WIND ATLAS OF THE NORTH PACIFIC

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Explanatory Note

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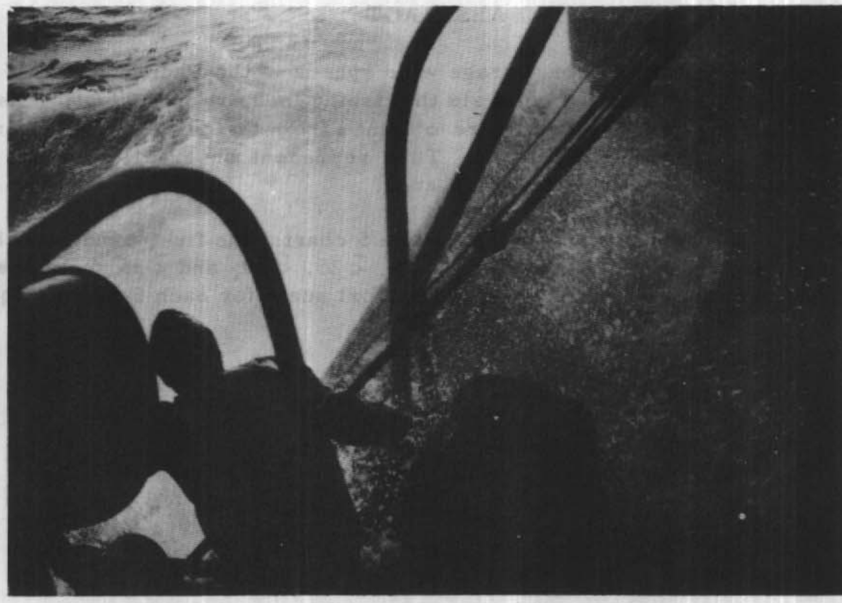

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By

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and

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Honolulu, T. H.

Special Scientific Report--Fisheries No. 243

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ABSTRACT

This atlas comprises a summary of average wind speeds in the Pacific north of 30°N. latitude, and was prepared with the hope that it would aid the fishing industry in evaluating fishing conditions and potentialities in that region. The data were obtained from the current files of unpublished wind data maintained by the U. S. Weather Bureau. They represent observations made over a 60-year period by a great number of ships traversing the area.

For each month, with a few exceptions, there are 5 charts; the first 4 indicate the geographical variations of the observed wind speeds that were $\leq$ 20, $\leq$ 25, $\leq$ 30, and $\leq$ 35 knots respectively. The fifth chart gives the maximum observed wind in Beaufort scale for each 5-degree square of latitude and longitude.

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FRONTISPIECE

Hauling gill nets in a 30-knot wind in the North Pacific on Cruise 33 of the John R. Manning.

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In commercial fishing, as in any other maritime operation, weather must be considered when evaluating the operating potentialities of an area. Regardless of the abundance of fish, if wind and sea prevent a vessel from obtaining pay loads, the area has greatly reduced value for a commercial fishery. The results of the first three exploratory fishing cruises of vessels of the Pacific Oceanic Fishery Investigations (POFI) to the waters north of Hawaii in search of new albacore grounds demonstrated this situation quite strikingly. On 12 of the 25 days spent north of 30°N. latitude, on John R. Manning cruise 19 (January-March 1954), the seas were considered too rough for longlining. On John R. Manning cruise 22 (September-November 1954), on 18 of 41 days, sea conditions were not suitable for fishing, and on John R. Manning cruise 23 (January-February 1955), fishing was not possible on 9 of 25 days (Shomura and Otsu 1956). Furthermore, the northern limit of the albacore distribution in the central North Pacific during the fall and winter months could not be definitely established because adverse weather forced the vessels to turn south.

As the result of this experience, work was started on a guide which, it was hoped, would aid in evaluating the operational limitations of small (80 to 130 feet) vessels at different seasons of the year in the North Pacific above 30°N. latitude. The resulting atlas consists of a series of four contour charts for each month, (with a few exceptions) showing the frequency of winds of 20 knots or less, 25 knots or less, 30 knots or less, and 35 knots or less, and a fifth showing the maximum wind that has been observed in each 5-degree square of latitude and longitude (charts 1-53).

The existing wind summaries (e.g., McDonald 1938, U. S. Navy 1956) published for the benefit of mariners in the North Pacific provide a wealth of data on average winds, percentage of winds of gale force or greater, and percentage of calms. While these data are useful they do not provide the essential information for evaluating operating areas in terms of potential operating time for fishing vessels since they do not provide a precise breakdown of data in the 20-30 knot range, where experience has shown that most fishing operations must cease.

Ideally, sea height would be a better indicator of operating conditions than wind, but there is not a sufficient number of wave observations available for the North Pacific to permit the preparation of reliable charts. The U. S. Weather Bureau and the U. S. Navy Hydrographic Office have been compiling wind data from ships' weather reports and deck logs since the latter part of the 19th century, but it was only recently, September 1, 1955, that a concerted effort was made to have all vessels report sea conditions (A. J. Rohlfs, USWB personal communication). The relation between wind and sea has long been recognized, and sea characteristics are still used as the basis for estimating wind speed on vessels not equipped with anemometers (Bowditch 1953, p. 52).

The validity of using wind as an indicator of sea state has also been demonstrated in the development of wave-forecasting techniques. Sverdrup and Munk (1947) derived equations for computing wave height and velocity from wind velocity, duration of wind, and fetch. Duration of wind refers to the period of time during which the wind velocity has been approximately uniform. Fetch is the length of the generating area or the distance over which the wind velocity has been approximately steady. Detailed instructions for computing these parameters and wave-forecasting techniques are given in USNHO Miscellaneous Publication 11275. Sverdrup and Munk (1947, p. 31) also found that the British Admiralty's empirical rule that waves lose roughly one-third of their height each time they travel a distance in miles equal to their length in feet was in general agreement with theoretical values and could be used to estimate the decay rate of waves after they left the generating area.

From data in Wave Report No. 73 (unpublished), Scripps Institution of Oceanography, table 1 was compiled showing the minimum time

Table 1.--Minimum time and fetch required for winds of various velocities to produce waves of a given height and the length of the waves produced under these conditions. (Calculated from Wave Report No. 73 (unpublished) of Scripps Institution of Oceanography, University of California)

To produce waves --	At a wind velocity of -- 20 knots	25 knots	30 knots	35 knots	40 knots	45 knots	50 knots	55 knots	60 knots
4 feet high:									
Time (hours)	3.2	2.0	1.3	1.0	0.9	0.8	0.7	0.6	0.5
Fetch (nautical miles)	11	7	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Length (feet)	40	43	46	49	50	51	51	52	52
8 feet high:									
Time	19.0	6.2	4.0	3.0	2.2	1.9	1.5	1.2	1.0
Fetch	120	26	18	14	11	9	7	6	5
Length	155	86	82	86	86	90	95	95	95
12 feet high:									
Time		20.0	8.0	5.4	4.0	3.1	2.8	2.2	2.0
Fetch		745	48	31	22	17	17	13	12
Length		216	133	123	125	133	138	138	141
16 feet high:									
Time			16.2	8.9	6.3	4.9	3.9	3.1	2.9
Fetch			125	59	42	32	26	20	19
Length			237	172	166	166	172	178	178
20 feet high:									
Time				14.0	9.1	7.0	5.7	4.8	4.0
Fetch				120	67	51	42	36	29
Length				258	216	206	207	210	213
24 feet high:									
Time				31.0	13.4	9.5	7.3	6.0	5.1
Fetch				320	115	76	59	48	41
Length				462	288	258	244	237	251
28 feet high:									
Time					20.9	13.0	9.7	7.8	6.4
Fetch					210	120	84	68	56
Length					406	328	296	288	280
32 feet high:									
Time					36.5	16.7	12.0	9.4	7.8
Fetch					440	170	115	87	71
Length					620	401	344	324	320
36 feet high:									
Time						24.4	15.4	11.6	9.3
Fetch						280	160	120	91
Length						533	424	379	361
40 feet high:									
Time						42.0	19.5	14.2	11.4
Fetch						575	220	150	120
Length						787	512	443	415
44 feet high:									
Time							25.6	16.0	13.4
Fetch							315	180	150
Length							642	512	462

Table 1.--Minimum time and fetch required for winds of various velocities to produce waves of a given height and the length of the waves produced under these conditions. (Calculated from Wave Report No. 73 (unpublished) of Scripps Institution of Oceanography, University of California) (cont'd)

To produce waves --	At a wind velocity of --								
	20 knots	25 knots	30 knots	35 knots	40 knots	45 knots	50 knots	55 knots	60 knots
48 feet high:									
Time (hours)							43.0	21.2	16.3
Fetch (nautical miles)							635	265	190
Length (feet)							919	608	543
52 feet high:									
Time								25.8	18.1
Fetch								340	220
Length								713	608
56 feet high:									
Time								36.1	21.5
Fetch								535	280
Length								919	677
60 feet high:								52.5	26.0
Time								890	355
Fetch								1214	800
Length									

and fetch required for winds of 20 to 60 knots to generate waves of various heights. These data are useful for estimating the maximum waves to be expected from storms at sea. The wave length was also included in the table to aid in estimating the wave heights to be expected downwind from storm areas. Wave length was computed from the periods given in the graphs by the formula

$$L = 5.12T^2$$

where L is the length in feet and T is the period in seconds (USNHO 1944).

SOURCE OF DATA

The data used in constructing the wind frequency charts were supplied by the U. S. Weather Bureau Records Center, Asheville, N. C., from their current files of unpublished marine wind tabulations as of May 1955. The data consist of tabulated individual Beaufort force frequencies for each month for each 5-degree square of latitude and longitude in the North Pacific and adjacent seas north of 30°N. latitude. The observations cover a period of more than 60 years. The total number of observations per square varies greatly. The squares in the regular steamer lanes have as many as 5, 808 observations for a single month, but many areas in the extreme northern portion have no reports during the winter months.

RELIABILITY OF THE DATA

Even at the present time only about 50 percent of the vessels plying the North Pacific are equipped with an anemometer (A. J. Rohlfs, USWB, personal communication) so most of the wind speeds have been reported in Beaufort scale estimates. For convenience in keeping records, the speeds observed by vessels having anemometers were also converted to the Beaufort scale. In the original scale, devised about 1805 by Admiral Beaufort of the British Navy, the effects of wind on a ship's sails were used as criteria for estimating the wind force (Byers 1944, p. 83). Since that time the criteria for estimating Beaufort force have been adapted to fit a variety of circumstances (Riesenberg 1936, p. 794; Bowditch 1943, p. 52), and the wind speed in knots corresponding to the various forces have been determined experimentally. On steam vessels the state of the sea has been commonly used for estimating wind speed. The criteria for this method, approved by the International Maritime Conference and in current use, are given in table 2 together with the range in knots and descriptive term for each force (USWB 1954, p. 14). Obviously such subjective

Table 2.--Determination of wind speed by sea condition (from USWB Circular M, 1954, p. 14)

Wind force (Beaufort)	Speed in knots	Descriptive terms	Sea conditions
0	Less than 1	Calm	Sea smooth and mirror-like
1	1-3	Light air	Scale-like ripples without foam crests
2	4-6	Light breeze	Small, short wavelets; crests have a glassy appearance and do not break.
3	7-10	Gentle breeze	Large wavelets; some crests begin to break; foam of glassy appearance. Occasional white foam crests.
4	11-16	Moderate breeze	Small waves, becoming longer; fairly frequent white foam crests.
5	17-21	Fresh breeze	Moderate waves, taking a more pronounced long form; many white foam crests; there may be some spray.
6	22-27	Strong breeze	Large waves begin to form; white foam crests are more extensive everywhere; there may be some spray.
7	28-33	Moderate gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind; spindrift begins.
8	34-40	Fresh gale	Moderately high waves of greater length; edges of crests break into spindrift; foam is blown in well-marked streaks along the direction of the wind.
9	41-47	Strong gale	High waves; dense streaks of foam along the direction of the wind; crests of waves begin to topple, tumble, and roll over; spray may reduce visibility.
10	48-55	Whole gale	Very high waves with long overhanging crests. The resulting foam in great patches is blown in dense white streaks along the direction of the wind. On the whole, the surface of the sea is white in appearance. The tumbling of the sea becomes heavy and shocklike. Visibility is reduced.
11	56-63	Storm	Exceptionally high waves that may obscure small and medium-sized ships. The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility reduced.
12	64 and above	Hurricane	The air is filled with foam and spray. Sea completely white with driving spray; visibility very much reduced.

methods of estimating wind speeds must have resulted in considerable differences among individual observers. Excellent results have been obtained, however, in oceanographic computations using ships' wind data by assuming that the observed values for a given Beaufort force form a Gaussian distribution about its midpoint and have a standard deviation of half a Beaufort interval (Reid 1948).

Apart from estimating the reliability of single observations on wind force is the problem of setting the minimum number of observations needed to give a reliable estimate of the wind forces over a given 5-degree square of ocean during a given month; that is, assuming observations are randomly distributed in time, how many are needed to furnish a reliable description of the winds in a 5-degree block of ocean during one month? Since the estimated standard deviation of a single observation is one-half a Beaufort force class, it was arbitrarily decided that the data from a 5-degree square for a particular month would not be considered unless there were enough observations to furnish a mean having a high probability of lying within 0.5 of a Beaufort force of the true mean. Following Snedecor (1946, p. 457) this minimum sample size was estimated by computing the standard deviation and standard error of the mean of a square from midocean represented by 427 observations. From these statistics n was computed for the 99-percent and 95-percent confidence levels as 37 and 27 respectively. In constructing the monthly charts all squares having less than 27 observations were omitted and the contours of the areas having between 27 and 37 observations were drawn with dotted lines.

PROCEDURES

Since marine weather reports and forecasts are now made in knots rather than in Beaufort scale, knots were used in the charts in this atlas, which show for each month the percentage of observed winds of 20, 25, 30, and 35 knots or less. Twenty knots was selected as the lowest speed for contouring, since at this wind speed any seagoing fishing vessel should still be able to carry out all types of fishing operations. It is slightly greater than the midpoint of Beaufort force 7 (17-21 knots) which is defined as the speed at which "smacks shorten sail" (Bowditch 1943, p. 52) and at which the U. S. Coast Guard begins to display small-craft warnings. Thirty-five knots was selected as the maximum wind speed for fishing operations because it lies in the lower limits of Beaufort force 8 (34-40 knots), which is defined as the speed at which "smacks remain in harbor, and those at sea lie to." The two intermediate velocities have been included as a basis for estimating the percentage of time larger vessels should be able to carry out limited operations such as trolling, or that smaller vessels must "lie to."

The experience of POFI vessels in the North Pacific has shown the validity of these limits. At wind speeds of 20 knots, gill nets begin to tangle and are difficult to retrieve, and longlining becomes extremely difficult. The records show that longline has been laid in winds up to 25 knots but only when the 30-hour weather forecast indicated that the weather would moderate, and there were other signs of improving weather. Both gill nets and longlines have been retrieved in winds up to 35 knots when it was a matter of saving the gear, but the operation was exceedingly difficult and hazardous. Thirty knots represents the upper limit of trolling; above this speed the lines tangle and do not fish properly. It has been POFI's experience that, above 35 knots, her research vessels must suspend fishing activities and either lie to or jog into or before the sea, depending on their particular characteristics.

The percentages used in preparing the contour charts were obtained from cumulative percentage distribution curves of the wind speeds. Monthly cumulative distribution curves for each square were constructed by first plotting the cumulative percentages for each Beaufort force at the speed in knots equivalent to the extreme upper limit; e.g., 16.5 knots for force 4. These points were then used as a basis for drawing smoothed ogive curves (Guilford 1950, pp. 121-126). Actually the smoothed curves passed through the points in the majority of cases. The percentiles for the 20-, 25-, 30-, and 35-knot levels were then taken from these curves.

The percentages were plotted at the midpoint of each square and the contours were drawn assuming that they represented the frequency at this point. After the values were plotted, examination showed that some of the squares off North America and Japan, which were largely land, e.g., the square bounded by 50°-55°N., 125°-130°W., and the confined waters between Japan and Asia had a much larger percentage of winds of lower speeds than the adjacent areas offshore. It was believed that this apparent increase in percentage of winds of lower speeds was due to vessels taking advantage of shelter when operating locally or awaiting good weather before departing from port. Data for these squares were therefore omitted from the chart. Another area where, in winter, the percentage of low-speed winds also seems abnormally higher than climatological data would indicate is the band between 50° and 55°N. latitude. The primary storm track, i.e., the path of the maximum concentration of individual storm tracks, lies in this band between October and April (U. S. Navy 1956), and hence the minimum percentage frequency of low winds would be expected. Such an abnormality in the records may have resulted from vessels taking shelter in the Aleutian Islands during periods of high winds. This tendency of wind data to become skewed towards lower speeds in coastal and insular areas will tend to become oceanwide in the future as more and more vessels take advantage of the increasing reliability and dissemination of marine weather forecasts in choosing their sailing routes.

The plots of maximum wind simply show the maximum Beaufort force that has been reported in each unit of area, regardless of the number of observations. Forces of 8 or less have been lumped into a single group, since lower speeds are adequately covered in the contour charts. In the majority of the squares the maximum values comprise less than 1 percent of the total observations, and in a large number of the areas they represent single observations. Nevertheless, they indicate wind speeds that have occurred and speeds that a vessel should be able to withstand if it is to operate in the area.

USE OF THE CHARTS IN EVALUATING OPERATIONAL POTENTIALITIES IN VARIOUS AREAS

The most practical method of illustrating the use of the charts is to compare the actual conditions encountered by POFI vessels with the average conditions indicated by the charts. Taking the most adverse season first, during John R. Manning cruise 19, some excellent longline catches of albacore were made in late January 1954 along 160°W. between 30° and 35°N. latitude, but because of rough seas, fishing was possible on only 4 of 7 days, or 57 percent of the time. The weather log shows that only 15 (65 percent) of the 23 wind observations were 20 knots or less and winds up to 50 knots were reported. Charts 1-5 show that the percentage of winds of 20 knots or less which might be expected in January lies between 60 and 65 percent and that the maximum speed is Beaufort force 11 or 56-63 knots. Thus it appears that the charts of winds of 20 knots or less give a fair estimate, although slightly on the high side in this case, of the percentage of time the Manning could expect to longline in the area.

Considering next the summer season, when the best conditions occur, and again using the John R. Manning as the example, on cruise 32 of the Manning (July 25 to September 3, 1956) excellent gill-net and troll catches of albacore were made in the area from 145°W. to 175°W. longitude, between 42°N. and 48°N. latitude (POFI unpublished data). During the cruise two independent series of wind observations were made, one by the scientists as part of the standard 6-hour weather observations and the other by the ship's officers at the end of each 4-hour watch. The officers also logged additional observations during periods of high winds. Both series indicated that the wind frequencies were about what the August charts (charts 32-34), the midpoint of the cruise period, indicate for the area. Of the 121 observations made by the scientists 90 percent were 20 knots or less, 96 percent were 25 knots or less, and the maximum was 30 knots. Of the 127 reports by the ship's officers, including the special observations, 87 percent were 20 knots or less, 94 percent 25 knots or less, 99 percent 30 knots or less, and the maximum was 32 knots. The observed conditions lie within the 85-90 percent range of the frequency of winds of 20 knots or less indicated for the area by the August chart (chart 32). During this cruise the weather conditions permitted gill nets to be set at 23 of the 26 planned stations, or 88 percent of the time. Thus, the frequency of winds of 20 knots or less appears to be an excellent index of the percentage of time suitable for gill netting. The trolling log showed that conditions were suitable for trolling with all lines (6) on 28-1/2 days and with a reduced number of lines on 2 days, for a total of 92 percent of the 32 days actually spent in the area. Although trolling was performed in winds of up to 27 knots under exceptional sea conditions, a comparison of the observed wind frequencies and the total trolling time indicates a more reliable index of the probable trolling time for the Manning would be about midway between the frequencies of winds of 20 and 25 knots or less.

The actual working limit of each vessel must be determined in the above manner by experience. Once this has been established, a reliable estimate of the time that it could expect to fish in the North Pacific can be obtained from the charts. It is apparent, however, from the frequency with which forces 10-12 appear in the charts of maximum observed wind for the summer months, that a vessel must be capable of riding out the seas generated by such winds if it is to operate in the open North Pacific during any season of the year.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to the many persons who contributed to this atlas. The data represent the efforts of many thousands of ships' officers and quartermasters. The data were located and made available by Roy L. Fox of the U. S. Weather Bureau. Dorothy D. Stewart made the statistical computations, Richard Callaway made the wave calculations, and Tamotsu Nakata drafted the charts.

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CHART INDEX

	Chart number for month of --											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Percentage of winds 20 knots or less	1	6	11	16	21	25	29	32	35	39	44	49
Percentage of winds 25 knots or less	2	7	12	17	22	26	30	33	36	40	45	50
Percentage of winds 30 knots or less	3	8	13	18	23	27	-3/	-5/	37	41	46	51
Percentage of winds 35 knots or less	4	9	14	19	-1/	-2/	-4/	-6/	-7/	42	47	52
Maximum observed winds	5	10	15	20	24	28	31	34	38	43	48	53

1/ Chart omitted since in only one square (50°-55°N., 145°-150°W.) was the frequency less than 95 percent.

2/ Chart omitted since all frequencies were 97 percent or greater.

3/ Chart omitted since in only one square (40°-45°N., 125°-130°W.) was the frequency less than 95 percent.

4/ Chart omitted since all frequencies were 97 percent or greater.

5/ Chart omitted since all frequencies were 95 percent or greater.

6/ Chart omitted since all frequencies were 98 percent or greater.

7/ Chart omitted since only three squares (in the Aleutian Islands - Bering Sea Area) had frequencies less than 95 percent.

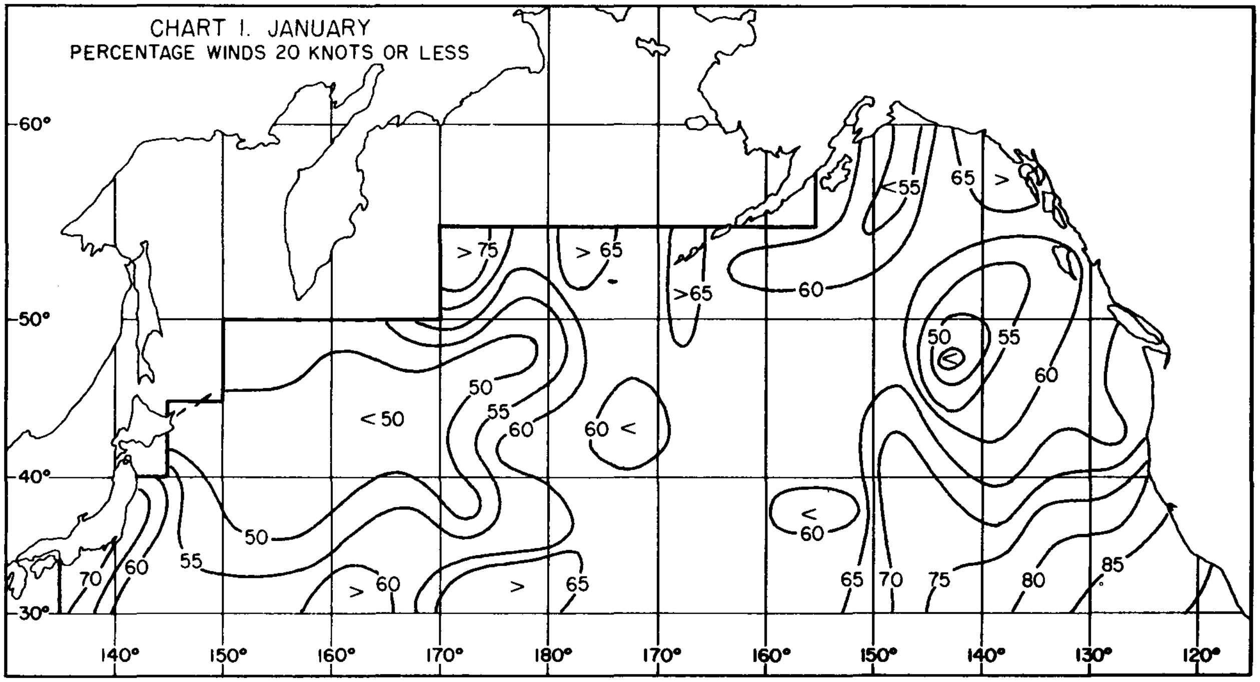
CHART 1. JANUARY
PERCENTAGE WINDS 20 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
> 75
> 65
>65
60
< 55
65
>
50
55
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65
70
75
80
85

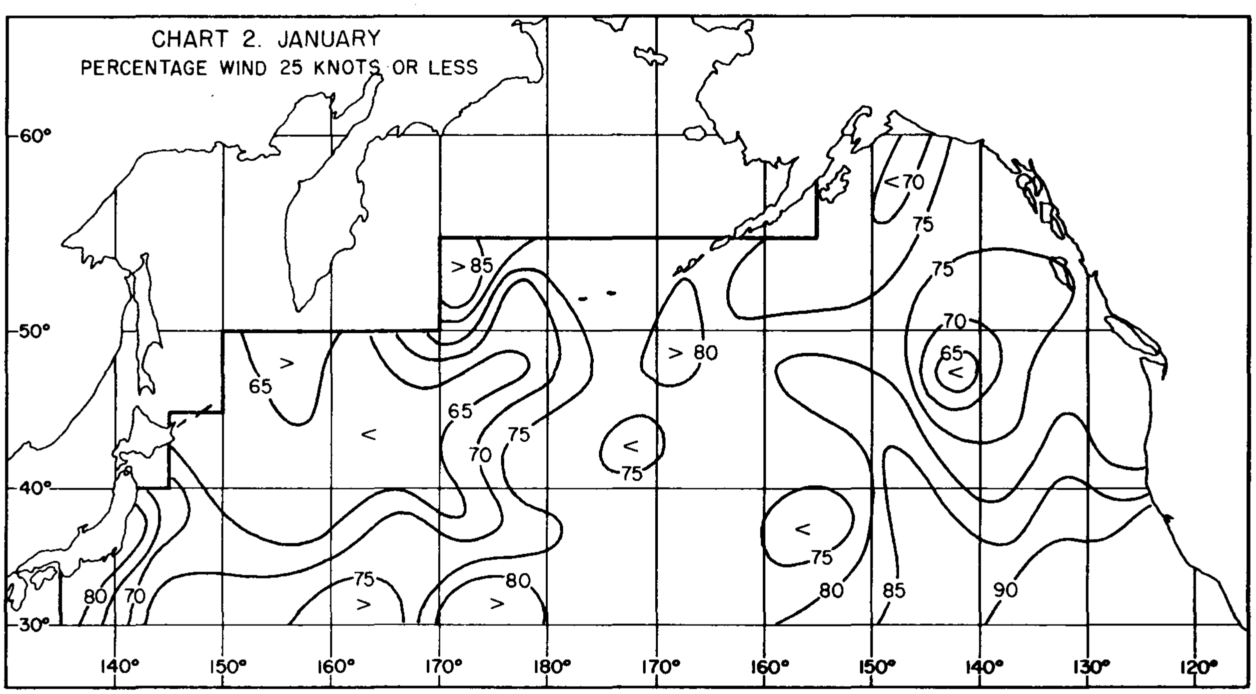
CHART 2. JANUARY
PERCENTAGE WIND 25 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
> 85
< 70
75
75
70
65
<
>
65
> 80
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75
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>
80
>
80
70
80
85
90

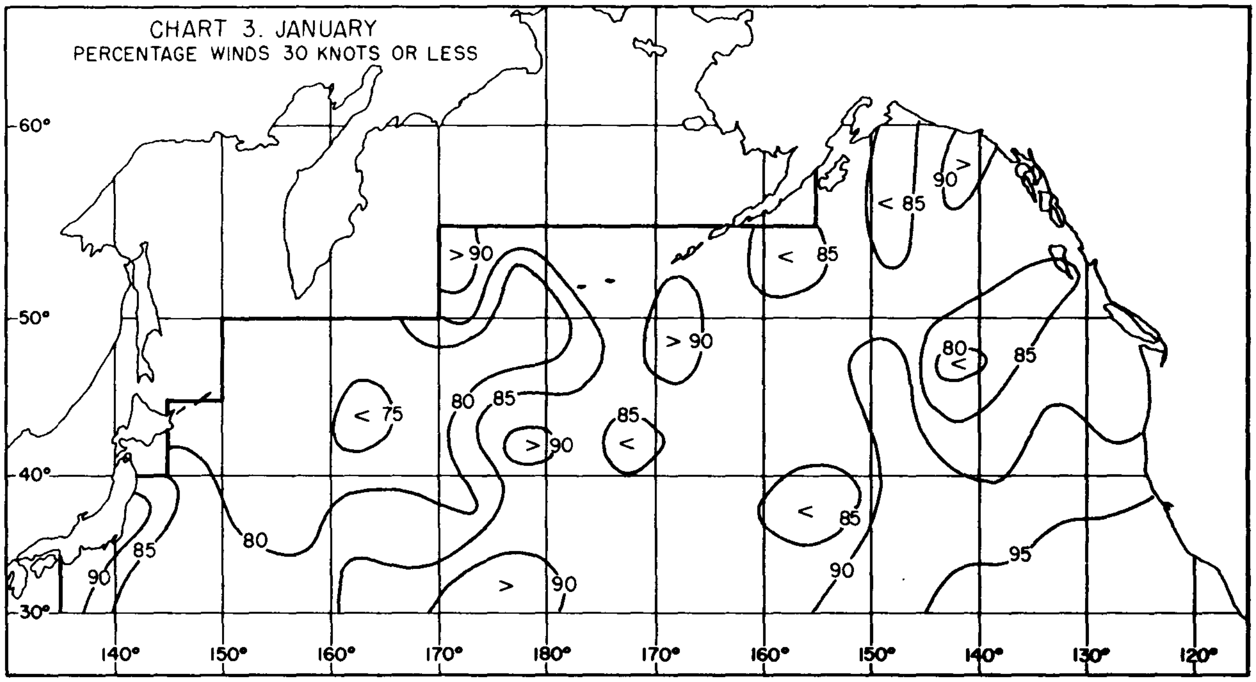
CHART 3. JANUARY
PERCENTAGE WINDS 30 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
> 90
< 75
80
85
> 90
85
<
> 90
< 85
< 85
90 >
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90
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80
85
90
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90

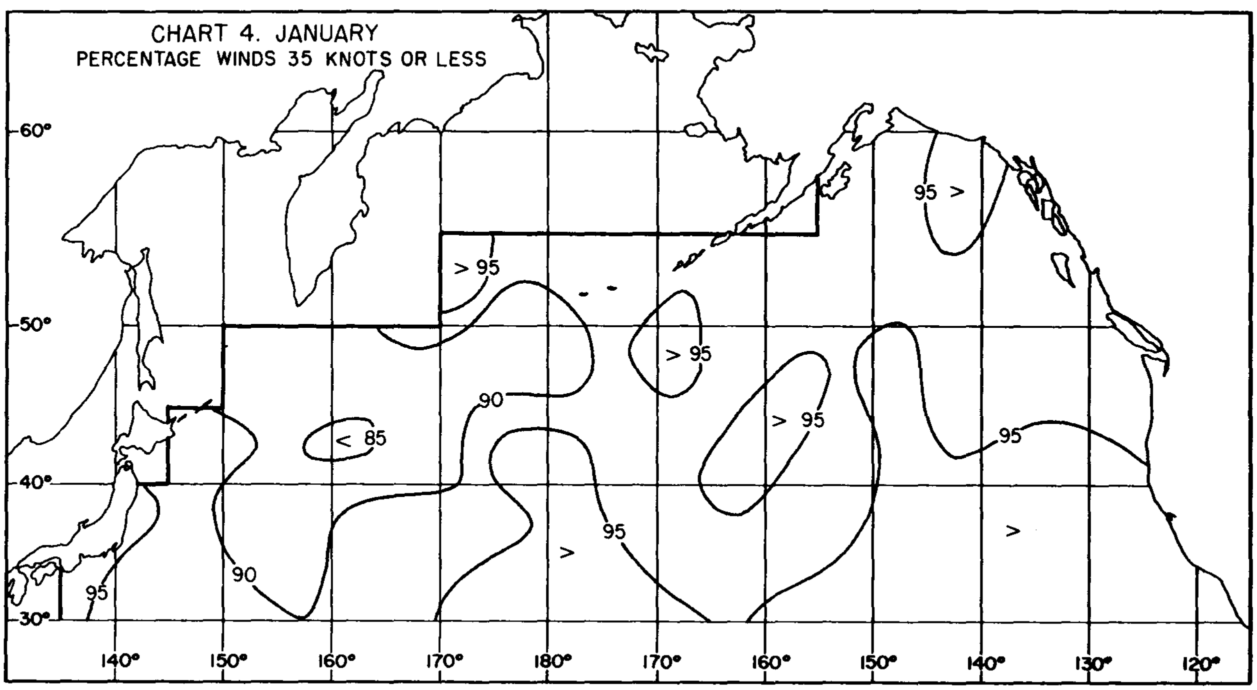
CHART 4. JANUARY
PERCENTAGE WINDS 35 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
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90
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95

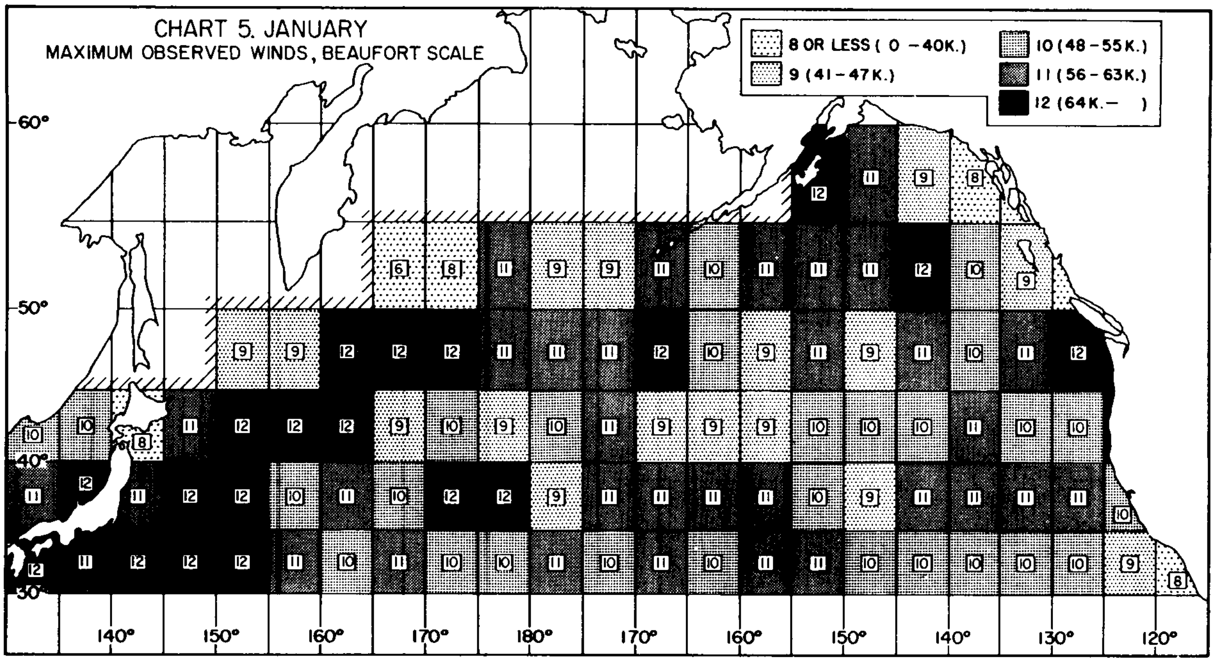

CHART 5. JANUARY
MAXIMUM OBSERVED WINDS, BEAUFORT SCALE

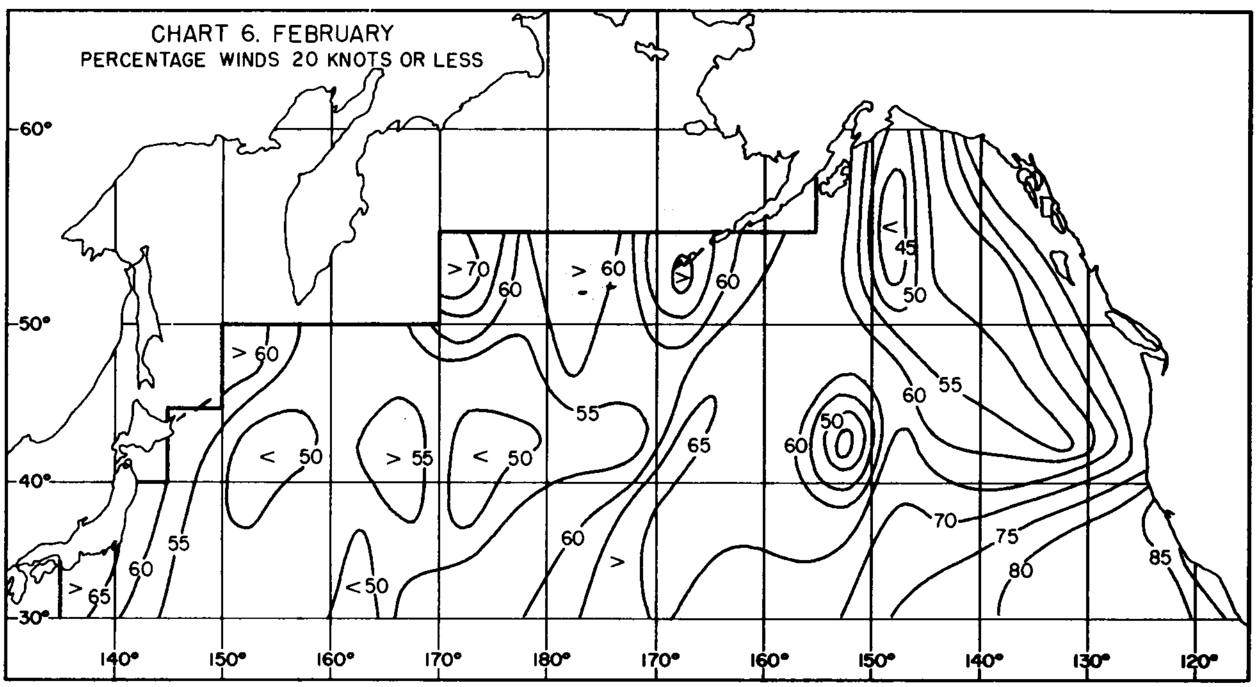

CHART 6. FEBRUARY
PERCENTAGE WINDS 20 KNOTS OR LESS

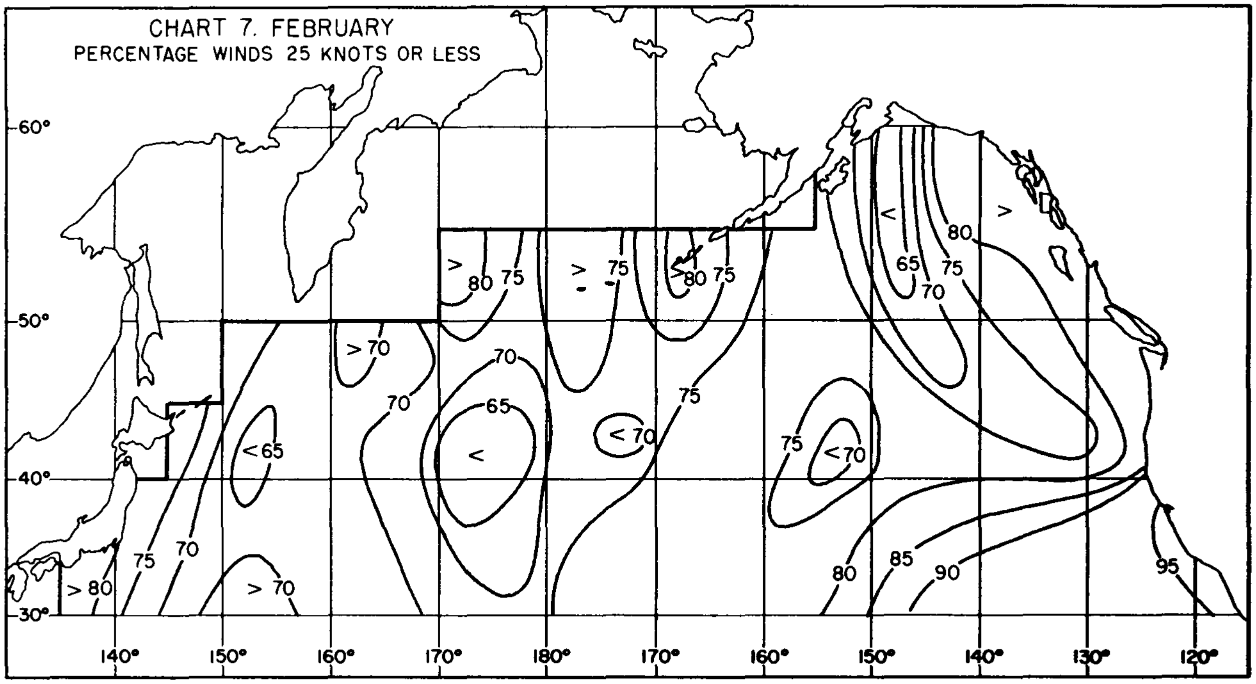
CHART 7. FEBRUARY
PERCENTAGE WINDS 25 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

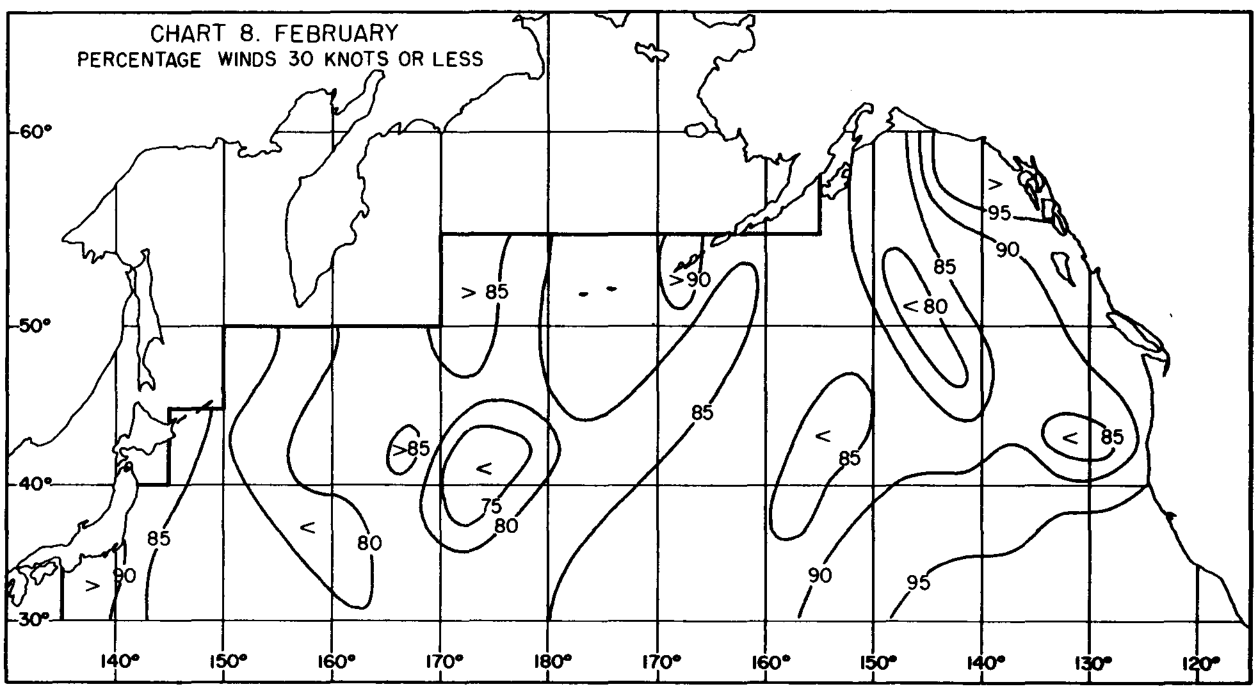
CHART 8. FEBRUARY
PERCENTAGE WINDS 30 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

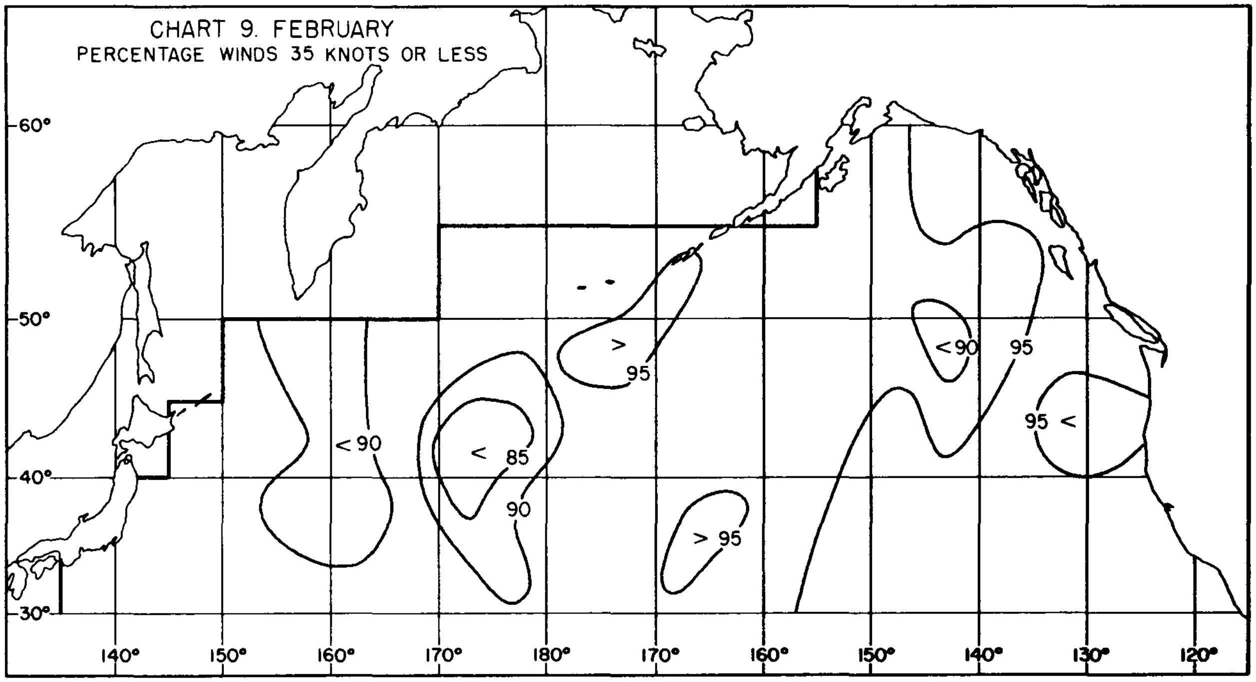

CHART 9. FEBRUARY
PERCENTAGE WINDS 35 KNOTS OR LESS

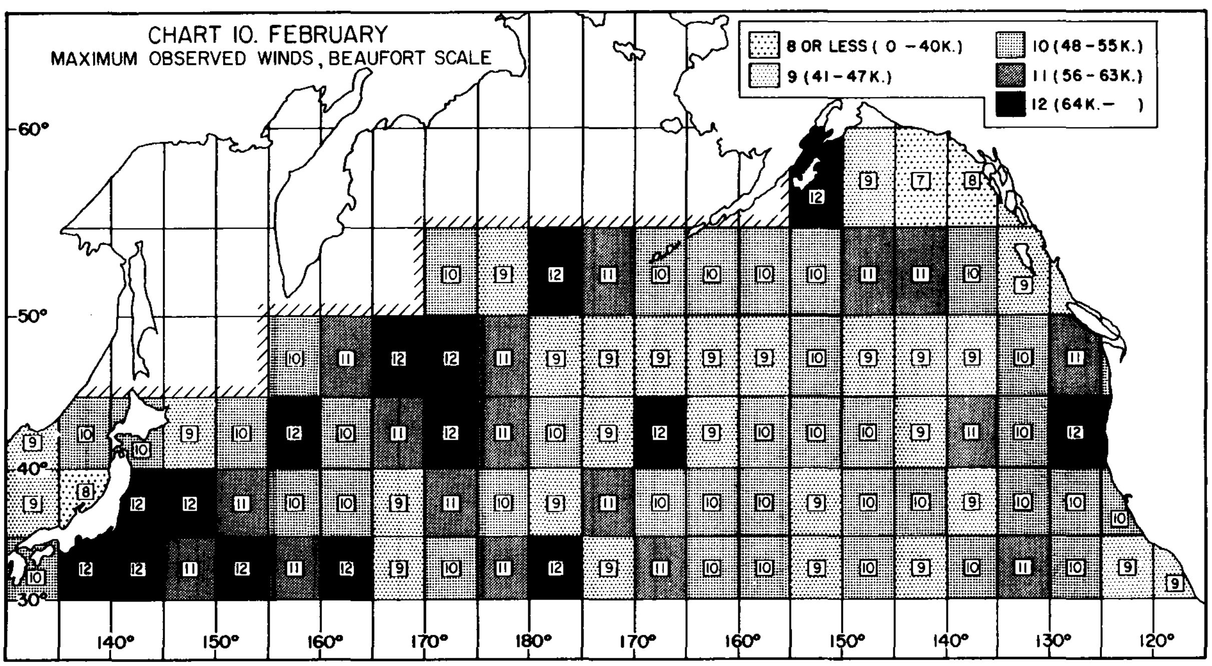

CHART 10. FEBRUARY
MAXIMUM OBSERVED WINDS, BEAUFORT SCALE

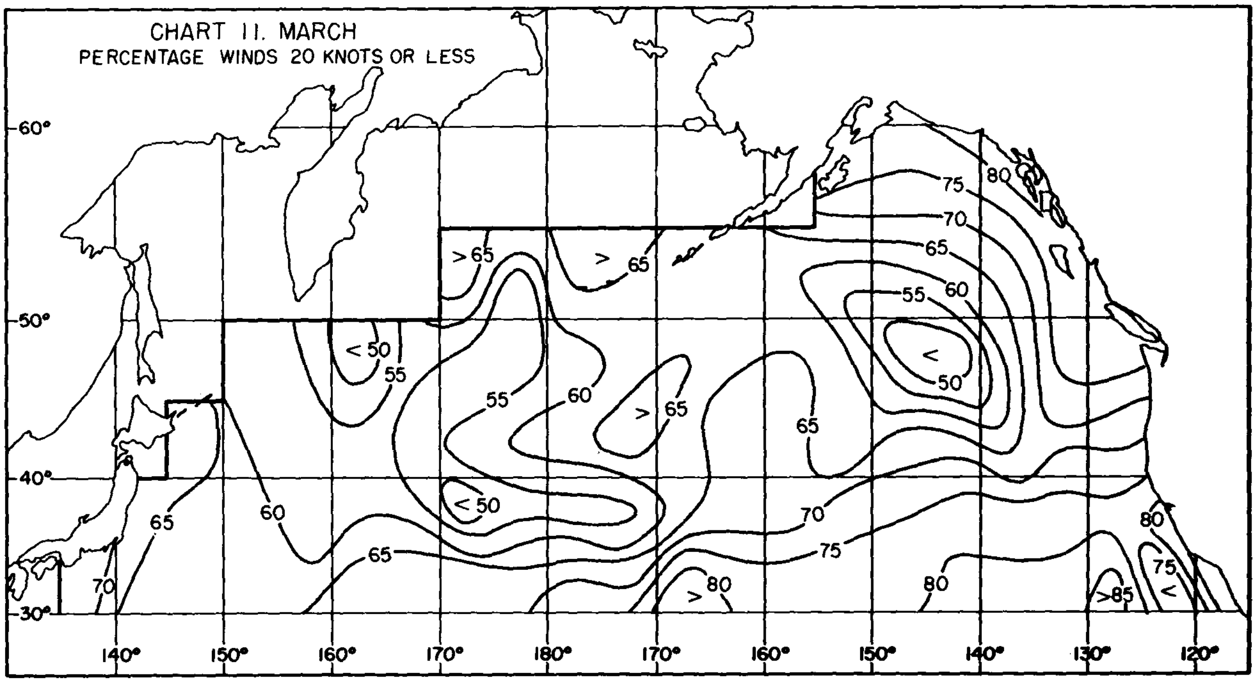

CHART 11. MARCH
PERCENTAGE WINDS 20 KNOTS OR LESS

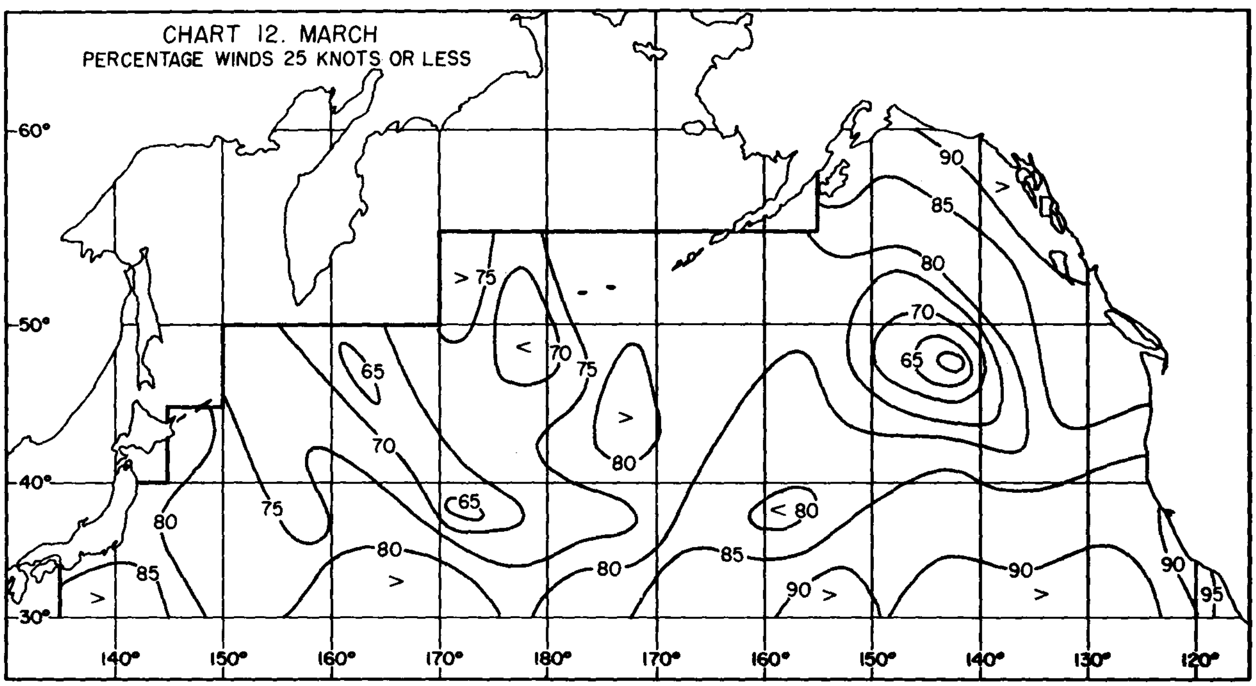

CHART 12. MARCH
PERCENTAGE WINDS 25 KNOTS OR LESS

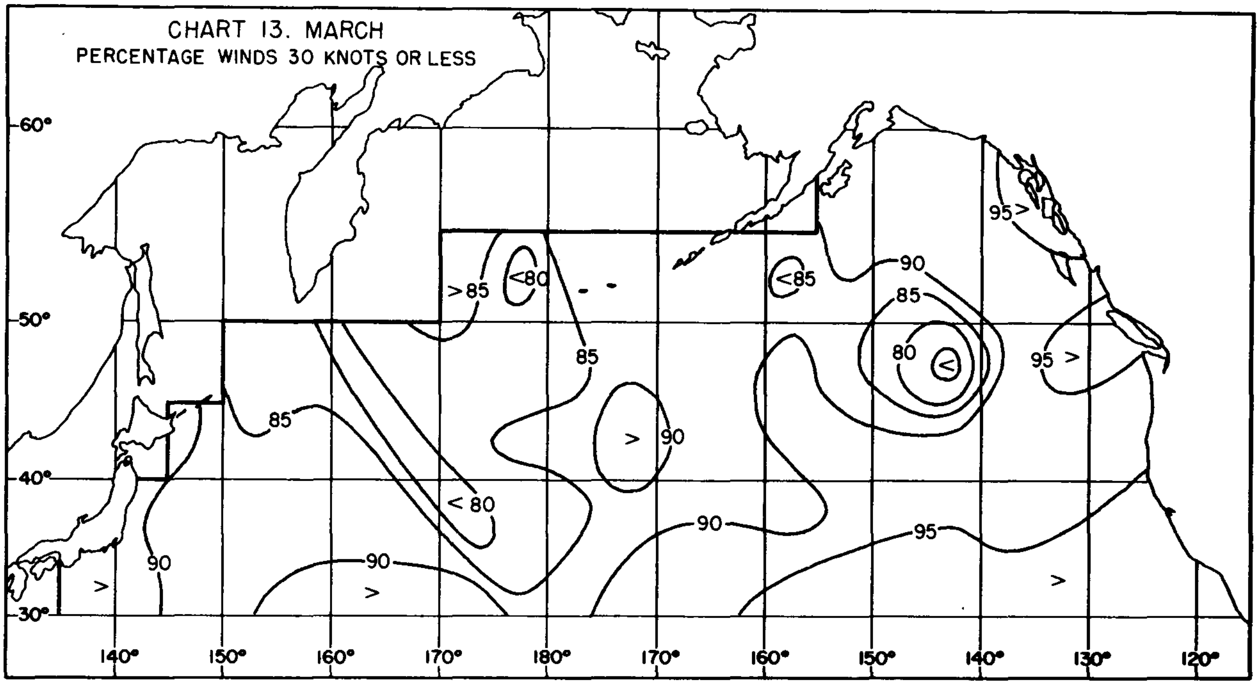
CHART 13. MARCH
PERCENTAGE WINDS 30 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
95>
90
85
>85
<80
<85
80
95 >
85
85
> 90
< 80
90
90
90
95
>
>
>

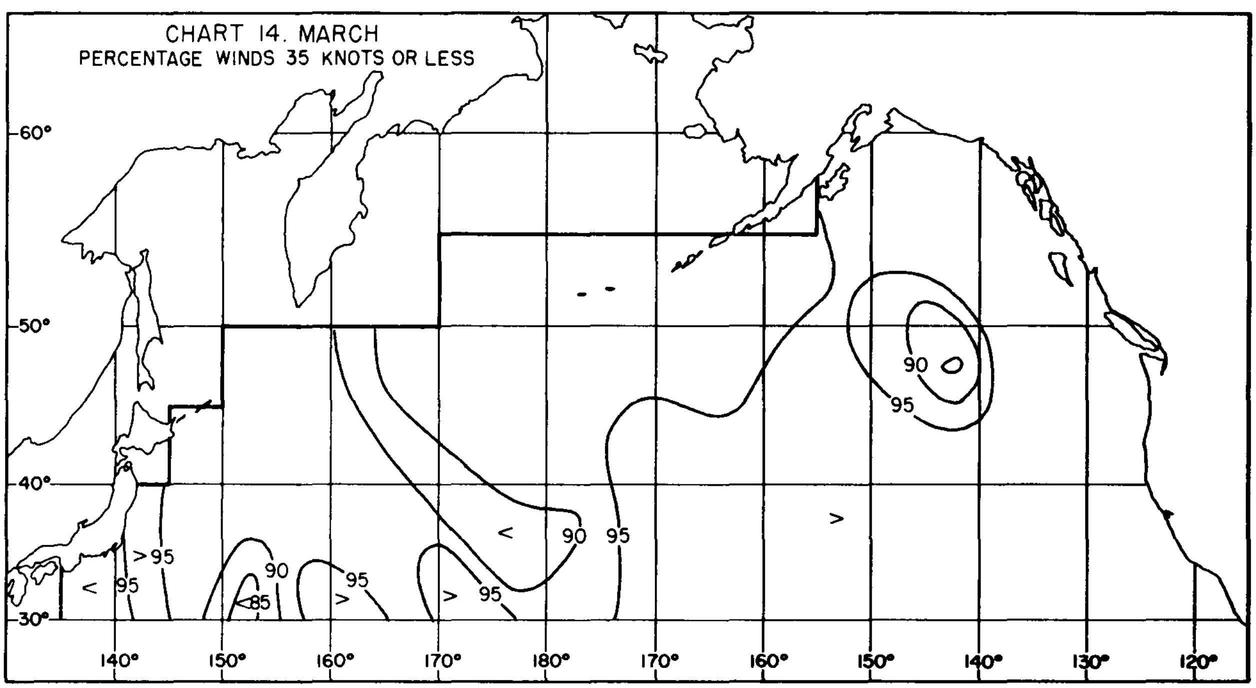
CHART 14. MARCH
PERCENTAGE WINDS 35 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
90
95
>
<
90
95
>95
< 95
90
<85
95
>
> 95

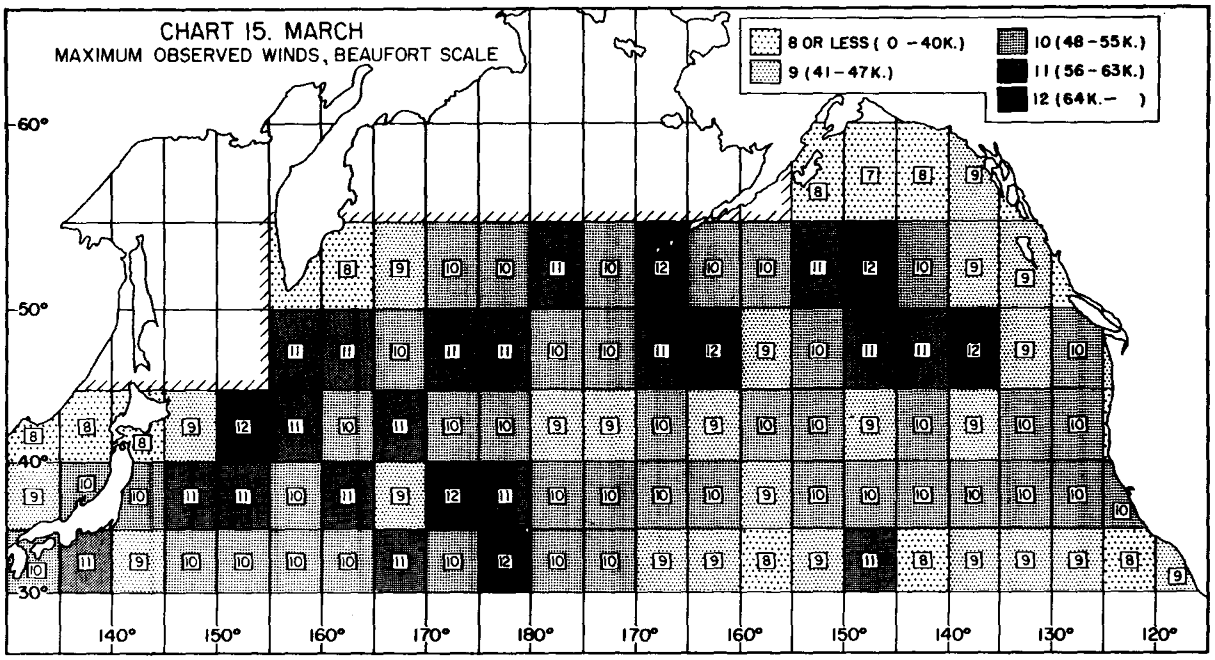
CHART 15. MARCH
MAXIMUM OBSERVED WINDS, BEAUFORT SCALE
8 OR LESS (0 - 40K.)
9 (41 - 47K.)
10 (48 - 55K.)
11 (56 - 63K.)
12 (64K. -)
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

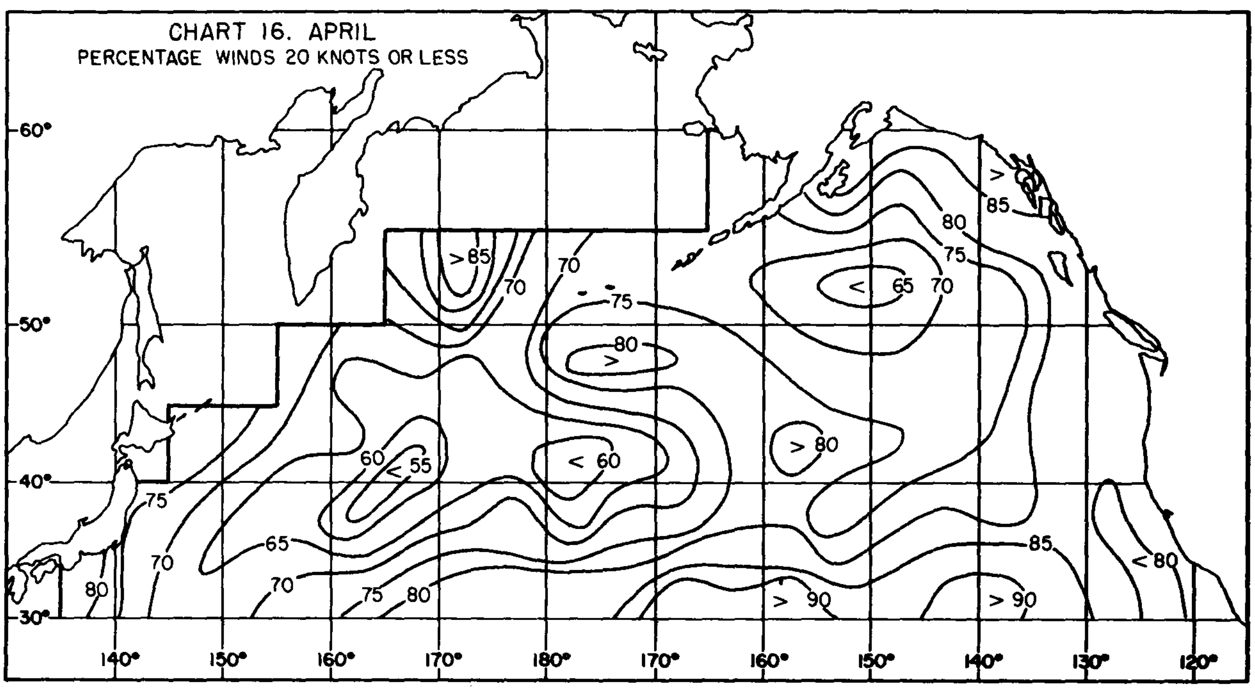
CHART 16. APRIL
PERCENTAGE WINDS 20 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

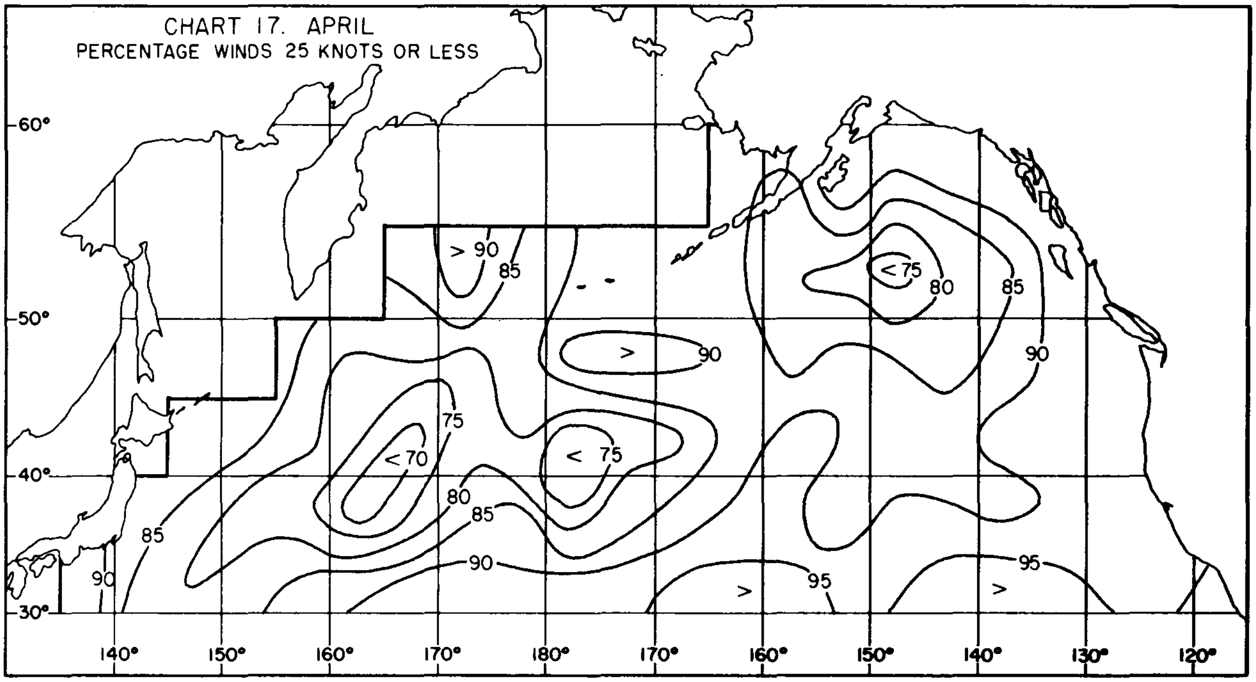
CHART 17. APRIL
PERCENTAGE WINDS 25 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
> 90
85
< 75
80
85
> 90
90
75
< 70
< 75
80
85
85
90
90
95
> 95
> 95

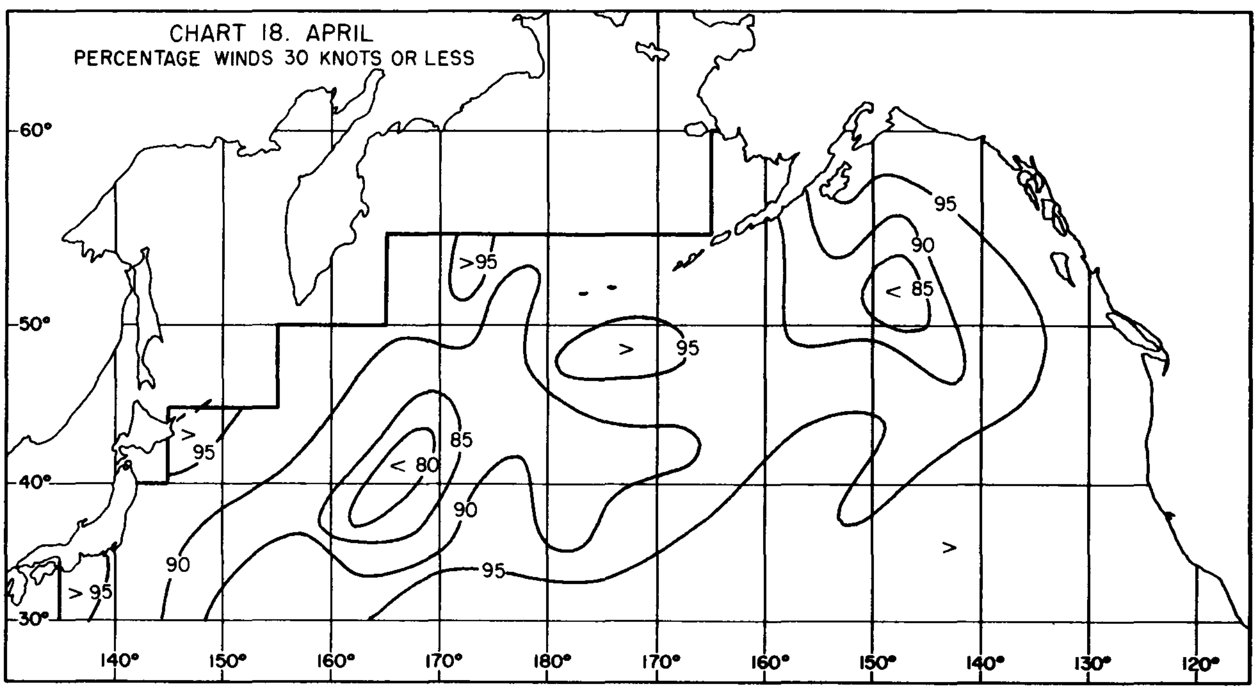
CHART 18. APRIL
PERCENTAGE WINDS 30 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
95
90
> 95
< 85
> 95
> 95
85
< 80
90
90
> 95
95
>

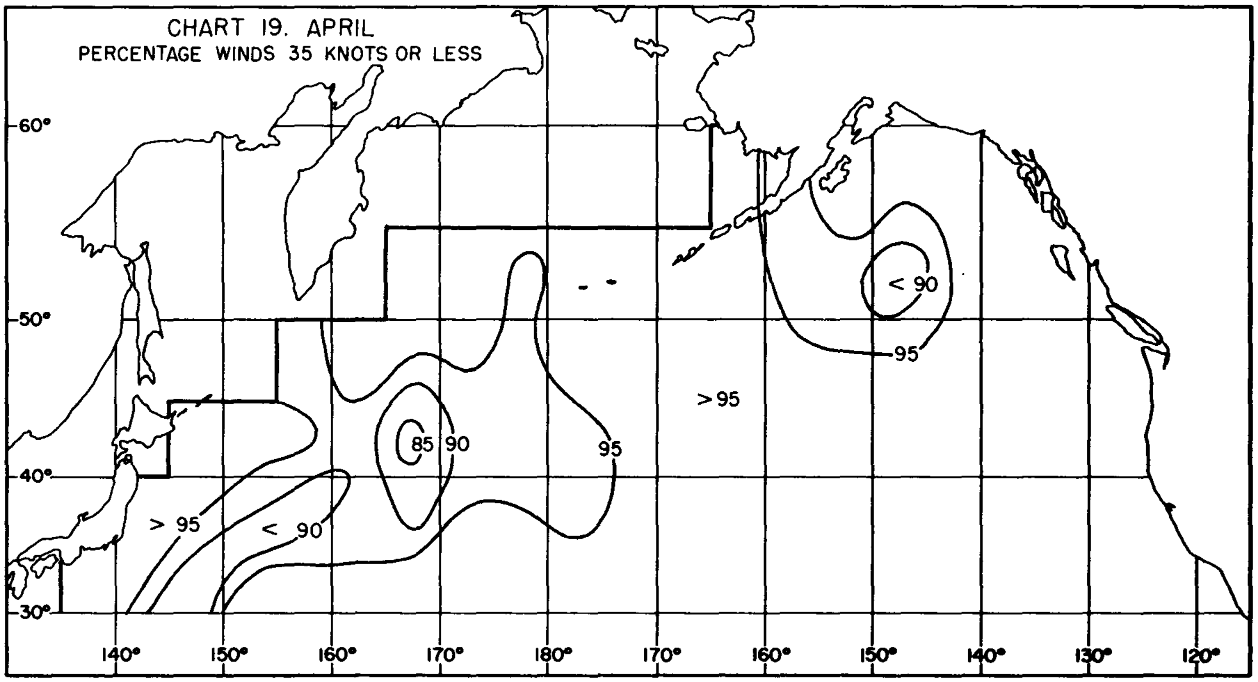
CHART 19. APRIL
PERCENTAGE WINDS 35 KNOTS OR LESS
60°
50°
40°
30°
< 90
95
> 95
85
90
95
> 95
< 90
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

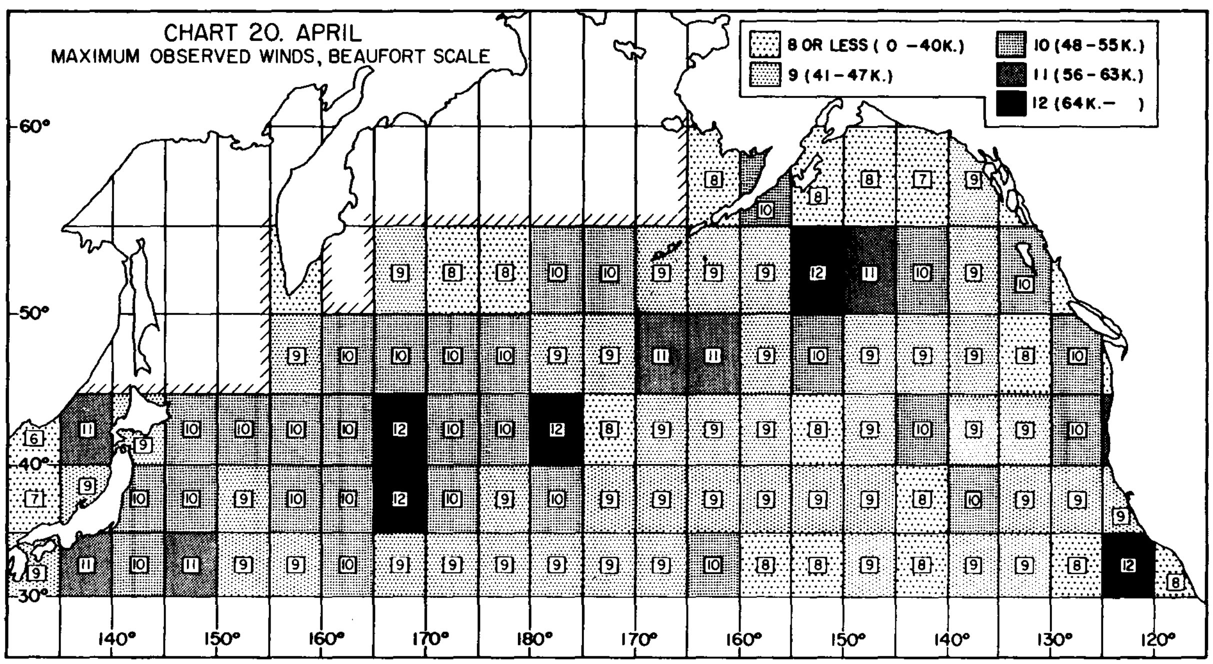
CHART 20. APRIL
MAXIMUM OBSERVED WINDS, BEAUFORT SCALE
8 OR LESS (0 -40K.)
9 (41-47K.)
10 (48-55K.)
11 (56-63K.)
12 (64K.-)
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

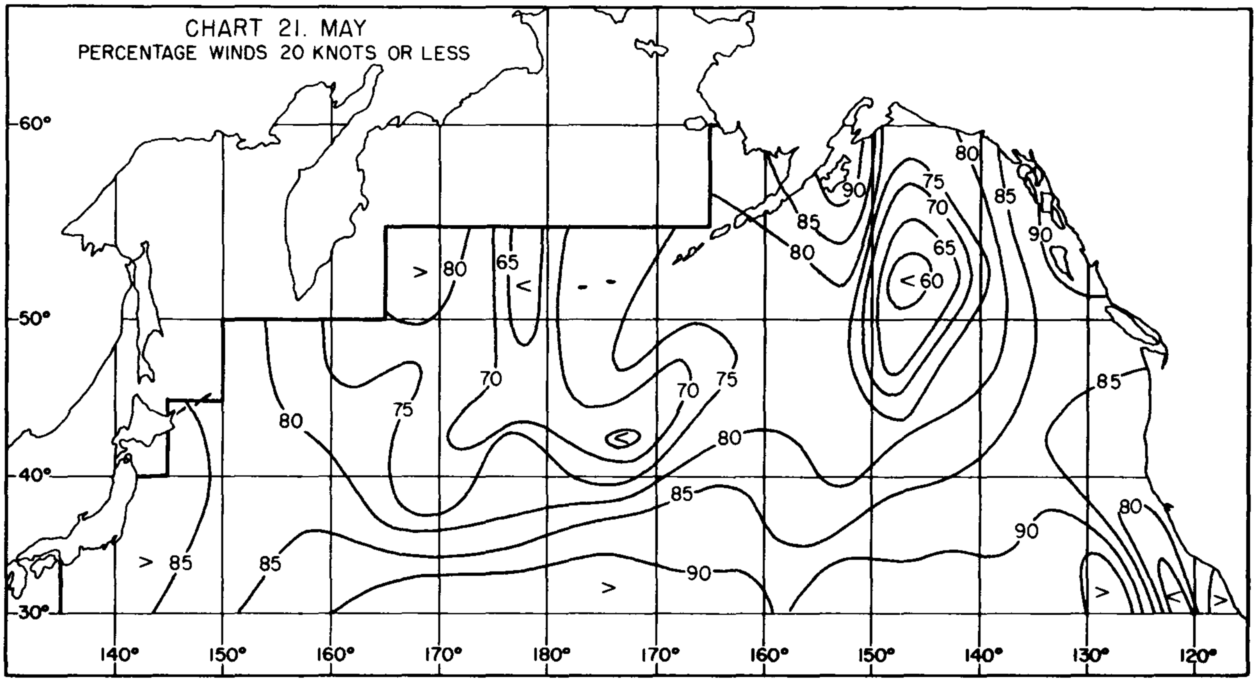
CHART 21. MAY
PERCENTAGE WINDS 20 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

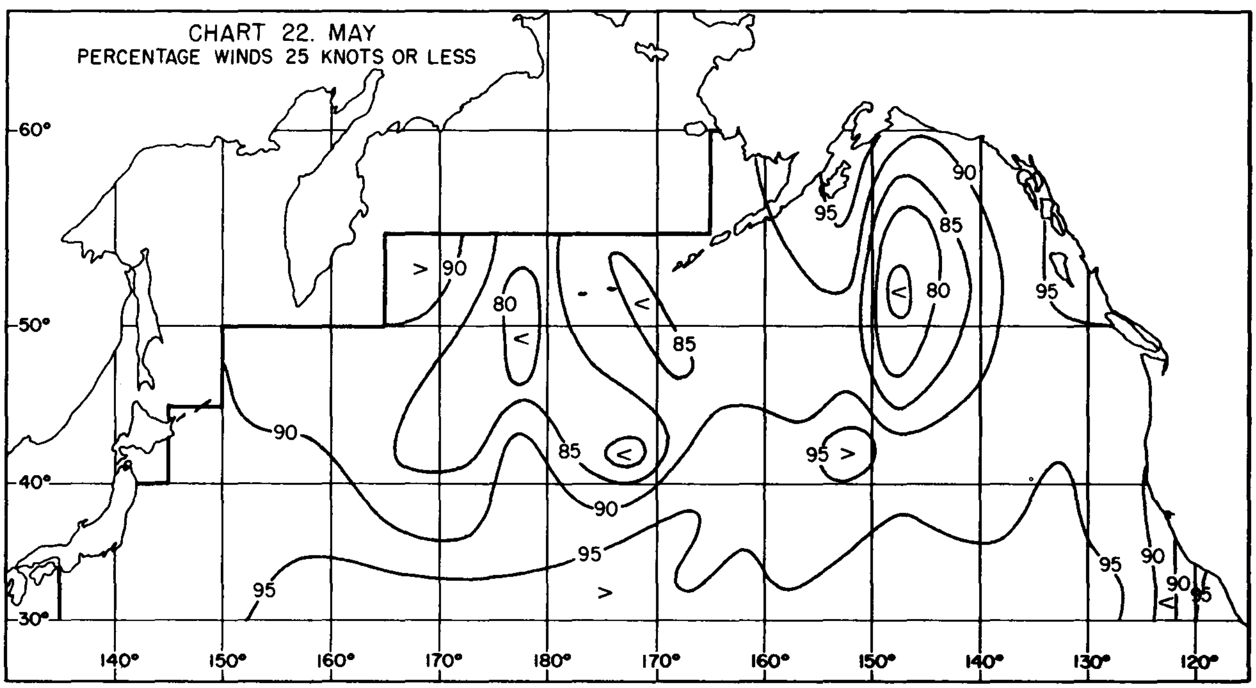
CHART 22. MAY
PERCENTAGE WINDS 25 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

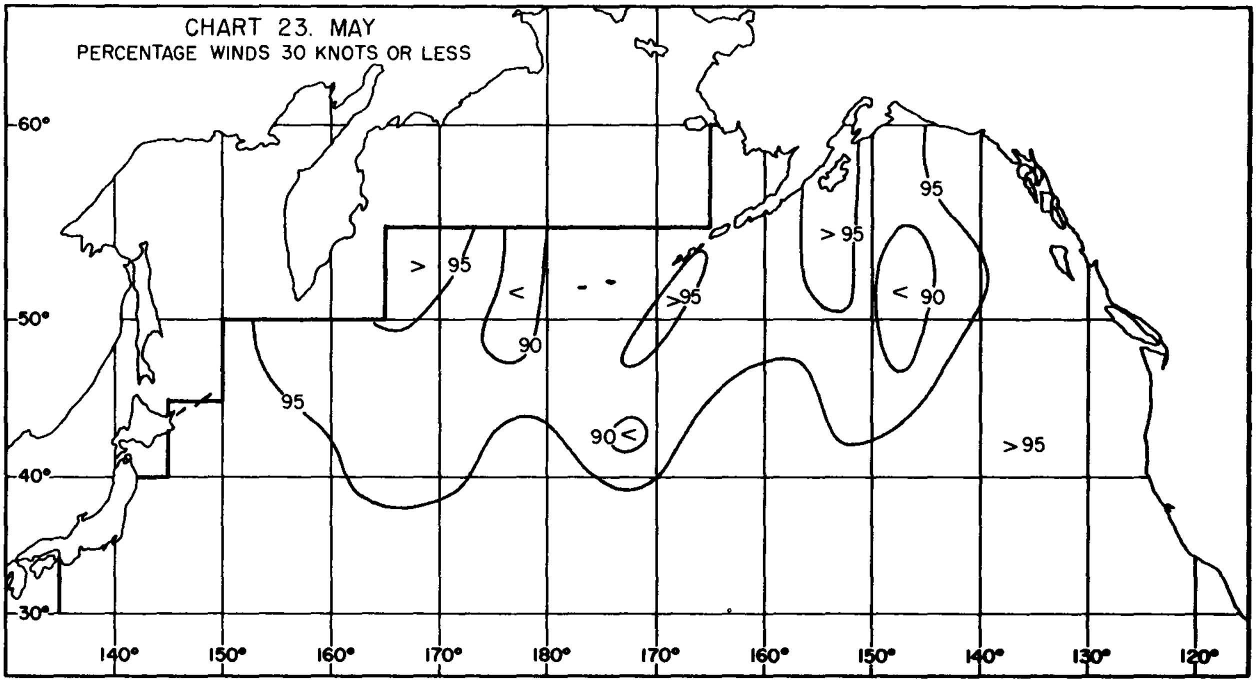

CHART 23. MAY
PERCENTAGE WINDS 30 KNOTS OR LESS

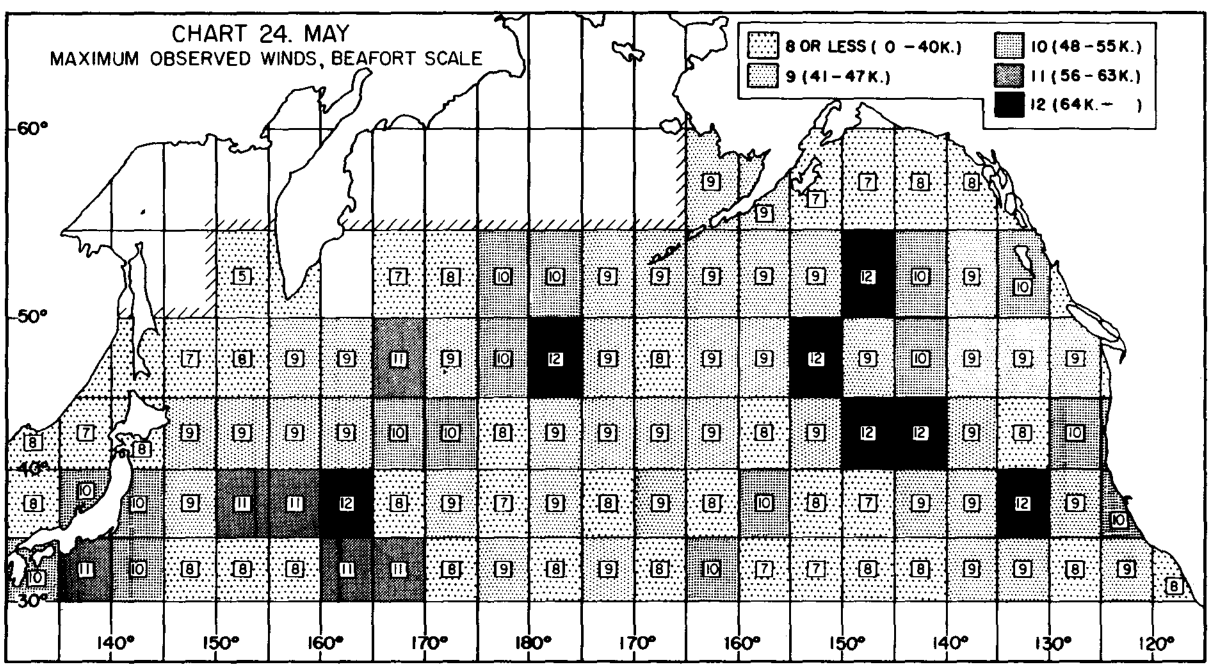

CHART 24. MAY
MAXIMUM OBSERVED WINDS, BEAFORT SCALE

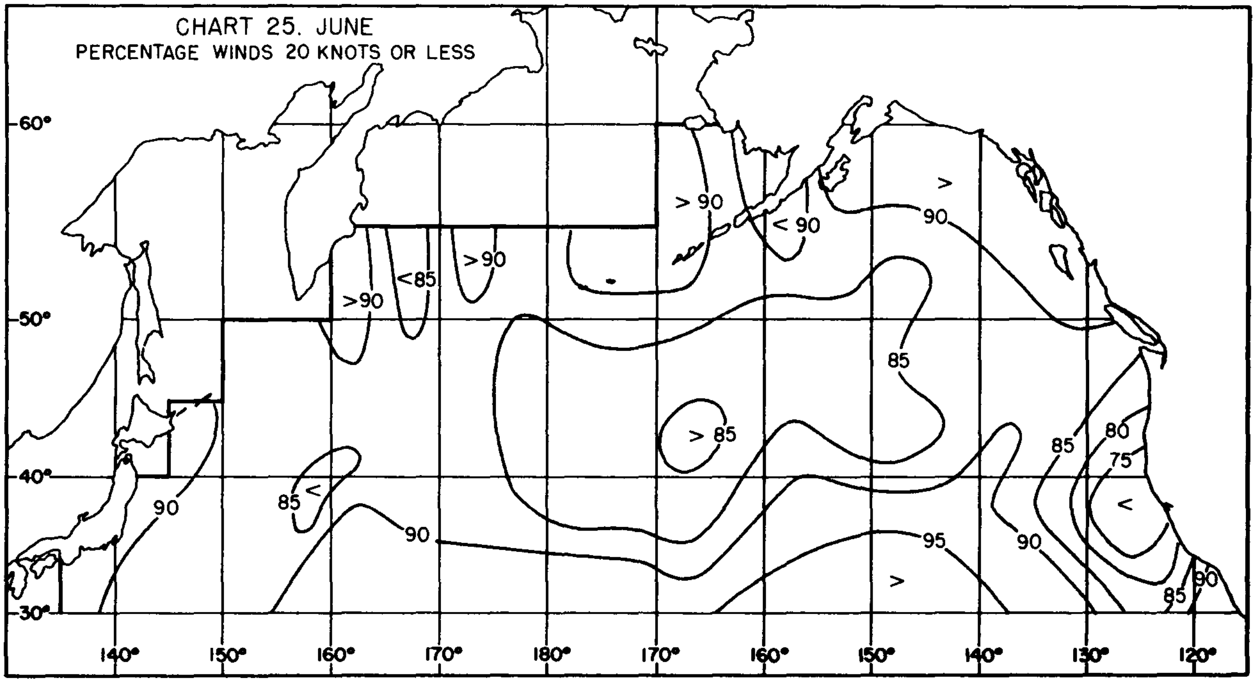

CHART 25. JUNE
PERCENTAGE WINDS 20 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
>90
<85
>90
>90
<90
90
85
>85
85
<
90
90
95
>
90
85
80
75
<
85
90
>

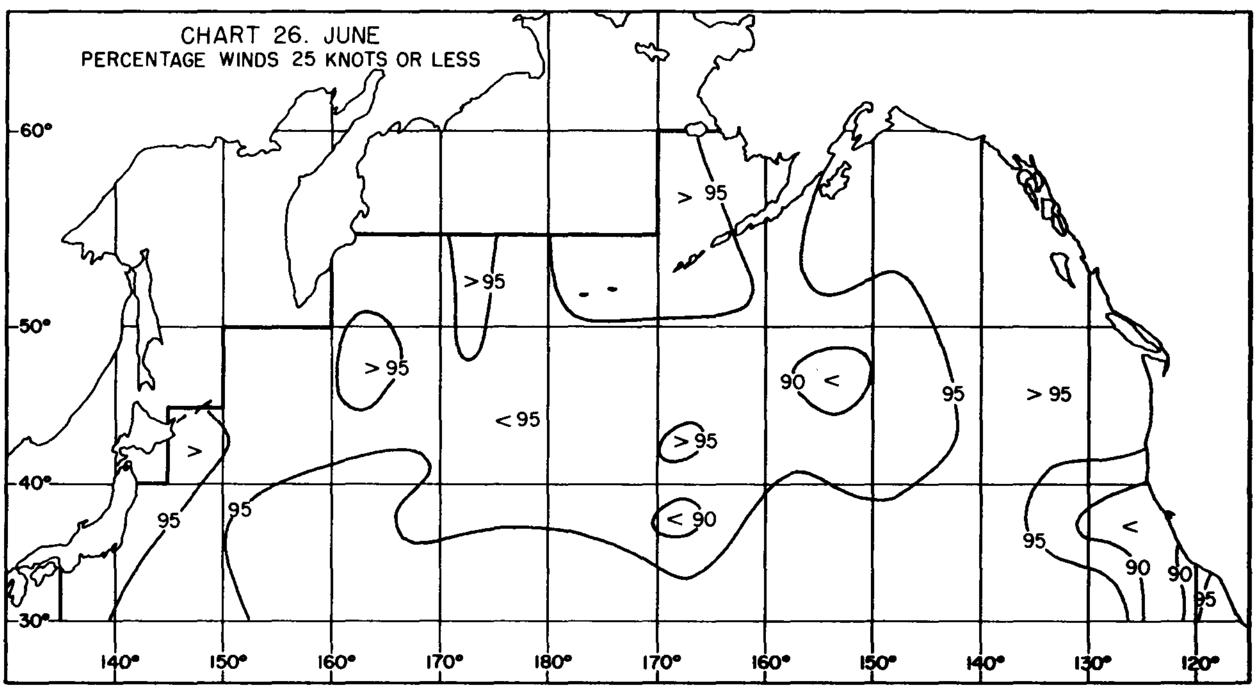

CHART 26. JUNE
PERCENTAGE WINDS 25 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
>95
>95
>95
<95
>95
90
<
95
>95
>
95
95
<90
95
<
90
90
95

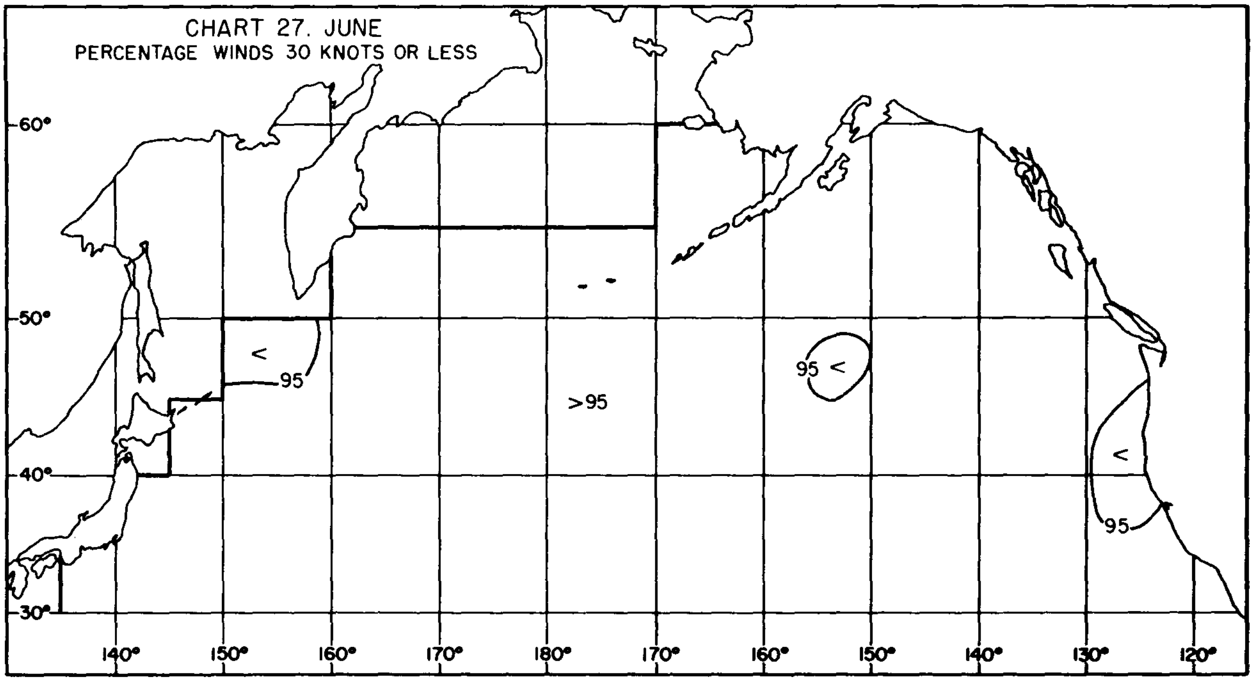
CHART 27. JUNE
PERCENTAGE WINDS 30 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
<
95
>95
95 <
<
95

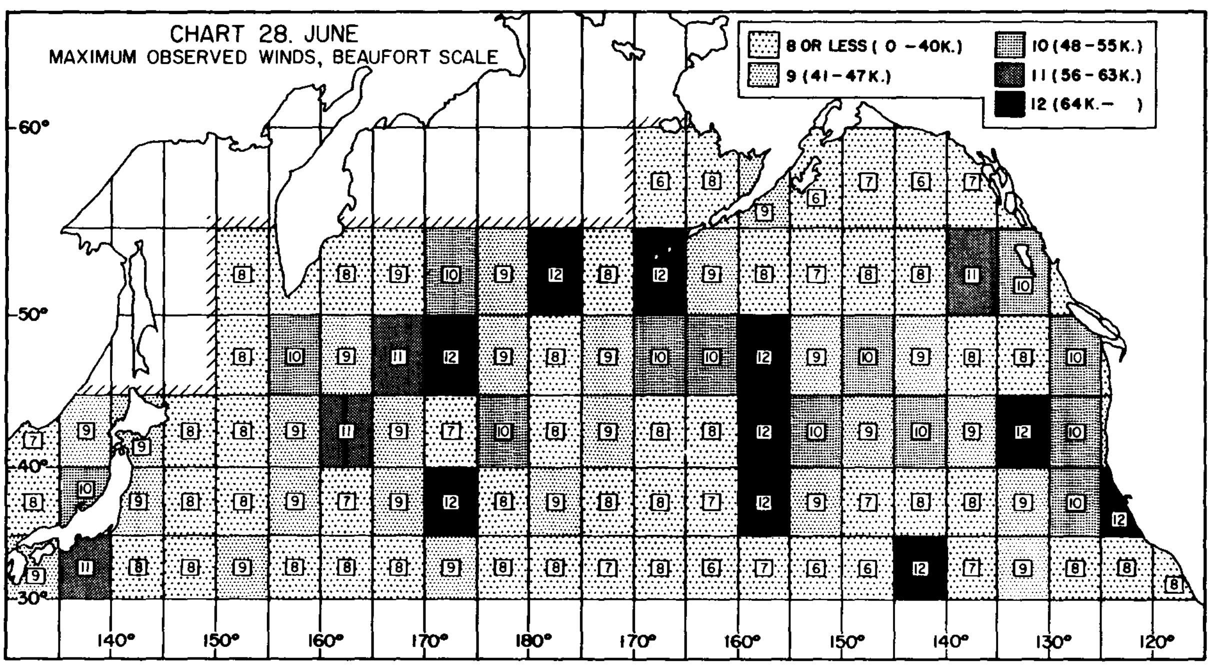
CHART 28. JUNE
MAXIMUM OBSERVED WINDS, BEAUFORT SCALE
8 OR LESS (0 - 40K.)
9 (41 - 47K.)
10 (48 - 55K.)
11 (56 - 63K.)
12 (64K.-)
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

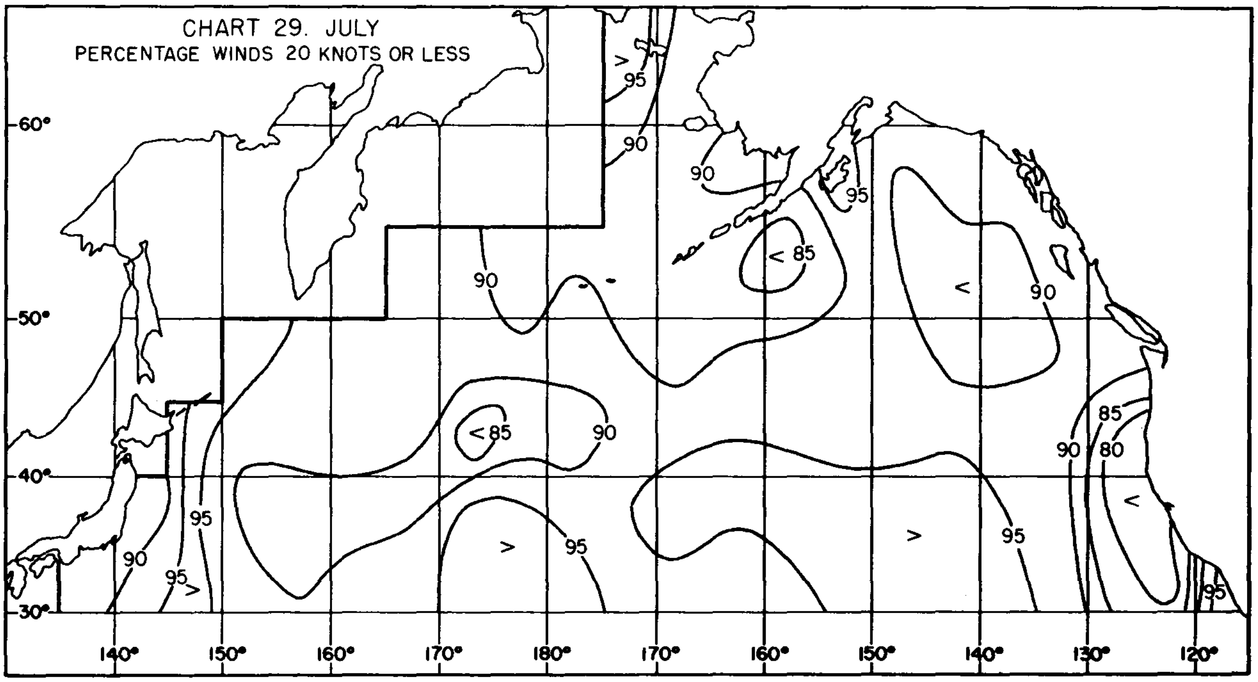
CHART 29. JULY
PERCENTAGE WINDS 20 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
>
95
90
90
95
< 85
90
<
90
<85
90
85
90
80
95
<
90
95
>
>
95
>
95
95

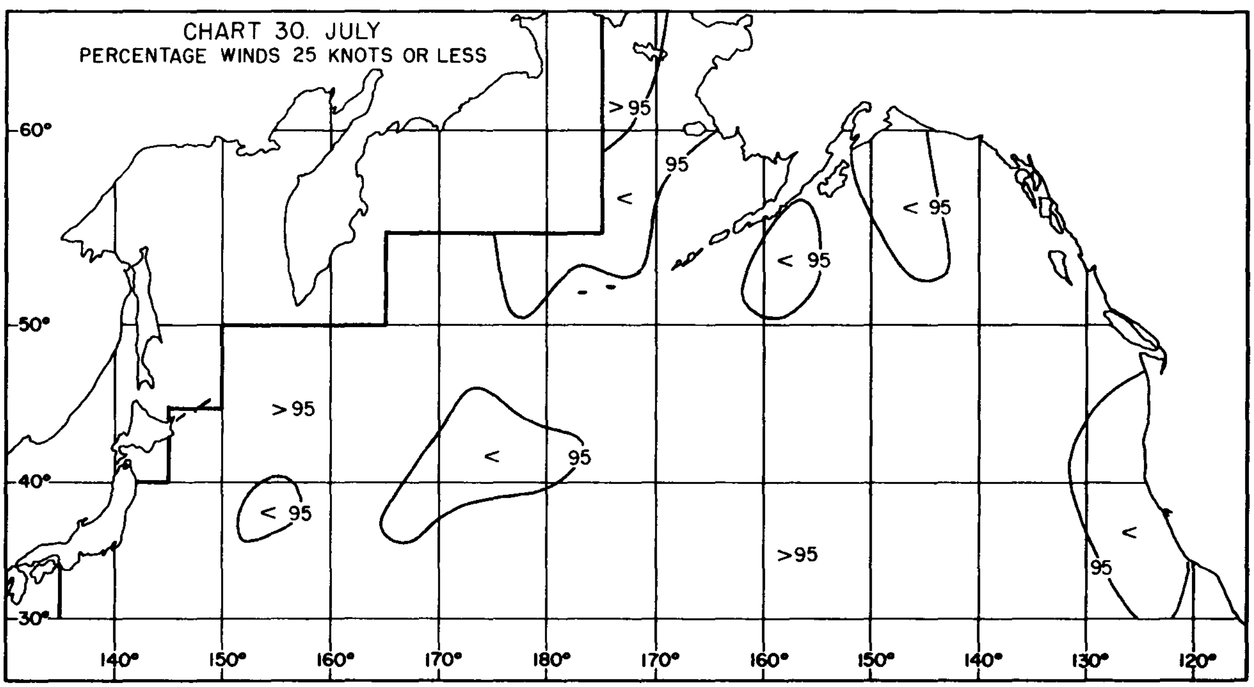
CHART 30. JULY
PERCENTAGE WINDS 25 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
>95
95
<
< 95
< 95
>95
<
95
< 95
>95
<
95

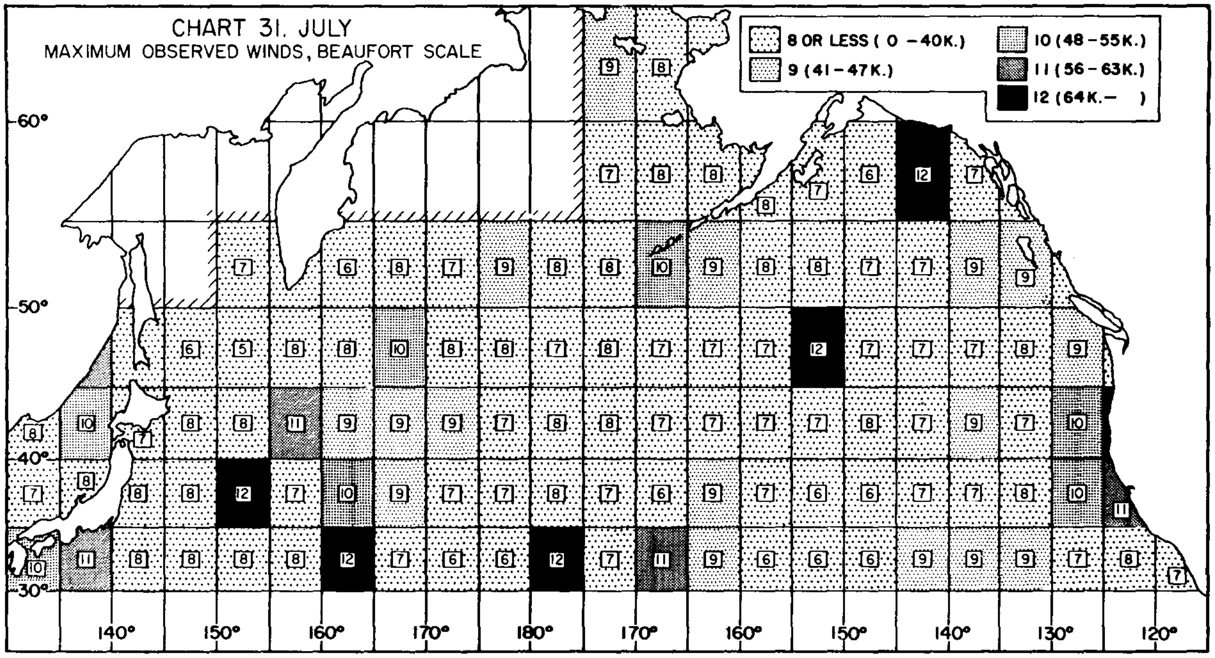

CHART 31. JULY
MAXIMUM OBSERVED WINDS, BEAUFORT SCALE

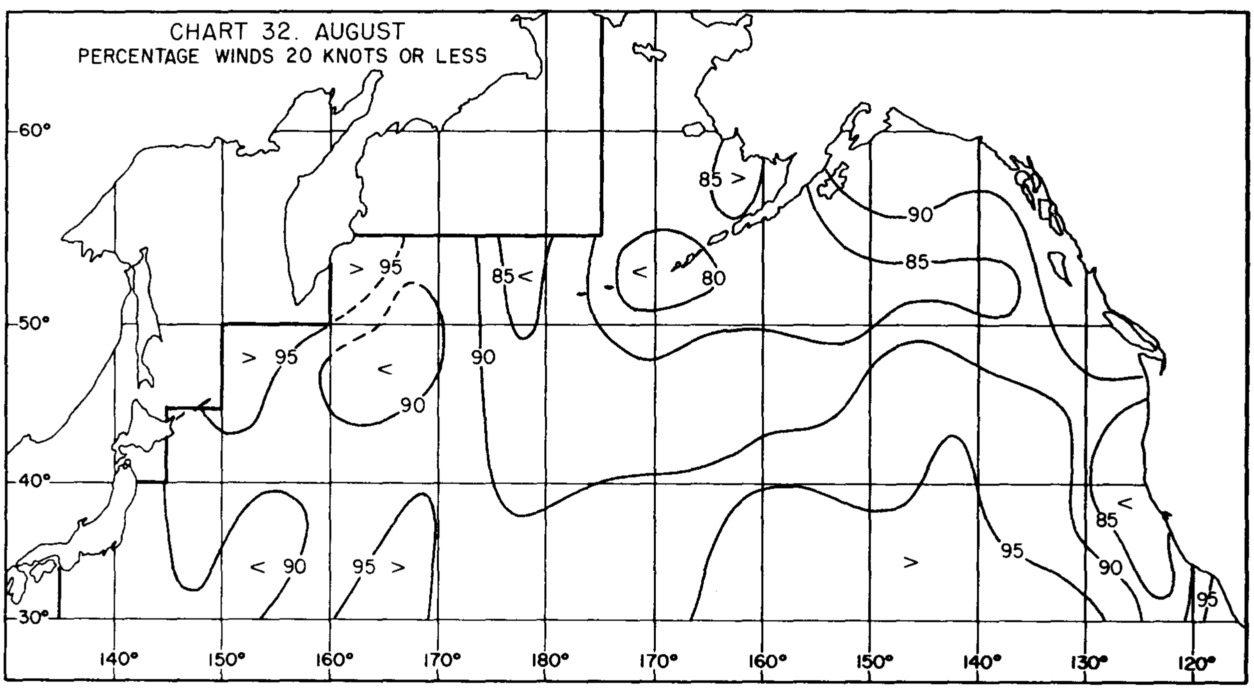

CHART 32. AUGUST
PERCENTAGE WINDS 20 KNOTS OR LESS

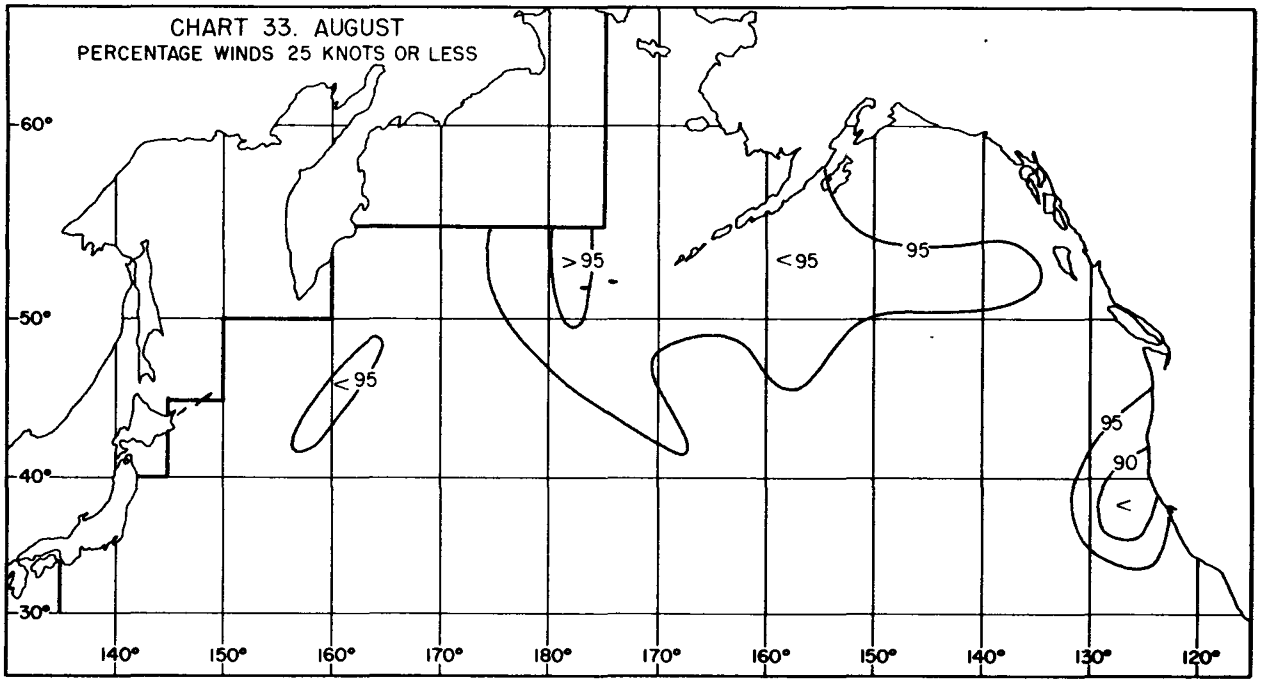

CHART 33. AUGUST
PERCENTAGE WINDS 25 KNOTS OR LESS

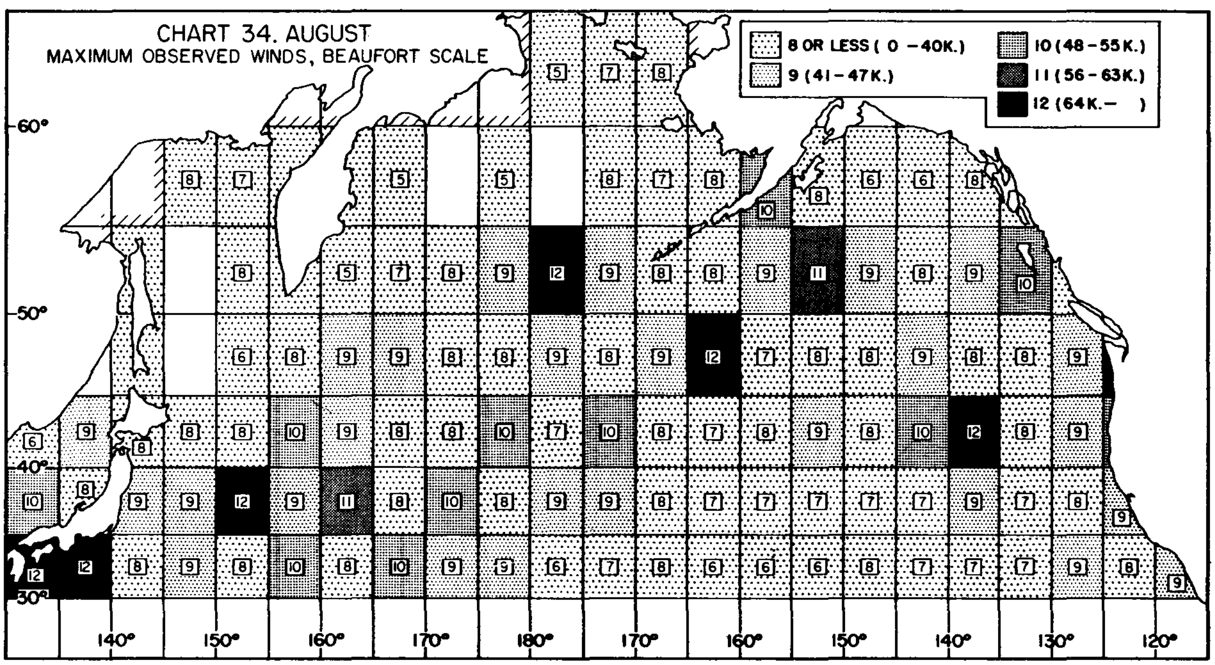

CHART 34. AUGUST
MAXIMUM OBSERVED WINDS, BEAUFORT SCALE

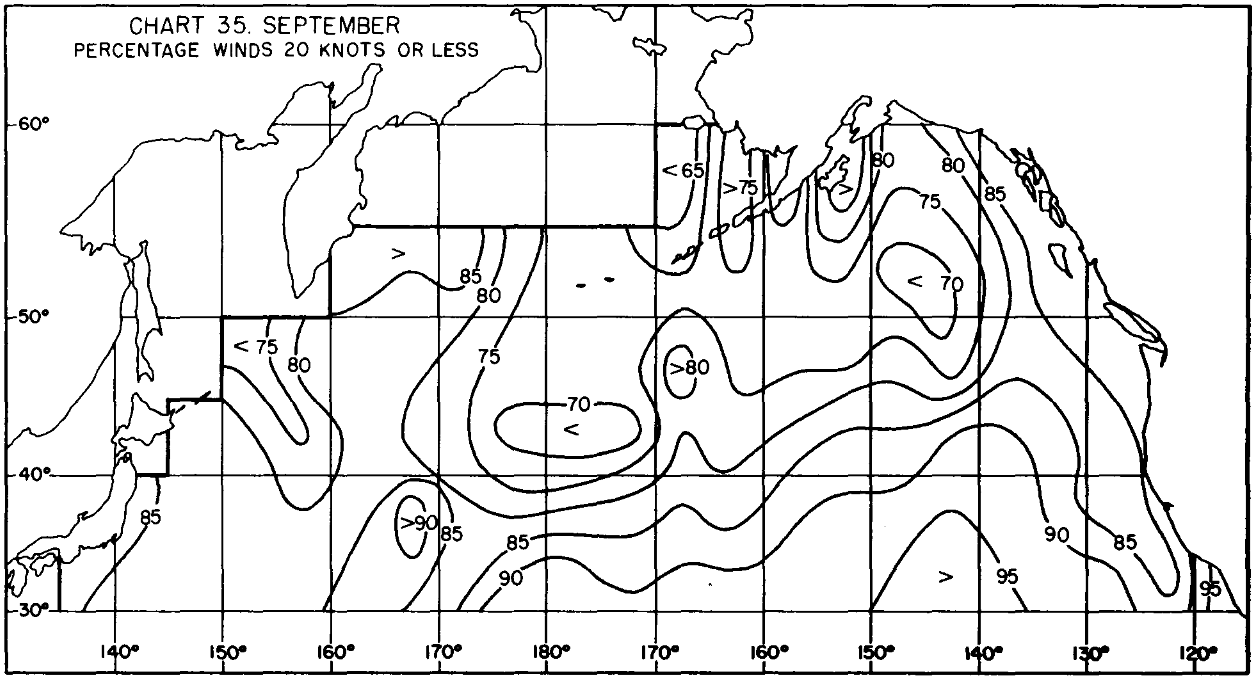
CHART 35. SEPTEMBER
PERCENTAGE WINDS 20 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
< 65
> 75
80
80
75
85
< 70
>
85
80
< 75
80
75
70
<
>80
85
>90
85
85
90
90
85
>
95
95

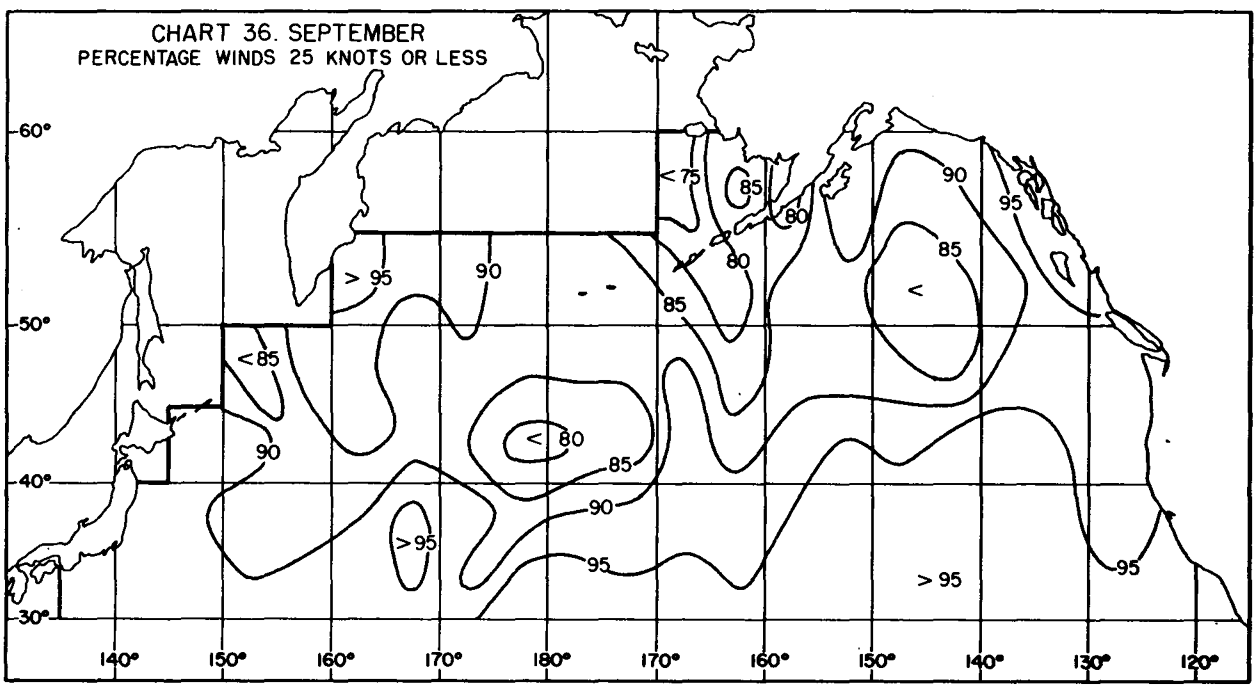
CHART 36. SEPTEMBER
PERCENTAGE WINDS 25 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
< 75
85
80
90
95
85
<
> 95
90
80
85
< 85
90
< 80
85
90
> 95
95
> 95
95

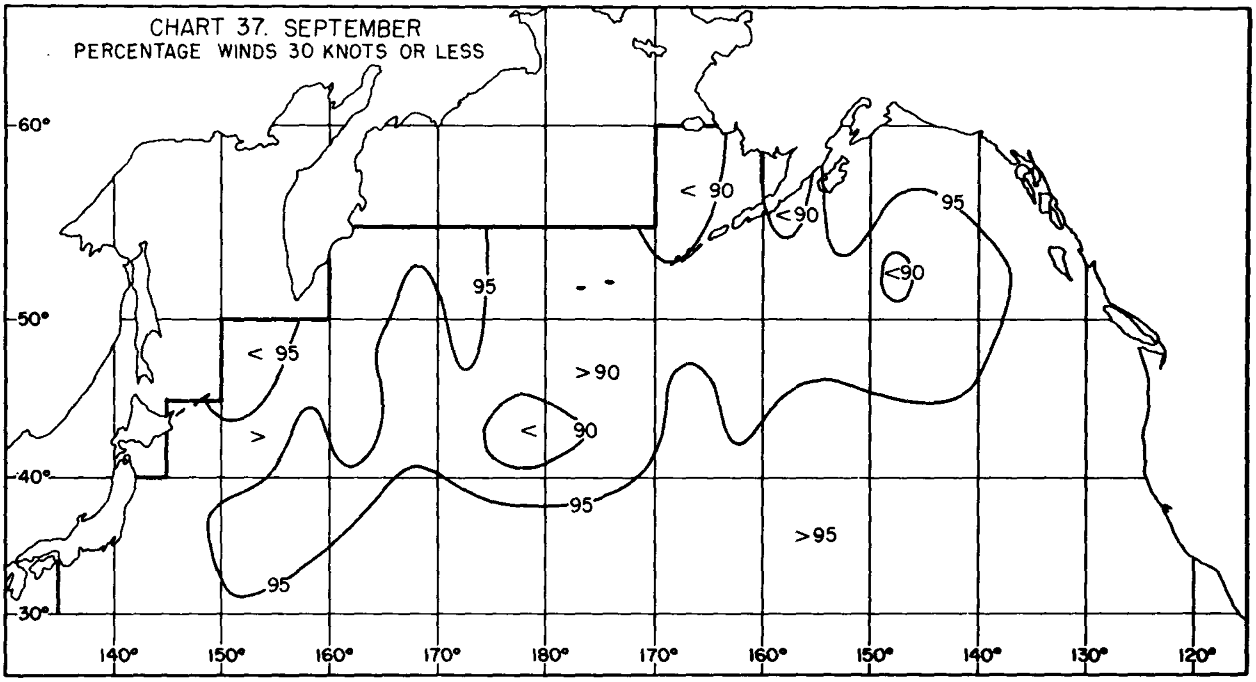
CHART 37. SEPTEMBER
PERCENTAGE WINDS 30 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
< 90
<90
95
<90
95
< 95
>90
>
<
90
95
>95
95

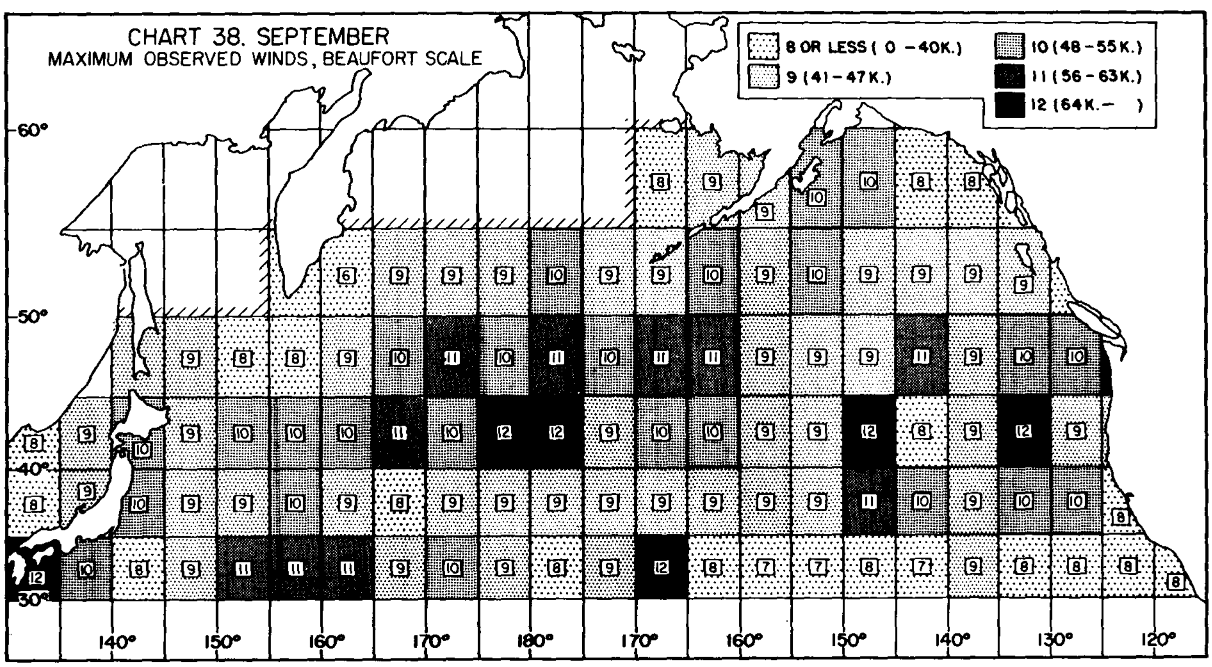
CHART 38. SEPTEMBER
MAXIMUM OBSERVED WINDS, BEAUFORT SCALE
8 OR LESS (0 -40K.)
9 (41-47K.)
10 (48-55K.)
11 (56-63K.)
12 (64K.-)
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

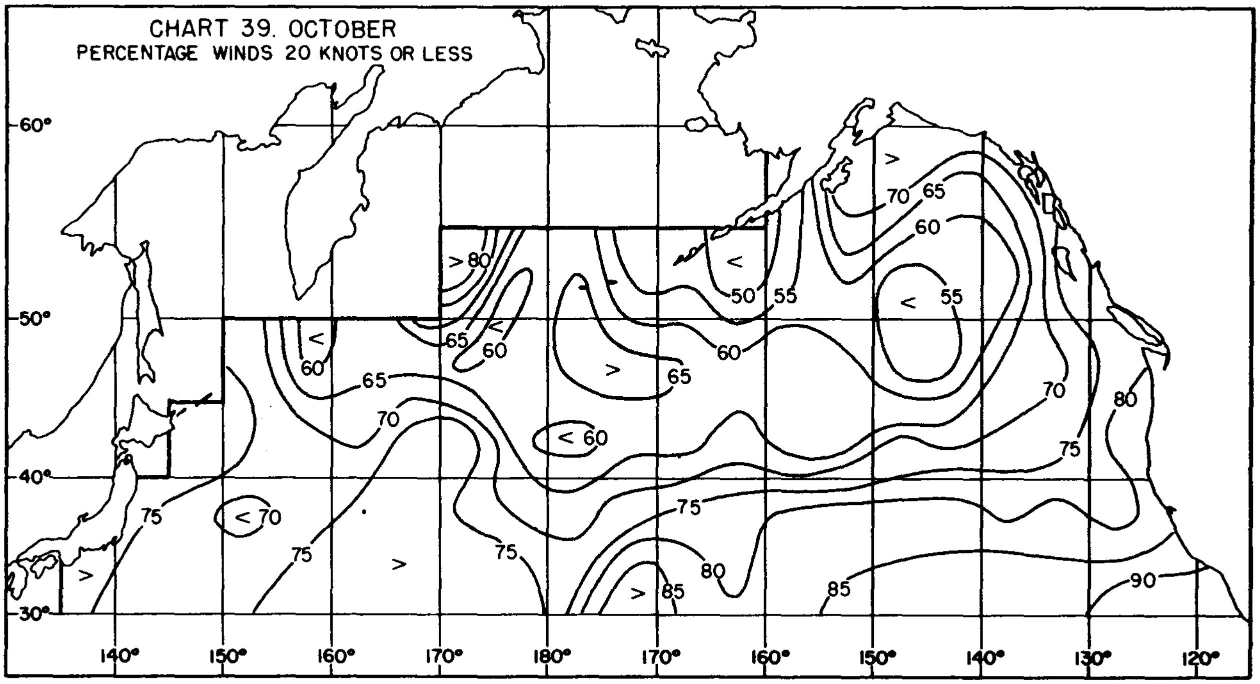
CHART 39. OCTOBER
PERCENTAGE WINDS 20 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

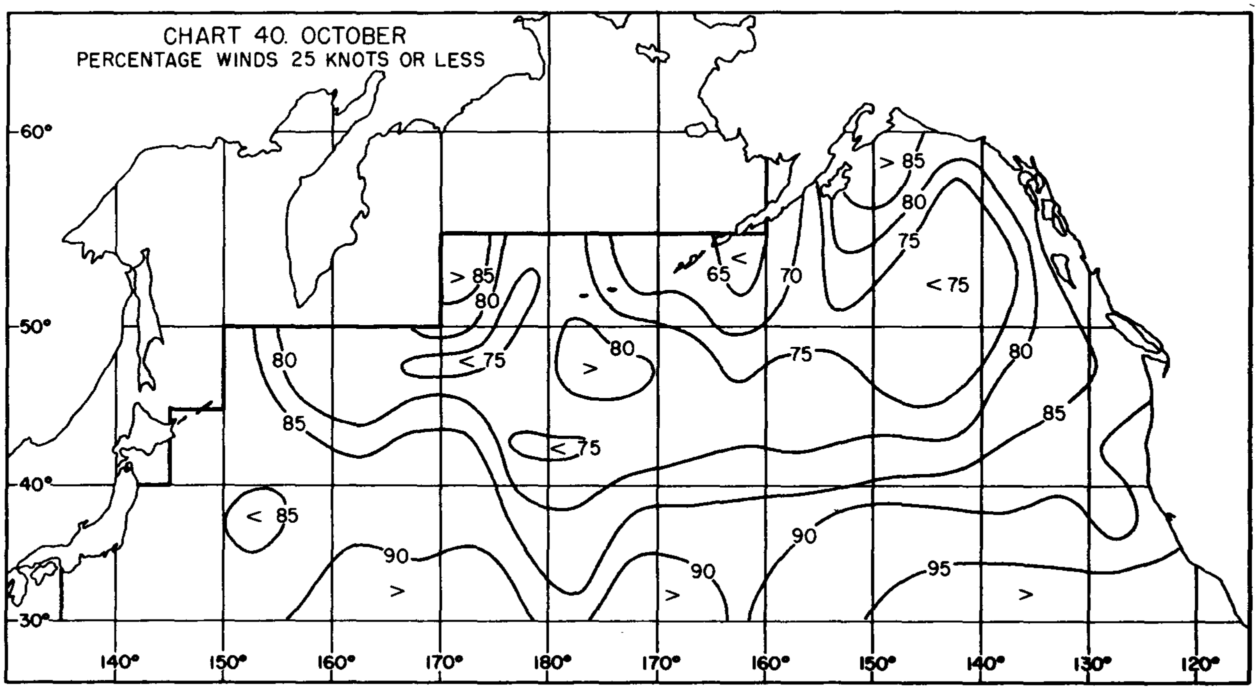
CHART 40. OCTOBER
PERCENTAGE WINDS 25 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

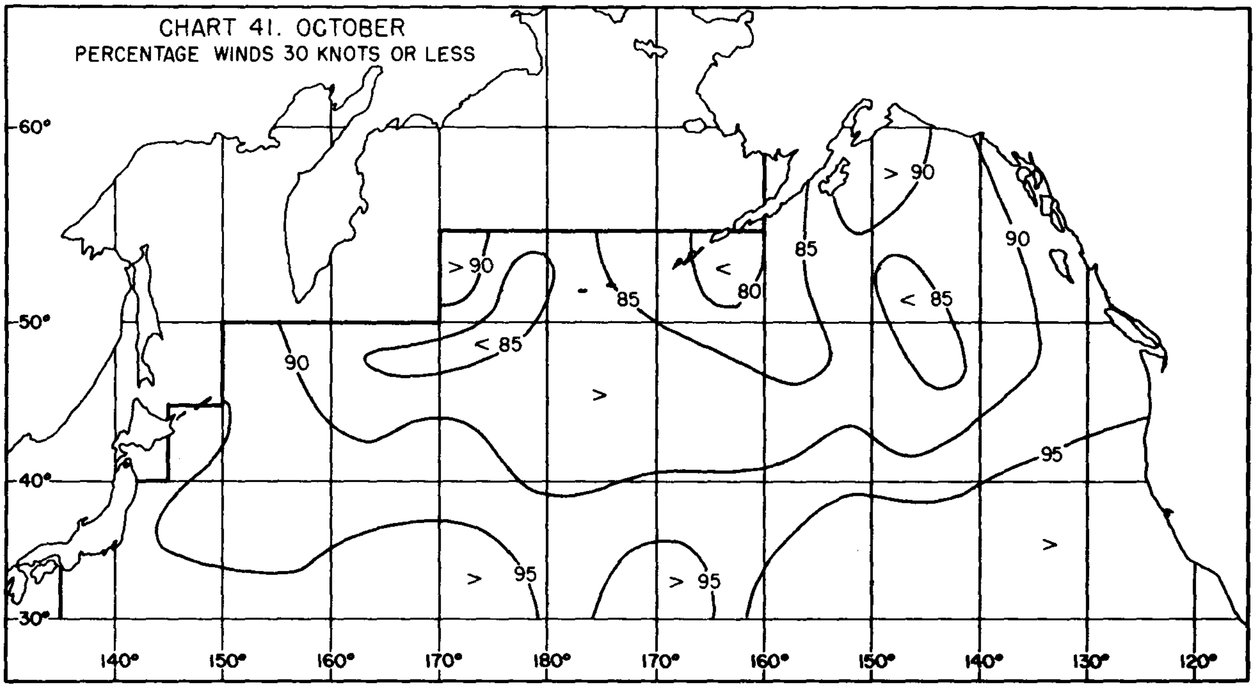
CHART 41. OCTOBER
PERCENTAGE WINDS 30 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
> 90
90
85
< 85
85
< 80
< 85
90
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95
>
> 95
> 95
90

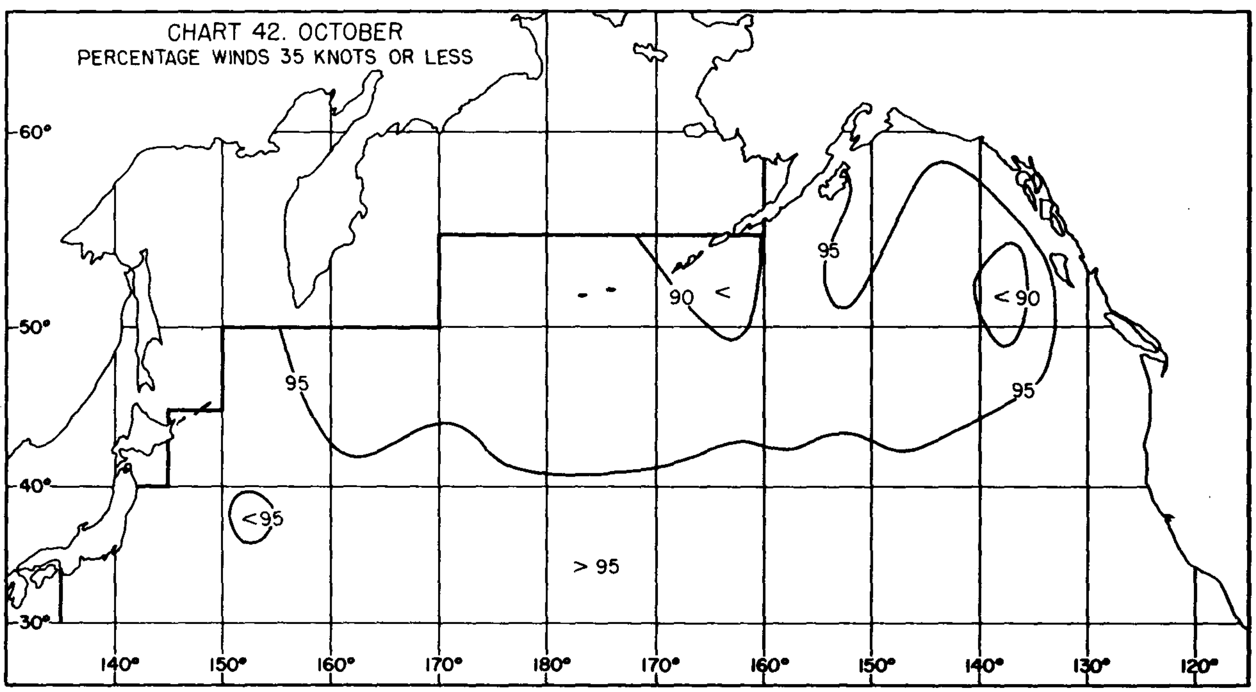
CHART 42. OCTOBER
PERCENTAGE WINDS 35 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
95
90 <
< 90
95
95
<95
> 95

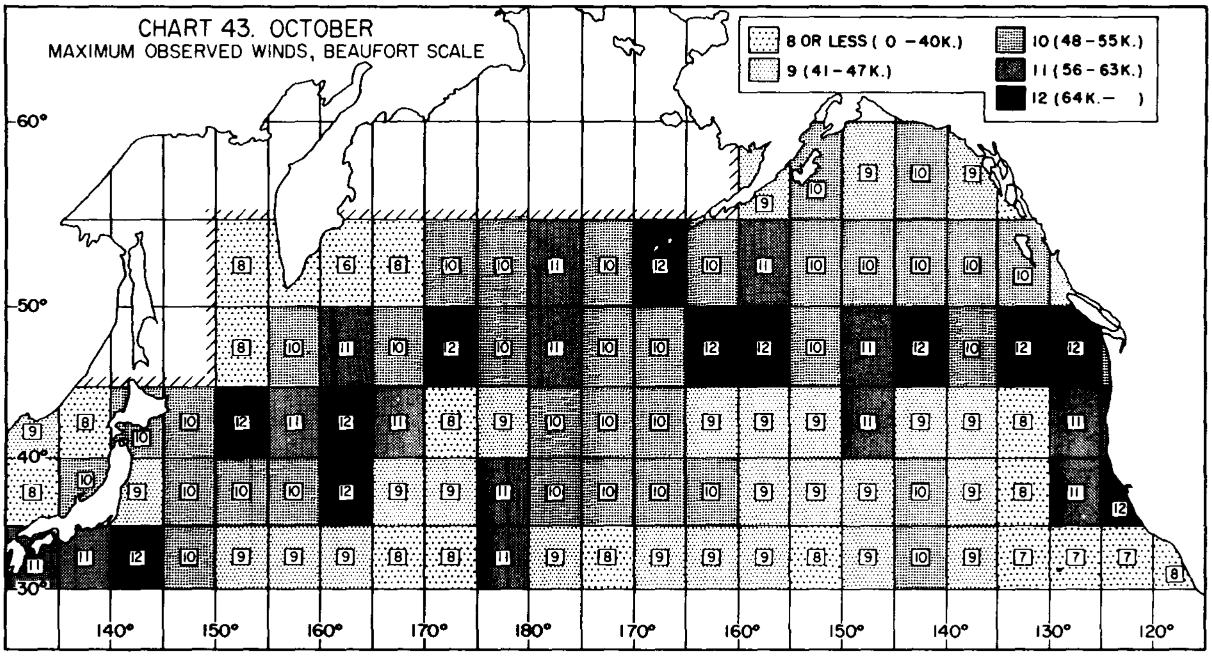
CHART 43. OCTOBER
MAXIMUM OBSERVED WINDS, BEAUFORT SCALE
8 OR LESS (0 -40K.)
9 (41-47K.)
10 (48-55K.)
11 (56-63K.)
12 (64K.-)
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

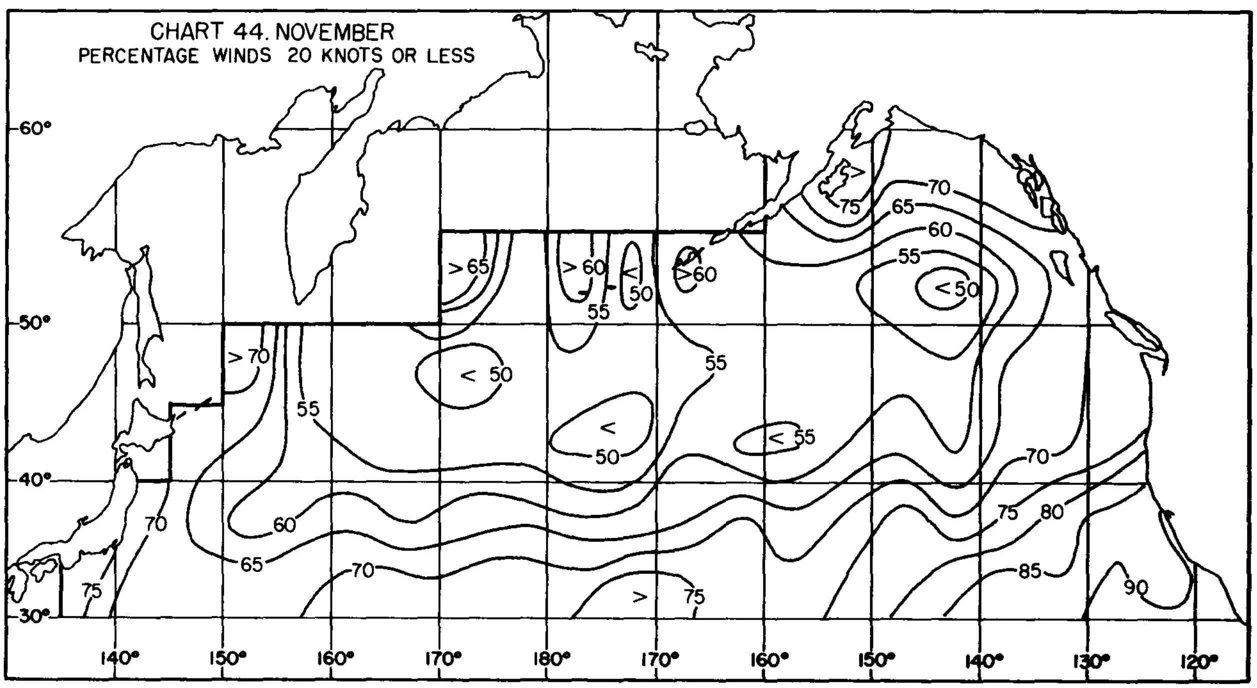
CHART 44. NOVEMBER
PERCENTAGE WINDS 20 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

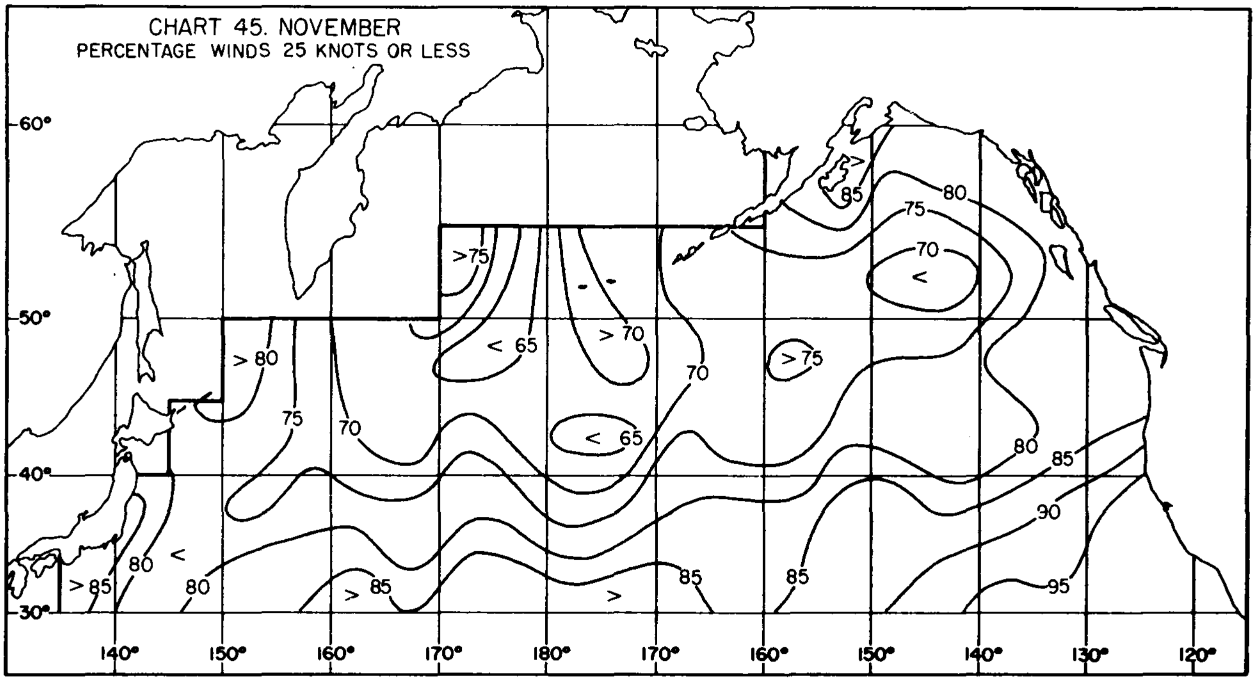
CHART 45. NOVEMBER
PERCENTAGE WINDS 25 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
>75
< 65
> 70
> 80
75
70
< 65
70
>75
85
80
75
70
<
80
85
90
95
> 85
80
<
80
> 85
>
85
85

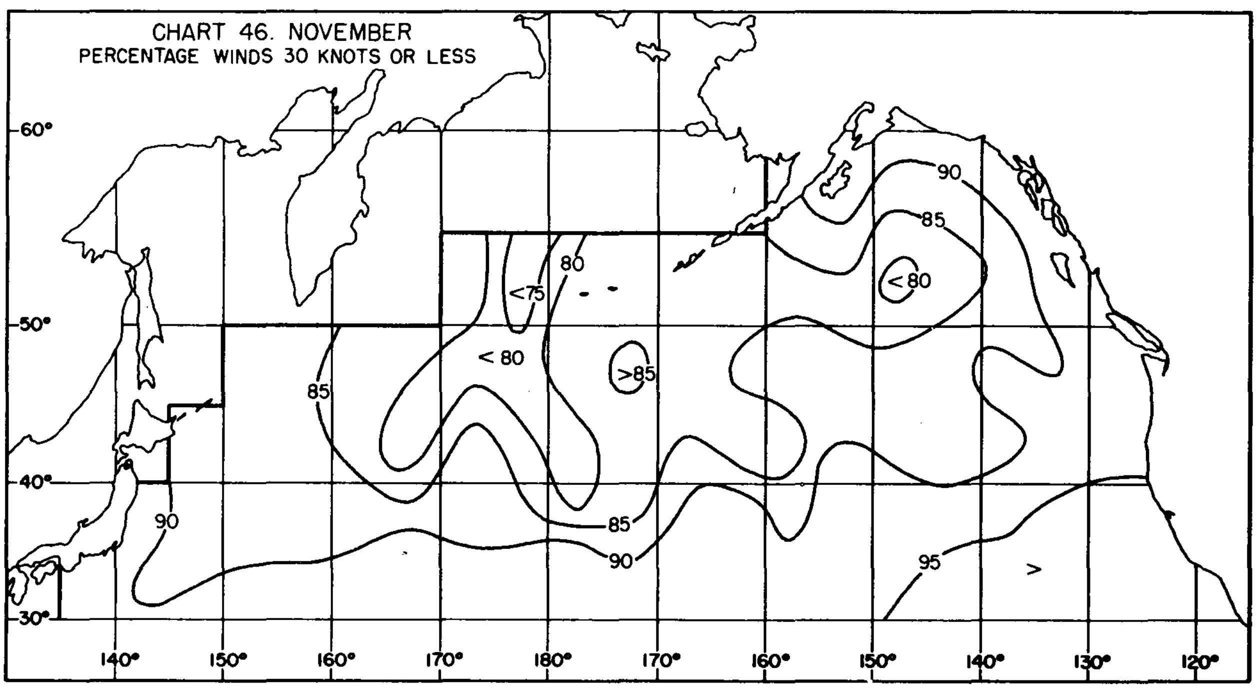
CHART 46. NOVEMBER
PERCENTAGE WINDS 30 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
80
<75
< 80
>85
85
90
85
<80
85
90
95
>
90

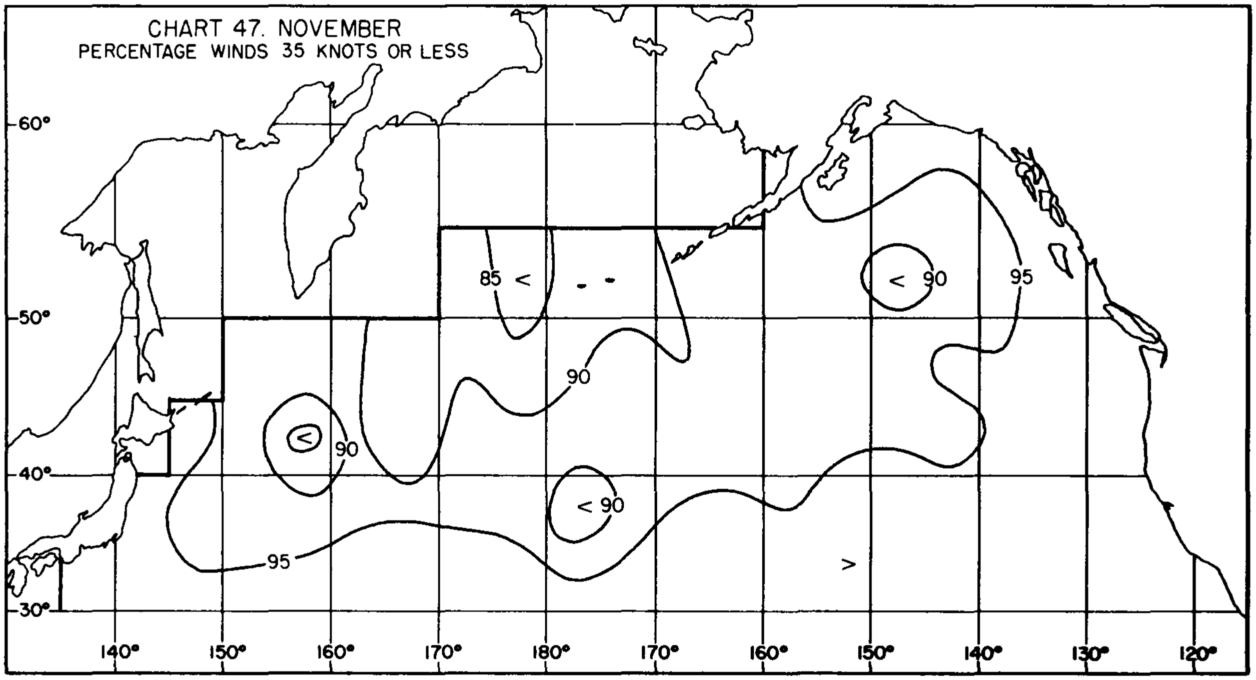
CHART 47. NOVEMBER
PERCENTAGE WINDS 35 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
85
90
95

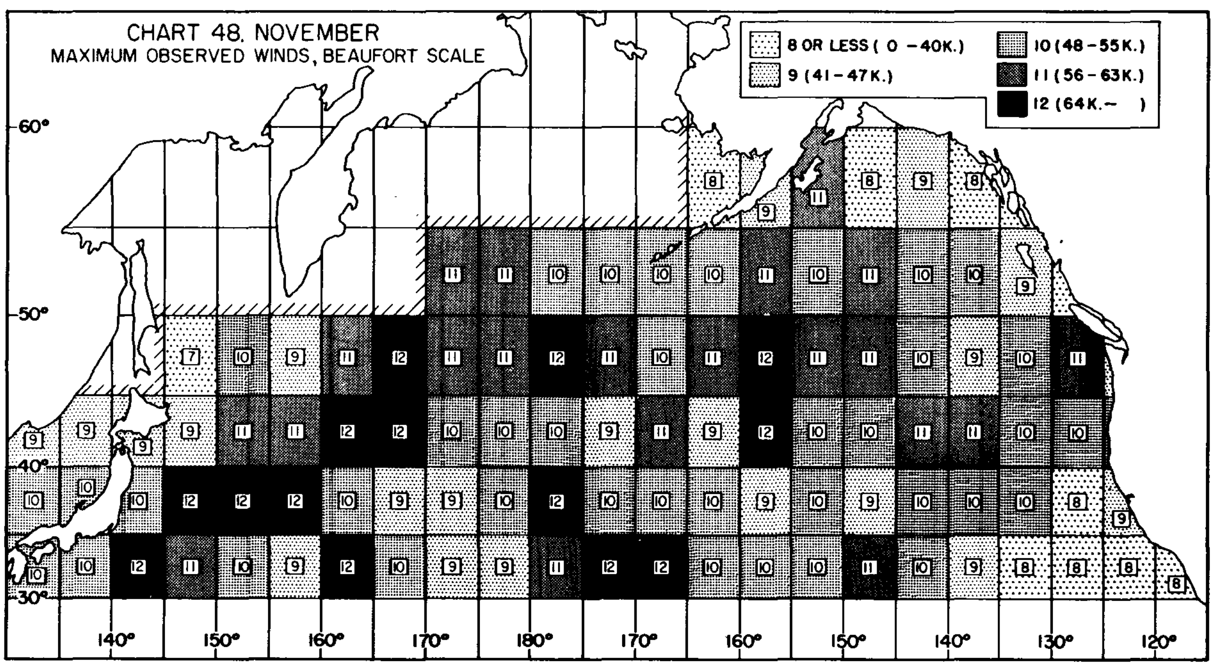
CHART 48. NOVEMBER
MAXIMUM OBSERVED WINDS, BEAUFORT SCALE
8 OR LESS (0 -40K.)
9 (41-47K.)
10 (48-55K.)
11 (56-63K.)
12 (64K.-)
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°

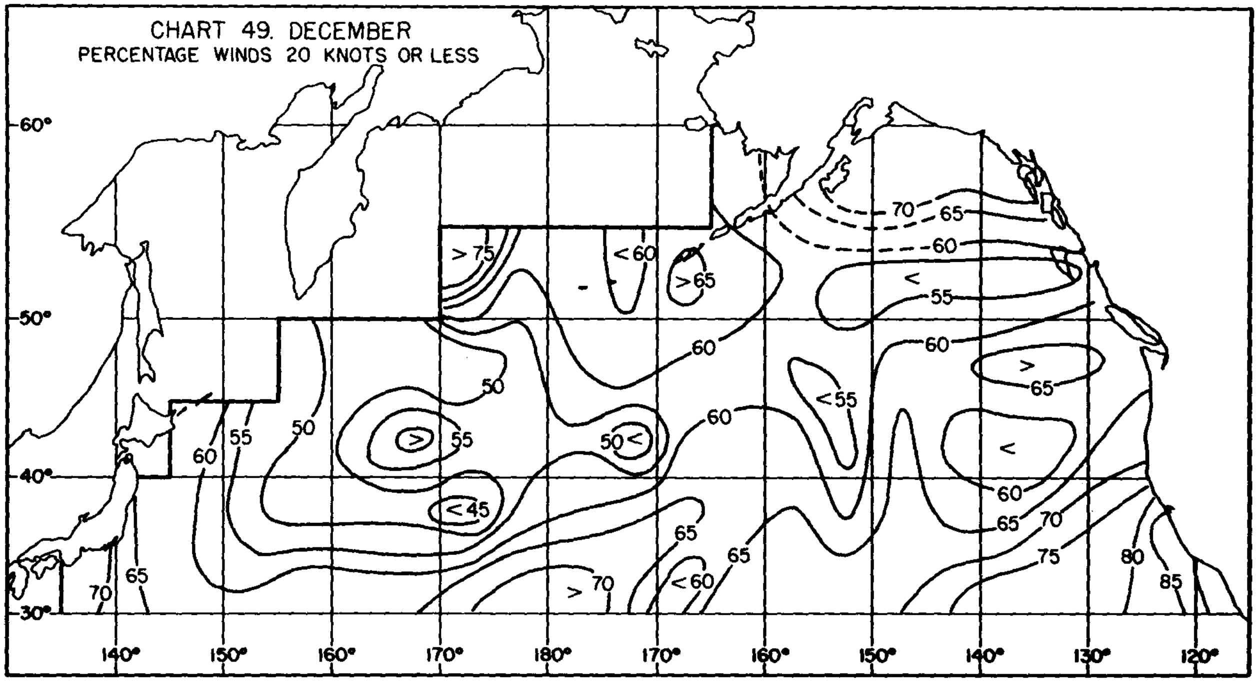
CHART 49. DECEMBER
PERCENTAGE WINDS 20 KNOTS OR LESS

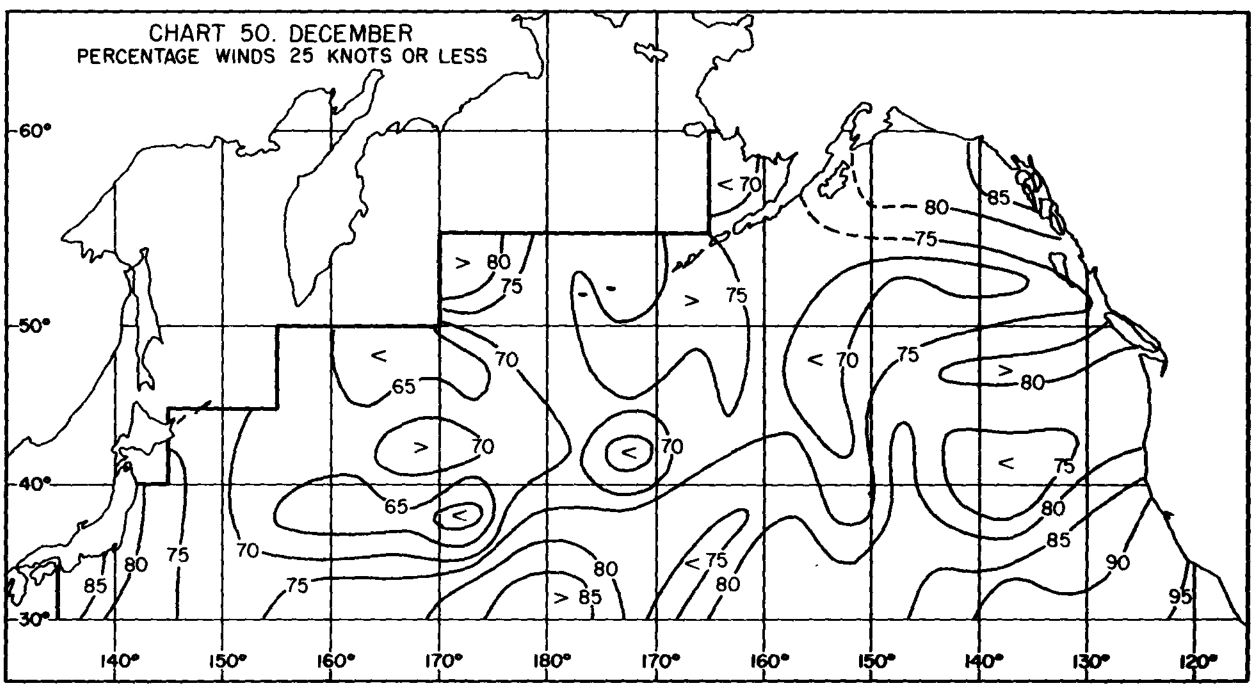
CHART 50. DECEMBER
PERCENTAGE WINDS 25 KNOTS OR LESS

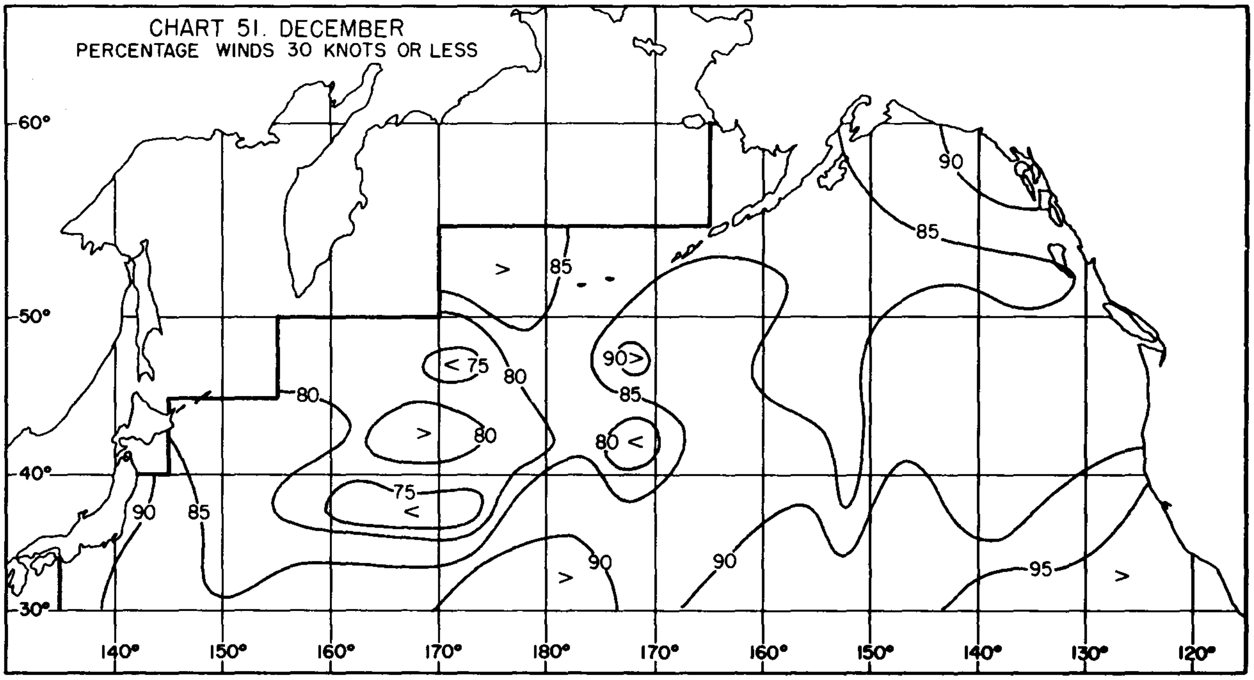
CHART 51. DECEMBER
PERCENTAGE WINDS 30 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
90
85
80
75
95

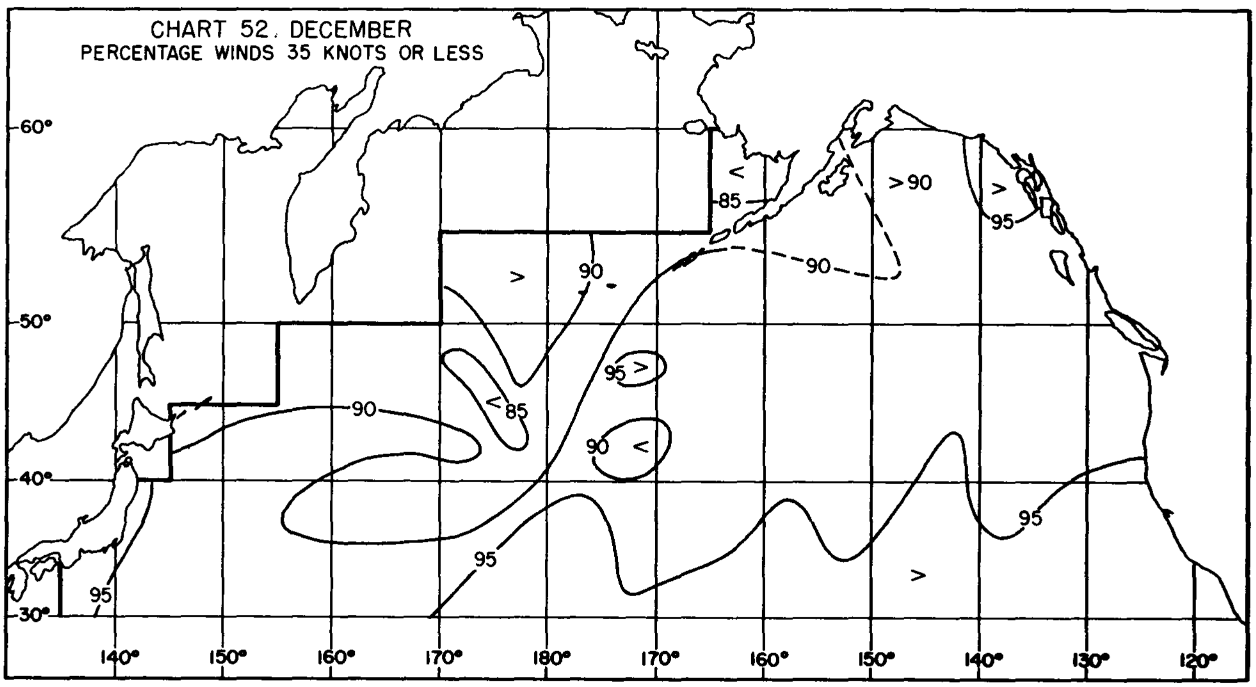
CHART 52. DECEMBER
PERCENTAGE WINDS 35 KNOTS OR LESS
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°
85
90
95

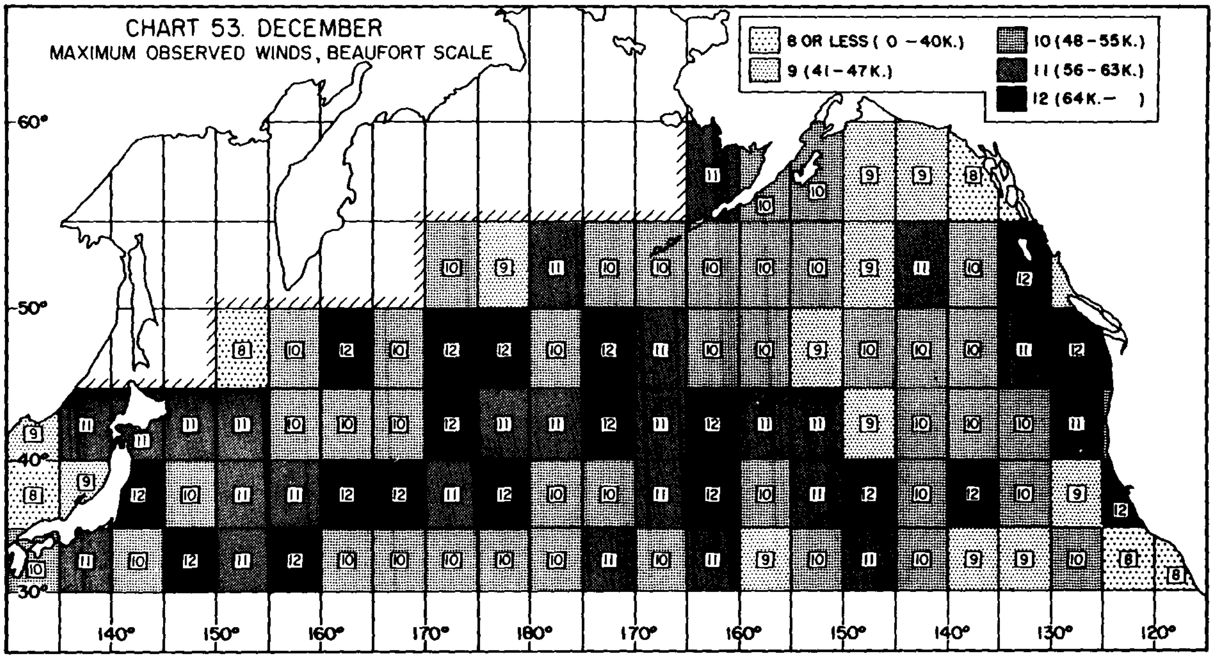
CHART 53. DECEMBER
MAXIMUM OBSERVED WINDS, BEAUFORT SCALE
8 OR LESS (0 –40K.)
9 (41–47K.)
10 (48–55K.)
11 (56–63K.)
12 (64K.–)
60°
50°
40°
30°
140°
150°
160°
170°
180°
170°
160°
150°
140°
130°
120°