind will not usually be experienced as such. It will merely tend to accelerate or retard the normal predominant current rate, according to whether there is a wind component in the direction of the normal current, or in opposition to it. It is possible, however, that continued adverse strong winds might arrest the normal flow of current, or even reverse it for a short time, locally.

SURFACE CURRENT ROSES

Arrows flow with the current, length represents frequency, and thickness, strength.

6 — 12 miles per day
13 — 24 ,, ,, ,,
25 — 48 ,, ,, ,,
49 — 72 ,, ,, ,,
> — 72 ,, ,, ,,

Distance from tail of arrow to circle represents 5%

Scale 0 10 20 30 40 50%

The upper figure in the centre of the rose gives total number of observations, the lower figure the frequency of currents less than 6 miles per day.

Vancouver
Portland
San Francisco
Los Angeles
San Diego
Panama

DECEMBER, JANUARY, FEBRUARY

SURFACE CURRENT, PREDOMINANT DIRECTIONS AND AVERAGE RATES

The thickness of the arrows indicates the constancy of the current in the direction shown as follows:—

25 — 50%
51 — 74%
75 — 100%

Constancies of under 25% are not shown.

The figures shown against the butts of the arrows give the rate in miles per day.
In regions where insufficient observations are available the generally accepted knowledge of the direction of flow is shown by a broken arrow thus: — — — — — — →

General Remarks on the Currents shown on the Predominant Charts

The chief currents shown on the charts are the California Current, the west-going North Equatorial Current, the east-going Equatorial Countercurrent and the northern part of the west-going South Equatorial Current, between the equator and about lat. 4°N.

Over much of the region covered by the charts the number of observations available is not very large and predominant currents have been computed only where the information appears adequate. For this reason the North Pacific Current flowing eastward across the ocean towards the American coast is only partially shown on the charts. The main part of this current is derived from the fanning out of the Kuro Shio, north-eastward of Japan. Northward of this is the colder water derived from the Oya Shio and the Kamchatka Current. The combined east-going flow across the ocean occupies the belt between about lats. 35°N. and 54°N. Towards the American coast, the cooler northern part of this flow turns north-eastward and finally north-westward, to set along the coast of the Gulf of Alaska in a counter-clockwise direction. The general flow of this current is shown on all the charts by pecked lines, no observations being available.

The warmer water of the North Pacific Current turns south-eastward and finally south-westward, in the region of the charts, to pass into the North Equatorial Current. The part of this southerly flow near the United States coast is known as the California Current. In varying degrees, according to the season of the year, part of the California Current continues to follow the coasts of Lower California and Mexico.

The Equatorial Countercurrent, which separates the two Equatorial Currents, flows between about lats. 4°N. and 8°N. or 10°N., according to season. Westward of the Central American coast it recurves northward and eventually passes into the North Equatorial Current. The northern limit to which this recurvature extends, giving a north-westerly set along the Central American coast, varies seasonally.

Some of the water of the South Equatorial Current recurves into the Equatorial Countercurrent. The charts show that this eddying occurs in different longitudes in different seasons.

There is an outflow from the Gulf of Panama throughout the year.

December to February

The flow of the California Current is less constant in this quarter than during the rest of the year.

The region of recurvature of the Equatorial Countercurrent off the west coast of Central America has its least extension northward during these months.

The outflow of water from the Gulf of Panama is strongest and most constant at this season.

A northerly current, known as the Davidson Current, flows between the south-going California Current and the coast. It begins to flow in the vicinity of San Diego about the beginning of November and continues until January or February. It extends up the whole coast to about the region of Vancouver Island. It flows close inshore, south of about lat. 40°N., but further northward it appears to widen. Northerly predominant currents are shown on this chart, off the coast between lats. 40°N. and 50°N.

Vancouver
Portland
San Francisco
Los Angeles
San Diego
Panama

160° 150° 140° 130° 120° 110° 100° 90° 80° 70°
60° 50° 40° 30° 20° 10° 0°

DECEMBER, JANUARY, FEBRUARY

SURFACE CURRENT ROSES

Arrows flow with the current, length represents frequency, and thickness, strength.

6 — 12 miles per day
13 — 24 ,, ,, ,,
25 — 48 ,, ,, ,,
49 — 72 ,, ,, ,,
> — 72 ,, ,, ,,

Distance from tail of arrow to circle represents 5%

Scale 0 10 20 30 40 50%

The upper figure in the centre of the rose gives total number of observations, the lower figure the frequency of currents less than 6 miles per day.

Vancouver
Portland
San Francisco
Los Angeles
San Diego
Panama

MARCH, APRIL, MAY

SURFACE CURRENT, PREDOMINANT DIRECTIONS AND AVERAGE RATES

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25 — 50%
51 — 74%
75 — 100%

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The warmer water of the North Pacific Current turns south-eastward and finally south-westward, in the region of the charts, to pass into the North Equatorial Current. The part of this southerly flow near the United States coast is known as the California Current. In varying degrees, according to the season of the year, part of the California Current continues to follow the coasts of Lower California and Mexico.

The Equatorial Countercurrent, which separates the two Equatorial Currents, flows between about lats. 4°N. and 8°N. or 10°N., according to season. Westward of the Central American coast it recurves northward and eventually passes into the North Equatorial Current. The northern limit to which this recurvature extends, giving a north-westerly set along the Central American coast, varies seasonally.

Some of the water of the South Equatorial Current recurves into the Equatorial Countercurrent. The charts show that this eddying occurs in different longitudes in different seasons.

There is an outflow from the Gulf of Panama throughout the year.

March to May

The flow of the South Equatorial Current is mainly weaker and less constant in this quarter than during the rest of the year.

Vancouver
Portland
San Francisco
Los Angeles
San Diego
Panama

MARCH, APRIL, MAY

SURFACE CURRENT ROSES

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25 — 48 ,, ,, ,,
49 — 72 ,, ,, ,,
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Distance from tail of arrow to circle represents 5%

Scale 0 10 20 30 40 50%

The upper figure in the centre of the rose gives total number of observations, the lower figure the frequency of currents less than 6 miles per day.

Vancouver
Portland
San Francisco
Los Angeles
San Diego
Panama

160° 150° 140° 130° 120° 110° 100° 90° 80° 70°
60° 50° 40° 30° 20° 10° 0°

56 55 54 53 52 51 49 48 47 46 45 44 43 42 41 40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 21 20 19 18 17 15 14 13 12 11 10 8 7 6 5 4 3 2 1

61 38 | 55 22 | 24 17 | 27 44 | 31 39 | 106 28 | 34 29 | 77 27 | 42 36 | 154 43 | 101 29 | 86 30 | 237 36 | 98 29 | 162 22 | 196 36 | 109 33 | 60 32 | 83 31 | 226 27 | 114 17 | 58 28 | 73 36 | 39 31 | 269 27 | 77 9 | 27 19 | 79 28 | 66 18 | 44 11 | 302 30 | 24 25 | 291 17 | 13 8 | 66 11 | 58 22 | 28 14 | 51 12 | 45 13 | 348 13 | 56 13 | 59 2 | 24 4 | 65 6 | 24 4 | 37 5 | 143 18 | 45 7 | 58 2 | 20 1 | 39 1 | 61 2 | 236 11 | 415 10

JUNE, JULY, AUGUST

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Some of the water of the South Equatorial Current recurves into the Equatorial Countercurrent. The charts show that this eddying occurs in different longitudes in different seasons.

There is an outflow from the Gulf of Panama throughout the year.

June to August

The region of recurvature of the Equatorial Countercurrent off the west coast of Central America reaches its most northerly extent during these months, so that there is a north-westerly current along this coast to about lat. 20°N.

The Equatorial Countercurrent extends into the bight southward of the Gulf of Panama during this quarter and the outflow from the Gulf of Panama is less constant than during the rest of the year.

SURFACE CURRENT ROSES

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Distance from tail of arrow to circle represents 5%

Scale 0 10 20 30 40 50%

The upper figure in the centre of the rose gives total number of observations, the lower figure the frequency of currents less than 6 miles per day.

Vancouver
Portland
San Francisco
Los Angeles
San Diego
Panama

SEPTEMBER, OCTOBER, NOVEMBER

SURFACE CURRENT, PREDOMINANT DIRECTIONS AND AVERAGE RATES

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Some of the water of the South Equatorial Current recurves into the Equatorial Countercurrent. The charts show that this eddying occurs in different longitudes in different seasons.

There is an outflow from the Gulf of Panama throughout the year.

September to November

As in June to August, the Equatorial Countercurrent extends into the bight southward of the Gulf of Panama.

Vancouver
Portland
San Francisco
Los Angeles
San Diego
Panama

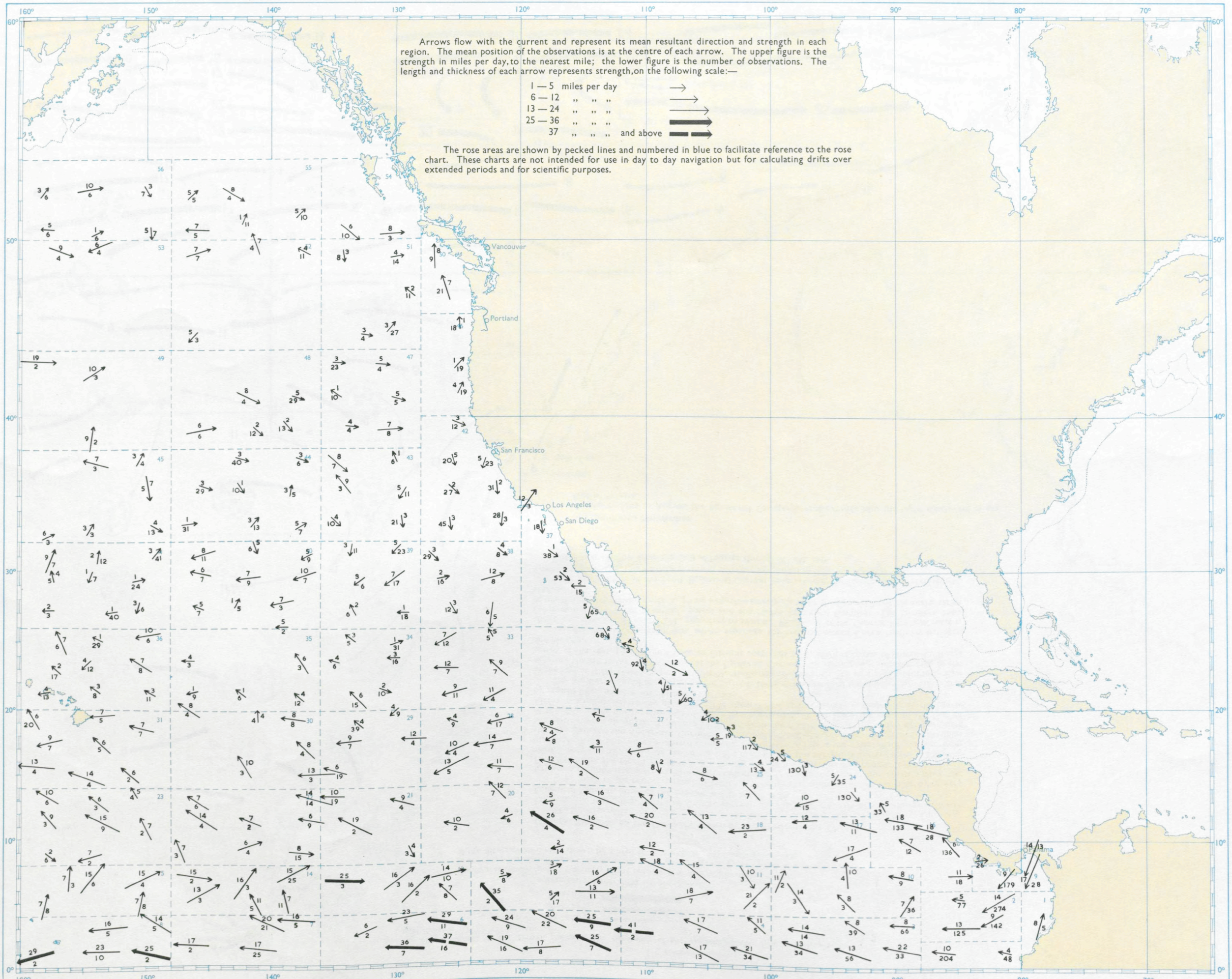
SEPTEMBER, OCTOBER, NOVEMBER

SURFACE CURRENT, VECTOR MEANS

Arrows flow with the current and represent its mean resultant direction and strength in each region. The mean position of the observations is at the centre of each arrow. The upper figure is the strength in miles per day, to the nearest mile; the lower figure is the number of observations. The length and thickness of each arrow represents strength, on the following scale:—

1 — 5	miles per day	→
6 — 12	,, ,, ,,	→
13 — 24	,, ,, ,,	→
25 — 36	,, ,, ,,	→
37	,, ,, ,, and above	→

The rose areas are shown by pecked lines and numbered in blue to facilitate reference to the rose chart. These charts are not intended for use in day to day navigation but for calculating drifts over extended periods and for scientific purposes.



DECEMBER, JANUARY, FEBRUARY

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Vancouver
Portland
San Francisco
Los Angeles
San Diego
Panama

MARCH, APRIL, MAY

SURFACE CURRENT, VECTOR MEANS

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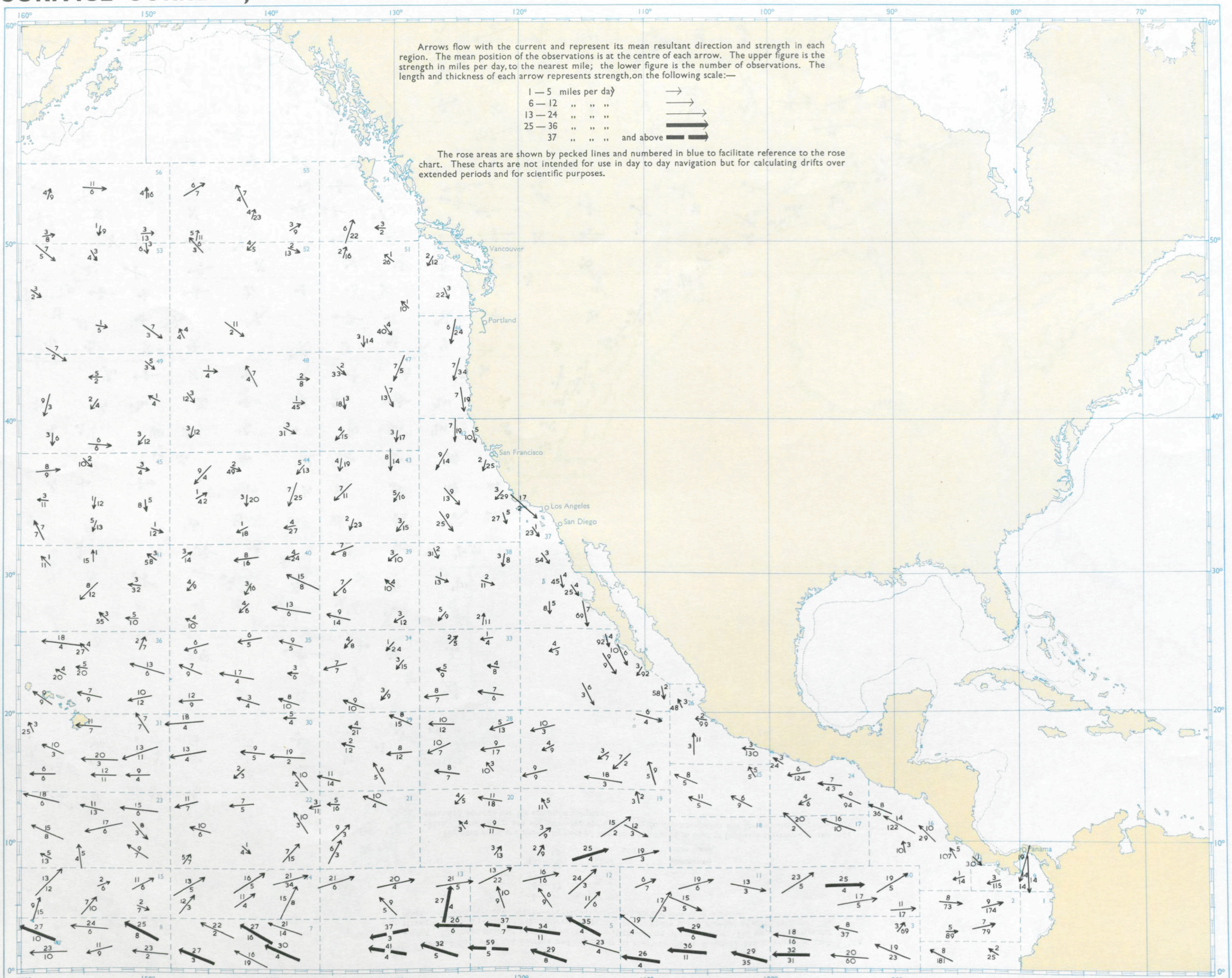

JUNE, JULY, AUGUST

SURFACE CURRENT, VECTOR MEANS

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25 — 36	,, ,, ,,	→
37	,, ,, ,, and above	→

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Vancouver
Portland
San Francisco
Los Angeles
San Diego
Panama

SEPTEMBER, OCTOBER, NOVEMBER

This page is merely a background chart, and is not intended to show any ocean current information.

Meteorological Office, London, March 1960

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