AD-A142 212 TROPICAL CYCLONE SEA-STATE PROBABILITY MODEL DEVELOPMENT AND APPLICATION(U) NAVAL ENVIRONMENTAL PREDICTION RESEARCH FACILITY MONTEREY CA 1/1

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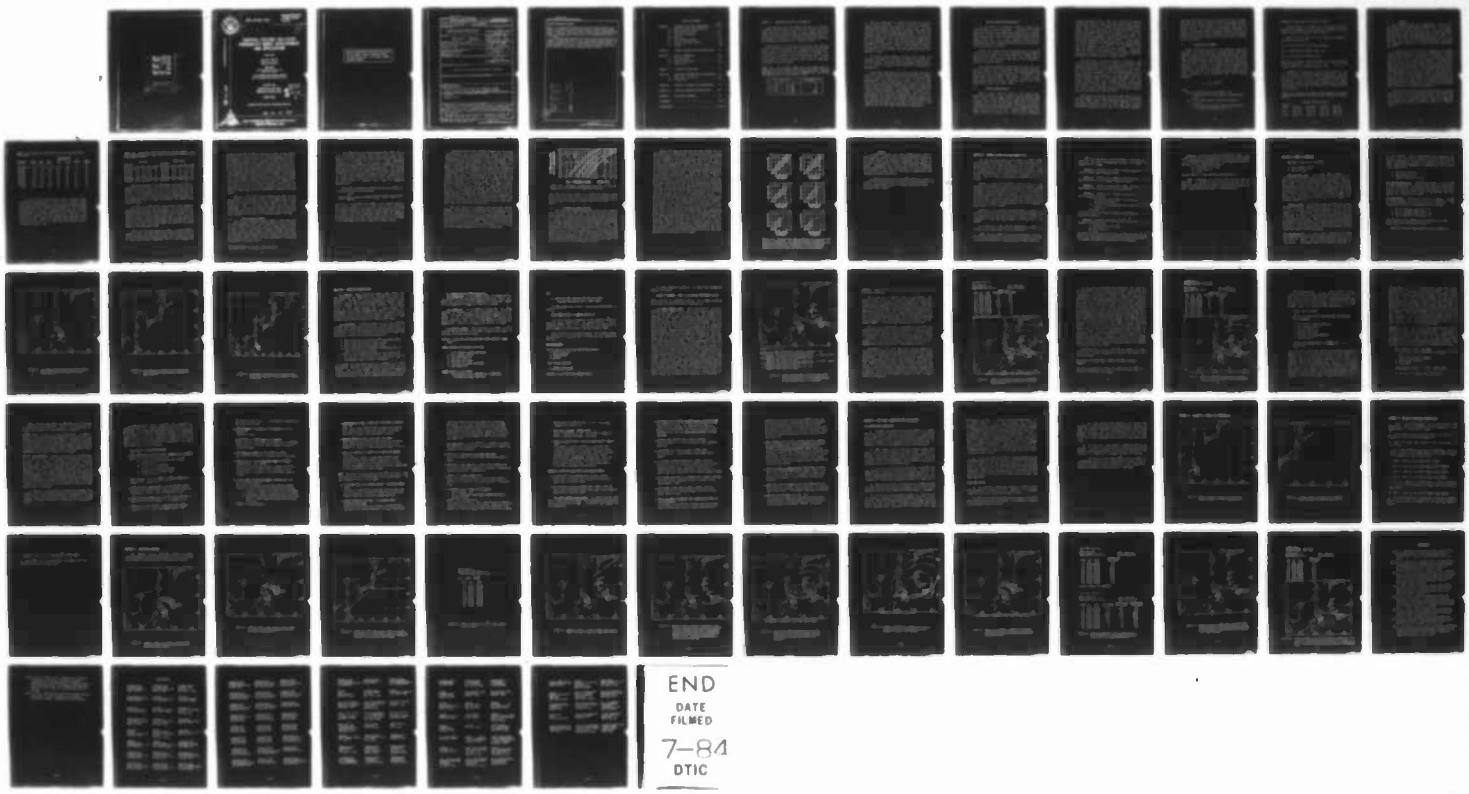

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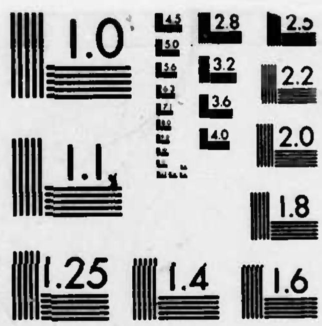

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TECHNICAL REPORT
TR 84-03

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TROPICAL CYCLONE SEA-STATE PROBABILITY MODEL DEVELOPMENT AND APPLICATION

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Contract Nos:

N00228-81-C-H361 (SAI)
N00228-82-C-6442 (SASC)

APRIL 1984

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NAVENVPREDRSCHFAC Technical Report TR 84-03	2. GOVT ACCESSION NO. AD-A142 212	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Tropical Cyclone Sea-State Probability Model Development and Application		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER TR 84-03
7. AUTHOR(s) Jerry D. Jarrell, Don Chin, Terry Brown, Samson Brand		8. CONTRACT OR GRANT NUMBER(s) N00228-81-C-H361 (SAI) N00228-82-C-6442 (SASC)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Environmental Prediction Research Facility Monterey, CA 93943		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PE 63207N PN 7W0513 TA CC00 NEPRF WU 6.3-14
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Air Systems Command Department of the Navy Washington, DC 20361		12. REPORT DATE April 1984
		13. NUMBER OF PAGES 76
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Sea state

Tropical cyclone

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Conditions of sea state around severe storms, especially tropical cyclones, are of major concern to ships. An encounter with a tropical cyclone has the potential for causing structural damage and perhaps even personnel casualties, thus accurate assessment of significant and possibly hazardous sea-state events is highly important.

Two models that predict sea state based on operationally available input are examined and compared in this report. ((Continued on reverse))

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Block 20, Abstract, continued.

While it is concluded that both models provide reasonable forecasts of sea height, a preference for one model over the other is shown. This preferred model is coupled with elements of tropical cyclone wind and strike probability models to create sea state probabilities. These sea state probabilities, when tested on independent data, are found to be in good agreement with observational data.

The preferred model developed in the first section of the report then is applied in subsequent sections to form a tropical cyclone threat analysis and display aid called TCASS (Tropical Cyclone Applications Software System). The TCASS is designed primarily for shipboard applications and may be used by environmentalists as a briefing aid, for analysis of tropical cyclone threat, and as a tool for formulating a recommended course of action.

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SECTION 1. BACKGROUND AND MODEL DEVELOPMENT

Ship captains and ship routing officials are seriously concerned with sea states around tropical cyclones, since sea conditions affecting storm evasion or ship movement can cover a much larger area than the wind associated with the storm. A miscalculation concerning a building sea condition could lead to a dangerous rendezvous with a tropical cyclone.

Ship captains are aware that any encounter with high sea states increases the probability of damage and that this damage is highly correlated with sea conditions (see Table 1-01). A miscalculation concerning sea conditions also impacts on the planning and execution of tactical operations and, in addition, impedes the effectiveness of ship routing of Department of Defense contracted vessels.

Table 1-01. The expected damage costs associated with sea height for U.S. Navy ships (other than small craft) based on Navy Safety Center records for the period 1969-75. Present day damage would have to take into consideration inflationary increases in costs (Lulejian *et al*., 1976).

Sea Height X in Meters (Feet)	Expected Damage Costs (dollars)
(0) ≤ X < 1.2 (4)	$ 0
1.2 (4) ≤ X < 2.4 (8)	2
2.4 (8) ≤ X < 3.7 (12)	14
3.7 (12) ≤ X < 4.9 (16)	41
4.9 (16) ≤ X < 6.1 (20)	537
6.1 (20) ≤ X < 7.3 (24)	3,172
7.3 (24) ≤ X < 8.5 (28)	7,656
X ≥ 8.5 (28)	34,145

There are many ways to forecast the state of the sea around tropical cyclones. The most accurate is probably a computer-based spectral wave model on a fine grid. For most real time (as opposed to hindcast) purposes, such models are severely limited by the meteorological input. That is, the forecasts of the track and wind distribution are so uncertain that the usefulness of the resulting sea state forecasts is all but destroyed. For this reason, simple models which parameterize ocean waves in terms of common measures associated with the cyclone (size, motion, and intensity) are nearly as accurate, are much faster, and are significantly more cost effective to use.

For evasion type problems including ship routing, the presence or absence of sea above a certain level may be a critical factor. Since this cannot be predicted with certainty, it is useful to express its occurrence as a likelihood, or probability.

Present day technology can be used to estimate the probability of a tropical cyclone striking a given point or causing winds in excess of some level at a point. To extend these developments to the probability of seas in excess of some critical value requires the adoption of a model to relate sea state (significant combined sea and swell height) to predicted tropical cyclone parameters. The purpose of this report is to relate the search and use for such a model. In the following paragraphs we will identify the desirable traits of the required model, and discuss two possible candidate models that were acquired and tested. The accuracy of the two models was compared and one model was selected for application. The second section of this report describes the application.

1.1 Desirable Model Characteristics

For the purpose of probability estimation there is no great premium on absolute accuracy. The better the model accuracy, the better the probability estimates, but a perfect model with imperfect input data produces probability estimates only slightly better than a greatly inferior model with imperfect input data. It is very important that the error characteristics of the model be known since they contribute to the joint probability problem.

Another very important model characteristic is required input. Since we expect to run the probability model using input data from tropical cyclone warnings, it is highly desirable that the model operate on data which can be extracted or derived from these warnings.

The nature of probability models requires that a particular sea forecast will be made many times (perhaps hundreds) for each forecast, thus the simplicity and running time of the model are also of paramount importance. In addition, the ideal model would consider a wide range of tropical cyclone descriptive parameters (size, intensity, motion, etc.) and apply equally well in all ocean areas.

1.2 Model Characteristics

Several complex numerical spectral wave models exist. Among them are the U.S. Navy Spectral Ocean Wave Model (SOWM or the Global version GSOWM) and an excellent British model (Golding, 1977). For the present purpose these are both too coarse and at the same time too slow. There are also specialized models for the hurricane which are of suitably fine resolution, but are still too slow. Notable among these is a model reported by Brand et al. (1977) and one discussed by Ross and Cardone (1977). There are at least two parametric models which predict a significant wave height around tropical cyclones as a function of tropical cyclone descriptive parameters. These are a Navy model first described by Brand et al. (1975) and a NOAA model described by Ross (1979). The Navy model is based on a simple linear regression of tropical cyclone descriptive parameters related to the radius of 9-, 12-, and 15-foot significant wave height contours. A simple empirical radial assymmetry is superimposed on the contours depending on the heading of the cyclone. The developmental data base was subjective analyses of ship reports. This early model was refined and subjected to extensive independent testing, the results of which provide an excellent basis for determining the distribution of forecast errors.

The NOAA model is based on physical principles. The scale and shape parameters of the tropical cyclone wave energy spectrum are related to a fetch parameterization which is implicitly proportional to the radial distance to the storm's eye. This latter distance is also non-dimensionalized by the average surface wind and gravity. The relationship was empirically determined based on actual wave measurements from Hurricanes Camille (1969), Ava (eastern Pacific, 1973), and Eloise (Gulf of Mexico, 1975). The Camille data was measured by resistance wire wave staffs on oil platforms; the Ava data by a laser altimeter aboard a low flying (150 meter) aircraft; and the Eloise data by a NOAA data buoy.

Both models use readily available input data, both are fast and simple, and the error characteristics of both models are well enough known. The NOAA model appears to be more universally applicable since the Navy model used longitude (developed on western Pacific data) as a predictor component, thus some redevelopment would be required for other oceans. The NOAA model uses as parameters only the distance from the storm (to the forecast point) and the wind speed at that point; however, the empirical relationship developed on Atlantic and eastern Pacific hurricanes may not hold for the largest of the western Pacific typhoons. The final consideration is accuracy which proved to be the most difficult consideration to compare.

1.3 Describing the Models

NOAA's simplified hurricane wave prediction model was developed from observations of one-dimensional ocean wave spectra in the three hurricanes mentioned previously. Based upon a parameterization of equivalent fetch and duration in terms of a dimensionless radial distance from the storm's center, the model is driven by the average surface wind speed as measured at an altitude of 10 meters, and the distance from the point of desired wave information to the center of the storm. The regression line variables including shape and the scale parameters, were simplified into the following equation:

$$h_{1/3} = 0.0217\, u_{10}^{1.55}\, r^{0.225}$$

where:

$h_{1/3}$ is the significant wave height or the average height of the highest 1/3 waves observed (feet)

u_{10} is the local surface ten meter wind speed in kt, and

r is the distance from the tropical cyclone center to the point of computation in n mi.

Asymmetry is provided only through the winds.

The Navy model is a simple set of regression equations based on the duration of the storm, its longitude, and the radius of the 30-kt and 50-kt wind isotachs.

Radii of 9-, 12- and 15-ft sea contours in degrees of latitude are estimated by:

$$R_{15} = -1.814+.013LON+.131DUR+.014R_{30}+.005R_{50},$$

$$R_{12} = -1.926+.017LON+.178DUR+.018R_{30}, \text{ and}$$

$$R_{09} = -2.211+.027LON+.224DUR+.021R_{30},$$

where LON is tropical cyclone longitude (°E), DUR is tropical cyclone duration in units of 12 hours , and R_{30} and R_{50} are radii of 30- and 50-kt winds in n mi.

Assymmetry is provided by offsetting the center of the 9-, 12- and 15-ft contours (assumed to be circular). The offset is a function of tropical cyclone heading and radius of the contour. Table 1-02 gives the bearing of offset center relative to tropical cyclone heading (always right rear quadrant between 90 and 180°) and distance as a fraction of the contour radius.

Table 1-02. Offset of sea height contour relative to tropical cyclone heading. Offset is expressed as a fraction of contour radius.

Contour	TROPICAL CYCLONE HEADING			
Height	000-090°	090-240°	240-300°	300-360°
9 ft	138°/.29	150°/.29	171°/.29	142°/.29
12 ft	144°/.30	149°/.30	167°/.32	136°/.28
15 ft	144°/.30	147°/.32	166°/.36	131°/.32

1.4 Testing

Both candidate models were independently tested by comparison with ship reports around western North Pacific tropical cyclones during the summer of 1979. The Joint Typhoon Warning Center (JTWC) warnings were used to locate the center position and determine the maximum winds and wind radii. It should be noted that only the nowcast portion of the warnings were used. The forecasts from these warnings were later used for independent testing of the sea probability forecasting algorithm.

In using ship reports there is a requirement to perform rather stringent quality control since typographical or garble type errors are common. In addition, it is possible to find the same ship report entering the data set from apparently different sources with slight format changes. Eliminating obvious erors and duplication reduced the original data set from about 40,000 to about 10,000. A consistency check was made by comparing reports from ships close together (less than 50 n mi) and showed large variations at times. To partially eliminate this problem, it was decided to use only paired ship reports and then use the average sea state positioned at the midpoint between the two. Prior to averaging, sea and swell were combined into a combined sea state by using the square root of the sum of the squared sea and swell.

The data set was further reduced by deleting any reports more than 1000 n mi from a tropical cyclone. With these deletions there were 426 combined observations left within 1000 miles of the test tropical cyclones. Table 1-03 summarizes the comparison of model predicted sea states to "observations".

Table 1-03. Comparison of predicted sea states of the models versus observations.

Distance from T.C.	AVG Verif.	AVG Navy	AVG NOAA	Seas Correctly Estimated ≥12' Navy	Seas Correctly Estimated ≥12' NOAA	Actual ≥ 12'	Total Cases
1000-900 n mi	6.3 ft	3.0 ft	4.2 ft	92%	95%	8%	78
900-800	6.2	3.1	4.0	95	95	5	76
800-700	6.2	3.5	5.2	96	94	4	70
700-600	8.4	3.8	4.9	84	78	16	55
600-500	7.0	4.3	5.1	91	84	9	43
500-400	10.9	6.7	5.1	69	69	31	39
400-300	10.7	8.5	6.8	65	68	29	31
300-200	13.1	11.4	8.9	75	58	50	24
<200	13.8	16.7	14.0	80	70	60	10

It can be seen that both models rather seriously under-forecast the reported seas. In part this is because in most cases seas several hundred miles away from the tropical cyclone are unrelated to the cyclone and the models virtually always forecast little or no sea at distances over 500 n mi. Neither of the models is markedly preferable in this comparison. The differences, however, were not symmetrical about the moving tropical cyclone. Table 1-04 compares those forecasts vs reports within 500 n mi on the right side of the moving cyclone to those on the left side.

Table 1-04. Comparison of the two models to actual reports stratified into left and right sides of the moving tropical cyclone (sea height in feet).

Left Side					Right Side				
Relative Bearing	Actual	Navy	NOAA	Cases	Relative Bearing	Actual	Navy	NOAA	Cases
180-225	15.5	9.7	10.5	11	000-045	10.6	9.3	4.7	12
225-270	13.6	10.6	11.8	5	045-090	11.5	9.3	4.9	18
270-315	11.0	12.7	15.0	3	090-135	12.2	7.2	3.5	23
315-360	9.1	11.2	11.5	17	135-180	12.1	6.9	5.1	16
180-360	11.8	10.8	11.5	36	000-180	11.7	8.0	4.4	69

The good agreement of the NOAA model on the left side is negated by a severe bias on the right side. Some bias is also evident in the Navy model, but it is not nearly so severe; in fact, it is not substantially less on the right side than on the left. As alluded to earlier, actual forecasting skill is less important that consistent performance with known error characteristics.

The bias in the NOAA model is attributed to less asymmetry than that built into the Navy model. It is this built-in assymmetry which suggests the difference from one side to the other is more than just stronger winds, but is related to the typical tropical cyclone speed being close to wave speed in some of the more important wavelengths and consequently these waves on the right side remain under the influence of strong winds for long periods of time.

There are two other aspects of Table 1-04 which deserve comment. First, why were there nearly twice as many ship reports from the right side than from the left? Second, if there is real right-to-left asymmetry, why is the average sea height on the left virtually identical to that on the right? The answer to the last question is straightforward. The average distance of ships from the tropical cyclone center is 49 n mi farther for ships on the right than for those on the left, thus suggesting seas at an equivalent distance are indeed higher on the right side. The answer to the first question may relate to the fact that ships on an intercept course with a tropical cyclone's right side will hold up at 300-500 n mi awaiting the storm's passage, thus accounting for a surplus on the right side. This might be offset by those on an intercept course with the left side, except for the fact that the common doctrine there is to fall in behind the tropical cyclone with the wind and seas on the stern; hence, there may be a net gain of ships on right side at some considerable distance from the center.

Because of the rather strong underforecast bias on the right side of the tropical cyclone in the NOAA model, it was decided that the Navy model would be easiest to use in the probability model. The Navy model had two other minor advantages: a) it was developed on western Pacific data and hence may handle the large typhoons better; and b) the input data required is all given in the tropical cyclone warnings.

1.5 The Probability Model

The sea state probability model (SEAP) is very much like the wind probability model.* Both predefine an array of probabilities associated with radii from an offset center of the tropical cyclone. The WINDP model assumes isotachs are circular while the SEAP model assumes contours of equal sea height are circular. Both assume the circle centers are offset from the tropical cyclone center and that the offset is inversely proportional to contour value.

---

*For more detail, see Jarrell, 1978 and 1981.

The predefined array contains probabilities that the radius of the actual contour (30-kt winds, 50-kt winds, 12-ft seas, etc.) will exceed the value associated with the array location (in increments of 75 n mi). These exceedance probabilities are assumed to be geography independent so they need only be computed once for each time step for each warning and then may be used for any geographical point. The implied assumption is that if the radius of a 12-ft sea height contour is x miles, the probability of observing seas in excess of 12 ft is the strike probability within x miles. The key then to the SEAP model is defining this array of exceednce probabilities.

Sea height exceedance probabilities for the radius (R_c) of critical height H_c are given by:

$$P(R_c \geq X) = \sum_{\text{all } V_i} P(V_m = V_i)\ P(R_{30} \geq X \mid V_m = V_i)\ P(R_c \geq X \mid R_{30} \geq X, V_m = V_i)$$

where V_m is the maximum wind speed in the tropical cyclone, R_{30} is the radius of 30 kt winds and V_i is a variable wind speed (assigned in the model at 10 kt intervals from 30 kt to 150 kt). The first two product terms under the summation are solved by the wind probability model to fill an exceedance probability array for R_{30}. The last product term is unique to the SEAP model and will be described in detail here.

Equations given earlier related the radii of the contour of sea height h (R_h) to its predictors: longitude, duration, radius of 30-kt winds and radius of 50-kt winds. In the above relationship only the dependency on R_{30} is expressed. This is done by assuming that longitude is correctly forecast, that R_{50} is directly determined by R_{30}, and that duration is known. The longitude assumption is of negligible consequence since an enormous 10° longitude error changes the estimate of the radius of the 12-ft contour by only 10 miles and the 15-ft contour even less. The assumption that R_{50} and R_{30} are directly related comes from the fact that in the 12-, 48-, and 72-hour forecasts only R_{50} is given; thus R_{30} is determined by assuming $Vr^{.5}$ = constant; thus for those forecasts R_{50} is simply related to R_{30} by a constant multiplier. In the 0- and 24-hour forecasts both R_{50} and R_{30} are adjusted in the WINDP model to conform to the $Vr^{.5}$ = constant profile, and again our estimate of R_{30} is precisely a constant times R_{50}. Duration is defined as the elapsed time since the issuance of the first warning and hence at any forecast time can be predicted without error.

For each value of x (distance from the offset contour center), a sea height is interpolated (or extrapolated) from predictions of the radii of the 9-, 12-, 15-ft contours. From the error characteristics of the sea height model the exceedance probability of the critical height is determined given the model specification of sea height. Figure 1-01 illustrates the curves fit to the probability of seas exceeding 9, 12, 15 and 18 ft given model predictions of 6-, 9-,...30-ft seas.

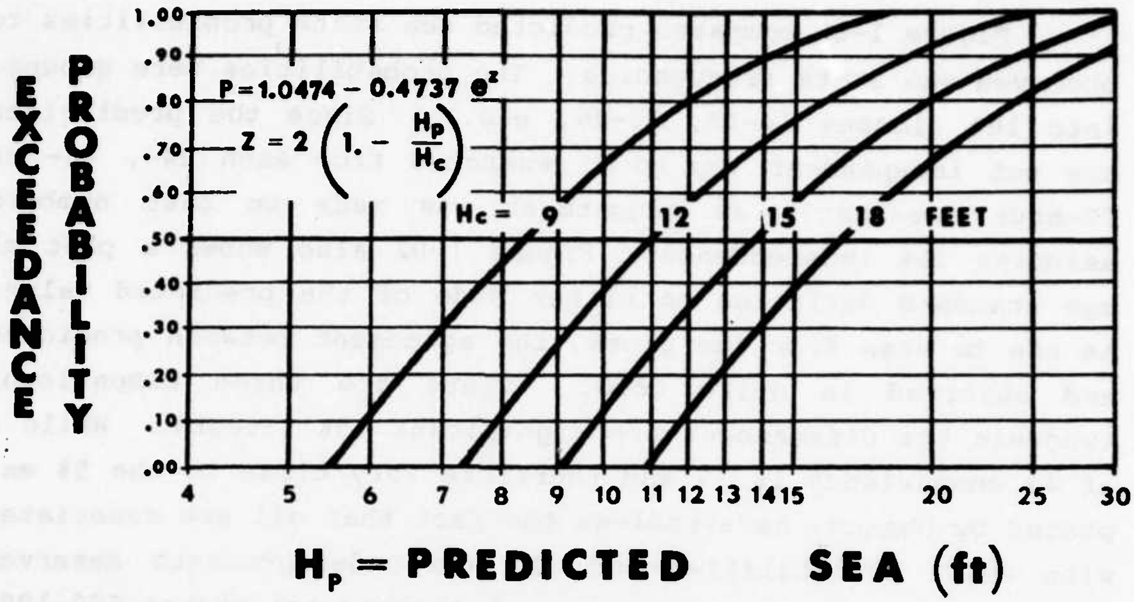


Figure 1-01. Exceedance probability for certain critical sea states (H_c) as a function of predicted seas (H_p).

Note that the actual height will exceed the modeled height about 57% of the time, thus the low side bias mentioned earlier was also seen in the model validation upon which Figure 1-01 is based.

1.6 Probability Model Testing

For this test random geographical points were selected around forecast points in such a way that they are uniformly distributed by direction and over the radial distance of 500 n mi. Actual verification data were extracted from hand analyses of combined sea height made by the Fleet Numerical Oceanography Center (FNOC) Optimum Track Ship Routing (OTSR) section. The frequency of observations of seas above 12 and 15 ft was then compared to the specified probability of occurrence of seas above 12 and 15 ft. It should be noted that all probabilities herein are instantaneous. While it is possible to calculate time integrated probabilities, they are not very useful for ship routing and are very difficult to verify.

Figure 1-02 compares predicted sea state probabilities to observed sea state frequencies. The probabilities were grouped into 10% classes (0-10, 10-20, etc.). Since the predictions are not independent (up to 8 generated from each 24-, 48- or 72-hour forecast), an adjustment was made to case numbers assuming 25% independence. Figure 1-02 also shows a plot of one standard deviation on either side of the predicted value. As can be seen from the plots, the agreement between predicted and observed is quite good. There are three comparisons (wherein the differences are significant (5% t-test). While 3 of 43 comparisons is 7% and therefore very close to the 5% expected by chance, nevertheless the fact that all are associated with small probabilities and all are underforecasts deserves comment. It was noted earlier that average sea states 500-1000 n mi from the tropical cyclone were 6-8 ft and it was suggested that most of this was from a source independent of the storm (another tropical cyclone or an extratropical cyclone). In that outer region fully 8-10% of the observations reported seas greater than 12 ft. Since these regions are also low probability regions, it fits that observations of high seas would exceed expectations. Notice that the "underforecasting" is less with shorter time intervals and higher seas (15 ft vs 12 ft). Both these observations are consistent with the hypothesized reason for the underforecasting. First, the observation points were randomly generated within 500 n mi of a forecast position, thus the frequency with which they are over 500 n mi from the verifying position increases with increasing forecast errors over time. Second, the frequency of chance encounter of 15-ft seas unrelated to a tropical cyclone is appreciably less than for 12-ft seas, hence the observed frequency of 15-ft seas when unexpected is less than for 12-ft seas.

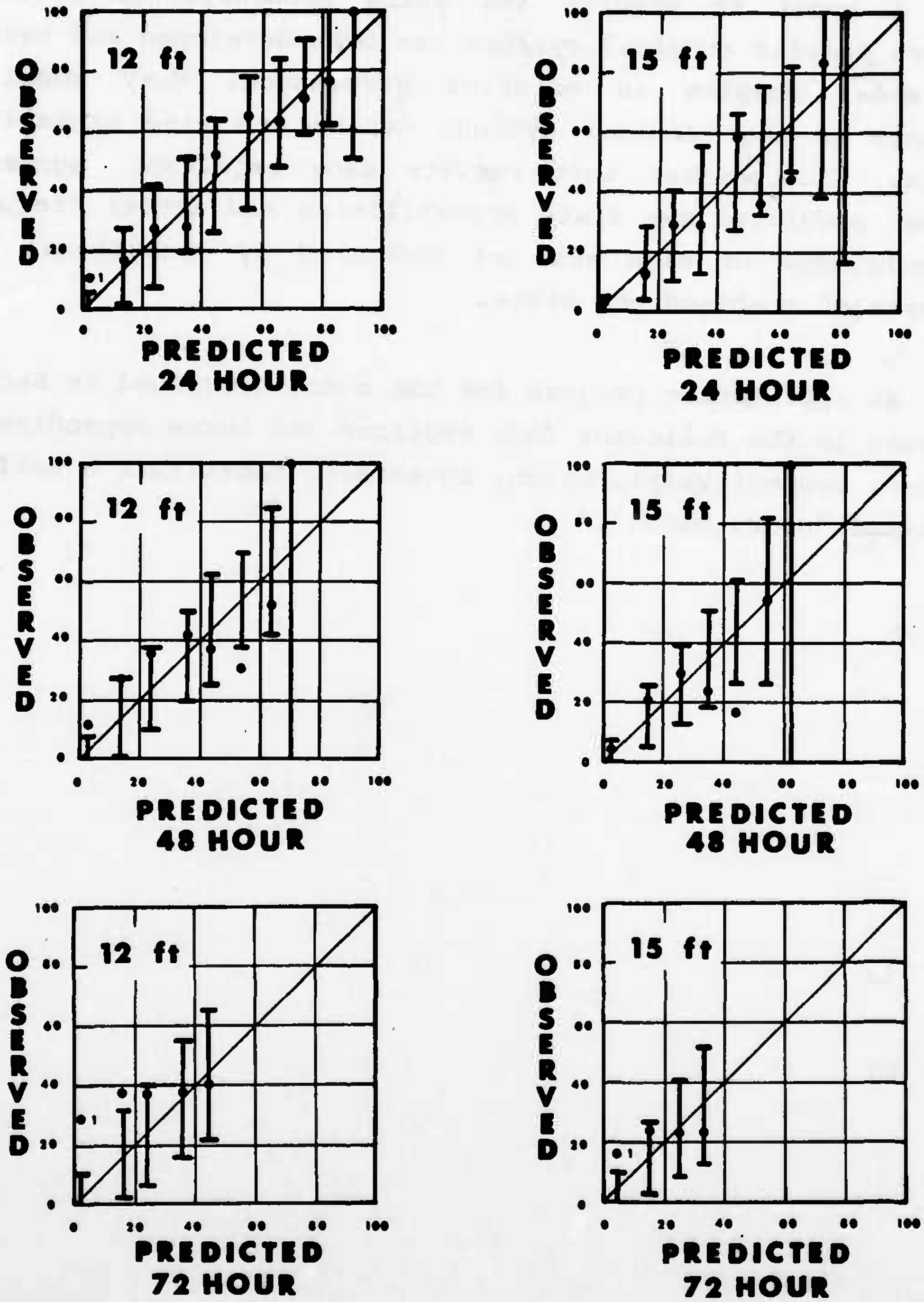


Figure 1-02. Predicted sea state probabilities versus observed sea state frequencies. One standard deviation confidence limits are shown based on an assumed binomial distribution with p=predicted probability. Superscript[1] indicates observed frequency was significantly different from the predicted probability using a t-test and 5% level of significance.

1.7 Summary

A model to predict sea state probabilities around a western Pacific tropical cyclone has been developed and tested. The model couples an existing statistical Navy model to elements of the tropical cyclone strike and wind probability models. Independent test results show excellent agreement between predicted sea state probabilities and actual frequency of occurrence of high seas as indicated by operational hand analyses of combined sea state.

An application program for the model described in Section 1 is given in the following four sections and three appendices (2-5 and A-C, respectively), which, in effect, constitute a self-contained "users manual."

SECTION 2. PROGRAM INTRODUCTION AND CAPABILITIES

The Tropical Cyclone Applications Software System (TCASS) for the Western North Pacific Ocean, is a set of programs for the Hewlett-Packard (HP) 9845 which assists the user during the period when tropical cyclone (TC) warnings are in effect. TCASS is designed primarily for shipboard applications and may be used by the environmentalist as a briefing aid, for analysis of the TC threat, and as a tool for formulating a recommended course of action.

Tropical cyclone wind probability forecasting is a new approach to evaluating the tropical cyclone wind threat. TCASS provides a near real-time quantitative measure of the wind threat throughout the period of the TC warning. The wind probability forecasts contained in TCASS are based on a statistical analysis of the forecast accuracy of the cognizant tropical cyclone warning center. The percentage probabilities of encountering 30 and 50 kt TC winds are determined using the wind probability calculations of the system.

Similarly, this version of TCASS provides a measure of the tropical cyclone sea height threat. The percentage probabilities of encountering 15 foot seas (from the tropical cyclone) are determined by the sea height probability calculations of the system.

The statistical data base and geographical display are tailored to the western North Pacific Ocean area.

TCASS has the capability of performing several functions. The user may designate the functions to be performed by selection of options corresponding to these functions as described next.

TCASS has the capability of performing six functions. These functions and their corresponding options, by number, are summarized as follows:

Option 1. Display up to 3 tropical cyclone warnings for the current warning date-time-group (DTG).

Option 2. Display the "danger" area for each warning as defined by the current CINCPACFLT Operation Orders.

Option 3. Display projected ship tracks, beginning at the warning DTG for the duration of the warning period.

Option 4. Evaluate the tropical cyclone threat along a ship's projected track by

(1) calculating the probabilities of encountering 30 and 50 kt TC winds,

(2) calculating the probabilities of encountering 15 ft seas, or

(3) both

at six hour intervals along the track for a given warning during the forecast period.

Option 5. Calculate and display the user specified critical probability isopleths for

(1) 30 and/or 50 kt TC winds,

(2) 15 ft seas, or

(3) both

at 24 hour intervals for each tropical cyclone during the warning period. Critical probabilities are those threshold values which, if exceeded, represent an unacceptable level of threat.

Option 6. Calculate and display the shortest route, from the ship's position at the beginning of the warning period toward a user designated secondary position, which does not exceed the user specified critical probabilities of

(1) 30 and 50 kt TC winds,

(2) 15 ft seas, or

(3) both

for each tropical cyclone during the warning period.

TCASS is designed for flexibility as well as ease of operation. To accomplish this within the constraints of the computer system there are two modes of operation available to the user. These modes are described in the next section.

SECTION 3. MODES OF OPERATION

TCASS may be operated in two modes:

a. Semi-automatic mode

b. Selective mode

Semi-automatic mode. In this mode TCASS performs all six functions. A minimum of user interaction is necessary and is mainly performed at the beginning of the processing. However, this mode is limited to the analysis of one tropical cyclone warning and one projected ship track. Furthermore, the evaluation of the ship's track, display of critical isopleths and auto-routing capabilities are limited to wind probability calculations only. [In this respect this version is the same as SNAP 7.0.] Results are displayed and hard copies of the products are provided automatically.

Selective mode. The selective mode allows the user a wider range of flexibility. Combinations of options (listed in Section 2) may be selected by the user for execution during a given TCASS run in this mode. Up to three TC warnings may be processed. Any number of projected ship tracks may be displayed at the option of the user. However, only one ship at a time may be evaluated or auto-routed. Hard copies of the products may be obtained as desired by the user. Upon completion of program execution in either mode the user may rerun the program selecting a different mode or different options.

3.1 Map Background. The total area of coverage of the TCASS map background extends from the equator to the arctic circle, from 90°E to 180°E. The latitude,longitude grid has no limitations. The graphic display is a mercator projection true at the equator. Three predesignated map backgrounds are available for selection by the user, as well as user defined dynamic backgrounds. Figures 3-01 through 3-03 illustrate the three predesignated backgrounds corresponding to the following areas, respectively:

a. South China Sea area
b. Okinawa-Japan area
c. western North Pacific area

3.2 Dynamic Background. TCASS has the capability of providing a dynamic background. By designating the latitude, longitude of the lower left corner (to the nearest ten degrees) and the "zoom" factor, the user may select an area of coverage and scale not pre-defined in subsection 3.1 above.

3.3 Zoom Factor. The zoom factor refers to a number (1 through 3) which changes the scale of the map background. The longitudinal extents of the backgrounds are as follows:

a. 90° of longitude (zoom factor = 1)
b. 60° of longitude (zoom factor = 2)
c. 45° of longitude (zoom factor = 3)

The latitudinal extent depends on the latitude of the lower left corner because of the mercator projection.

Examples of dynamic backgrounds are given in Appendix A.

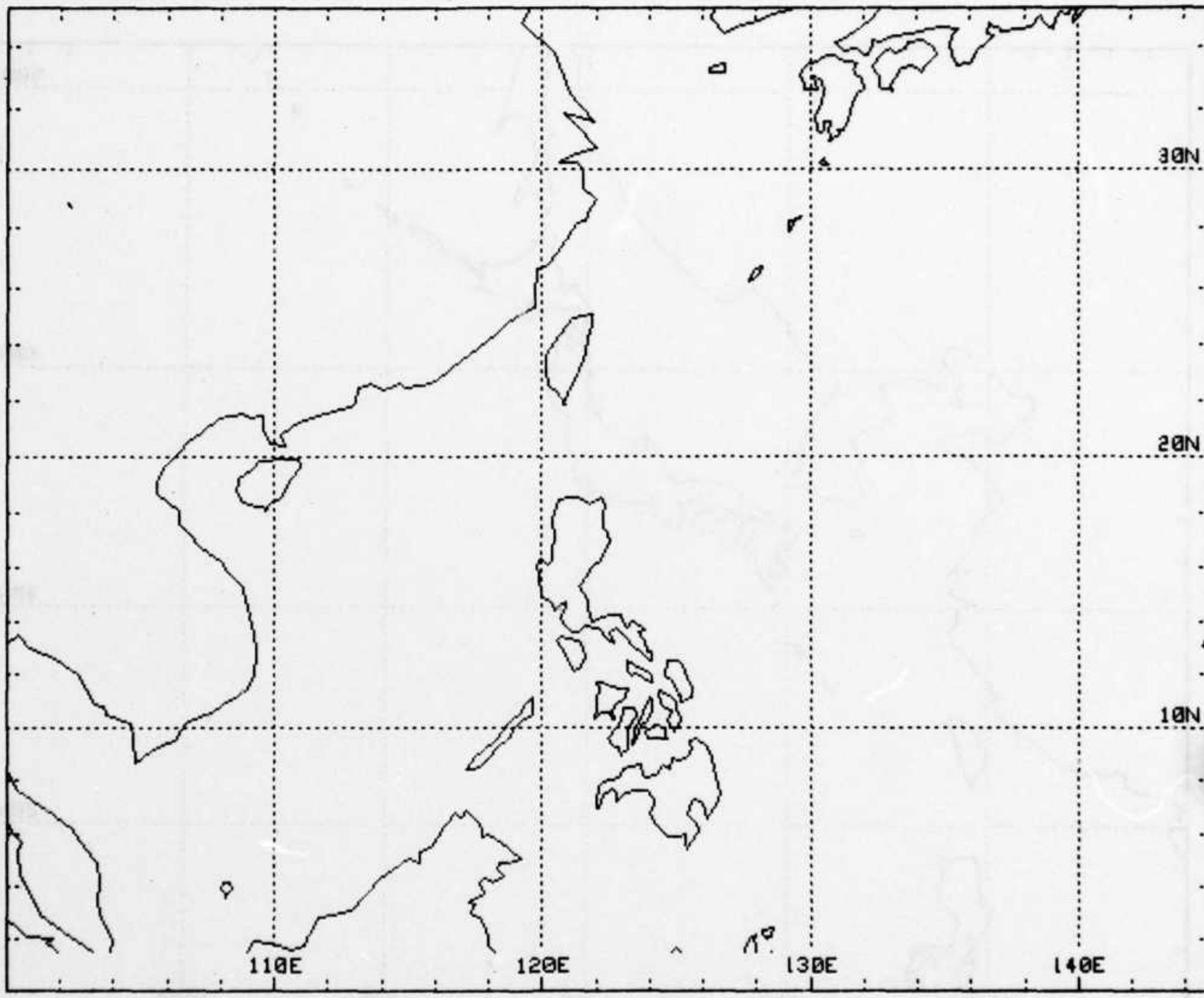


FIGURE 3-01. Predesignated map background for the South China Sea area. Reference latitude,longitude = 0°,110°E. Zoom factor = 3.

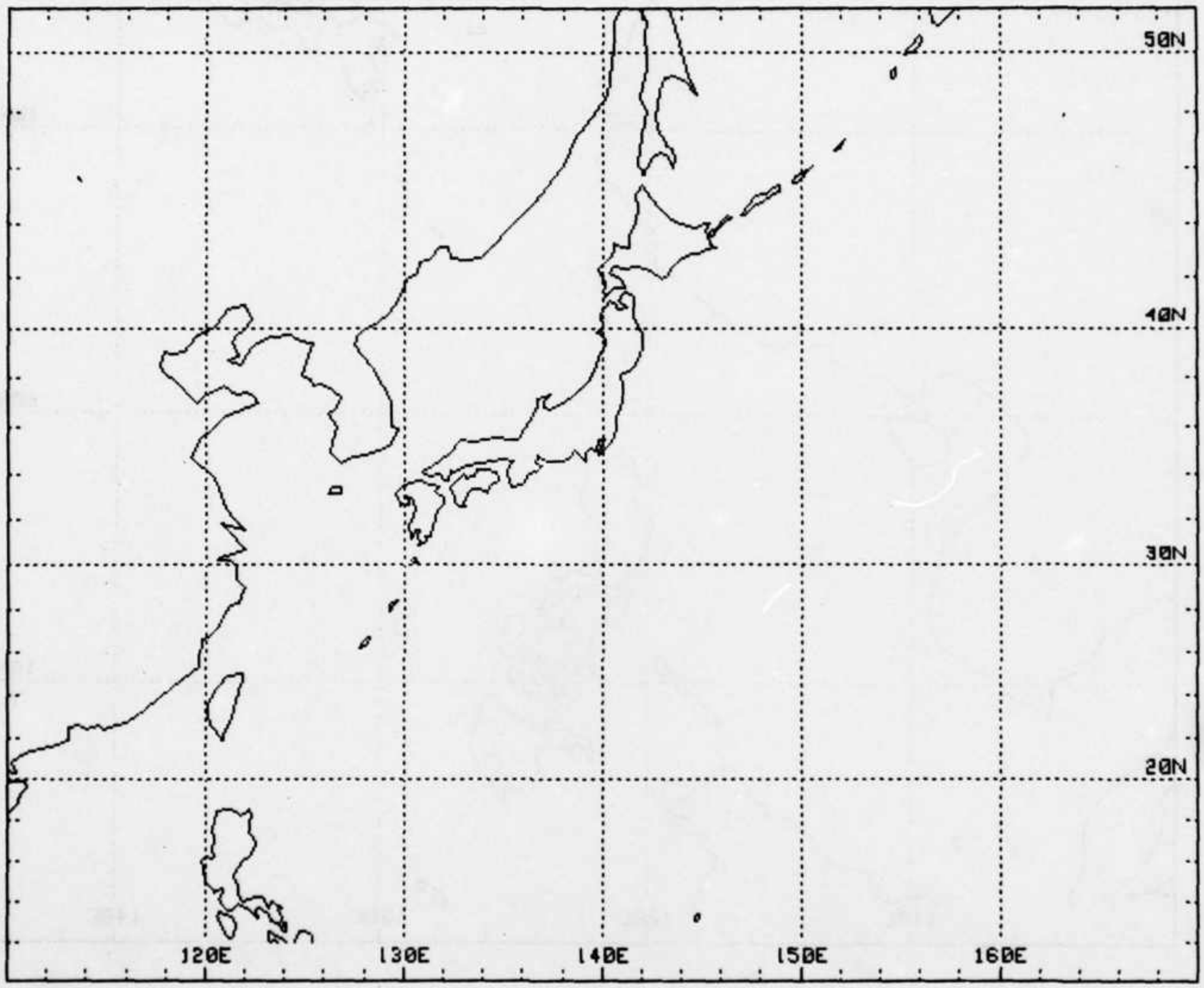


FIGURE 3-02. Predesignated map background for the Okinawa-Japan area. Reference latitude,longitude = 10°N,110°E. Zoom factor = 2.

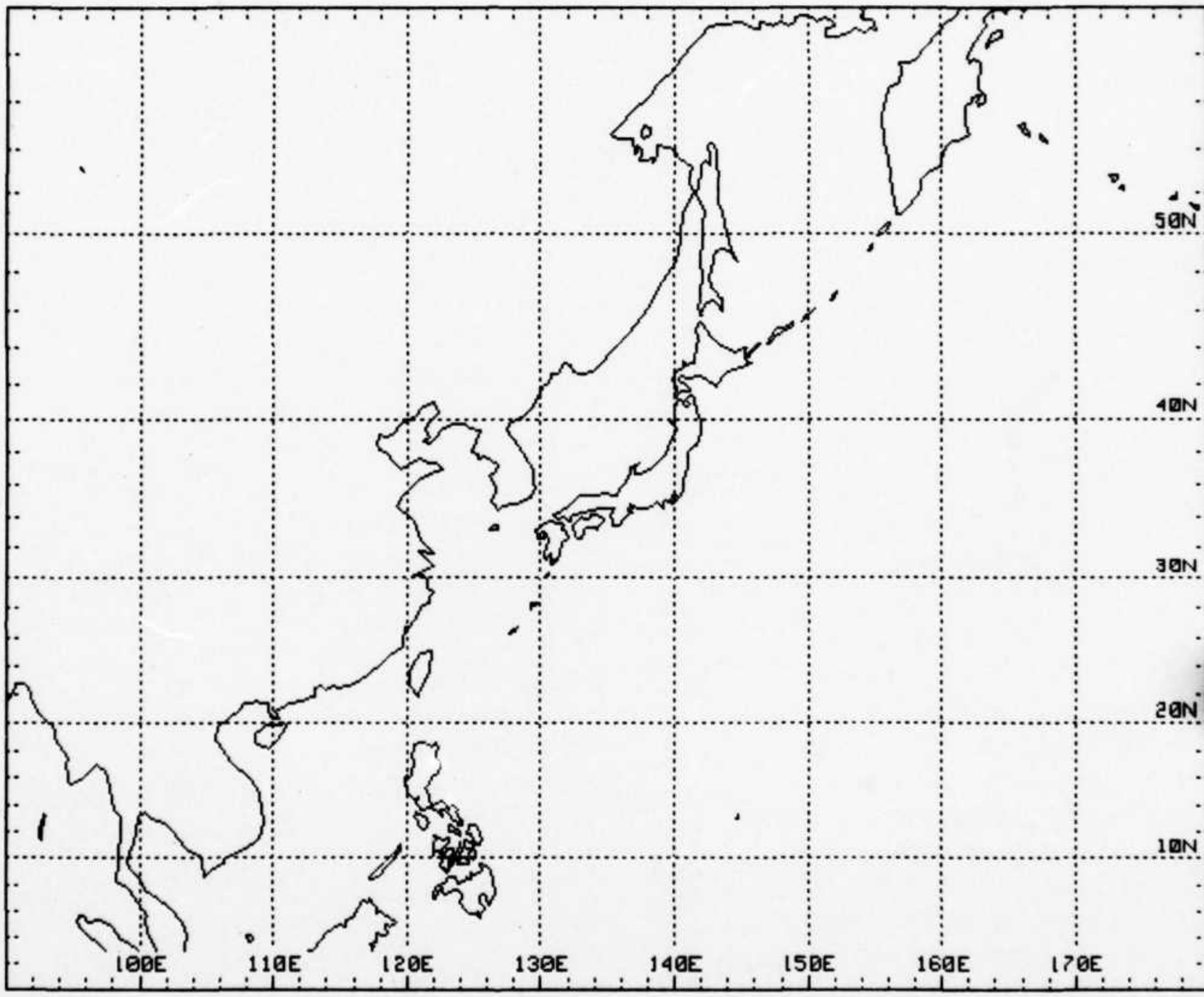


FIGURE 3-03. Predesignated map background for the western North Pacific area. Reference latitude,longitude = 0°,90°E. Zoom factor = 1.

SECTION 4. OPERATING INSTRUCTIONS

a. General. These instructions assume a basic familiarity with operating the HP9845 and are intended for, but not necessarily limited to, use by geophysics personnel. The Tropical Cyclone Applications Software System - western North Pacific (TCASS) is contained on a tape cassette. The program files on the tape cassette are in data format for transportability between HP9845A and B models. To obtain an executable system the files must be converted to program format according to the instructions contained in Appendix B. The original tape should be retained as a backup master tape.

b. Input Data. To operate TCASS, certain input data are needed. In preparation for execution, the user requires as a minimum the current western North Pacific Ocean Tropical Cyclone warning(s). To take full advantage of the features of TCASS, the user may also require the following information:

1. Ship's position at the warning date-time-group (DTG).
2. Ship's projected speed of advance (SOA).
3. Ship's base course or projected track.
4. Ship's destination or secondary intended position (in case of re-routing or evasion).
5. The critical probability values (%) of encountering 30 and 50 kt winds and/or 15 ft seas which pose an unacceptable level of threat if exceeded.

The prompts for the input data are intended to be self-explanatory. Because of the constraints on the length of the display line on the HP9845 screen, explicit prompting instructions are limited. Amplifying information concerning the input data entries is contained in subsection 4e (Data Entries).

c. <u>Loading and Initiating Execution</u>.

<u>(1) HP9845 OFF</u>. If the HP9845 is OFF, the TCASS cassette is inserted in the right hand cassette tape drive (T15). The AUTOST key is depressed and the POWER switch turned ON. TCASS will be automatically loaded and execution initiated.

<u>(2) HP9845 ON</u>. If the HP9845 is already ON, the TCASS cassette is inserted in the right hand cassette tape drive as above. By typing in SCRATCH A and pressing the EXECUTE key, the HP9845 will be initialized by clearing memory and setting the machine defaults. Next, type in LOAD "TCASS",10 and press the EXECUTE key. TCASS will be loaded and execution initiated.

d. <u>Operating Modes</u>. Upon execution of TCASS, a brief program description and the two modes of operation available to the user are displayed as follows:

TROPICAL CYCLONE APPLICATIONS SOFTWARE SYSTEM (WESTPAC)-<u>TCASS</u>
SNAP 7.1

<u>TCASS</u> PERFORMS THE FOLLOWING FUNCTIONS:

1. PLOT TROPICAL CYCLONE WARNING(S)
2. PLOT "DANGER" AREA(S)
3. PLOT SHIP TRACK(S)
4. EVALUATE SHIP TRACK
5. PLOT CRITICAL PROB. ISOPLETHS
6. AUTO-ROUTE SHIP

<u>TCASS</u> OPERATES IN TWO MODES:

1. SEMI-AUTOMATIC MODE (PERFORMS ALL 6 FUNCTIONS)
   - INCLUDES WIND PROB. MODE ONLY

-OR-

2. SELECTIVE MODE (PERFORMS SELECTED FUNCTIONS)
   - INCLUDES WIND AND/OR SEA HT. PROB. MODES

A prompt appears for the user to select the mode desired, as follows:

ENTER MODE DESIRED, BY NUMBER (DEFAULT=1)

1 or 2 is entered to designate the semi-automatic mode or selective mode, respectively. The default mode is 1 (semi-automatic mode); that is, if the CONT key is pressed with no entry, TCASS is pre-set to select the semi-automatic mode.

After selection of the operating mode, the following prompt is displayed to allow the user to select the map background desired:

MAP BACKGROUNDS

YOU MAY SELECT THE FOLLOWING PRE-SET BACKGROUNDS:

1. SOUTH CHINA SEA
2. OKINAWA-JAPAN
3. WESTPAC

-OR- DEFINE YOUR OWN

4. DYNAMIC BACKGROUND

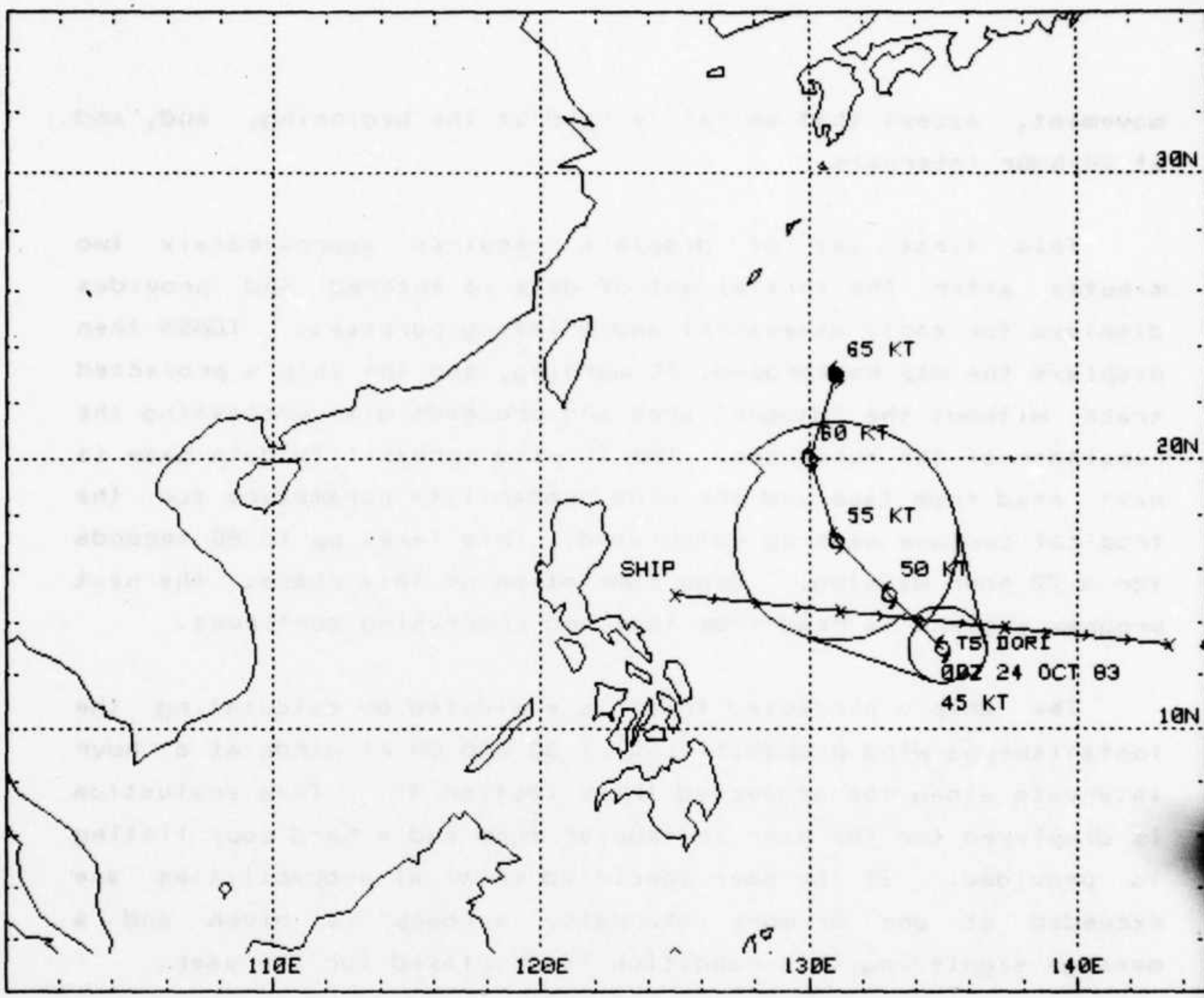
[DEFAULT IS 3 OR PREVIOUSLY ENTERED VALUE]

A prompt appears for the user to select the background option, as follows:

ENTER, BY NUMBER (1 THRU 4) THE DESIRED BACKGROUND OPTION

Upon entering the background option, the program proceeds according to the operating mode selected earlier.

(1) Semi-automatic mode. With selection of the semi-automatic mode, TCASS initially notifies the user to ensure that the printer paper is at the top of form. The program then requests the user to enter the number of hard copies desired on the current run. Next, the input data needed to process the TC warning and the projected ship's track are requested. In this mode only one TC warning and one ship track may be processed during a given run. The user will be prompted by the program on how to proceed. Subsection 4e should be referred to in the event further amplification of the prompts or messages are required. Input data are displayed as data entry progresses, and upon completion of the entries the program initially processes the first three functions of TCASS. The map background is read from the tape cassette and plotted on the screen. The initial and forecast positions of the TC warning are then plotted (option 1) along with the "danger" area associated with the warning (option 2) and the ship's projected track (option 3). A hard copy of the graphic display and a listing of the TC warning data is provided without user intervention. An example of these products are given in Figure 4-01. Note that the display shows the tropical cyclone name (or TD number), DTG, and maximum wind speed at the initial position, and the maximum winds after the initial DTG for the forecast positions. The ship's 4-letter identification is shown at the initial ship's position with ">" marks each six hours along the projected track indicating the direction of




```
WARNING DTG: 00Z 24 OCT 83

TROPICAL STORM DORI  WARNING NR 4  DIR/SPD  310 DEGREES  9 KTS
00 HR INITIAL  POSITION 13.0N 135.0E MAX WIND  45 KT
   RADIUS OF 30 KT WINDS  100  MILES NE SEMICIRCLE,  80  MILES  ELSEWHERE
12 HR FORECAST  POSITION 15.0N 133.0E MAX WIND  50 KT
24 HR FORECAST  POSITION 17.0N 131.0E MAX WIND  55 KT
   RADIUS OF 50 KT WINDS  50  MILES
   RADIUS OF 30 KT WINDS  150  MILES NE SEMICIRCLE,  100  MILES  ELSEWHERE
48 HR FORECAST  POSITION 20.0N 130.0E MAX WIND  60 KT
   RADIUS OF 50 KT WINDS  50  MILES
72 HR FORECAST  POSITION 23.0N 131.0E MAX WIND  65 KT
   RADIUS OF 50 KT WINDS  80  MILES
```

FIGURE 4-01. Example of semi-automatic mode output (first page) showing graphic display of warning, "danger" area, and ship's projected track. An alphanumeric listing of the input warning data is also provided.

movement, except that an "X" is used at the beginning, end, and at 24-hour intervals.

This first set of displays requires approximately two minutes after the initial set of data is entered and provides displays for early assessment and briefing purposes. TCASS then displays the map background, TC warning, and the ship's projected track without the "danger" area and proceeds with processing the remainder of the functions. The TC wind probability data base is next read from tape and the wind probability parameters for the tropical cyclone warning calculated. This takes up to 80 seconds for a 72 hour warning. Upon completion of this phase, the next program segment is read from tape and processing continues.

The ship's projected track is evaluated by calculating the instantaneous wind probabilities of 30 and 50 kt winds at 6 hour intervals along the projected track (option 4). This evaluation is displayed for the user in tabular form and a hard copy listing is provided. If the user specified critical probabilities are exceeded at one or more intervals, a "beep" is given and a message signifying this condition is displayed for the user.

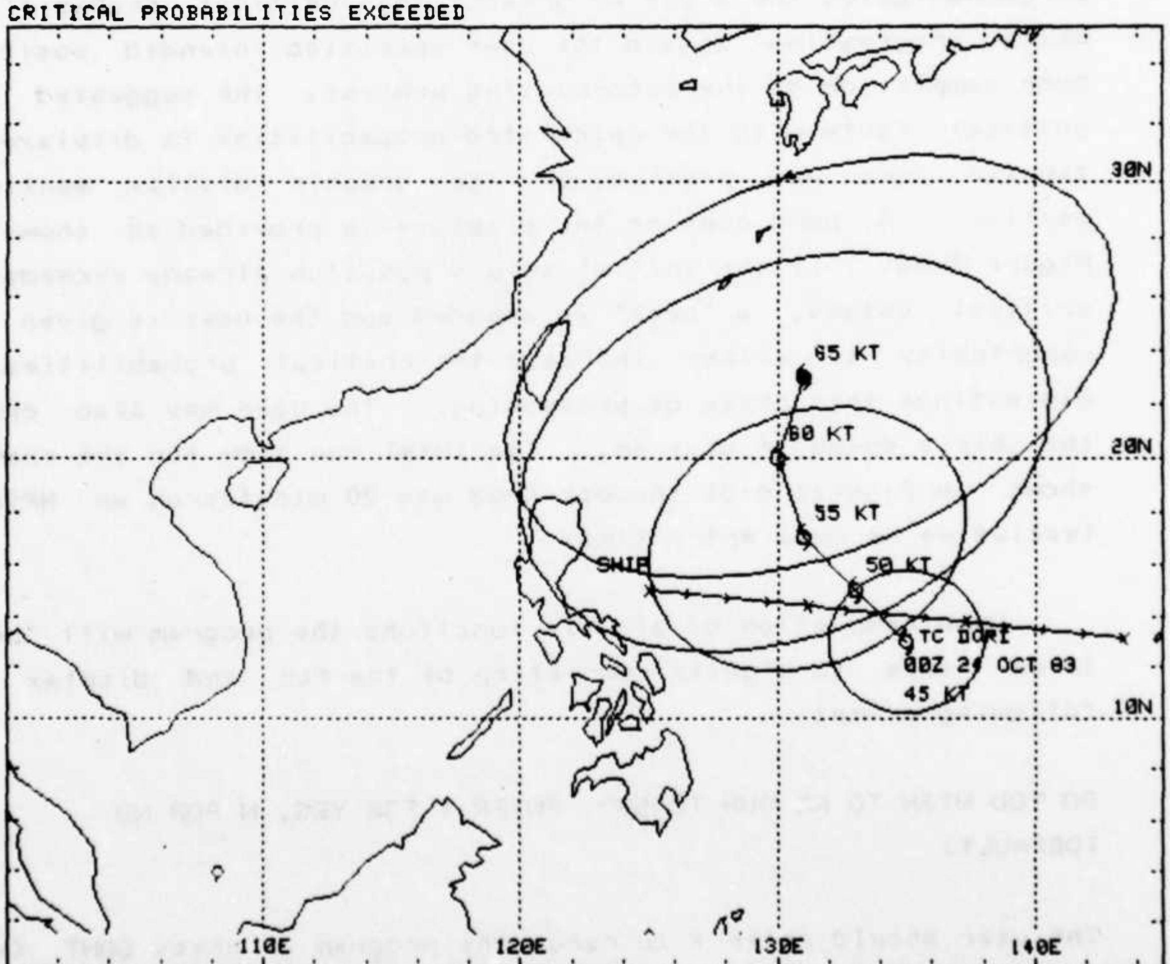
Subsequently, the user specified critical probability isopleths of 30 and/or 50 kt TC winds are calculated at 24 hour intervals and graphically displayed (option 5). This takes approximately 4-5 minutes for the 30 kt wind isopleths and another 2-3 minutes for the 50 kt wind isopleths. The time will vary somewhat depending on the critical values selected and the extent of the tropical cyclone winds. A hard copy of the graphics display is produced. Figure 4-02 contains an example of a tabular listing of the wind probabilities along the ship's projected track and the graphic display of the critical probability isopleths.

SHIP TRACK EVALUATION

SHIP'S ID: SHIP
SHIP'S SPEED: 15 KT — DIST: 1000 NMI
WARNING DTG: 00Z 24 OCT 83 — TROPICAL STORM DORI

			PROBABILITIES	
TIME	LAT	LONG	30 KT WINDS	50 KT WINDS
0	15.0N	125.0E	0.0	0.0
6	14.8N	126.5E	.3	0.0
12	14.7N	128.1E	.6	.0
18	14.5N	129.6E	17.3	2.5
24	14.4N	131.2E	18.5	3.2
30	14.2N	132.7E	9.1	1.2
36	14.1N	134.2E	4.0	.4
42	13.9N	135.8E	2.2	.2
48	13.8N	137.3E	1.3	.1
54	13.6N	138.9E	.6	.0
60	13.5N	140.4E	.2	.0
66	13.3N	141.9E	.1	.0
72	13.2N	143.5E	.0	.0

CRITICAL PROBABILITIES EXCEEDED



5% PROBABILITY ISOPLETHS OF 30KT WINDS (SOLID LINES)

FIGURE 4-02. Example of semi-automatic mode output (second page) consisting of warning, 5% isopleths of 30 kt winds and ship's track.

If the ship's projected track exceeds the user specified critical probabilities, a "sub-critical" route is determined from the ship's initial position towards the user specified ship's intended position (option 6). A "beep" is given to indicate that processing is interrupted temporarily to allow the user to enter this position which may be the destination or some secondary position. This sub-critical route, if one can be found within the given constraints, may be a direct route at a slower speed or an alternate (evasive) route, at the ship's average speed, which circumnavigates the areas of greater than critical probabilities while progressing toward the user specified intended position. Upon completion of the auto-routing process, the suggested sub-critical route with the calculated probabilities is displayed in tabular form and plotted on the graphic display mentioned earlier. A hard copy of the displays is provided as shown in Figure 4-03. If the initial ship's position already exceeds the critical values, a "beep" is sounded and the user is given the opportunity to either increase the critical probabilities or discontinue this phase of processing. The user may also change the ship's speed if desired. The total run time for the example shown in Figures 4-01 through 4-03 was 20 minutes on an HP9845A (exclusive of data entry time).

Upon completion of all six functions the program will "beep" three times to signify completion of the run and display the following prompt.

DO YOU WISH TO RE-RUN TCASS? ENTER Y FOR YES, N FOR NO [DEFAULT]

The user should enter Y to rerun the program or press CONT (with no entry) to terminate the program.

ALTERNATE ROUTE
BEGINNING POSITION: 15.0N 125.0E
INTENDED POSITION: 13.0N 145.0E

SHIP'S ID: SHIP
SHIP'S SPEED: 15 KT
WARNING DTG: 00Z 24 OCT 83

DIST: 1080 NMI
TROPICAL STORM DORI

			PROBABILITIES	
TIME	LAT	LONG	30 KT WINDS	50 KT WINDS
0	15.0N	125.0E	0.0	0.0
6	14.1N	126.3E	.1	0.0
12	13.2N	127.5E	.3	.0
18	12.4N	128.8E	4.0	.3
24	11.5N	130.0E	2.3	.2
30	11.6N	131.5E	2.1	.2
36	11.8N	133.0E	1.5	.1
42	11.9N	134.6E	1.1	.1
48	12.1N	136.1E	.9	.1
54	12.3N	137.6E	.4	.0
60	12.4N	139.1E	.2	.0
66	12.6N	140.7E	.1	.0
72	12.7N	142.2E	.1	.0

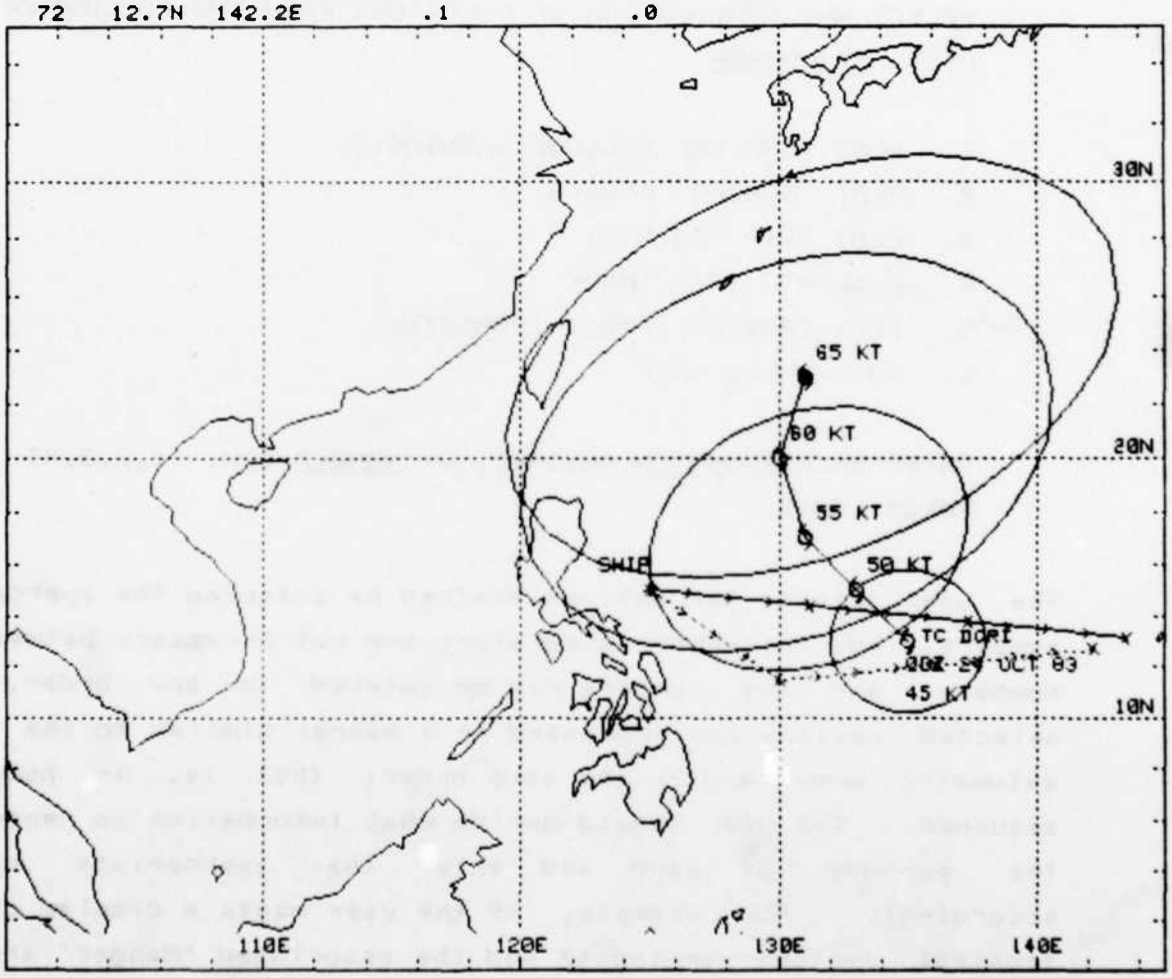


FIGURE 4-03. Example of semi-automatic mode output (third page). Similar to Figure 4-02 except alternate route (dashed lines) is also shown.

(2) Selective mode. In the selective mode, the user selects, as options, the functions which TCASS is to perform. This feature allows greater flexibility but requires more user interaction and time at the terminal. Upon entering this mode, the map background selection prompt is given as in the semi-automatic mode. The following display appears next:

TCASS - SELECTIVE MODE

SELECT ANY COMBINATION OF FUNCTIONS FROM THE FOLLOWING LIST, BY NUMBER

1. PLOT TROPICAL CYCLONE WARNING(S)
2. PLOT "DANGER" AREA(S)
3. PLOT SHIP TRACK(S)
4. EVALUATE SHIP TRACK
5. PLOT CRITICAL PROB. ISOPLETHS
6. AUTO-ROUTE SHIP

ENTER EACH FUNCTION DESIRED, BY NUMBER [EX: 1,2,3,4] - PRESS 'CONT'

The user selects the options desired by entering the appropriate numbers. For this entry separators are not necessary between the numbers, and the numbers may be entered in any order. The selected options are processed in a manner similar to the semi-automatic mode and in the same order; that is, in numerical sequence. The user should decide what information is needed for the purpose at hand and enter the appropriate options accordingly. For example, if the user wants a display of the tropical cyclone warning(s) and the associated "danger" area(s), options 1 and 2 would be chosen. Please note that unlike the semi-automatic mode which is limited to one TC warning, up to 3 warnings may be processed in the selective mode. The program provides the appropriate prompts to obtain the necessary input data, the selected options are processed, and the results displayed. In this mode, as tabular products are completed, the user is given the opportunity to obtain a hard copy listing by a query from the program. **NOTE:** When a graphic display product is completed, the program "beeps" twice to indicate completion of the plot and pauses about 2 seconds to allow the user to survey the display. The program responds with a prompt to allow the user to elect to receive a hard copy or not before proceeding. Upon completion of all options selected the program allows the user to rerun TCASS by issuing the same prompt given at the conclusion of a run in the semi-automatic mode.

PROBABILITY MODE. Within the selective mode the user selects the options to be performed as described above. If options 4 or 5 or 6 or any combination is selected, the user is presented with a choice of probability modes. That is, the user may further designate whether wind probabilities, sea height probabilities, or both are to be used in performing the options selected. The following information and prompt are displayed on the screen:

SELECT PROBABILITY MODE - BY NUMBER

THE SELECTED MODE IS APPLICABLE TO OPTIONS 4, 5, AND 6 ONLY

1. WIND PROB. MODE ONLY [DEFAULT]
2. SEA HT PROB. MODE ONLY
3. BOTH MODES

ENTER PROBABILITY MODE (1, 2, OR 3) - PRESS 'CONT'

The user enters, by number, the mode desired.

NOTE: The selected probability mode applies to all options if selected for the TCASS run. There is no provision, for example, to run option 4 in one mode and 6 in another.

RUNNING TIME. It should be noted that options 1 through 3 require no wind or sea height probability calculations and can therefore be processed relatively rapidly. Processing of options 4 through 6 requires numerous calculations, particularly options 5 and 6. Processing with the sea height probability mode selected is slower than the wind probability mode. The processing time is compounded if more than 1 TC warning is processed.

OPTION INTERDEPENDENCE. Because the options are interdependent to a certain extent, certain options are invoked even if not selected. For instance, if options 4, 5 and 6 are selected, options 1 and 3 are automatically processed in order to provide the necessary information to process the other options. In addition, if option 6 is selected with options 3 and 4, and the projected track is evaluated as sub-critical (not exceeding the critical probabilities), then processing of option 6 is cancelled as not necessary. It should be noted that the ship's projected track to be evaluated (option 4) and the auto-route calculated (option 6) is for the last ship track plotted in option 3 if more than one ship is processed.

In addition to the examples in Figures 4-01 through 4-03, examples of various products obtained in the selective mode and various option selections are provided in Appendix C. These examples illustrate applications which may be operationally useful.

e. Data Entries. Input parameters are requested by prompting within the program according to the functions to be performed. This subsection describes the data entries which may be encountered. Included are explanatory remarks, the acceptable range values, and the default value(s) if provided. To enter the default value the user merely presses the 'CONT' key. In the event an invalid entry is detected, the program will go "beep" and invoke a data re-entry procedure.

(1) Tropical Cyclone warning data:

- ENTER WARNING DTG USING THE FORMAT: YYMMDDHH-[EX: 82062508]
  where YY = last 2 digits of the year
  MM = 2 digit designator for the month (JAN=01, FEB=02, etc.)
  DD = 2 digit day of the month
  Range: 01 - last day of month
  HH = 2 digit hour of the day (ZULU)
  Range: 00 - 23

- ENTER NUMBER OF ACTIVE CYCLONES IN WESTPAC [DEFAULT=1]
  Range: 1 to 3 (default = 1)

- ENTER CRITICAL PROBABILITIES (%) OF 30 AND 50 KT WINDS
  Enter 2 values separated by a comma. Leading zeroes are disregarded. Range: 1-99, 1-99 (default = 5,3)

- ENTER CRITICAL PROBABILITY (%) OF 15 FT SEAS [DEFAULT = 5]
  Enter critical value. Range: 1 - 99 (default = 5)

- ISOPLETHS TO BE CALCULATED - ENTER 30 OR 50 OR BOTH
  Possible entries: 30 or 50 or BOTH (default = 30)

This entry refers to the critical probability isopleths of 30 and/or 50 kt winds.

- ENTER NUMBER OF TC WARNINGS TO BE PROCESSED (UP TO 3, DEFAULT=1)
  (self-explanatory)

- ENTER TROPICAL CYCLONE NAME (OR TD NUMBER)
  Range: Up to 12 alphanumeric characters with no imbedded blanks (default - previous name or number, or blank if no previous name).

- ENTER WARNING NUMBER FOR THIS TROPICAL CYCLONE
  Self-explanatory (default = previous value if one given).

- ENTER TROPICAL CYCLONE DIRECTION, SPEED OF MOVEMENT (DEGREES, KTS) [EX: 310,8]
  Two entries required separated by a comma. Direction in whole degrees True (range: 0-360) and speed in kts (range: 0-50). (Defaults = 0,0 or previously entered values.)

- TC LAT, LONG, AND MAX WIND SPEED AT WARNING DTG + HH [EX: 11.0N,135.5E,55]
  where HH is the number of hours after the warning DTG.
  Three entries are required, each separated by a comma:
    1. Latitude in degrees and tenths, with N for NORTH.
    2. Longitude in degrees and tenths, with E for EAST.
    3. Maximum wind speed in whole knots (max sustained). Range: 15-250 (default=previous value for this position).

  Example: 12.2N,128.5E,60

- LARGER RADIUS OF 100 KT WINDS (OR 0 FOR NONE) AT WARNING DTG + HH?
  Enter larger radius (NM) of 100 kt winds at the Warning DTG + HH, where HH is the hours from the initial DTG. This entry is used if only one radius is given.

- SMALLER RADIUS OF 100 KT WINDS (OR 0 FOR NONE)
  Enter smaller radius (NM) of 100 kt winds for the above time [default=0 or previously entered value for this parameter]. Enter 0 if radius of 100 kt winds is a circle.

- DIR (8 PT COMPASS) OF LARGER 100 KT RADIUS AND SECTOR (S OR Q)
  This prompt is issued if larger radius entered and a non-zero smaller radius entered. DIR refers to the direction of the semi-circle or quadrant of the larger radius, and SECTOR refers to a semi-circle(S) or quadrant(Q) of the larger radius of 100 kt winds.

NOTE: The above 3 prompts issued for the radius of 100 kt winds are also provided for the 50 and 30 kt radii as applicable. The user response is similar to the above.

- IF NO MORE POSITS THIS WARNING ENTER 0 - OTHERWISE PRESS 'CONT'
  An entry of 0 signifies no additional forecast positions for this warning. Pressing the 'CONT' key with no entry causes prompting for the next forecast position.

- CHECK TC WARNING INPUT DATA - IF OK PRESS 'CONT' - OTHERWISE ENTER NOGO
  Upon entering the data for a tropical cyclone warning, the user is provided an opportunity to check the entries

with this prompt and press the 'CONT' key to continue processing. If an error is detected, an entry of NOGO will cause the program to return to the TC warning data entry prompts and allow the user to re-enter the correct data before continuing processing. NOTE: for those entry lines which require no changes the user need only press the 'CONT' key.

(2) Ship Data. If ship information is needed to perform the TCASS functions selected, the program will request the necessary ship parameters.

- ENTER SHIP'S CALL SIGN OR 4 LETTER IDENTIFIER
  Up to 4 alphanumeric characters may be entered (default = SHIP).

- ENTER SHIP'S LAT, LONG [EX: 13.2N,64.8E] AT WARNING DTG
  Latitude and longitude separated by a comma, in degrees and tenths with N and E. (No defaults)

- ENTER SHIP'S AVERAGE SPEED (KTS)
  Range: 0 to 59 (default = 0 or prior average speed if previously entered). An entry of 0 signifies a stationary ship.

- TO DETERMINE SHIP'S TRACK YOU MAY ENTER:
  1. SHIP'S COURSE -OR-
  2. UP TO 4 ADDITIONAL POSITS WHICH DEFINE THE SHIP'S PROJECTED TRACK

  ENTER 1 OR 2 [NO DEFAULTS] -
  Valid entries are 1 or 2. This allows the user to determine the ship's track by one of two methods. Depending on the method selected, the program issues the appropriate prompts

(shown below) to allow the user to enter the necessary information (no defaults).

- ENTER SHIP'S COURSE (DEGREES TRUE) -
  Range: 0-360 (default = 0). This prompt is issued if method 1 (course and speed) is selected.

- ENTER LAT,LONG OF POSIT n (OR IF NO MORE POSITS - PRESS 'CONT')
  This prompt is issued if method 2 is selected, where n is the next sequential point (from 2 to 5). At least one additional position is required. The same latitude, longitude convention is used as the ship's initial position entry. No defaults. Pressing the 'CONT' key with no entry signifies to the program that no more positions are to be entered. If the average speed is 0, the ship is assumed to be stationary.

Rhumbline tracks are generated by the above methods.

- DO YOU WISH TO PLOT ANOTHER SHIP? ENTER Y FOR YES
  Allows user to plot more than 1 ship in the selective mode, option 3 [default = NO]

- DO YOU WISH TO EVALUATE ANOTHER SHIP? ENTER Y FOR YES
  Allows user to evaluate another ship track in the selective mode, option 4 [default = NO]

(3) Other prompts and messages. In addition to the data entry prompts described above, other prompts may be encountered during the execution of TCASS. In general, the prompts are self-explanatory.

- FOR PROPER PAGE ALIGNMENT, ENSURE PAPER IS AT TOP OF FORM
This message is given in the semi-automatic mode only to inform the user to begin the TCASS run with the print paper at the TOP OF FORM. In the selective mode no such message is given and the proper page alignment is up to the user.

- HOW MANY HARD COPIES OF EACH DISPLAY DESIRED?
(0 to 10, default = 1) Self-explanatory (semi-automatic mode only)

- INPUT ERROR [or similar message] - PRESS 'CONT'
Self-explanatory. Error messages are accompanied by a "beep".

- DO YOU WANT A GRAPHICS HARD COPY? ENTER Y FOR YES -
This allows the user to obtain a hard copy of the current graphics display. If Y is entered, a hard copy is produced and the prompt repeated to allow the user to obtain additional copies until NO is entered (default = NO).

- DO YOU WANT HARD COPY OF TC WARNING DATA - ENTER Y FOR YES -
Self-explanatory. Response process is similar to the above (default = NO).

- DO YOU WANT A HARD COPY OF TRACK? ENTER Y FOR YES -
Self-explanatory. Response process is similar to the above (default = NO).

- ENTER LAT,LONG OF SECONDARY POSIT TOWARD WHICH ROUTE IS TO BE DETERMINED
This prompt is displayed when the auto-route option has been selected and the ship's original projected track

exceeds the user specified critical probabilities. The user enters the ship's intended destination or secondary position toward which a sub-critical route is to be calculated by the program. This position should be within approximately 72-120 hours of the initial position. Enter latitude, longitude according to previous convention for ship positions.

- WIND PROBABILITIES AT SHIP'S INITIAL POSITION EXCEEDS CRITICAL PROBABILITIES - CRITICAL PROBABILITIES MUST BE CHANGED TO HIGHER VALUES TO CONTINUE AUTO-ROUTING - DO YOU WISH TO CONTINUE PROCESSING? ENTER Y FOR YES, N FOR NO - (Default = NO) The program has determined that the probabilities for the ship's position at the initial DTG already exceeds the critical values. This prompt allows the user the option of continuing or discontinuing the auto-route process.

- ENTER NEW CRITICAL PROBABILITIES OF 30 AND 50 KT WINDS Two values required separated by a comma. Range: 1 to 99, 1 to 99 (no defaults) - To continue the auto-route process, new (higher) critical probabilities must be entered.

- ENTER NEW CRITICAL PROBABILITY OF 15 FT SEAS [EX: 10] Enter new value. Range: 1-99 (no default) - To continue auto-route process, a new (higher) value must be entered.

- ENTER SHIP'S NEW SPEED (KT) [EX: 15] To allow user to change ship's speed during the auto-routing option if the wind probabilities at the ship's initial position is exceeded. (Range: 3 - 59 kt)

SECTION 5. ADDITIONAL INFORMATION AND LIMITATIONS

5.1 Additional Information.

a. Although the products are self-explanatory to a broad spectrum of viewers, the use and interpretation of the products can be applied most effectively when analyzed by a geophysicist familiar with the system. For a more detailed treatment of the technical aspects of wind probability forecasting the user is referred to the Contractor Reports listed in the references.

b. When TCASS is used in the semi-automatic mode, hard copies of the products are provided without user intervention. However, in the selective mode the user may choose whether or not to obtain a hard copy. User attention is necessary to position the paper using the PAPER ADVANCE or TOP OF FORM keys so that the products are not split at the page margin.

c. If at any time (except when input data is expected) the user desires a hard copy of the current graphics display, the PAUSE key may be depressed to stop the program temporarily. By typing in DUMP GRAPHICS and pressing the EXECUTE key, a hard copy is obtained. Processing is resumed by pressing the 'CONT' key.

d. When options 4 and 6 are selected in the SELECTIVE MODE and more than one ship track is processed, the last ship track entered is the one to be evaluated and auto-routed, if necessary.

e. In the auto-routing process (option 6), a direct route is initially attempted at decreasing speeds from the initial position toward the intended destination or secondary position which the user specifies. The speeds tested range from the ship's average speed, decreasing at 2 kt intervals, until the test speed is less than one-half the original average speed. If no speed along the direct route satisfies the critical probability criteria, then the alternate routing process is used in determining a satisfactory route. Alternate routes are tested at 10 degree intervals on either side of the direct route (to a maximum of 70 degrees relative to the direct course). Once a satisfactory route is found past the critical areas, the route turns back toward the intended destination. If no satisfactory route is found under these constraints the user is so informed and processing is terminated. TCASS may then be rerun, if desired, changing the ship's parameters such as average speed, intended destination, and/or critical probabilities in an effort to find a suitable route.

f. In the event the user wishes to abort execution of the program the STOP key should be pressed. To restart the program, the user should first insure that the computer is not in the graphics mode by entering EXIT GRAPHICS and pressing the EXECUTE key. The program can then be restarted by entering LOAD "TCASS",10 and pressing the EXECUTE key. The program retains the most recently entered TC warning data unless the power has been turned OFF.

5.2 Limitations.

a. The geographic background is currently limited to the area mentioned in subsection 3.1. However, the latitude, longitude grid is not constrained by these limits.

b. There are no land-sea discrimination capabilities within the auto-routing process; therefore, it is possible to obtain ship projected routes over land.

c. The wind and sea height probability calculations are restricted to tropical cyclone winds and seas only, and do not infer any winds or seas/swells from the existing large scale synoptic situation, such as the tightening of the gradient between the subtropical ridge and the tropical cyclone or the influence of local topography as the tropical cyclone approaches land.

d. Sea and swell conditions are important factors to consider in tropical cyclone threat situations. Sea height probability forecasting capabilities have been incorporated into this version of TCASS, but no sea/swell direction is implied.

e. The wind and sea height probabilities in TCASS are instantaneous probabilities of encountering 30 or 50 kt tropical cyclone winds and 15 ft seas, respectively. Time integrated (or cumulative) probabilities are not directly available.

APPENDIX A. EXAMPLES OF DYNAMIC MAP BACKGROUNDS

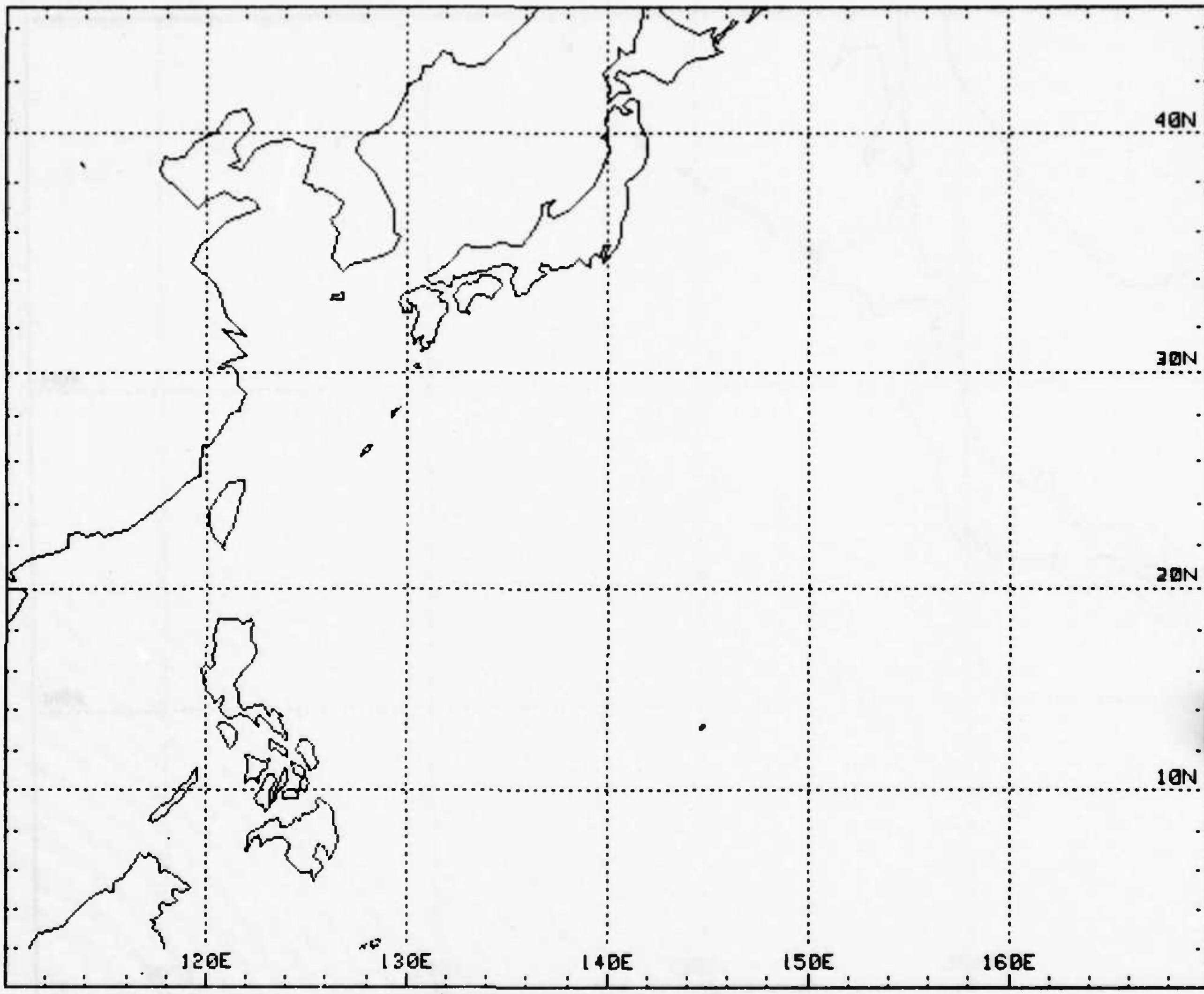


FIGURE A-01. Example of dynamic map background using reference latitude,longitude = 0°,110°E. Zoom factor = 2.

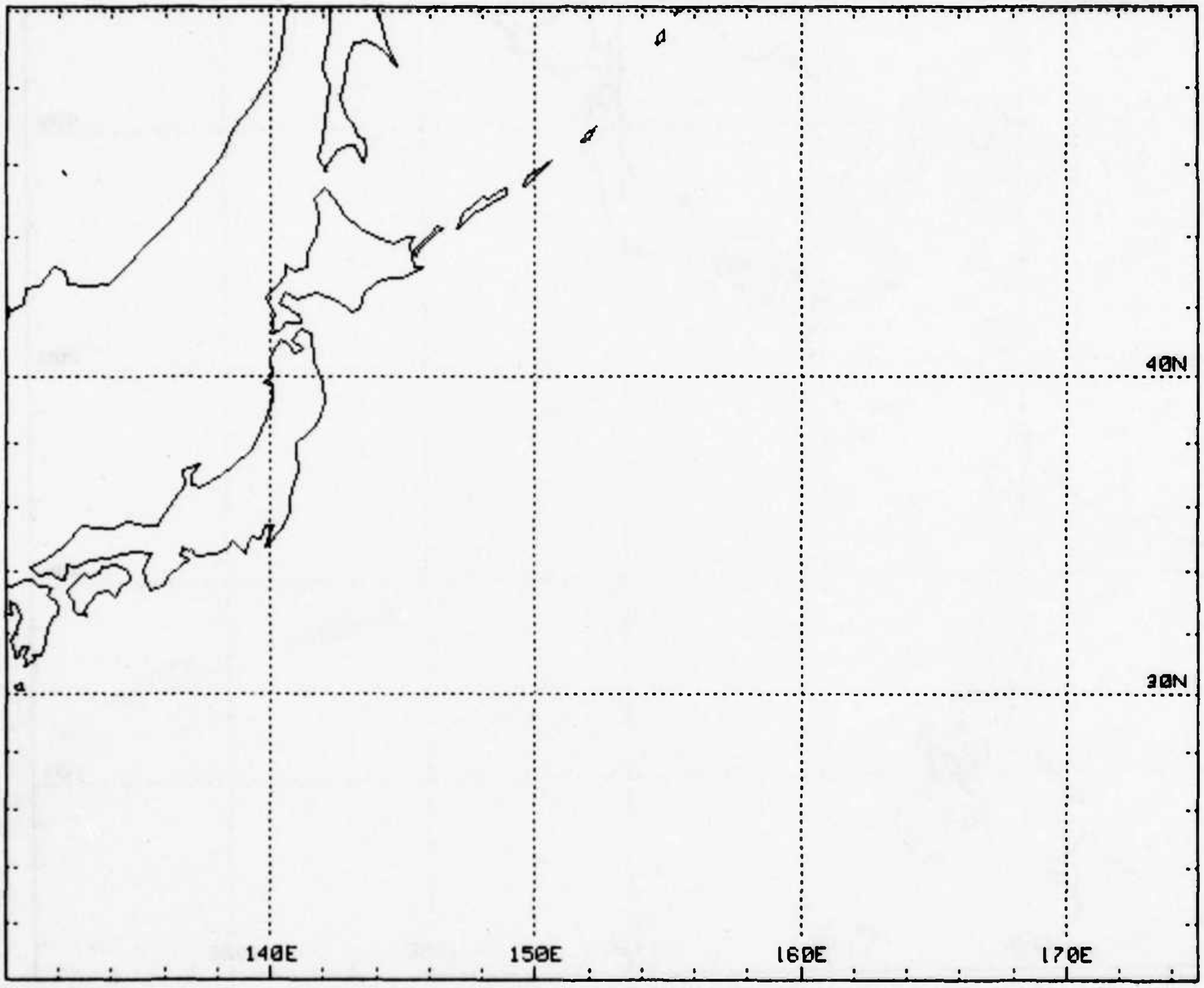


FIGURE A-02. Example of dynamic map background using reference latitude,longitude = 20°N,130°E. Zoom factor = 3.

APPENDIX B. MAKING AN EXECUTABLE PROGRAM TAPE

1. Insert a blank tape cassette into the right cassette tape drive (T15). Be sure the RECORD lock on the cassette is in the RECORD position (in direction of arrow).

2. If the blank tape cassette has not been initialized, type in INITIALIZE ":T15" and press the EXECUTE key.

3. Insert the TCASS tape cassette into the left cassette tape drive (T14).

4. Type in GET "AUTOST:T14" and press the EXECUTE key. When the program is loaded, enter STORE "AUTOST" and the AUTOST program will be stored on the right cassette tape.

5. Repeat 4. above for the program named "TCASS".

6. Repeat 4. above for the program segment named "BKGDWP".

7. Repeat 4. above for the program segment named "SHIPW".

8. Repeat 4. above for the program segment named "BKW2".

9. Enter COPY "WPDAT:T14" TO "WPDAT:T15" and press the EXECUTE key. This will copy the data file "WPDAT" onto the right hand cassette tape.

10. Repeat 4. above for the program segment named "PARAM".

11. Enter COPY "WINDY:T14" TO "WINDY:T15" and press the EXECUTE key to copy the data file "WINDY" onto the right hand cassette tape.

12. Repeat 4. above for the program segment named "WPW".

13. Upon completion of the above steps, the tape in the right cassette drive is an executable copy.

APPENDIX C. ADDITIONAL EXAMPLES

This appendix contains additional examples of graphic displays obtained in the selective mode with a brief description of the scenario and options used in producing the displays.

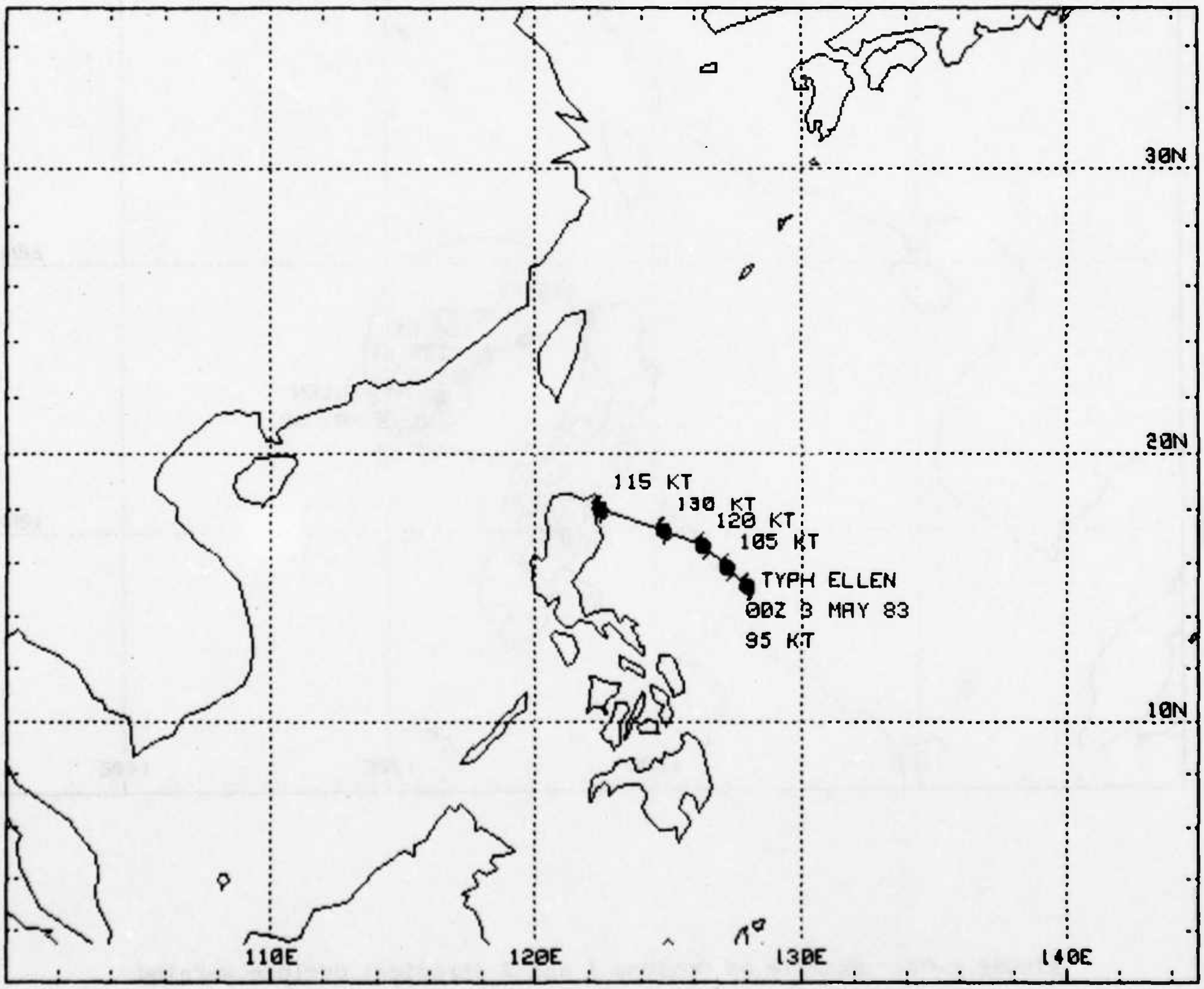


FIGURE C-01. Example of Option 1 only (tropical cyclone warning display) for Typhoon Ellen on the South China Sea predesignated map background.

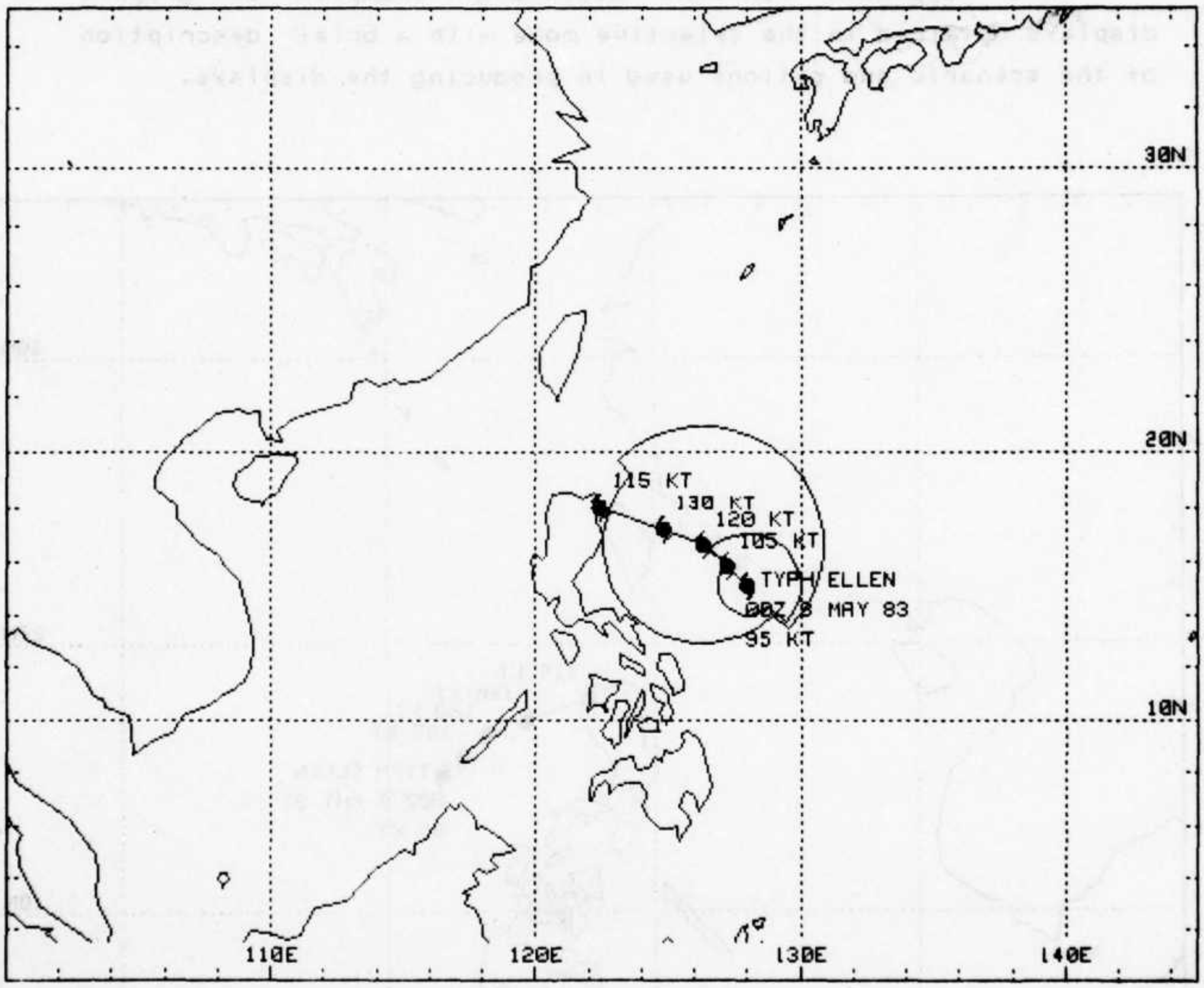


FIGURE C-02. Example of Options 1 and 2 (tropical cyclone warning and danger area) displays for Typhoon Ellen on the South China Sea map background.

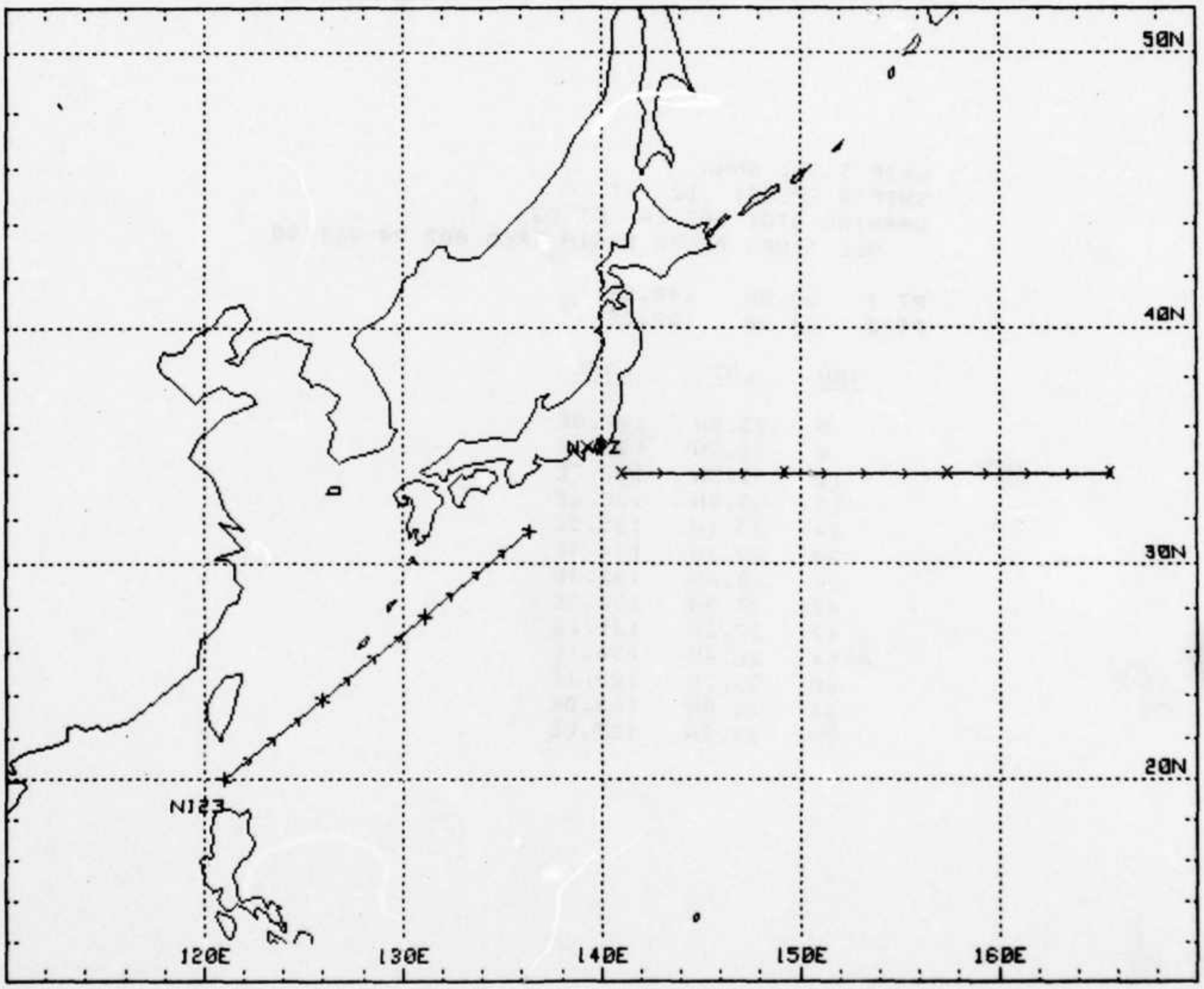


FIGURE C-03. Example of two ship tracks plotted in the selective mode using Option 3 only. No warnings in effect. Predesignated map background of the Okinawa-Japan area used. Alphanumeric listings of the ship tracks are also available.

SHIP'S ID: NNNX
SHIP'S SPEED: 12 KT
WARNING DTG: 00Z 24 OCT 83
ALL TIMES BELOW BEGIN FROM 00Z 24 OCT 83

PT 1 33.0N 140.0E
PT 2 24.2N 127.0E

TAU	LAT	LONG
0	33.0N	140.0E
6	32.3N	138.9E
12	31.5N	137.7E
18	30.8N	136.6E
24	30.1N	135.5E
30	29.3N	134.4E
36	28.6N	133.3E
42	27.9N	132.3E
48	27.2N	131.2E
54	26.4N	130.1E
60	25.7N	129.1E
66	25.0N	128.0E
72	24.2N	127.0E

FIGURE C-04. Example of alphanumeric listing of ship's track at 6 hour intervals.

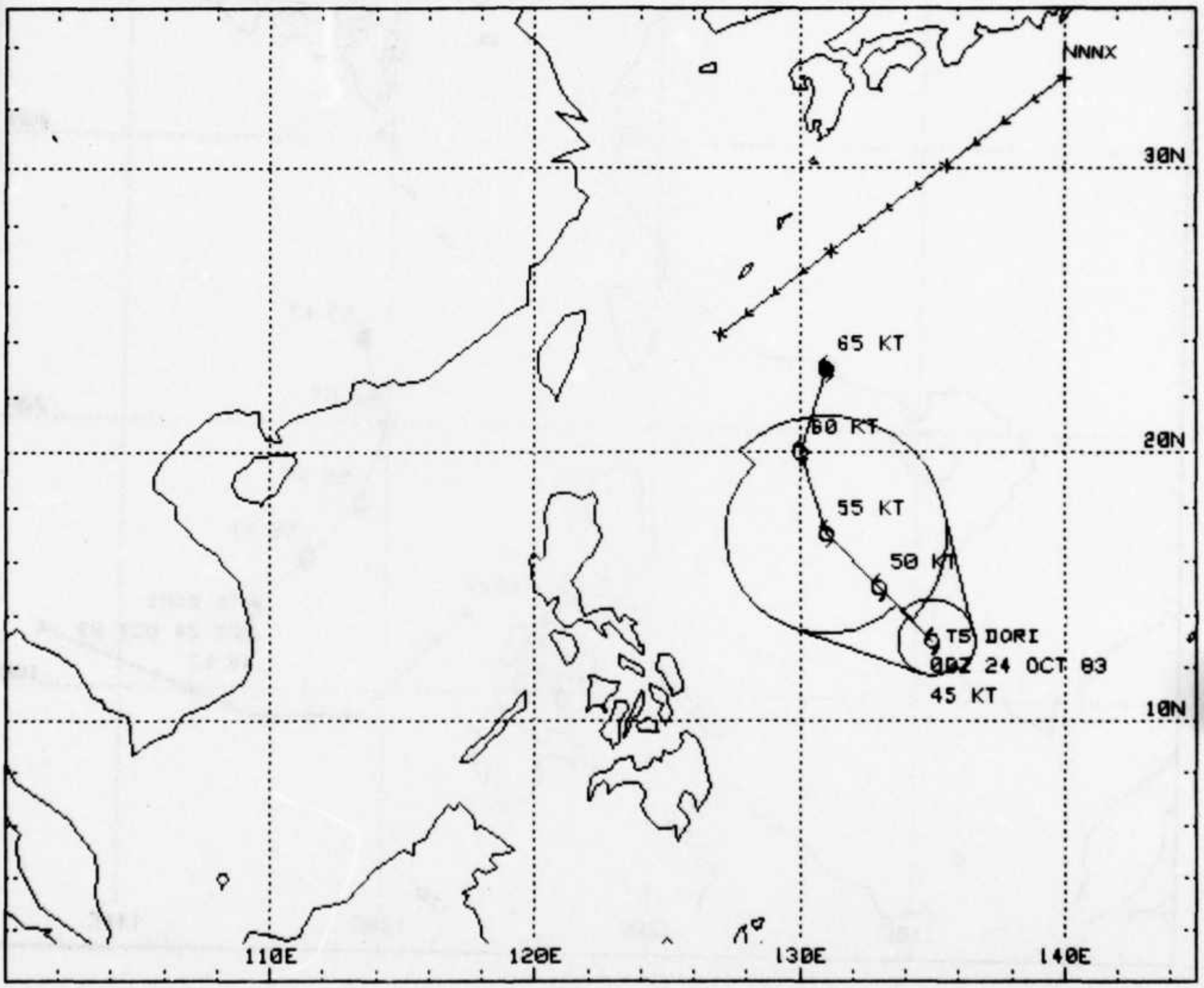


FIGURE C-05. Example of Options 1, 2, and 3 (tropical cyclone warning, danger area, and ship track plot, respectively) display.

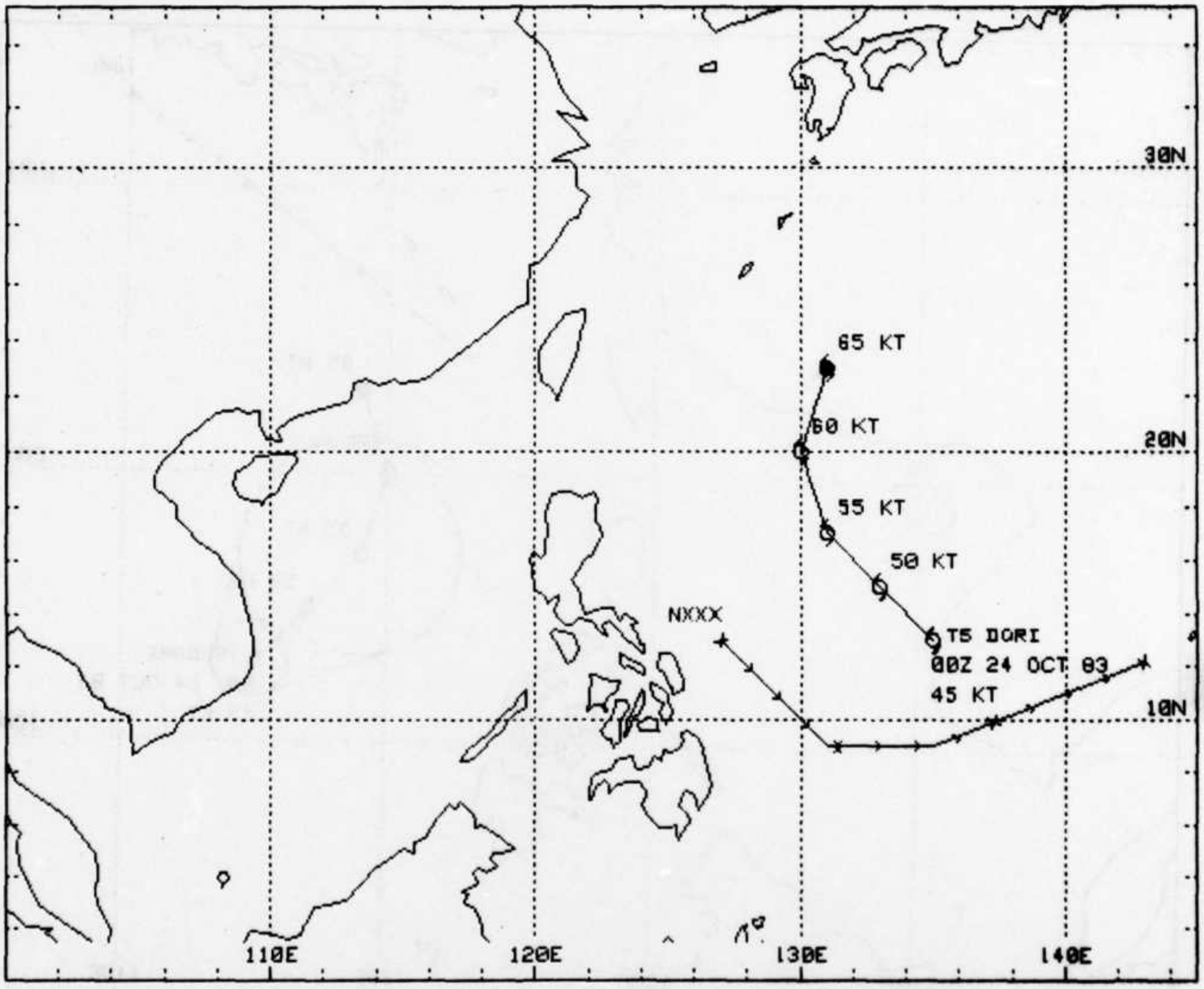


FIGURE C-06. Example of a ship's projected track plotted in the selective mode using Options 1, 3 and 4 with a warning in effect. The ship's track is plotted as an evasion route to be evaluated using Option 4. Alphanumeric listings of the ship's track and the wind/sea height probabilities along the track are also available (Options 3 and 4). Predesignated map background of the South China Sea area used.

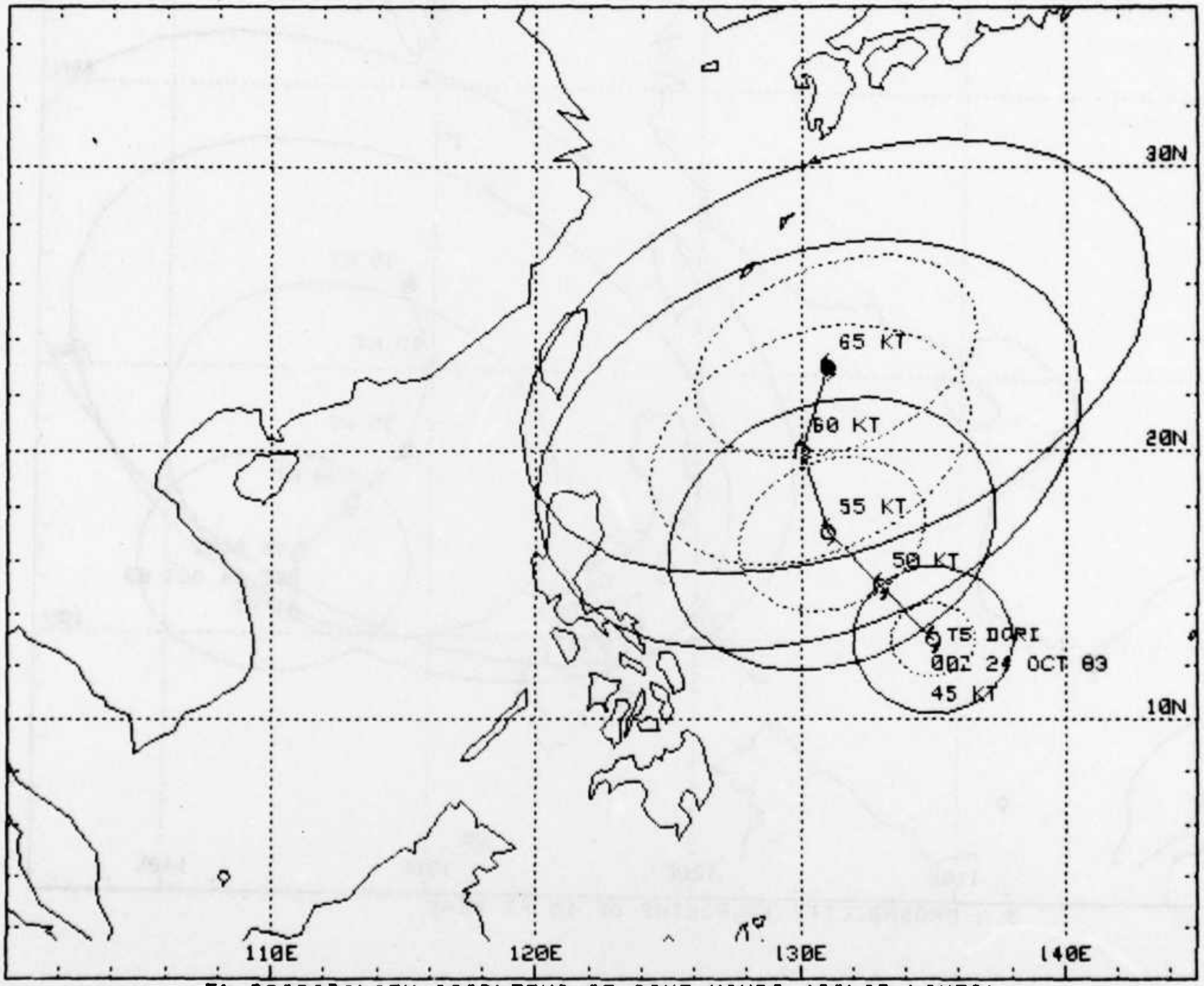


FIGURE C-07. Example of 5% probability isopleths of 30 kt winds (solid lines) and 3% probability isopleths of 50 kt winds (dashed lines) at 24 hour intervals. Options 1 and 5 selected using the South China Sea map background.

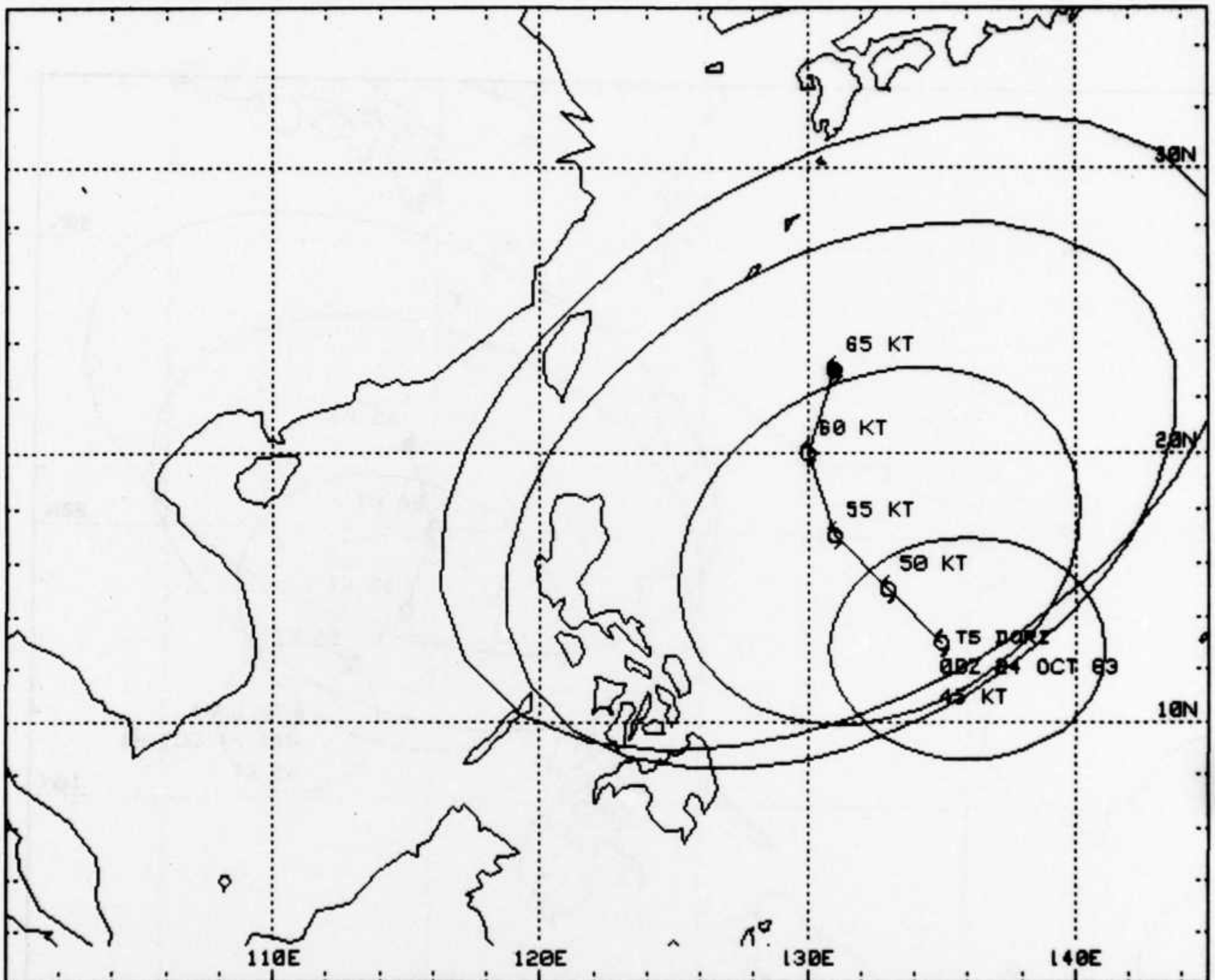


FIGURE C-08. Example of 5% probability isopleths of 15 ft seas at 24 hour intervals using the South China Sea map background. Options 1 and 5 selected.

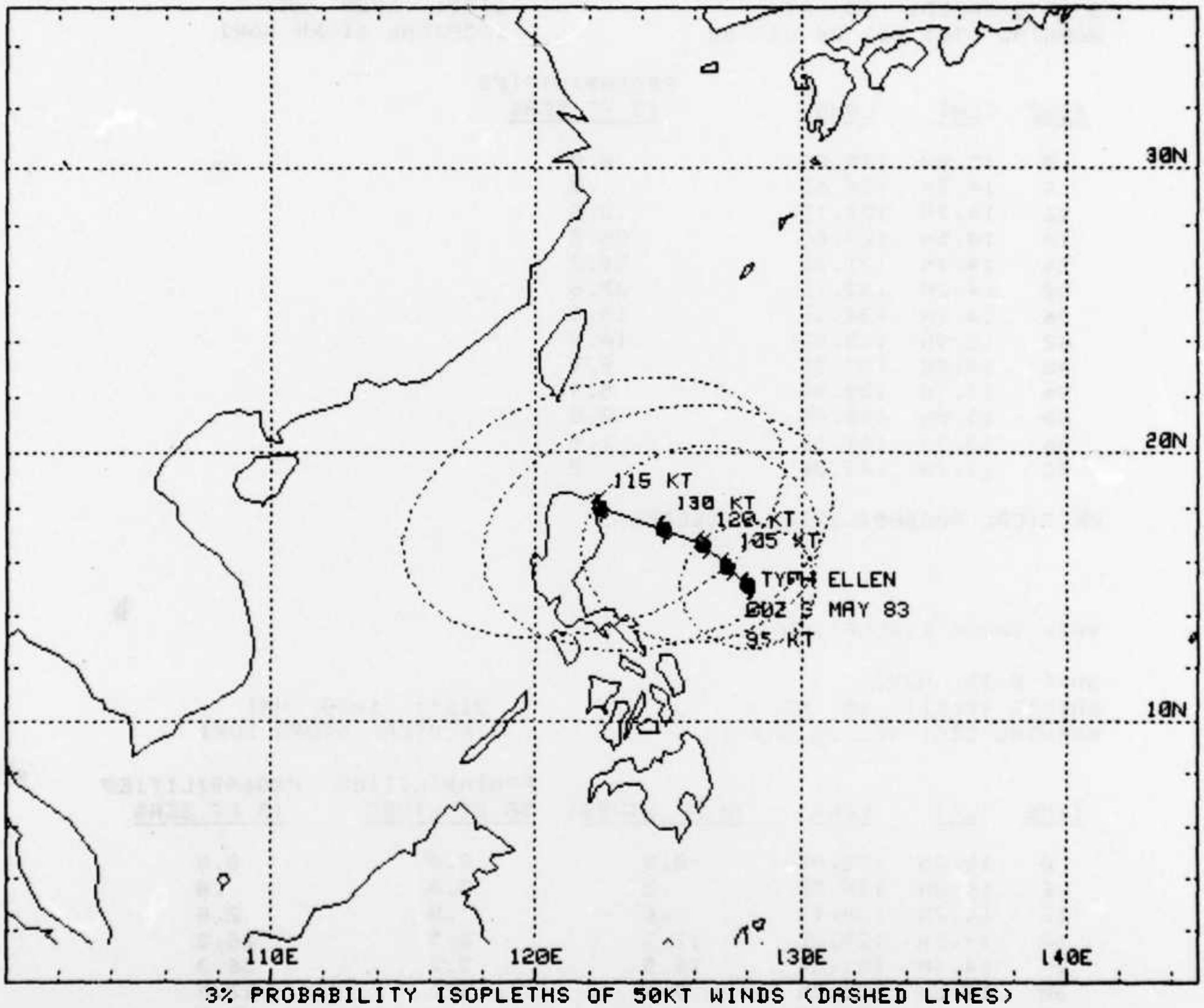


FIGURE C-09. Example of 3% probability isopleths of 50 kt winds (dashed lines) at 24 hour intervals for Typhoon Ellen. For the South China Sea predesignated map background using Options 1 and 5.

SHIP TRACK EVALUATION **a**

SHIP'S ID: SHIP
SHIP'S SPEED: 15 KT DIST: 1080 NMI
WARNING DTG: 00Z 24 OCT 83 TROPICAL STORM DORI

TIME	LAT	LONG	PROBABILITIES 15 FT SEAS
0	15.0N	125.0E	0.0
6	14.8N	126.5E	.0
12	14.7N	128.1E	2.6
18	14.5N	129.6E	26.5
24	14.4N	131.2E	36.3
30	14.2N	132.7E	27.6
36	14.1N	134.2E	19.6
42	13.9N	135.8E	14.8
48	13.8N	137.3E	9.9
54	13.6N	138.9E	5.4
60	13.5N	140.4E	2.8
66	13.3N	141.9E	1.4
72	13.2N	143.5E	.8

CRITICAL PROBABILITIES EXCEEDED

SHIP TRACK EVALUATION **b**

SHIP'S ID: NXYZ
SHIP'S SPEED: 15 KT DIST: 1080 NMI
WARNING DTG: 00Z 24 OCT 83 TROPICAL STORM DORI

TIME	LAT	LONG	30 KT WINDS	PROBABILITIES 50 KT WINDS	PROBABILITIES 15 FT SEAS
0	15.0N	125.0E	0.0	0.0	0.0
6	14.8N	126.5E	.3	0.0	.0
12	14.7N	128.1E	.6	.0	2.6
18	14.5N	129.6E	17.3	2.5	26.5
24	14.4N	131.2E	18.5	3.2	36.3
30	14.2N	132.7E	9.1	1.2	27.6
36	14.1N	134.2E	4.0	.4	19.6
42	13.9N	135.8E	2.2	.2	14.8
48	13.8N	137.3E	1.3	.1	9.9
54	13.6N	138.9E	.6	.0	5.4
60	13.5N	140.4E	.2	.0	2.8
66	13.3N	141.9E	.1	.0	1.4
72	13.2N	143.5E	.0	.0	.8

FIGURE C-10. Example of alphanumeric listing of track evaluation of ship NXYZ for (a) 15 ft sea height probabilities and (b) wind and sea height probabilities.

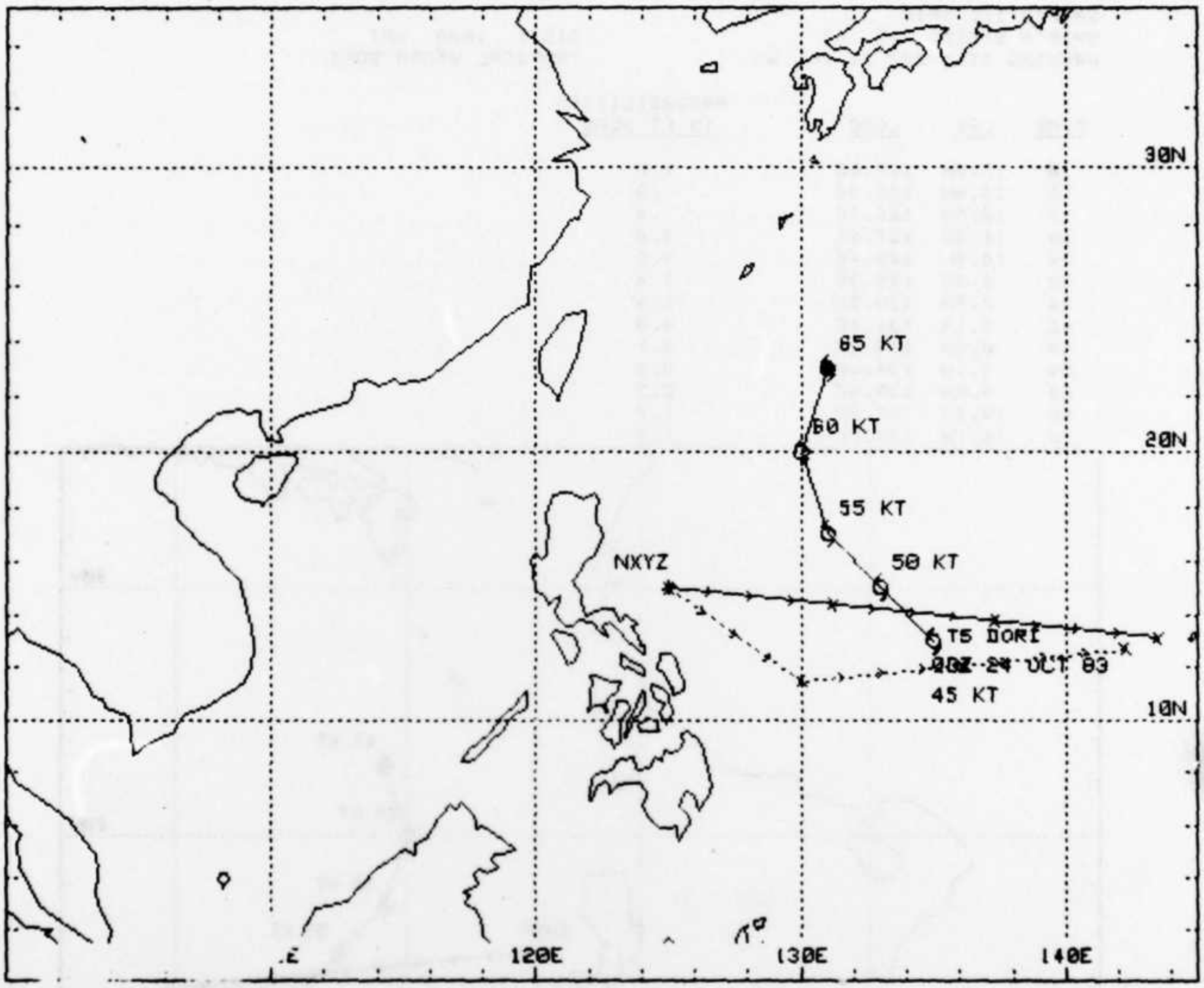


FIGURE C-11. Example of original intended track of ship NXYZ (solid line) which exceeds critical wind probabilities. Also shown is Alternative route determined by program (dashed lines) which does not exceed critical values. Options 1, 3, 4, and 6 selected.

ALTERNATE ROUTE
BEGINNING POSITION: 15.0N 125.0E
INTENDED POSITION: 13.0N 145.0E

SHIP'S ID: SHIP
SHIP'S SPEED: 15 KT — DIST: 1080 NMI
WARNING DTG: 00Z 24 OCT 83 — TROPICAL STORM DORI

TIME	LAT	LONG	PROBABILITIES 15 FT SEAS
0	15.0N	125.0E	0.0
6	13.8N	125.9E	.0
12	12.5N	126.7E	.4
18	11.3N	127.6E	3.0
24	10.0N	128.4E	3.2
30	8.8N	129.3E	3.4
36	7.5N	130.2E	2.4
42	8.1N	131.6E	3.8
48	8.6N	133.0E	3.7
54	9.1N	134.4E	3.0
60	9.6N	135.8E	2.3
66	10.2N	137.3E	1.7
72	10.7N	138.7E	1.2

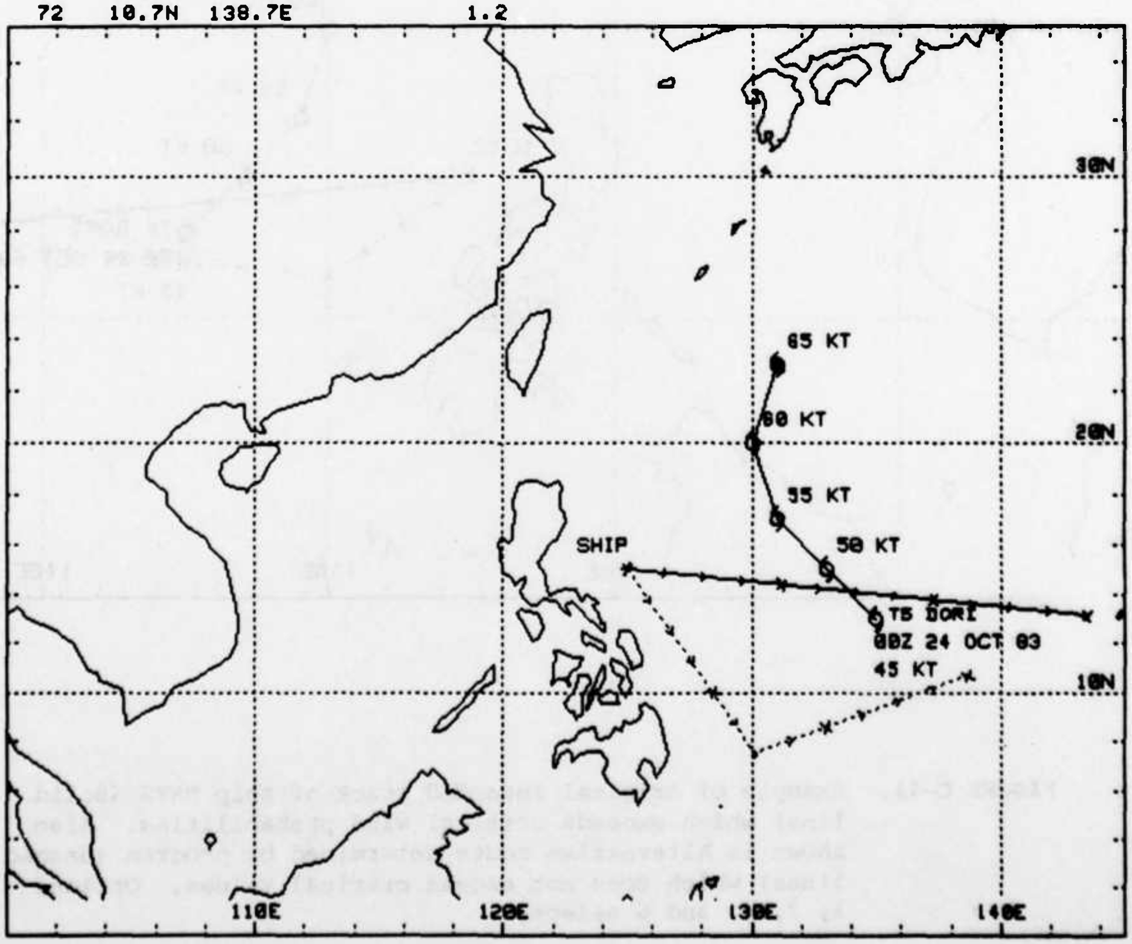


FIGURE C-12. Example of tropical storm and ship's original intended track (solid line) which exceeds the critical probabilities of 15 ft seas. Shown also is the program generated alternative route (dashed lines) which is sub-critical and the six hourly positions of the alternate route.

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