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Typhoon Havens Handbook for the Western Pacific and Indian Oceans, Change 3

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1. Discard all front matter. Replace with equivalent Change 3 pages i-xii.
2. Discard Appendixes I-A,B,C,D that follow Section I in basic volume.
3. Discard all Section V (Japan). Replace with Change 3 pages V-1--V-241.
4. Add Change 3 Appendixes A,B,C,D at end of handbook following Section XV.
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Thirty-one ports in the western Pacific and Indian oceans are evaluated to describe their potentials as havens for ships threatened by typhoons. These evaluations are designed to serve as decision-making aids for force commanders, ship captains, and ship-routing personnel. A general introductory section describes tropical cyclones and discusses ship performance in storms, warning services, and calculation of danger zones. Mean storm tracks for four ocean areas are depicted in appendices.

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FOREWORD

This publication originally was developed in response to a COMSEVENTHFLT request that certain ports in the western Pacific and Indian Oceans be evaluated as potential havens for ships threatened by typhoons.

Incorporating thirty-one port studies in a single reference work, the Handbook is designed to be a decision-making aid for force commanders, ship captains, ship-routing personnel, and others responsible for planning and accomplishing storm evasions in the vicinities of the ports evaluated.

Every effort has been made to make this Handbook as concise as possible, yet sufficiently comprehensive to cover most contingencies that might be encountered under actual or threatened typhoon conditions affecting the ports.

Some of the earlier port studies were undertaken as thesis projects by officer-students in the meteorology curriculum at the Naval Postgraduate School in Monterey, and were condensed for inclusion herein. Subsequent studies were developed expressly for this volume. More recently, in the early 1990's, additional port have been added while some older studies have been updated.

Copies of the first printing were widely distributed to units and facilities afloat and ashore, and are no longer available in the original looseleaf-binder format. Since then, several reprint versions duplicate the material that appeared in the complete first printing. Change 3 provides a revised Section V (Japan) plus some minor format revisions.

INTRODUCTION

Severe tropical cyclones, also known as typhoons or hurricanes, are among the most destructive weather phenomena a ship may encounter whether the ship be in port or at sea. When faced with an approaching tropical cyclone, a timely decision regarding the necessity and method of evasion must be reached. Basically, the question is: Should the ship remain in port, evade at sea, or if at sea, should it seek the shelter offered by the harbor? This Handbook examines a number of western Pacific and Indian Ocean ports and evaluates their potential as typhoon havens. This information should provide useful guidance to commanding officers in answering the above questions.

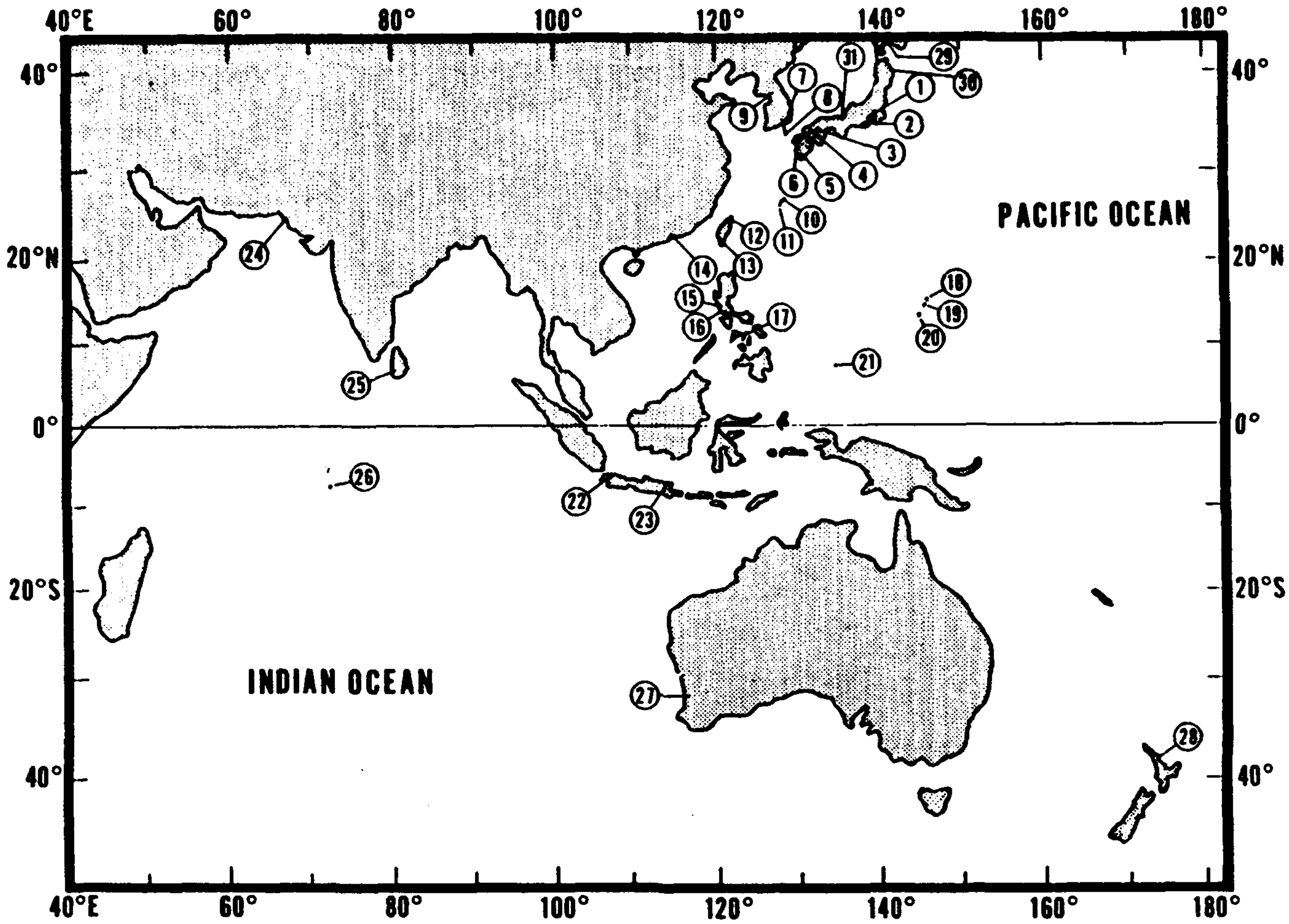
In general it is an oversimplification to label a harbor as merely good or bad. Consequently, an attempt is made to present enough information about the harbors to aid a commanding officer in reaching a sound decision with respect to the ship. The decision should not be based on the expected weather conditions alone, but also on the ship itself, as well as characteristics of the harbor. These characteristics include: natural shelter provided, port congestion, and support facilities (normal and emergency) available.

Chapter I presents a general description of tropical cyclones and the environmental phenomena associated with them. Discussion of ship performance under tropical cyclone conditions, and details of tropical cyclone warnings are also given.

Each remaining chapter presents information about a particular geographical area including details of individual ports and harbors, local topographical influences on tropical cyclones, and helpful guidelines for the decision-making process of whether to sortie or remain in port.

On the basis of the studies conducted in the development of this Handbook, each port considered has been given a adjective rating of its suitability as a typhoon haven. These ratings are presented as Table 1.

INTRODUCTION



1 - Yokosuka
2 - Numazu
3 - Kure
4 - Iwakuni
5 - Kagoshima
6 - Sasebo
7 - Pusan
8 - Chinhae
9 - Inchon
10 - Buckner Bay
11 - Naha
12 - Chilung
13 - Kaohsiung
14 - Hong Kong
15 - Subic Bay
16 - Manila
17 - Cebu
18 - Saipan
19 - Tinian
20 - Guam
21 - Palau
22 - Jakarta
23 - Surabaya
24 - Karachi
25 - Colombo
26 - Diego Garcia
27 - Fremantle
28 - Auckland
29 - Muroran
30 - Hachinohe
31 - Maizuru

Figure 1. Locator map of western Pacific and Indian Ocean ports evaluated as typhoon havens.

Table 1. Ratings of western Pacific and Indian Ocean ports evaluated as typhoon havens.

GUAM	
APRA HARBOR	POOR
TAIWAN	
KAOHSIUNG	POOR
CHILUNG (KEELUNG)	POOR
HONG KONG	
HONG KONG HARBOR	POOR
JAPAN	
YOKOSUKA	GOOD
NUMAZU OPERATING AREA	POOR
IWAKUNI	MARGINAL (but has easily accessible anchorages close by which are considered good)
KURE	GOOD
SASEBO	GOOD (except for carriers)
KAGOSHIMA	POOR
BUCKNER BAY, OKINAWA	POOR
NAHA, OKINAWA	POOR
MURORAN	POOR
HACHINOHE	POOR
MAIZURU	GOOD (except for large ships)
PHILIPPINE ISLANDS	
SUBIC BAY	MARGINAL TO POOR
MANILA	POOR
CEBU	POOR

INTRODUCTION

Table 1 (con't)

KOREA

INCHON . . . . POOR (unless shelter is available in the tidal basin; then it would be considered a good haven)

PUSAN . . . . POOR

CHINHAE . . . . MARGINAL (but has easily accessible anchorages close by which are considered good)

SRI LANKA

COLOMBO . . . . GOOD

PAKISTAN

KARACHI . . . . MARGINAL

NEW ZEALAND

AUCKLAND . . . . GOOD TO MARGINAL

AUSTRALIA

FREMANTLE . . . . MARGINAL (unless shelter is available in Cockburn Sound or the inner harbor; then it would be considered good)

DIEGO GARCIA

DIEGO GARCIA HARBOR . . . . POOR

PALAU . . . . POOR

SAIPAN . . . . POOR

TINIAN . . . . POOR (but marginal for small ships)

INDONESIA

JAKARTA . . . . UNAFFECTED

SURABAYA . . . . UNAFFECTED

V JAPAN

1. GENERAL

Japan is an island nation in the western part of the North Pacific Ocean off the eastern coast of the Asiatic mainland consisting of a chain of islands extending in an arc from northeast to southwest. The four main islands of Japan from north to south are Hokkaido, Honshu, Shikoku and Kyushu. Hundreds of smaller islands lie off the coasts of the main ones.

Honshu is the largest of the main Japanese Islands. Yokosuka, a major port city in southeast Honshu, is used continuously by the U.S. Navy. It is currently homeport for a number of SEVENTH FLEET units. The Numazu Operating Area in south central Honshu is used routinely by the U.S. Navy. Additionally, commercial shipping firms utilize three small harbors in the Numazu area. Iwakuni and Kure are located in the southwestern region of Honshu. Hachinohe is located on the northwestern coast of Honshu and Maizuru on the central eastern coast.

Kyushu is the third largest and the southernmost major island land mass of Japan. The two major ports of interest for the U.S. Navy on this island are Sasebo and Kagoshima.

The port of Muroran is located on the northernmost island, Hokkaido, on the southern coast.

Okinawa is located approximately 350 nmi south of Kyushu and has two major ports of interest to DOD vessels, Buckner Bay and Naha.

A detailed description of the coasts and harbors of Japan can be found in the Sailing Directions (Enroute), Pub. No. 156.

2.0 **YOKOSUKA**

SUMMARY

The conclusion reached in this study is that the port of Yokosuka is a "safe" typhoon haven; a port in which to remain if already there or one in which to seek shelter if at sea when threatened by a typhoon. The primary factors in reaching this conclusion are:

(1) The port provides shelter from wind and sea due to the surrounding land masses.

(2) Wave action induced by typhoons is negligible in most parts of the port.

(3) Storm surge has a negligible effect.

(4) The orientation of the berths and drydocks with respect to the local topography is good.

(5) The extensive experience level and the high degree of competence of Port Services personnel.

(6) The history of the port. Conversations with employees of Fleet Activities, Yokosuka, civilian Japanese authorities, and Japanese Maritime Self Defense Forces (JMSDF) personnel indicate that there is no need for properly moored U. S. Navy, JMSDF, or merchant ships to sortie from the port of Yokosuka during a typhoon.

(7) Except for aircraft carriers, the only situations in which the port would not be a safe haven is when a very intense typhoon (>120 kt) passed directly over or within 100 nmi to the northwest of Yokosuka. For aircraft carriers, if a berth shift to drydock 6 is not feasible, a sortie from Yokosuka is recommended when Tropical Cyclone condition of Readiness Three (48 hours) is set for sustained winds of 75 kt or greater at Naval Oceanography Command Facility, Yokosuka.

2.1 LOCATION AND TOPOGRAPHY

The port of Yokosuka is located at 35°17'N, 139°40'E on the southeast coast of Honshu, the largest of the four main Japanese islands. The U. S. Navy port is situated adjacent to the central part of the Miura Peninsula on the southwest side of landlocked Tokyo Bay. See Figure V-1. A separate, commercial port of Yokosuka is located southeast of the U. S. Navy port.

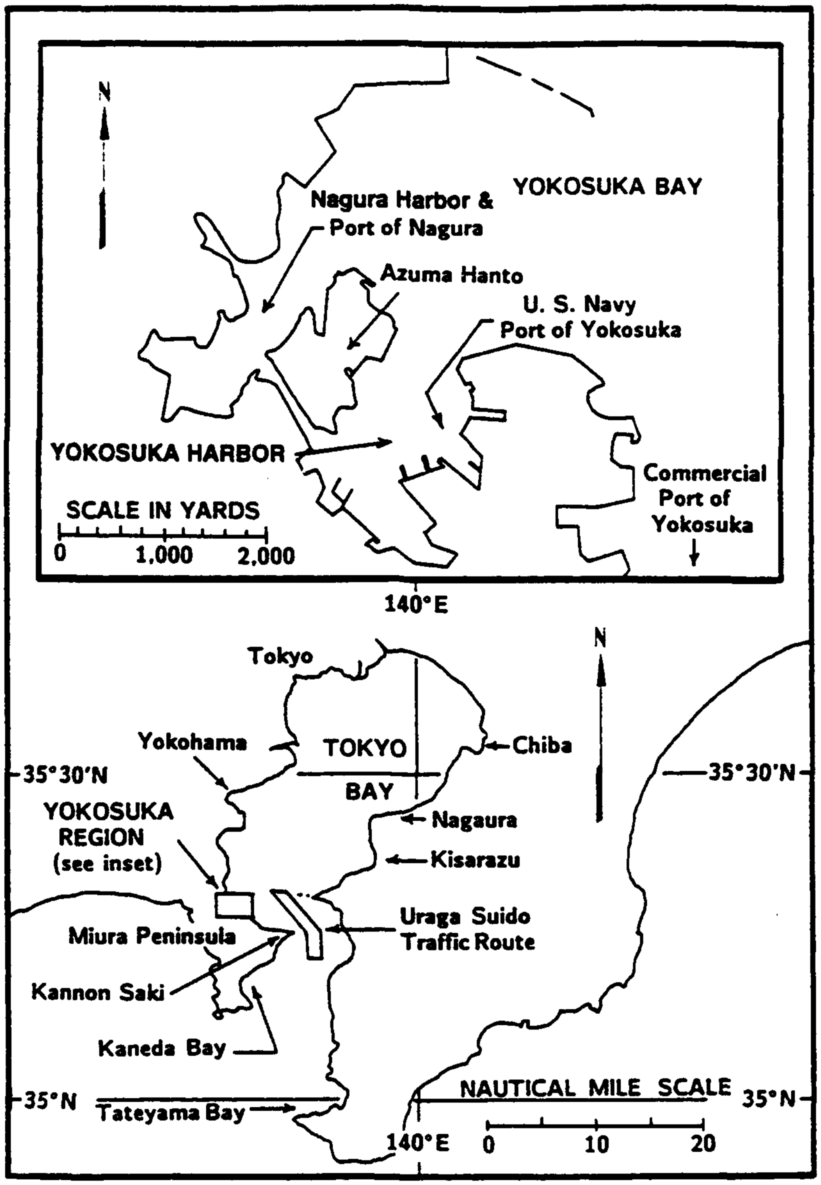


Figure V-1. Tokyo Bay and the surrounding land area. See inset for enlargement of Yokosuka region.

YOKOSUKA

Yokosuka is one of three major ports in the area; the ports of Yokohama and Tokyo are also located on Tokyo Bay. The harbor of Yokohama, a large commercial port, is about 10 nmi north of Yokosuka Bay, and Tokyo Harbor is about 20 nmi north-northeast of Yokosuka. Tokyo Bay is relatively large, being about 35 nmi long from north to south and, except for its 4.75 nmi wide southern entrance, is surrounded by land. Over 200 ships transit Uraga Suido, the entrance to Tokyo Bay, daily.[1]

The terrain immediately adjacent to Tokyo Bay is low, but high mountains dominate Honshu to the west and northwest (Figure V-2). The mountains of north central Honshu average 5,000 to

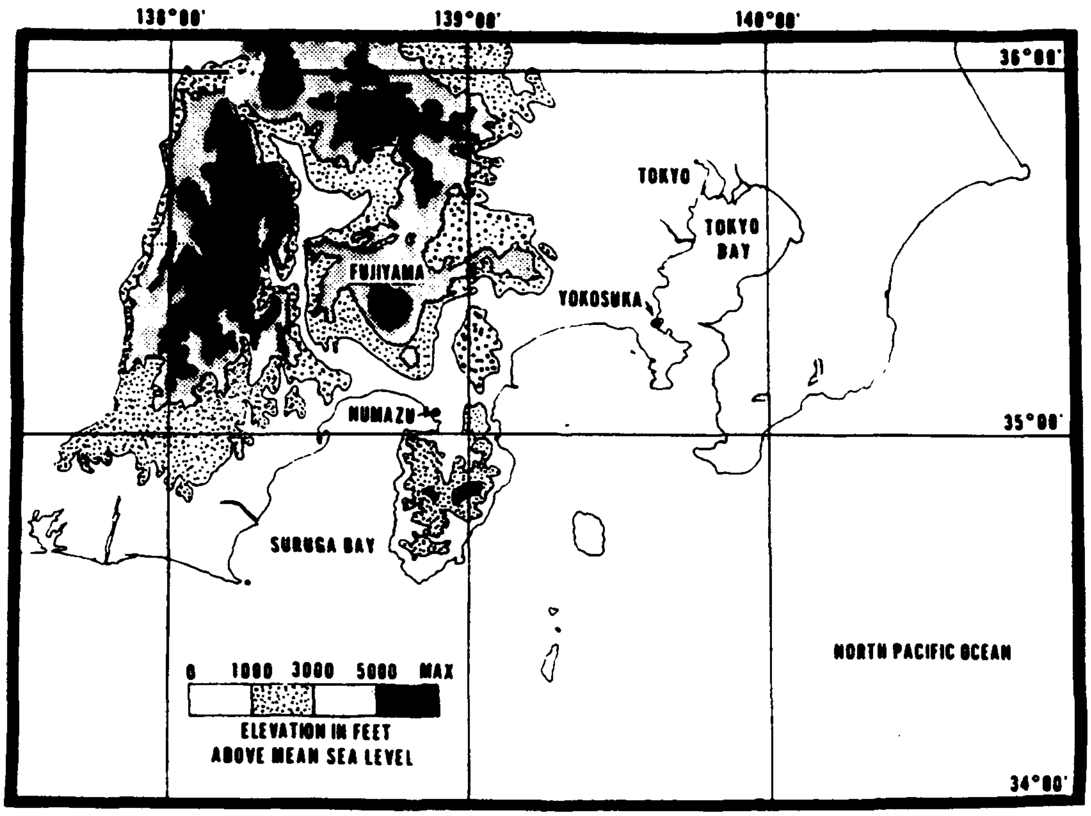


Figure V-2. Topography of central Honshu.

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[1] Uraga Suido is a controlled traffic route, one of several controlled routes established by the Japanese Maritime Safety Agency to regulate shipping traffic in highly congested areas in an effort to avert marine accidents.

10,000 ft (1,524 to 3,048 m) in height and are often called the Japanese Alps. The highest mountain, 12,395 ft (3,778 m) Fujiyama, is located 60 mi due west of Yokosuka. Northern and southern Honshu's terrain is less rugged; southern Honshu has no peaks rising over 5,000 ft (1,524 m). The mountainous terrain of Honshu greatly influences the weather at Yokosuka.

2.2 YOKOSUKA HARBOR

Yokosuka Harbor is entered through Yokosuka Bay in the southwestern part of Tokyo Bay. The harbor is bounded on the east by part of the Miura Peninsula, which is the site of U. S. Fleet Activities (FLEACTS) Yokosuka, and on the west by the island of Azuma Hanto (Figure V-1). Azuma Hanto separates Yokosuka Harbor from Nagura Harbor which is a commercial port and is also used by the Japanese Maritime Self Defense Force (JMSDF). Nagura Harbor is entered from the southwestern part of Yokosuka Bay. A small, narrow channel separates Azuma Hanto at its southwestern end from the mainland.

The entrance to the harbor is about 440 yd (400 m) wide between the 5-fathom (10 m) curves. Depths in the harbor range from 12 fathoms (22 m) in the harbor entrance to less than 4 fathoms (7 m) at the south end. Harbor configuration is shown in Figure V-3. Extensive dredging was in progress at various Navy berths in November 1992 and, when completed in 1993, will result in the following project depths adjacent to the berths as indicated below:

Berth B-1	36 ft
Berths B-2, B-3, B-4(S and N), B-6 B-7, B-8, B-9, B-10, and Harbor Master Pier (E and W)	38 ft
Berths B-11 and B-12	41 ft

A pilot is required when proceeding into or out of dry docks. Pilot services are recommended for all vessels over 5,000 tons and for those with a single screw when maneuvering in the

YOKOSUKA

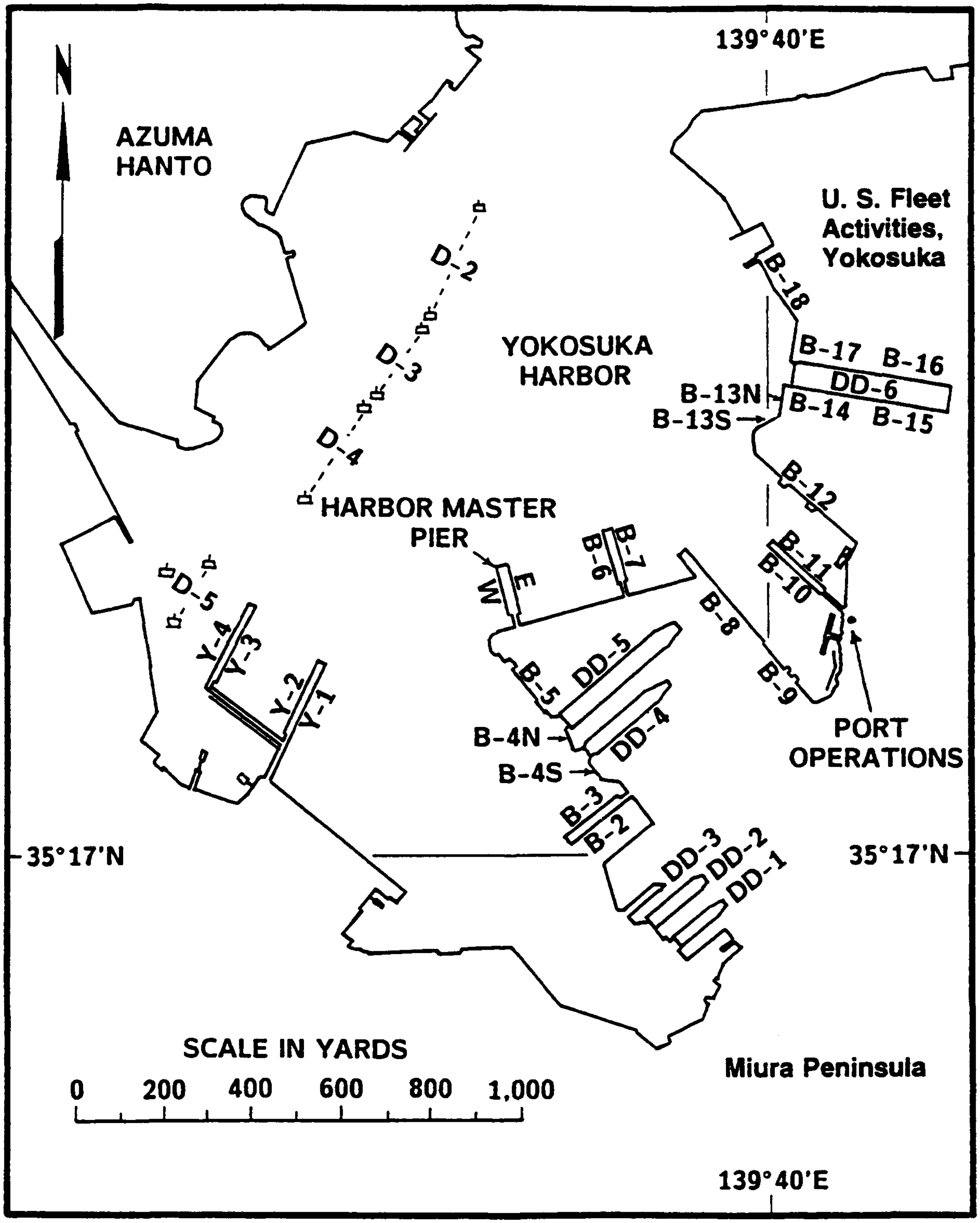

Figure V-3. Harbor configuration of Fleet Activities, Yokosuka.

harbor. The harbor can accommodate about 12 to 15 ships of various types at any one time[2]. An average of about 35 to 40 ships enter or leave the port each month.

2.3 TROPICAL CYCLONES AFFECTING YOKOSUKA

2.3.1 Tropical Cyclone Climatology at Yokosuka

Tropical cyclones which affect Japan generally form in the area bounded by 5°N to 30°N and 120°E to 165°E. The latitudinal boundaries shift poleward during the summer months and then equatorward in winter in response to the seasonal changes of the synoptic environment.

For the purpose of this study, any tropical storm or typhoon approaching within 180 nmi of Yokosuka is considered to represent a threat to the port. Table V-1 contains a descriptive history of all tropical storms and typhoons passing within 180 nmi of Yokosuka during the 47-year period 1945-1991. All of the tropical cyclone statistics used in this report for storms passing within 180 nmi of Yokosuka are based on the SAIC generated data set used to compile Table V-1.

The primary tropical cyclone season for Yokosuka is from June to October, although historically they have occurred in all months in the genesis area described in a preceding paragraph. As shown in Table V-2, only a few storms passing within 180 nmi of Yokosuka have occurred as early as May and as late as November since 1945, and none during the months of December through April. Table V-2 also shows the motion history of the 115 tropical storms and typhoons which passed within 180 nmi of Yokosuka during the period 1945-1991. Approximately one of every three tropical cyclones passing within 180 nmi of Yokosuka is of at least minimum typhoon strength (≥64 kt) at CPA. The average movement for the storms at CPA is 041° at 27 kt.

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[2] The trend toward larger and wider ships has reduced the overall ship loading capacity of the port at any one time.

YOKOSUKA

Table V-1. Descriptive history of the 115 tropical storms and typhoons passing within 180 nmi of Yokosuka during the 47-year period 1945-1991.

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAXIMUM WIND AT STORM CENTER	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
1	OPAL	1945	JUL	21	6	37	81 (ESE)	024/15.2
2	GRACE	1945	AUG	22	12	40	165 (SE)	320/ 9.1
3	IDA	1945	SEP	18	18	55	53 (NW)	056/31.5
4	KATE	1945	OCT	5	22	43	16 (ESE)	137/47.3
5	LOUISE	1945	OCT	11	23	47	105 (WNW)	027/32.2
6	GWEN	1947	AUG	7	7	40*	37 (SSE)	078/19.2
7	KATHLEEN	1947	SEP	15	11	52*	2 (NNE)	041/19.3
8	BERTHA	1948	AUG	6	8	38*	101 (E)	009/10.1
9	IONE	1948	SEP	16	14	77	14 (NNW)	046/26.0
10	LIBBY	1948	OCT	6	17	60*	45 (SSE)	067/21.1
11	AGNES	1948	NOV	19	23	53	14 (SSE)	059/32.2
12	HESTER	1949	JUL	28	6	20	155 (W)	006/12.0
13	KITTY	1949	AUG	31	9	58*	11 (W)	358/19.1
14	PATRICIA	1949	OCT	27	17	85	153 (SE)	054/34.8
15	JANE	1950	SEP	3	8	58	176 (NW)	032/27.7
16	MISSATH	1950	SEP	19	11	48	74 (ESE)	028/38.9
17	RUBY	1950	OCT	31	14	80	138 (ESE)	030/32.9
18	KATE	1951	JUL	2	5	58*	19 (SW)	087/30.4
19	RUTH	1951	OCT	15	11	48	110 (N)	076/31.3
20	DINAH	1952	JUN	23	2	51	16 (SW)	065/33.3
21	JEANNIE	1952	AUG	8	7	29	84 (ESE)	030/17.8
22	LOLA	1953	AUG	1	6	65	98 (ESE)	027/14.5
23	MAMIE	1953	AUG	7	7	35	108 (SE)	035/10.7
24	TESS	1953	SEP	25	15	64	87 (NW)	042/33.6
25	GRACE	1954	AUG	19	4	30	138 (WNW)	075/11.2
26	LORNA	1954	SEP	18	11	58*	8 (SE)	042/31.3
27	ELLEN	1955	JUL	22	7	40	139 (SE)	040/15.1
28	FRAN	1955	JUL	20	8	33	137 (SE)	038/14.4
29	TS5550	1955	JUL	19	9	41	138 (SE)	042/24.6
30	NORA	1955	OCT	11	18	77	59 (SSE)	050/30.0
31	OPAL	1955	OCT	20	19	43	81 (NW)	055/54.9
32	HARRIET	1956	SEP	27	15	70	164 (WSW)	052/28.0
33	VIRGINIA	1957	JUN	28	5	20	131 (W)	044/ 5.7
34	BESS	1957	SEP	7	9	50	175 (NW)	043/37.6
35	FAYE	1957	SEP	27	13	67	125 (SSE)	066/42.5
36	JUDY	1957	OCT	25	18	65	154 (SE)	047/13.5
37	ALICE	1958	JUL	23	9	50*	7 (NNE)	036/26.7
38	FLOSSIE	1958	AUG	25	12	36	35 (N)	068/21.8
39	HELEN	1958	SEP	17	14	82	20 (ESE)	047/32.4
40	IDA	1958	SEP	26	15	70	9 (E)	014/25.6
41	ELLEN	1959	AUG	9	6	50	19 (N)	073/20.4
42	GEORGIA	1959	AUG	13	7	83	47 (W)	346/35.0
43	VERA	1959	SEP	26	15	103	134 (WNW)	030/35.5
44	AMY	1959	OCT	7	16	42	40 (SE)	083/46.4
45	CHARLOTE	1959	OCT	18	18	60	106 (SE)	052/35.9
46	WENDY	1960	AUG	13	11	45	168 (NNW)	057/29.6
47	BESS	1960	AUG	20	13	65	58 (ESE)	037/17.7
48	FAYE	1960	AUG	30	17	67	127 (ESE)	023/20.4
49	NANCY	1961	SEP	16	18	68	150 (NW)	033/45.4
50	VIOLET	1961	OCT	9	23	67	26 (ESE)	037/26.8
51	LOUISE	1962	JUL	28	7	30	32 (NNW)	071/16.1
52	RUTH	1962	AUG	20	12	85	120 (ESE)	031/ 9.4
53	THELMA	1962	AUG	25	14	58*	168 (W)	358/21.0
54	POLLY	1963	JUN	5	2	65	121 (ESE)	034/28.4
55	VIRGINIA	1963	JUL	9	6	38	93 (SE)	060/37.4
56	DELLA	1963	AUG	28	11	70	51 (SSE)	071/14.9
57	KATHY	1964	AUG	24	15	55	169 (NW)	046/17.6
58	WILDA	1964	SEP	25	24	58*	164 (NW)	046/51.9
59	AMY	1965	MAY	27	7	50*	32 (E)	034/45.7
60	LUCY	1965	AUG	22	18	53*	18 (NW)	035/11.2

NOTES:
Datetimes are in UTC, winds are in knots, distances are in nautical miles. Parenthetical expression in column 8 gives bearing of storm from site at closest point of approach to site (CPA). Maximum winds are at time of CPA and did not necessarily occur at site. Asterisk (if any) after maximum wind indicates that storm was classified as a typhoon (at least 64 kts) somewhere within 180 nautical mile radius of site but not at CPA. Site location is 35.3°N, 139.7°E.

Table V-1 (continued). Descriptive history of the 115 tropical storms and typhoons passing within 180 nmi of Yokosuka during the 47-year period 1945-1991.

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAXIMUM WIND AT STORM CENTER	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
61	TRIX	1965	SEP	17	25	78	41 (NW)	042/30.0
62	VIRGINIA	1965	SEP	16	26	48	159 (ESE)	028/24.4
63	WENDY	1965	SEP	25	27	43	146 (SSE)	077/16.1
64	FAYE 2	1965	NOV	25	34	66	178 (SE)	049/64.4
65	KIT	1966	JUN	28	4	65	74 (ESE)	040/31.7
66	VIOLA	1966	AUG	22	13	38	72 (SW)	319/21.3
67	IDA	1966	SEP	24	23	75	60 (WNW)	017/34.6
68	LOUISE	1967	AUG	23	15	35	105 (WSW)	059/ 1.8
69	OPAL	1967	SEP	14	20	61*	159 (ESE)	035/ 6.0
70	DINAH	1967	OCT	28	30	55	71 (NW)	037/26.2
71	CORA	1969	AUG	23	9	35	61 (NW)	059/31.1
72	FLOSSIE	1969	OCT	9	13	50	129 (SE)	049/44.2
73	CLARA	1970	AUG	28	11	76	129 (E)	002/ 5.1
74	IVY	1971	JUL	7	13	35	29 (NW)	060/21.7
75	VIRGINIA	1971	SEP	7	24	70	90 (S)	033/16.2
76	CARMEN	1971	SEP	26	28	40	38 (NW)	072/27.5
77	PHYLLIS	1972	JUL	15	7	48	150 (WSW)	338/16.8
78	ALICE	1972	AUG	7	13	62*	72 (E)	015/16.4
79	HELEN	1972	SEP	16	20	62*	150 (WNW)	019/30.9
80	KATHY	1972	OCT	6	23	55	151 (SE)	045/35.4
81	ELLEN	1973	JUL	28	6	25	125 (WSW)	335/ 5.7
82	MARY	1974	AUG	26	15	38	75 (NW)	027/34.6
83	RITA	1975	AUG	23	8	51	152 (NW)	050/23.1
84	CORA	1975	OCT	5	15	100	104 (SSE)	069/33.0
85	EMMA	1977	SEP	19	13	43	101 (SE)	035/18.5
86	VIRGINIA	1978	AUG	1	7	55	94 (ESE)	024/12.2
87	OWEN	1979	SEP	30	19	45	94 (NW)	046/39.3
88	TIP	1979	OCT	19	23	60*	75 (NW)	046/61.0
89	ELLEN	1980	MAY	21	4	35	100 (SE)	039/41.3
90	WYNNE	1980	OCT	14	23	70	80 (SSE)	066/38.6
91	THAD	1981	AUG	22	15	68	10 (SE)	016/29.3
92	GAY	1981	OCT	22	24	68	24 (SE)	045/42.6
93	BESS	1982	AUG	1	11	57*	126 (W)	001/34.0
94	JUDY	1982	SEP	12	19	60*	113 (W)	001/26.1
95	MAC	1982	OCT	8	23	96	173 (SE)	052/26.7
96	ABBY	1983	AUG	17	5	45*	23 (NW)	068/11.6
97	BEN	1983	AUG	14	7	45	47 (S)	284/21.2
98	IDA	1983	OCT	11	14	52	72 (SSE)	065/34.5
99	IRMA	1985	JUN	30	6	64	16 (W)	047/42.5
100	RUBY	1985	AUG	30	14	47	8 (SE)	011/14.5
101	NELSON	1988	OCT	8	20	70	171 (SSE)	064/27.7
102	MAC	1989	AUG	6	15	50*	68 (ENE)	336/17.6
103	ROGER	1989	AUG	27	20	40	153 (NW)	035/22.1
104	WAYNE	1989	SEP	19	25	58	25 (SE)	062/40.8
105	VERNON	1990	AUG	4	11	70	157 (SSE)	063/ 5.0
106	WINONA	1990	AUG	10	12	60*	35 (WNW)	037/17.5
107	FLO	1990	SEP	19	20	63*	119 (NW)	035/33.4
108	GENE	1990	SEP	30	21	55	7 (WSW)	065/24.2
109	HATTIE	1990	OCT	8	22	43	23 (NNE)	057/43.2
110	PAGE	1990	NOV	30	29	48	52 (NW)	039/25.8
111	HARRY	1991	AUG	30	16	40	37 (WNW)	041/23.7
112	IVY	1991	SEP	9	17	90	148 (SSE)	062/17.9
113	KINNA	1991	SEP	14	19	53	140 (N)	072/34.6
114	LUKE	1991	SEP	19	20	45	82 (ESE)	030/42.7
115	ORCHID	1991	OCT	12	23	55	167 (SE)	058/16.9

NOTES:
Datetimes are in UTC, winds are in knots, distances are in nautical miles. Parenthetical expression in column 8 gives bearing of storm from site at closest point of approach to site (CPA). Maximum winds are at time of CPA and did not necessarily occur at site. Asterisk (if any) after maximum wind indicates that storm was classified as a typhoon (at least 64 kts) somewhere within 180 nautical mile radius of site but not at CPA. Site location is 35.3°N, 139.7°E.

Table V-2. Frequency of motion of tropical storms and typhoons passing within 180 nmi of Yokosuka during the 47-year period 1945-1991.

Month when storm was at CPA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Total number of storms passing within 180 n mi	0	0	0	0	2	5	12	37	32	24	3	0	115
Number of storms having at least typhoon intensity at CPA	0	0	0	0	0	3	0	9	12	10	1	0	35
Number of storms less than typhoon intensity at CPA	0	0	0	0	2	2	12	28	20	14	2	0	80
Average heading (degs) towards which storms were moving at CPA	---	---	---	---	*	050	035	028	042	056	*	---	041
Average storm speed (knots) at CPA	---	---	---	---	*	28	19	18	30	35	*	---	27

** indicates insufficient storms for average direction and speed computations.*

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It should be noted that the average storm speed at CPA given in Table V-2 is relatively high, ranging from 18 kt in August to 35 kt in October. The reason lies in the location of Yokosuka. As shown in Figures A-1 through A-24, most tropical cyclones that pass close to Yokosuka recurve between 20 and 30 degrees north latitude and then accelerate to the northeast. Because Yokosuka is north of the normal latitudinal recurvature range, most storms passing within 180 nmi of the port have already recurved and are accelerating northeastward at their CPA.

During the 47-year period from 1945 through 1991 there were 115 tropical storms and typhoons that met the 180 nmi threat criterion for Yokosuka, an average of over 2 per year. Figure V-4 shows the monthly distribution of the 115 storms by 7-day periods. The period of peak activity extends from early August until late October.

Figure V-5 depicts the annual distribution of tropical storms and typhoons passing within 180 nmi of Yokosuka during the 47-year period 1945 through 1991.

Figure V-6 presents a graphical depiction of the number of tropical cyclones versus CPA. The storm classification is based on the maximum wind near the storm center while that center was within 180 nmi of Yokosuka, not necessarily at CPA. The sloping lines represent mathematical fits to the data points for the various intensity classifications. The average radii of maximum wind for 34, 100, and 140 kt tropical cyclones at Yokosuka are 29.6, 28.1, and 25.2 nmi, respectively.

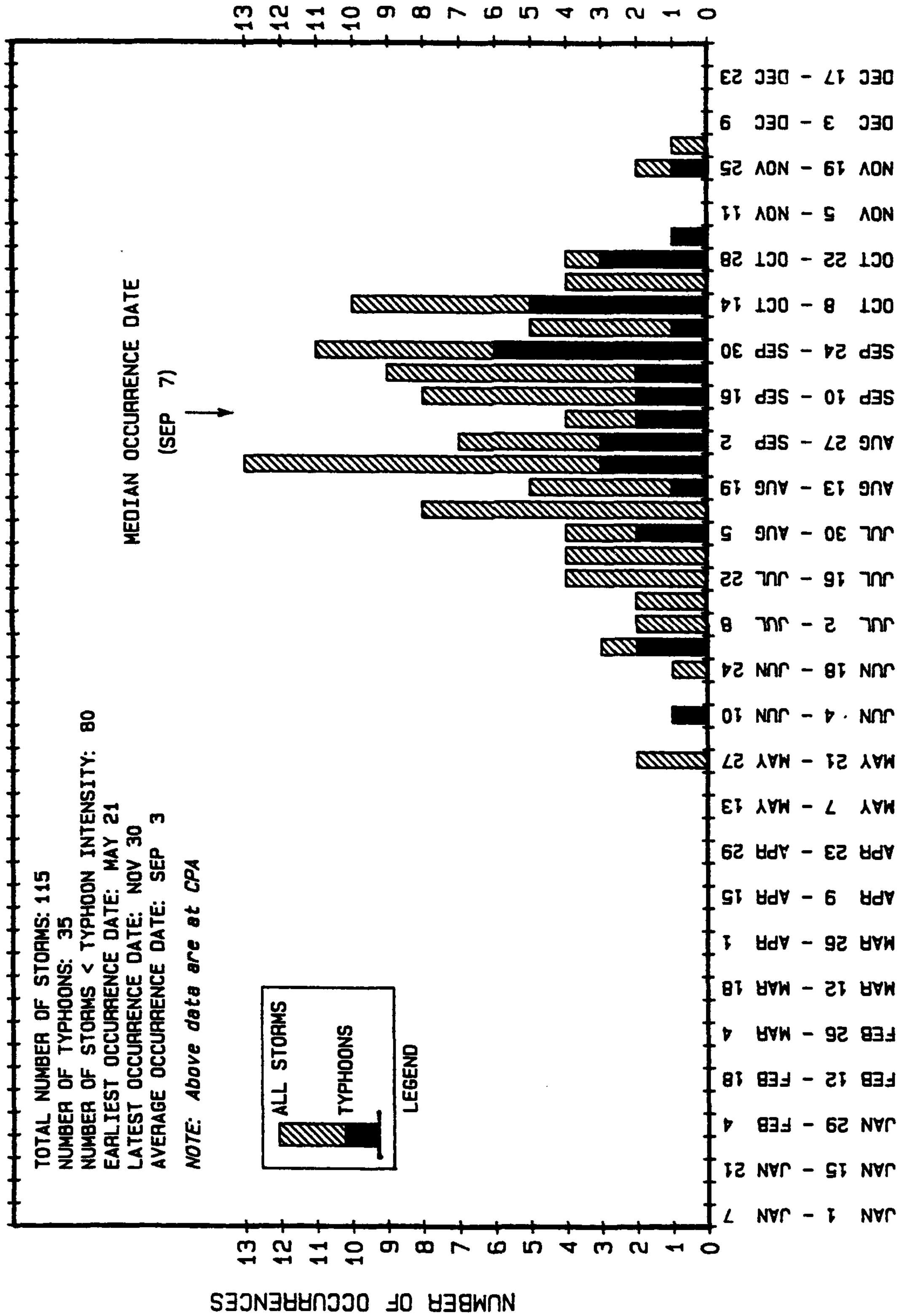

Figure V-4. Monthly distibution of the 115 tropical storms and typhoons passing within 180 nmi of Yokosuka during the 47-year period 1945-1991.

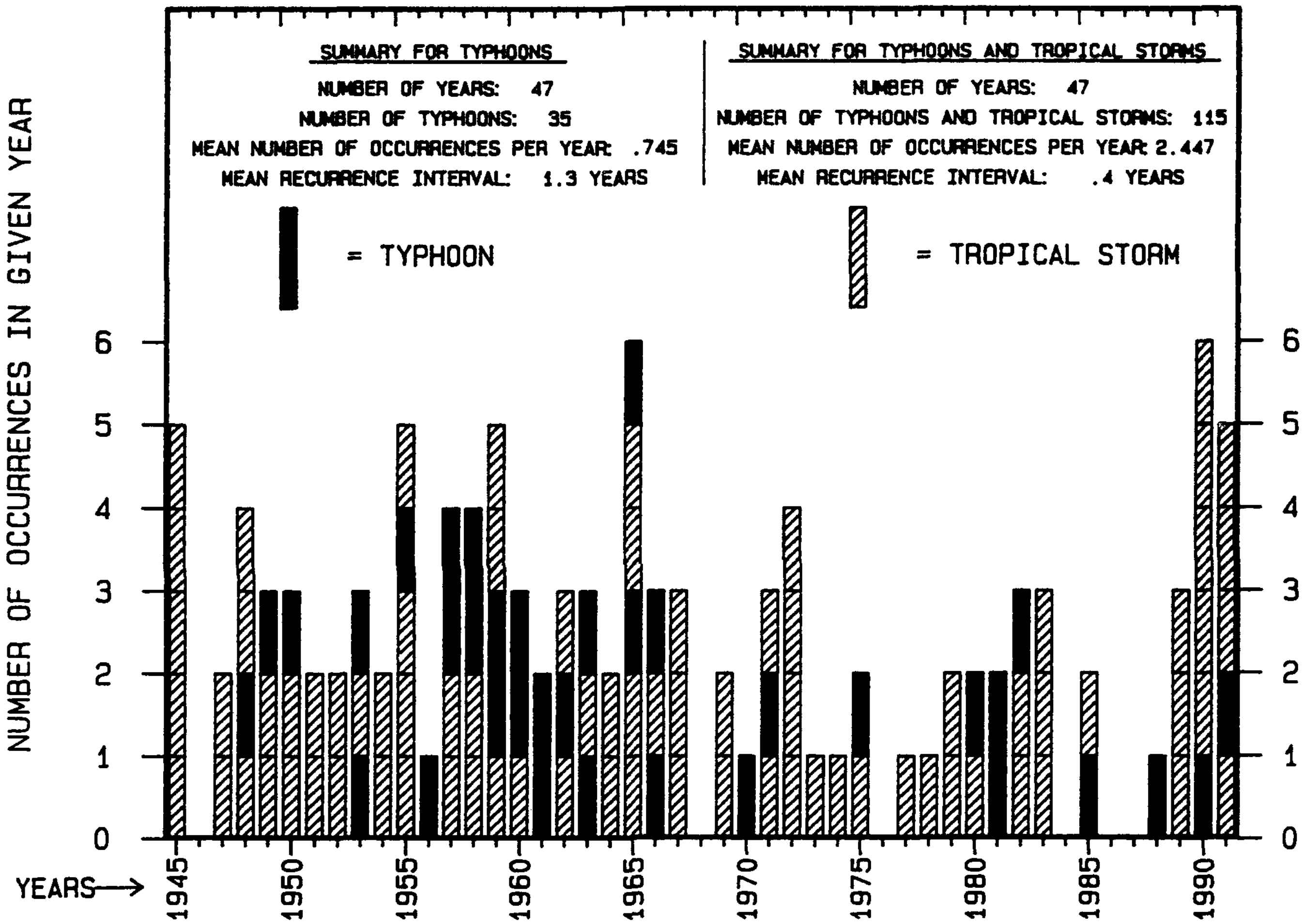

Figure V-5. Chronology of all tropical storms and typhoons passing within 180 nmi of Yokosuka during the 47-year period 1945-1991. Storm intensity is determined at time of closest point of approach (CPA) to Yokosuka.

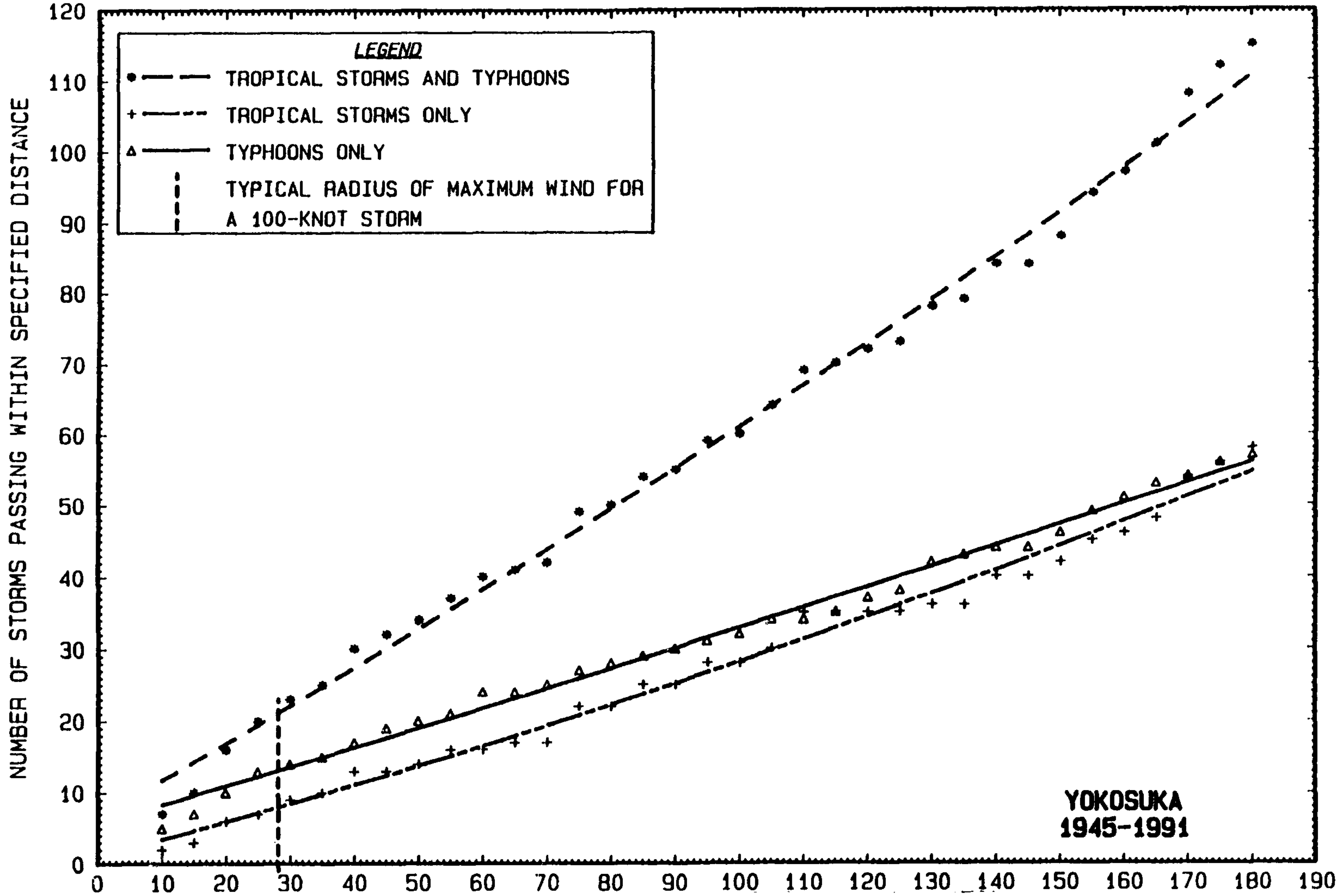

Figure V-6. Number of tropical cyclones passing at various distances from Yokosuka during the 47-year period 1945-1991. Tropical storm or typhoon classification is based on maximum wind near storm center while that center was within 180 nmi of Yokosuka, and not necessarily at CPA. Sloping lines represent mathematical fit to data points. Average radii of maximum wind for 34, 100, and 140 kt storms at Yokosuka are 29.6, 28.1 and 25.2 nmi respectively.

Figure V-7 depicts the octants from which the 115 tropical cyclones in the data set approached Yokosuka. Almost 95 percent of the storms entering the 180 nmi threat radius of Yokosuka approach from the south, southwest or west octants.

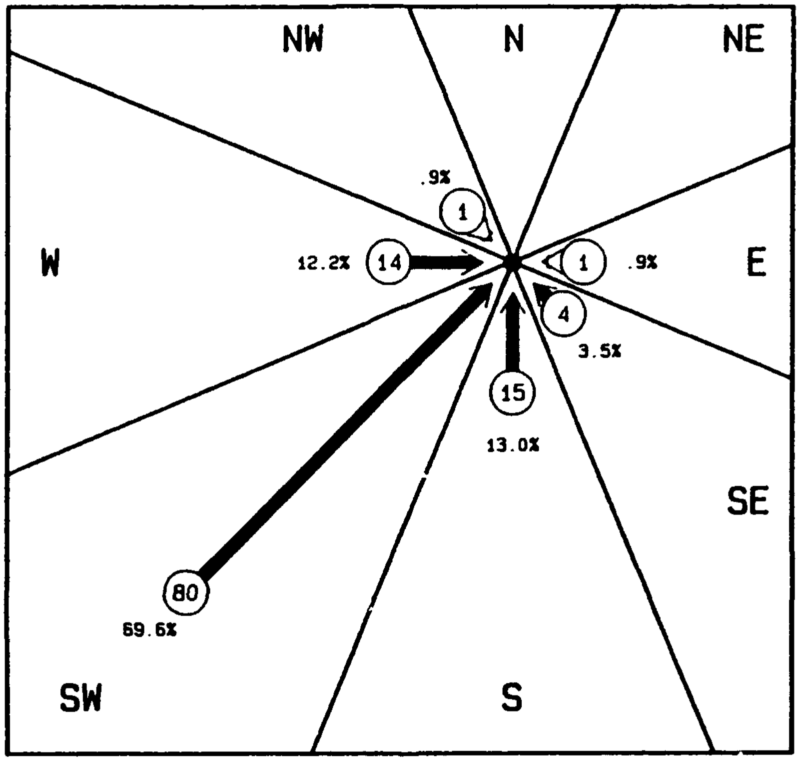

Figure V-7. Directions of approach for 115 tropical storms and typhoons passing within 180 nmi of Yokosuka during the 47-year period 1945-1991. Length of directional arrow is proportional to the number of storms given in the circles of each octant. Approach directions are determined at CPA.

Figures V-8 through V-10 provide information on the probability of remote tropical storms/typhoons passing within 180 nmi of Yokosuka and average time to CPA. The solid lines represent a "percent threat" for any tropical cyclone location within the area depicted. The heavy dashed lines represent the approximate time in days for a system to reach Yokosuka. Example: in Figure V-8 (July and August), a tropical cyclone located at 25°N 145°E has an approximate 40% probability of passing within 180 nmi of Yokosuka, reaching Yokosuka in 3-4 days.

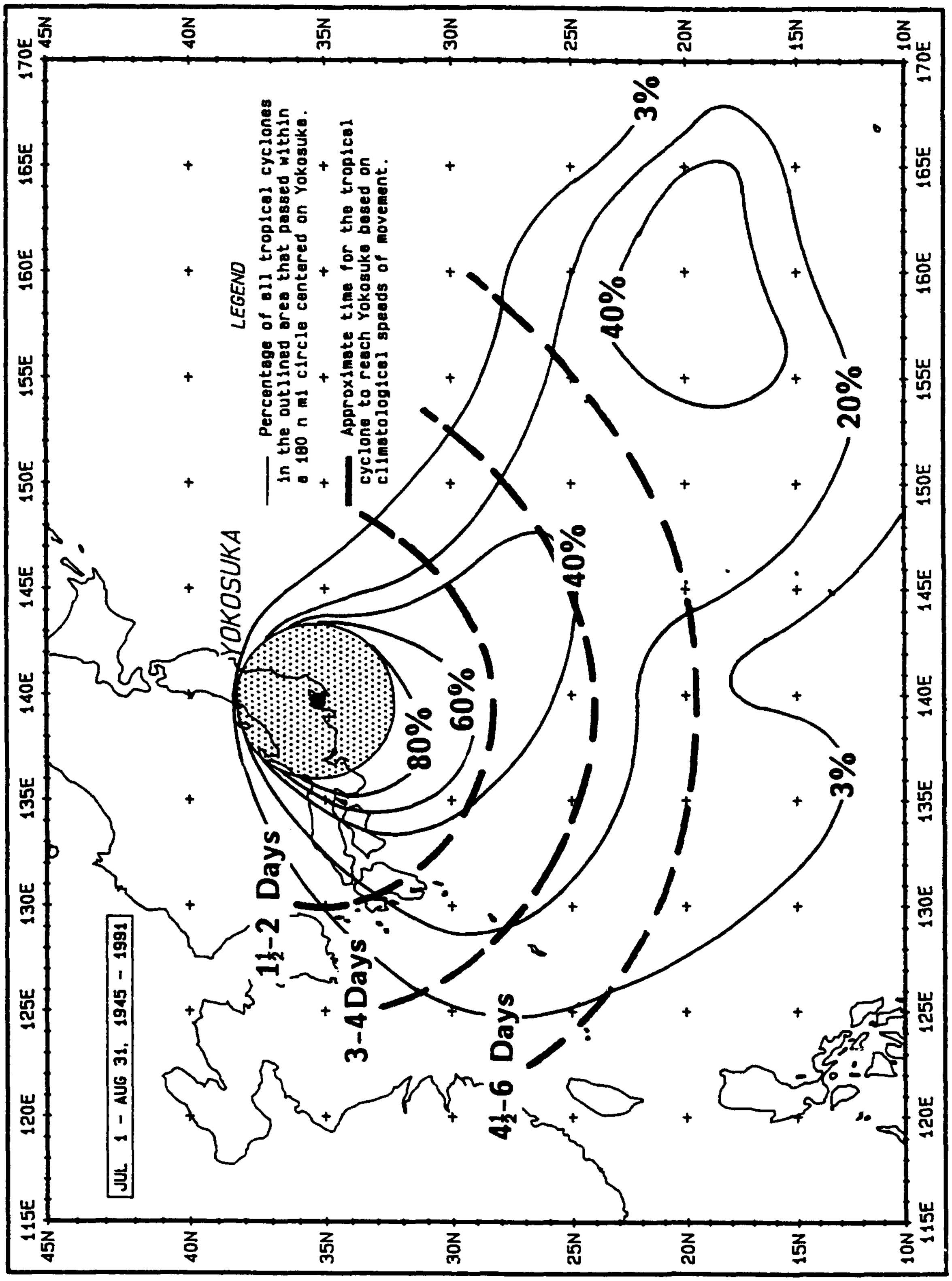

Figure V-8. Probability that a tropical storm or typhoon will pass within 180 nmi of Yokosuka (circle), and approximate time to closest point of approach, during the July and August (based on data from 1945-1991).

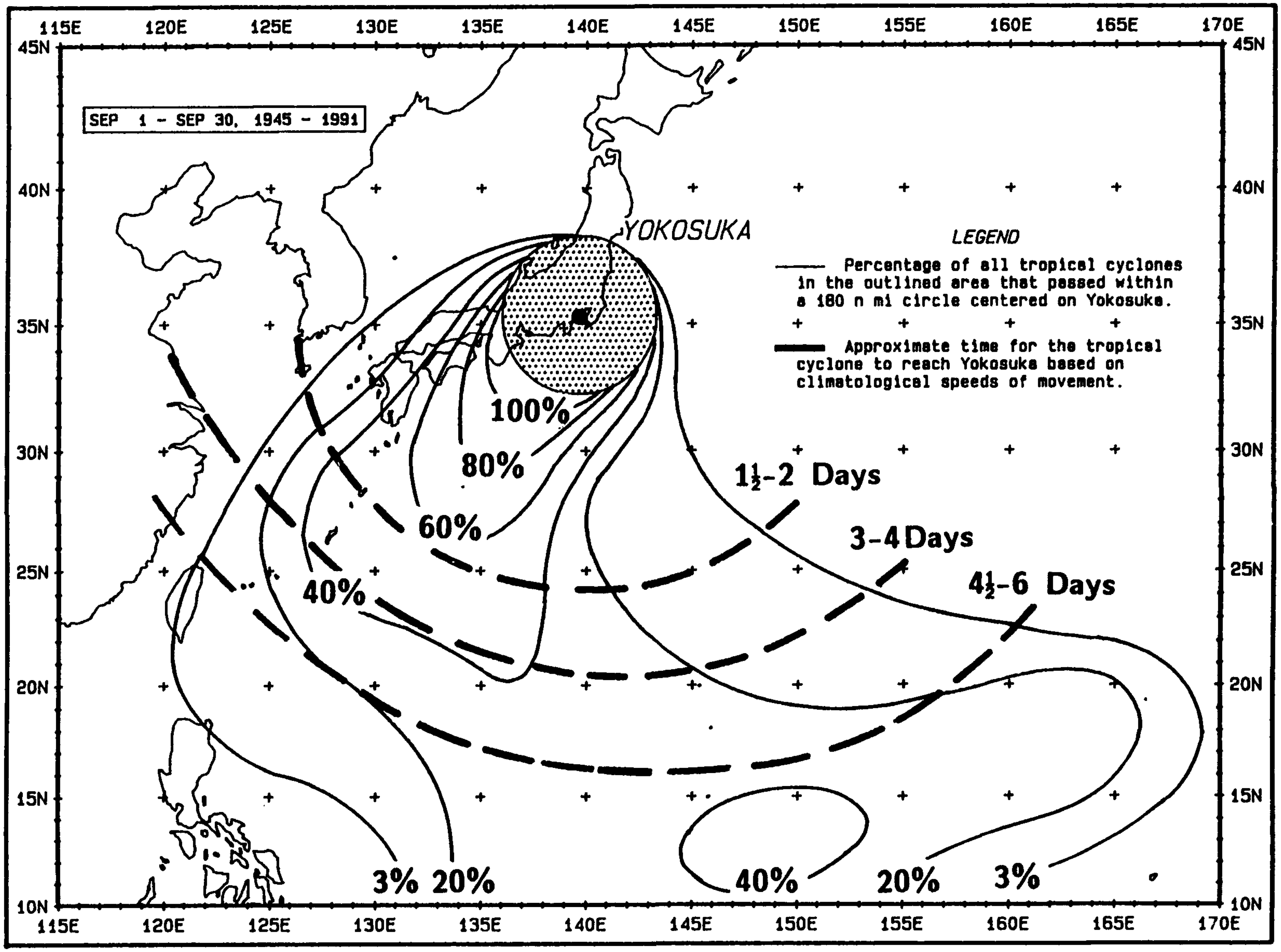

Figure V-9. Probability that a tropical storm or typhoon will pass within 180 nmi of Yokosuka (circle), and approximate time to closest point of approach, during September (based on data from 1945-1991).

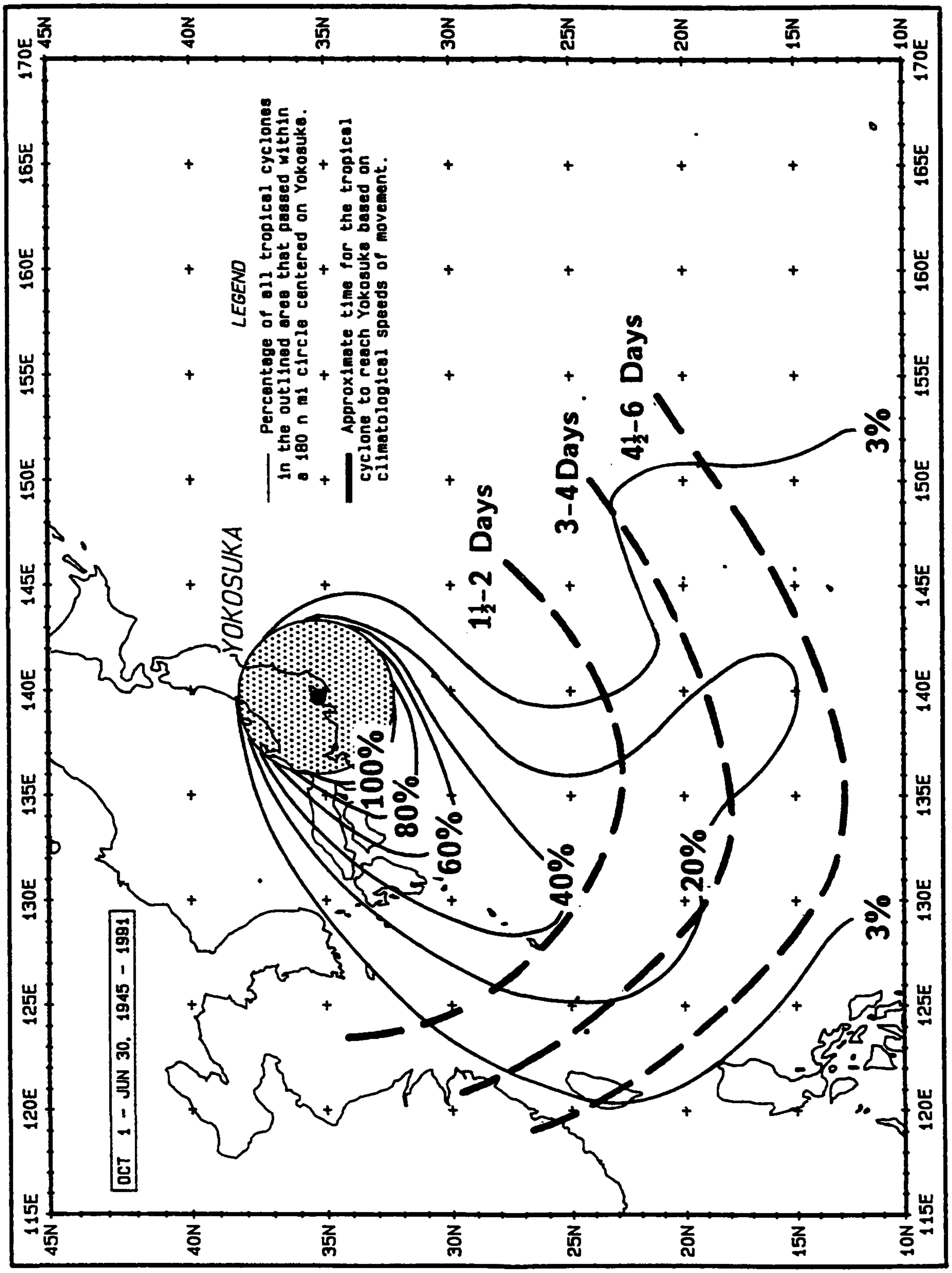

Figure V-10. Probability that a tropical storm or typhoon will pass within 180 nmi of Yokosuka (circle), and approximate time to closest point of approach, during the period 1 October through 30 June (based on data from 1945-1991).

A comparison of the preceding figures shows some distinct differences in threat axes according to time of year. The July and August storms' axis (Figure V-8) extends south from Yokosuka to approximately 30°N before turning southeastward to about 20°N after which it extends eastward at the same approximate latitude. The September axis (Figure V-9) is significantly different, extending south-southwestward from Yokosuka to about 25°N before turning southeastward to the more tropical latitudes between 10° and 20°N. The primary axis for the remaining months, October through June (Figure V-10), extends southwestward from Yokosuka to about 25°N before turning southeastward.

2.3.2 Wind and Topographical Effects

The observation station for the Naval Oceanography Command Facility (NAVOCEANCOMFAC) is located on top of a 175 ft hill at FLEACTS Yokosuka, and the wind instrument is another 55 ft above the station; the observed wind velocity is about 10 kt greater than that observed in the harbor, but otherwise is representative. A new multi-level NAVOCEANCOMFAC building has been built adjacent to the older building and scheduled to be occupied by mid-1993. Although the elevation of the wind instrument at the new building will likely be different than that of the older one, the exposure will be approximately the same.

A new Port Operations building was being built at the time of the most recent port visit, with a scheduled completion date of April 1993. An anemometer is to be installed on a pole and placed on the roof of the building, and should provide readings that are closely representative of those experienced by ships in the harbor.

2.3.3 Local Weather Conditions.

The data contained in Table V-3 has been selected from observations recorded at NAVOCEANCOMFAC Yokosuka during the passage of the tropical cyclones listed in the table.[3] It should be noted that no record of observations is available during the period 1945 through July 1953.

[3]Based on hourly observations provided by Naval Oceanography Command Detachment, Asheville, NC.

Table V-3. Center data and related weather associated with selected tropical cyclone passages within 180 nmi of Yokosuka 1953-1991. No observational data are available for the period 1945-1953.

TYPHOON DATA				RELATED LOCAL WEATHER		
DATE (NAME)	MVMT DIR/SOA (KT)	DIR/CPA FM STAT (NMI)	CNTR WIND (KT)	MAX WIND & GUSTS (KT)	24-HR PRECIP (IN)	COMMENTS
53/09/25 TESS	042/34	312/87	64	SSW 40G74	3.29	
54/09/19 LORNA	042/31	135/8	58	N 38G55	3.62	EYE PASSED OVERHEAD
55/10/11 NORA	050/30	153/59	77	WSW 48G62	3.30	
58/09/17 HELEN	047/32	119/20	82	SSE 43G78	2.61	TOP OF RAIN GAUGE BLEW OFF
58/09/26 IDA	014/26	098/9	70	S 50G96	7.27	
59/09/26 VERA	030/35	300/134	103	S 50G81	1.76	
64/09/25 WILDA	046/52	326/164	58	SSW 42G67	1.85	
650917 TRIX	042/30	310/41	78	S 48G65	1.52	
66/06/28 KIT	040/32	119/74	65	N 42G54	9.44	
79/10/19 TIP	046/61	317/75	60	S 44G82	3.13	
81/10/22 GAY	045/43	131/24	68	NNW 40G60	9.38	
82/08/01 BESS	001/34	267/126	57	SSE 50G80	2.15	
85/06/30 IRMA	047/42	268/16	64	SW 50G80	3.29	
90/09/19 FLO	035/33	311/119	63	S 50G74	0.74	
91/09/09 IVY	062/18	148/148	90	NNE 44G57	5.16	

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A total of 91 tropical storms or typhoons passed within 180 nmi of Yokosuka during the period August 1953 through December 1991, the period during which surface observations for Yokosuka are available. Of those storms, 69 (76%) caused sustained winds of ≥22 kt at the port, and 29 (32%) caused sustained winds of at least gale force, ≥34 kt. Whether or not the individual storm passed east or west of the port seems to make little difference in wind speeds at the port. Thirty-seven of the 69 storms (54%) causing winds of ≥22 kt passed on the seaward (east) side of Yokosuka while 32 (46%) passed to the west. Storms passing on the seaward side of Yokosuka brought winds of ≥34 kt to the area in 52% of the cases (15 of 29), while those passing on the west comprised 48% (14 of 29).

The basic difference between an east passage and a west passage is the direction of the resultant wind on the harbor. If the tropical cyclone passes to the west of Yokosuka, the winds will generally be from the south. For a passage to the west, the storm must necessarily cross the mountain ranges of Honshu (see Figure V-2). An example of this was Typhoon Bess (August, 1982) which had a CPA of 126 nmi west of Yokosuka. Bess pounded the harbor with gusts to 80 kt from the southeast and sustained gale force winds (≥34 kt) for almost 9 hours.

If the tropical cyclone passes east of Yokosuka, the path will be over water and the winds at the port will be generally northerly. An example of this was Typhoon Gay (October 1981). The storm had a CPA of 24 nmi southeast of Yokosuka, and brought sustained winds of 40 kt with gusts to 60 kt to the port area.

Figure V-11 shows the track segments for the 69 tropical cyclones that correspond to periods of sustained winds ≥22 kt at Yokosuka. Twenty-two of the storms did not cause

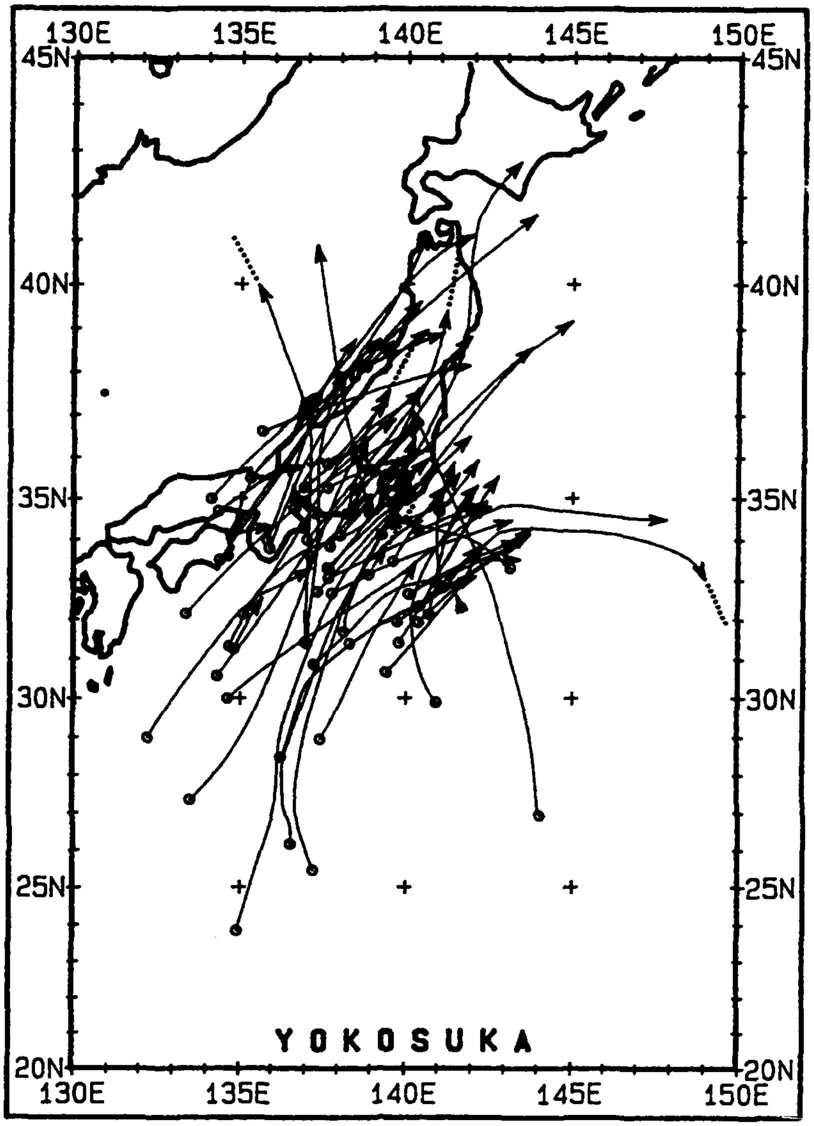

Figure V-11. Track segments of the 69 tropical storms or typhoons causing sustained winds of at least 22 kt at Yokosuka during the 39-year period 1953-1991. Dots at the end of the track indicate that the winds continued for a period beyond that for which a track is available.

sustained winds of ≥22 kt. Similarly, Figure V-12 shows the positions of the centers of the 29 tropical cyclones that brought sustained winds ≥34 kt to Yokosuka. Sixty-two of the storms did not cause sustained ≥34 kt winds.

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In Figure V-11, only 9 of the 69 storms which caused winds of ≥22 kt did so while the storm center was south of 30°N. All of the storms causing winds of ≥34 kt (see Figure V-12) were north of 32°N before the onset of the wind at Yokosuka.

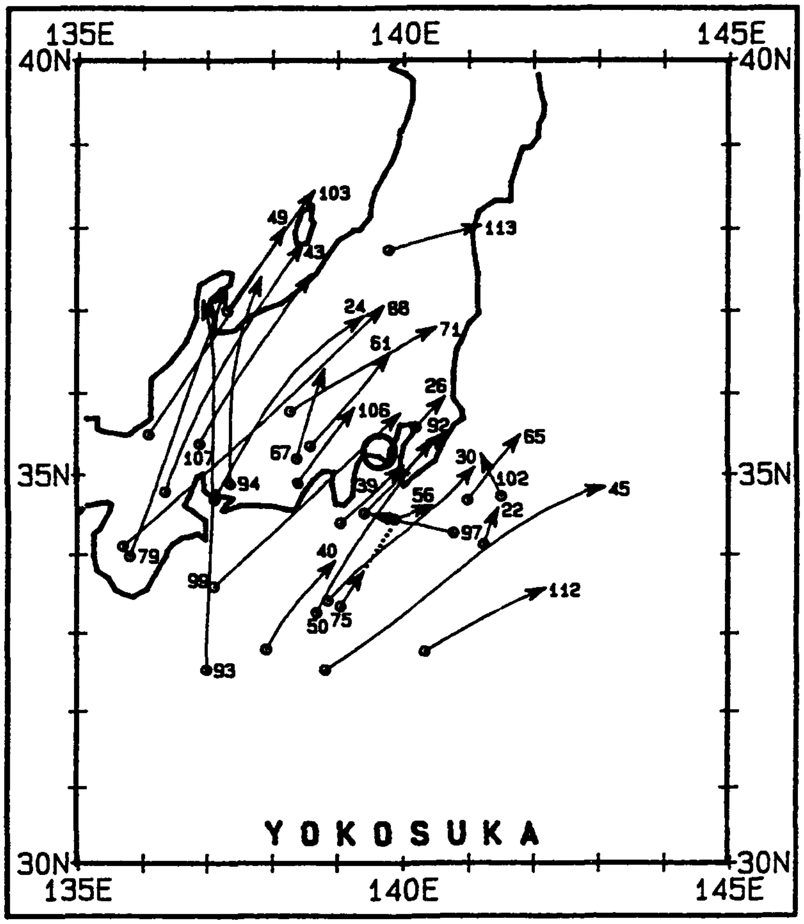

Figure V-12. Track segments of the 29 tropical storms or typhoons causing sustained winds of at least 34 kt at Yokosuka during the 39-year period 1953-1991.

2.3.4 Wave Action

The port of Yokosuka normally experiences very little wave motion as the result of a typhoon transiting the vicinity, but specific typhoon trajectory/strength combinations can cause problems. The amount of wave action will vary with the wind directions which result as the typhoon passes to the west or to the east of the port. The surrounding land masses and the breakwater located near the entrance to Yokosuka Harbor are major factors in limiting the wave action in the port. Wave action will be greater for a northerly wind (typhoon passage east of Yokosuka). The port of Yokosuka is more-or-less open into Tokyo Bay in a north-northeasterly direction for a distance of about 25 nmi. Waves from a north-northeasterly direction must traverse various natural and man-made obstacles before reaching the port, so much of the energy contained in the waves is depleted. Although the limited fetch area of Tokyo Bay reduces the wave heights that can be generated with a given wind speed, the distance is sufficient to produce waves that have the potential to enter the port of Yokosuka and impact exposed facilities.

An example of the potential for damage from wave action occurred in November 1992, when Typhoon Kelsey passed south of Yokosuka. The northerly winds on the northwest side of the storm generated waves in Tokyo Bay that passed through the entrance to Yokosuka Harbor as 8 to 10 ft swell. Two AEGIS CG's that were moored to the newly constructed Harbor Master Pier (see Figure V-3) were rolling about 5° at their berths but no significant damage was reported. A small open boat moored to the lee side of a JMSDF pier located in the Y-designated berths area in the southwest part of Yokosuka Harbor sunk after being swamped by waves washing over the pier. As shown in Figure V-3, both of the affected piers are exposed to any wave energy that moves southward through the harbor entrance. In addition, Berths 6 and 7 are also exposed and vulnerable.

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An estimate of the maximum wave height that may be encountered for typhoon force winds in the region of Yokosuka and Tokyo Bay is summarized in Table V-4. The major factors considered in this listing were the direction of tropical cyclone passage relative to Yokosuka, the direction and velocity of the resultant typhoon force winds, the length of fetch, a duration greater than 1 hour but less than 5 hours, and the location of obstacles in the path of the progressing waves. There is no single theoretical development for determining the actual growth of waves generated by winds over relatively shallow water (U. S. Army Coastal Engineering Research Center, 1973).

Table V-4. Table V-4. Approximate maximum wave heights for the Port of Yokosuka, and Yokosuka and Tokyo Bays.

Wave Height (ft) in the Vicinity of:	Direction of Passage of Tropical Cyclone Relative to Yokosuka	
	East	West
Port of Yokosuka	6 ft	3 ft
Yokosuka Bay	9 ft	5 ft
Tokyo Bay (about 10 nmi NNE of Yokosuka)	12 ft	11 ft

The wave heights presented in Table V-4 are a guide only, and as was the case with the November 1992 storm discussed above, specific storms may generate waves in Tokyo Bay that pass through the entrance to the port of Yokosuka with heights greater than those in the table.

2.3.5 Storm Surge

Storm surge may be visualized as a raised dome of water, moving with the storm, and centered a few miles to the right of its path. Storm surge is caused by wind stress on the water surface and the effects of atmospheric pressure reduction. The piling up of water on a coast ahead of a tropical storm or typhoon is more apparent in the dangerous semicircle, the region of most intense winds which is located to the right of the storm's direction of movement. The speed of the storm adds to the wind velocity generated by the mechanics of the storm itself. The port of Yokosuka will be placed in the dangerous semicircle when a typhoon passes to the west of the area.

The storm surge effect is most evident in the shallow waters of large inland bays open to the south coast of Japan (Miyazaki, 1974). The surge forms to a large extent after entering the inland bays since the width of the continental shelf is generally narrow along the Japanese coast. Most of the surge occurs, therefore, at the inshore side of these bays, and not along the open coasts nor near the mouth of the bays. Peak surges of 7.6 ft (October 1919) and 7.3 ft (September 1938) were observed at the inshore (north) side of Tokyo Bay. They were the result of southerly winds caused by typhoons passing generally to the west of Tokyo Bay. Due to its sheltered position within Tokyo Bay and its location near the entrance, Yokosuka experiences little storm surge. Conversations with personnel of the Port Services Office, Yokosuka indicates that storm surges of about 3 ft have been felt within the harbor, but have not been a problem. Surges of this magnitude coupled with the normal tide range of 4 to 5 ft would not present any unusual difficulty to moored vessels if lines are tended.

2.4 THE DECISION TO EVADE OR REMAIN IN PORT

2.4.1 General

The responsibility for overall coordination of action to be taken by Naval activities in the Yokosuka area has been assigned to Commander, Fleet Activities, Yokosuka. The Naval

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Oceanography Command Facility, Yokosuka issues local wind warnings. The established procedures when hazardous weather is expected are given in SOPA (ADMIN) YOKOSUKA INSTRUCTION 5000.1.

As directed by SOPA, wind from any direction with expected sustained speeds of 48 kt or gusts in excess of 55 kt is sufficient to set tropical cyclone conditions. Typhoon conditions will be set for an approaching typhoon, i.e., expected sustained winds of 64 kt or greater. The same precautions taken for a typhoon will also be taken for any tropical cyclone.

2.4.2 Evasion Rationale

It is of utmost importance that the commander recognize the inherent dangers that exist when exposed to the possibility of hazardous weather. Proper utilization of meteorological products, especially the NOCC/JTWC Guam Tropical Cyclone Warnings, and a basic understanding of weather will enable the commander to act in the best interest of the unit, and complete the mission when the unfavorable weather subsides. The following time/action sequence aid, to be used in conjunction with Figures V-13 to V-15, is provided.

I. An existing tropical cyclone moves into or development takes place in Area A with long range forecast movement toward Yokosuka (recall that 40% of all tropical cyclones recurve):

   a. Review material condition of ship.

   b. Reconsider any maintenance that would render the ship incapable of riding out a storm or typhoon with the electrical load on ship's power, or would render the ship incapable of getting underway, if need be, within 48 hours.

c. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

II. Tropical cyclone enters Area B with forecast movement toward Yokosuka (recall that prior to recurvature tropical cyclones tend to slow in their forward motion and after recurvature accelerate rapidly):

a. Reconsider any maintenance that would render the ship incapable of shifting to a new berth assignment, anchorage or buoy or otherwise getting underway prior to the onset of strong winds within the harbor.

b. Anticipate Tropical Cyclone Condition III.

c. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

III. Tropical cyclone has entered Area C and is moving toward the Yokosuka area:

a. Anticipate Tropical Cyclone Conditions II and I, and take appropriate actions.

b. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

A strong wind is the most important factor to be considered. Wave action has only limited effect in the port of Yokosuka and storm surge effects are negligible.

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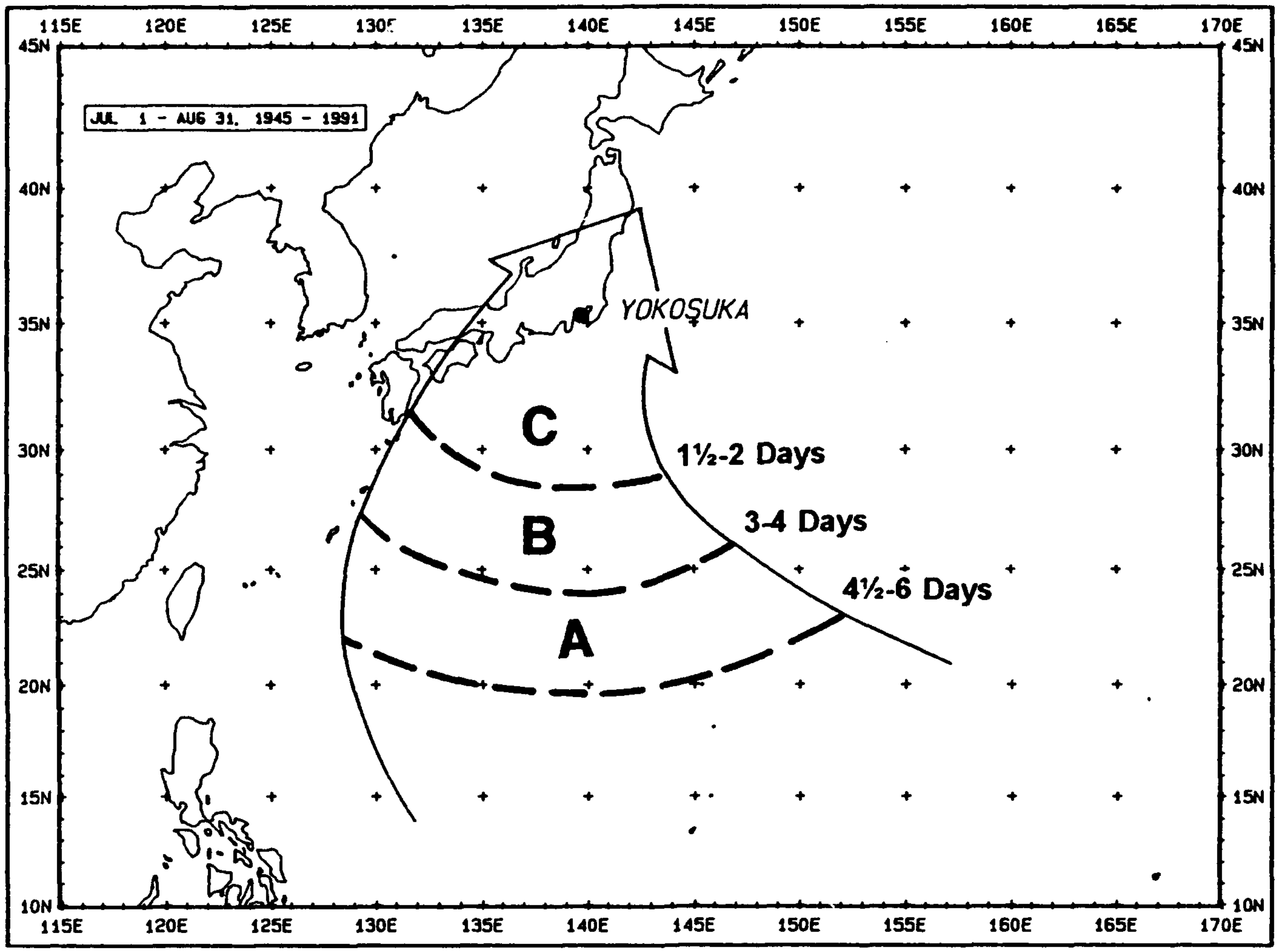

Figure V-13. Tropical cyclone threat axis for Yokosuka for July and August. The area within the limits of the arrow approximates a 50% or greater probability of a tropical cyclone coming within 180 nmi of Yokosuka.

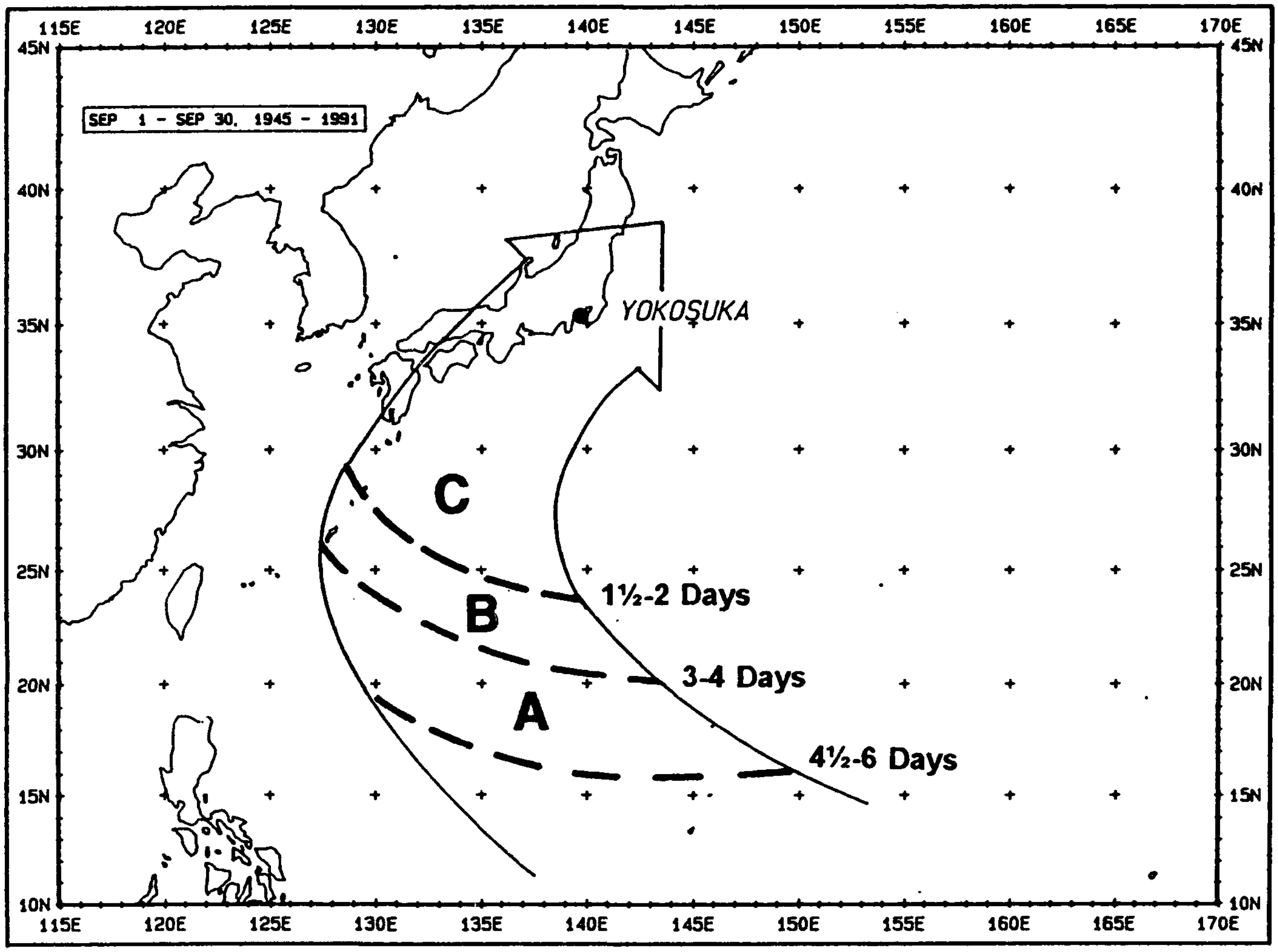

Figure V-14. Tropical cyclone threat axis for Yokosuka for September. The area within the limits of the arrow approximates a 50% or greater probability of a tropical cyclone coming within 180 nmi of Yokosuka.

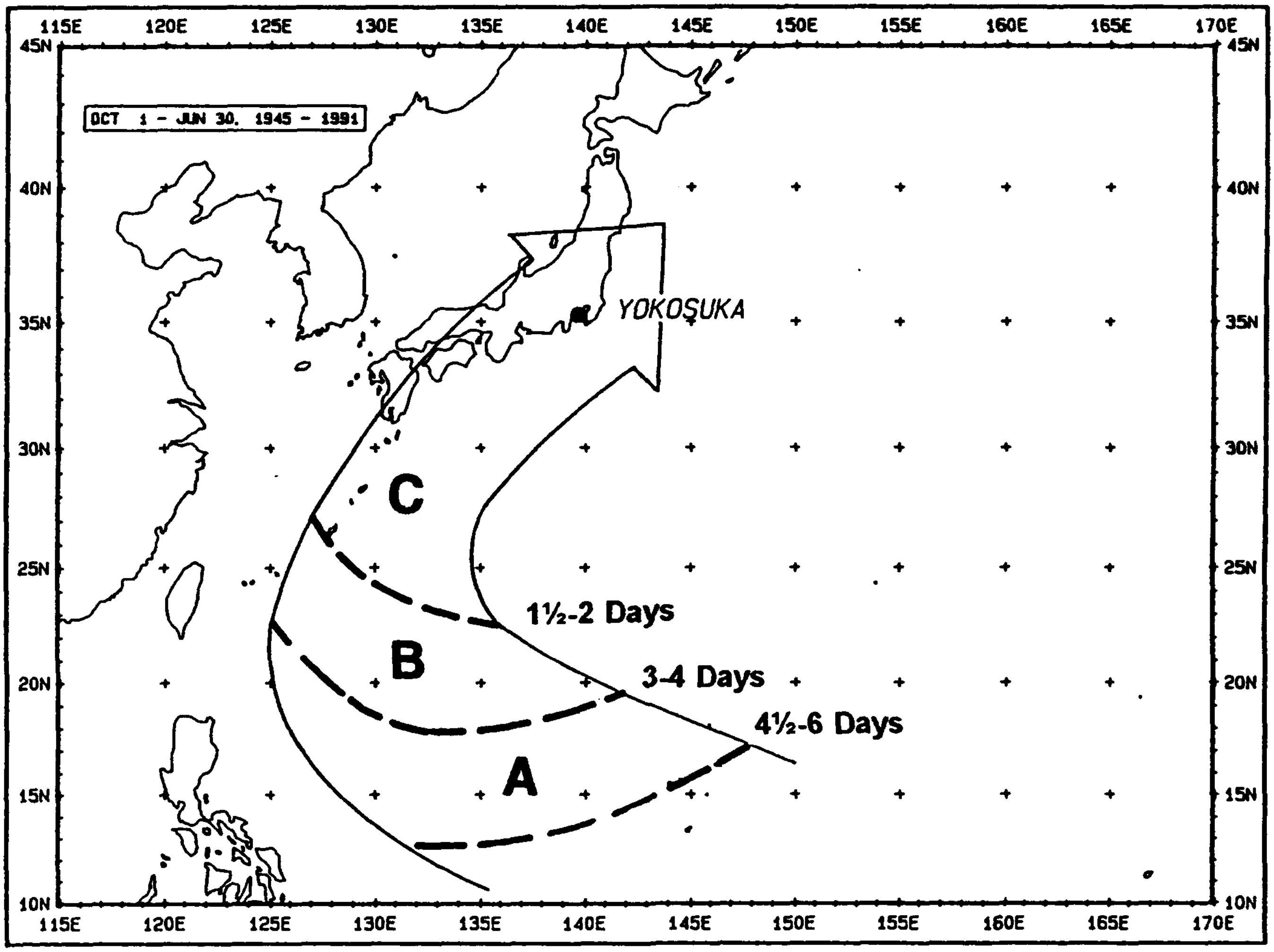

Figure V-15. Tropical cyclone threat axis for Yokosuka for the period 1 October through 30 June. The area within the limits of the arrow approximates a 50% or greater probability of a tropical cyclone coming within 180 nmi of Yokosuka.

2.4.3 <u>Remaining in Port</u>

Remaining in port is, in almost all instances, the recommended course of action when a tropical storm or typhoon threatens Yokosuka. Berths and bollards are in good repair and a number of large, rubber "Yokohama" fenders are available to reduce the potential for damage to ships and piers. Prior to going into Typhoon Condition Three, nests of ships are broken up if at all possible. If any piers are empty, a berthing plan is prepared that will put ships in the most protected berths. Some of the smaller dry docks are flooded in order to store small craft, barges, donuts, pusherboats, tugs and pleasure craft. Captain Norman Kempf, Chief Harbor Pilot at the port of Yokosuka (Nov 1992) suggested many of the following actions that should be considered when a tropical cyclone is approaching:

(1) Berth reassignment, if necessary, should be accomplished before 20 kt winds begin. Ships with large sail areas should be assigned preferred berthing depending on the direction of the closest point of approach (CPA); i.e., if a typhoon is forecast to pass to the east, use berth 8, and use berth 12 if the forecast passage is to the west. Vessels should light off and secure shore power if at all possible. For CV's, a shift to Dry Dock 6 is recommended when Tropical Cyclone Condition of Readiness Three (48 hours) is set for sustained winds of 75 kt at NOCF Yokosuka. If shift is not feasible, a sortie should be considered.

(2) Anchors should be placed under foot except in dry docks.

(3) Extra attention should be given to the brow and mooring lines during the passage of the storm. Ships should put out extra line and wire as deemed necessary and should be ready to tend mooring lines. Wires may be checked out from Port Services Dockmasters

for added holding capabilities. Rat guards and other flying objects should be removed or otherwise secured.

(4) Ships with large sail areas should consider having a tug stand by during the period of highest winds. Port Operations has pilots and tugs available for assistance.

(5) Although the rated holding strength of the mooring buoys inside the harbor is good, they are not the preferred location to be when strong winds are expected. Their exposure to northerly winds through the harbor entrance and orientation with respect to the surrounding land masses does not give them the same protection as do the pierside berths. Mooring buoys outside the harbor are unprotected from northerly winds and have only limited protection from southerly winds.

(6) The anchorages within Yokosuka Bay have mud and sand bottoms with fair to good holding quality when enough chain is used under light to moderate wind conditions, but are unprotected from northerly winds and have only limited protection from southerly winds. Vessels using the anchorages should have engines in standby to ease the strain on the chain and to keep the anchor from dragging in moderate wind situations. Use of the anchorages is not recommended if strong winds are forecast.

(7) Flooding, caused by heavy precipitation, of the Fleet Activities land complex may occur; therefore, all ships should provide their own electrical power.

When there are many ships in port and only limited pierside facilities, a ship may elect to evade the typhoon at sea or anchor in Tokyo Bay. JMSDF ships consider the port of Nagura (see Figure V-1) a good typhoon haven if a ship is pierside and do not generally sortie from Nagura to avoid a typhoon. However, JMSDF ships anchored near Nagura or moored to a buoy usually get underway and proceed to anchorages in various parts of Tokyo Bay.

2.4.4 Evasion in Tokyo Bay

Any vessel within the confines of Yokosuka Harbor will need to make an early decision if a departure from the harbor is being considered. Local authorities state that the large number of Japanese fishing boats that move into Yokosuka Bay for shelter prior to typhoon passage severely restricts the ability of larger vessels from leaving (or entering) the port.

JMSDF ships use Tateyama Bay (see Figure V-1) as an anchorage when a typhoon is expected to pass east of Tokyo Bay. Water depths in Tateyama Bay are deep enough for vessels of all sizes and the bottom offers good holding. Kisarazu Harbor, also identified on Figure V-1, is also used.

Merchant vessels have at times, depending on the direction of the tropical storm or typhoon CPA, anchored in the following areas:

(1) Tropical cyclone passage to the east or south of Tokyo Bay - anchor in Chiba Harbor or Kisarazu Harbor.

(2) Tropical cyclone passage to the west or north of Tokyo Bay - anchor in Kaneda Bay.

The 3rd Regional Maritime Safety Headquarters has issued a brochure titled INFORMATION SERVICE FOR VESSELS AT ANCHOR IN TOKYO BAY IN THE EVENT OF A TYPHOON APPROACHING THE MAIN ISLAND OF HONSHU, dated June, 1992. The following information has been excerpted from the brochure.

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During the period when typhoons are approaching the main island of Honshu, Tokyo Bay anchorages tend to become overcrowded with vessels seeking shelter from the approaching bad weather. Overcrowding of anchorages during stormy weather can lead to the additional hazards of collisions and grounding due to anchor dragging. To prevent and reduce the risk of such accidents, the Tokyo Bay Traffic Advisory Service Center (Call sign TOKYO MARTIS) provides information services for vessels at anchor or seeking anchorage in Tokyo Bay. The Center airs information services broadcasts following advisory warnings to evacuate the port or harbor due to an approaching typhoon.

Broadcasts will be in Japanese on the hour and half hour, on a frequency of 1,665 kHz, and contain information on the number of vessels anchored in each of the following areas:

1.	Off Kurihama	2.	Off Yokosuka
3.	Off Yokohama	4.	Off Kawasaki
5.	Off Tokyo	6.	Off Funabashi
7.	Off Chiba	8.	Off Banzu-Hana
9.	Off Kisarazu	10.	Off Futtu
11.	Off Sasage	12.	Naka-No-Se

The brochure also makes the following recommendations to be taken during stormy weather:

(1) Maintain a listening watch on VHF Channel 16 or by radio on 1665 Khz.

(2) Listen for warnings on vessels which are dragging their anchors. The warnings will be broadcast on VHF Channel 12 following a general call on Channel 16.

(3) Keep a proper watch with sufficient lookouts. If necessary, main engines should be ready for immediate use. Power to windlasses should also be available for emergency use.

(4) Maintain a safe distance from other vessels and be alert for signs of anchor dragging either by your own vessel or others in the vicinity. Be aware that a sudden change of wind speed and direction may affect anchor holding power.

(5) Take into account the depth of water and type of holding ground in the anchorage and if necessary use both anchors with sufficient scope of cable laid out. Main engines should be used to back-up the anchors if necessary.

(6) Improve the vessels sea-keeping qualities at anchor in order to reduce the risk of anchor(s) dragging. For example, vessels with large sail areas should consider such measures as taking on additional ballast, altering the vessels trim and use of main engines to prevent the vessel from dragging her anchor.

Vessels carrying a dangerous cargo must anchor as directed by the Japanese Maritime Safety Office. Ships requiring a pilot to transit the Uraga Suido Traffic Route may be unable to secure pilot services if winds are greater than about 35 kt because pilots embark and debark from small motor launches.

2.4.5 Evasion at Sea

Evasion routes at sea may be developed by the use of the NOCC/JTWC Guam tropical cyclone warnings (see Chapter I), and Appendix A (mean tropical cyclone tracks, track limits, and average speed of movements) for the month of interest in conjunction with Figures V-13 to V-15 (tropical cyclone threat axis and approach times to Yokosuka). In each specific case, Optimum Track Ship Routing (OTSR) should be consulted as to the best evasion route.

YOKOSUKA

The widely held doctrine of evasion at sea rather than remaining in port for the single purpose of minimizing typhoon-related damage is not generally recommended when in port at Yokosuka. In 1989 two large Navy ships were berthed at Berth 8 when a typhoon threatened the Yokosuka area. The one that was moored outboard chose to evade at sea, and suffered damage. All of the vessels that remained in port incurred no damage.

If a ship Captain makes the decision to evade at sea, plan to get underway days in advance of the storm's arrival. It must be remembered that tropical cyclones are notoriously difficult to accurately forecast, especially in the recurvature phase, and the 48-hour forecast position error may exceed 200 nmi. A storm may be closer to or farther from Yokosuka than the forecast indicates, or right or left of the storm's forecast track.

A late departure from port may make the sortie difficult due to fishing boat congestion at the harbor entrance and increase the likelihood of encountering heavy weather as the ship departs Tokyo Bay. Each tropical storm or typhoon must be considered as differing from those preceding it. The accompanying synoptic situation must be fully understood. To blindly establish and follow one technique or rule for avoiding the storm's danger area is not practical. The Japanese say "the only solution is that there is no one solution."

In general, the effects of wave/swell generated by a tropical cyclone initially will be encountered in the vicinity of Kannon Saki by departing ships (see Figure V-1) and may reduce the speed of advance (SOA) thereby increasing the time required to reach open sea. If a ship is caught in the wave/swell pattern ahead of a tropical cyclone, particularly an intense tropical storm or typhoon, the SOA may be reduced to the point that the ship will be unable to maneuver to clear the danger area (see Figure I-4). If the typhoon is forecast to follow a recurving track, with a CPA to the east of Yokosuka, then a course downsea/downwind in the left or navigable semicircle may be advisable.

Any course to the north along the east coast of Honshu is considered unwise. The possibility of being overrun exists if the storm accelerates and/or turns suddenly to the north. The average speed of advance in the higher latitudes (30-40°N) of tropical cyclones is about 25 kt; however, they have been tracked as fast as 50 kt. Typhoon wind intensities tend to decrease as the system moves into the northern latitudes, but nevertheless can be quite destructive.

Port Visit Information

November 1992: NRL Meteorologists CDR R. G. Handlers, USN, and Mr. L. Phegley, and SAIC Meteorologist Mr. R. D. Gilmore met with CDR D. T. Ward, Operations Officer, COMNAVFORJAPAN, Mr.Duncan, QMC Stevens, CAPT Kempf, and CAPT Toomey, all of CFAY Port Operations, Mr. C. Hariki, Captain of the Port, Yokosuka and Chief, Yokosuka Maritime Safety Office, COL Takei, JASDF Air Weather Squadron, CAPT Nagata and CDR Yoshimura, JMSDF Oceanographic Command, and LCDR Iimura, JMSDF District Headquarters in Yokosuka to obtain much of the information included in this port evaluation. In Addition, Mr. Terui of NOCF Yokosuka greatly aided this data collection effort by translating much of the data acquired during visits to Yokosuka and other Japanese ports.

3. NUMAZU OPERATING AREA

SUMMARY

The conclusion reached in this study is that Suruga Bay, including the Numazu Operating Area should not be considered a "safe" typhoon haven for ships operating in the area or transiting the south central coast of Honshu. The primary factors in reaching this conclusion are:

(1) The openness of the bay to the effects of the ocean -- especially in the southwestern quadrant.

(2) The lack of any suitable sheltered area for a ship to lie to or anchor in.

(3) Wind and swell wave action can be as devastating in the Suruga Bay area as on the open ocean if these effects are being felt from the south-southwest. (A southwesterly wind gust of 97 kt was recorded at Numazu on 25 September 1966 as Typhoon Ida passed 30 n mi to the west. Winds in excess of 34 kt existed for 5 hours.)

Some protection from northeasterly winds (associated with a tropical cyclone passing to the east) may be found by keeping close to the Izu Peninsula (eastern) side of the bay. This should reduce the effects of the wind and wind generated waves because of the shorter fetch the winds would blow over. In spite of the deep water in Suruga Bay, caution should be exercised when operating close to land as visibility may be reduced and radar reception hindered by the effects of a tropical cyclone passing close by. Also the confused sea state with accompanying wind may set up unpredictable local currents.

Additionally, it has been concluded that surf conditions in the Numazu Operating Area may be unsafe for small craft operation for a number of days after a tropical cyclone passes CPA because of the slow decay rate of swells associated with such a storm. This conclusion can also be applied to tropical cyclones, especially typhoons, that pass well to the south of the 180 n mi threat circle used in this study.

To avoid the effects of tropical cyclones that pose a threat to the Numazu Operating Area, evasion to the Yokosuka/Tokyo Bay area is highly recommended.

3.1 LOCATION AND TOPOGRAPHY

The terrain around Suruga Bay is generally rugged and mountainous. The dominant topographic feature in the area is Fujiyama (12,395 ft), the highest mountain in Japan. This extinct volcano rises from the northern shore of the bay to its peak, 12 n mi away. Along the eastern and western coasts, the mountains rise abruptly to heights in excess of 4000 ft and 6000 ft, respectively.

These ridges lie generally in a north-south orientation with a "saddle" between them and Fujiyama. Figure V-2 (Yokosuka section) shows the topographic features of this region.

The Numazu Operating Area takes its name from the city of Numazu, which is located at 35°05'N, 138°52'E at the northwestern side of the Izu Peninsula on the northeast shore of Suruga Bay. The harbors of Shimizu and Tagonoura are also located, respectively, on the western and northern shore of Suruga Bay. Figure V-19 locates some pertinent features. Suruga Bay penetrates the southern coast of Honshu in a north-northeasterly direction for a distance of approximately 35 n mi. Numerous ships of various sizes transit the bay enroute to the harbors mentioned.[7]

Suruga Bay itself is characterized by extreme depths. At its entrance, the depth is in excess of 2500 m. An exception is in the south central region of the bay where the bottom rises up to within 30 m of the surface. Along the northern shore the bottom drops off to over 200 m within a mile of the coast.

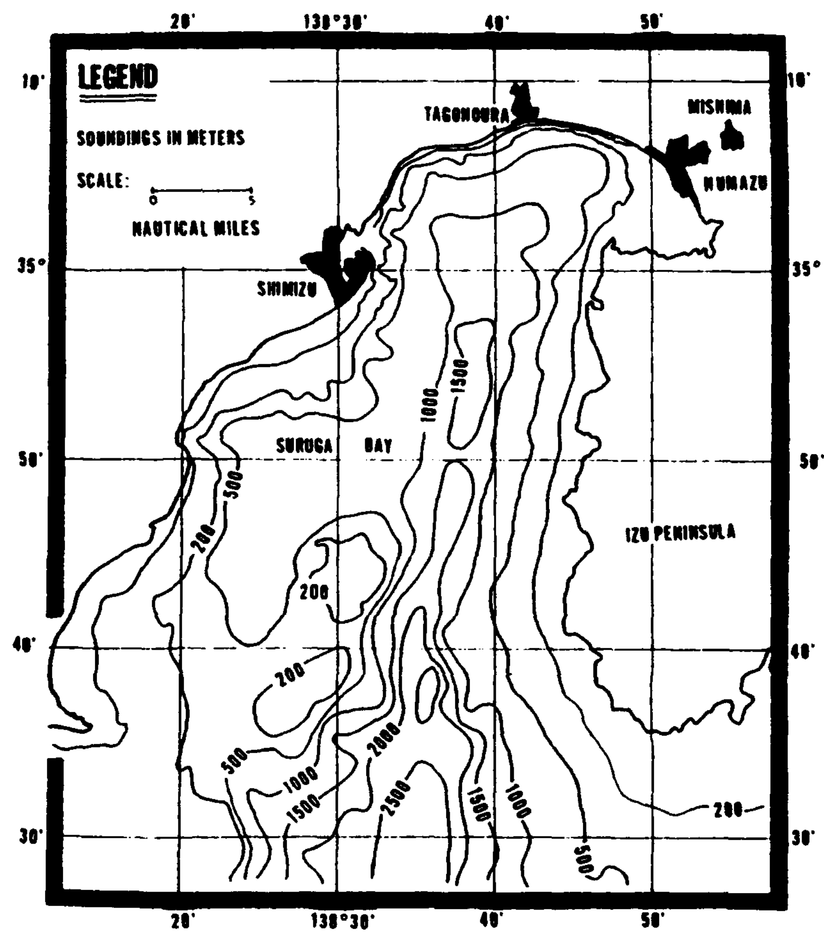

Figure V-19. Geographical depiction of Suruga Bay featuring the bathymetry of the Bay.

[7] Shimizu is a major container ship port for central Honshu; Tagonoura is a small exporting industrial city; and Numazu is a local port for small (less than 500 tons) fishing and rock gathering boats.

3.2 TROPICAL CYCLONES AFFECTING THE NUMAZU OPERATING AREA

3.2.1 Tropical Cyclone Climatology for Numazu

Tropical cyclones which affect the Numazu Operating Area generally form in an area bounded by the latitudes 5°N and 30°N and the longitudes 120°E and 165°E. The latitudinal boundaries shift poleward during the summer months and then equatorward in winter in response to the seasonal location of the southern boundary of the prevailing easterlies.

In the genesis area mentioned above, typhoons have occurred in all months but, with rare exceptions, those affecting the main Japanese Islands are confined to the period May to November. Late summer and early autumn are the likeliest seasons. Size and intensity of the storms vary widely. The majority of those that pose a "threat" to the area (any tropical cyclone approaching within 180 n mi of Numazu is defined as a "threat" for the purpose of this study) occur during the months June-October. Figure V-20 gives the frequency distribution of threat occurrences by 5-day periods. This summary of 84 tropical cyclones is based on data for the 28-year period, June-October 1947-1974. Note that the maximum number occur during August and September.[8]

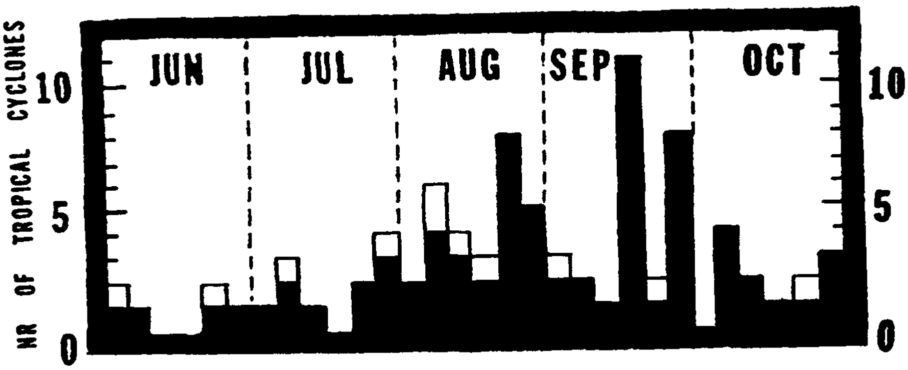

Figure V-20. Frequency of tropical cyclones that passed within 180 n mi of the Numazu Operating Area. Subtotals are based on 5-day periods for tropical cyclones that occurred during 1947-1974. Shaded area indicates recurving tropical cyclones per 5-day period (that is, had a northeasterly direction of movement at CPA).

[8]A total of 89 tropical cyclones passed within 180 n mi of the Numazu Operating Area during the May-November period for the years 1947-1974. Eighty-four (94%) of these tropical cyclones passed within 180 n mi during the 5 months, June-October, and the remaining 5 passed in the months May and November.

Figure V-21 displays the "threat" of tropical cyclones according to the octant from which they approached the 180 n mi radius threat area. The circled numbers indicate the total that approached from an individual octant. The figure count for an octant of approach includes both recurving and non-recurving tropical cyclones. (See Chapter I, paragraph 3 for description of recurving tropical cyclones.) The adjacent numbers express this as a percentage. It is evident that a majority of these approach from the southwestern quadrant. A more detailed inspection of the sample of 84 tracks reveals that 11 (13%) did not recurve before passing the closest point of approach (CPA) to the Numazu Operating Area.

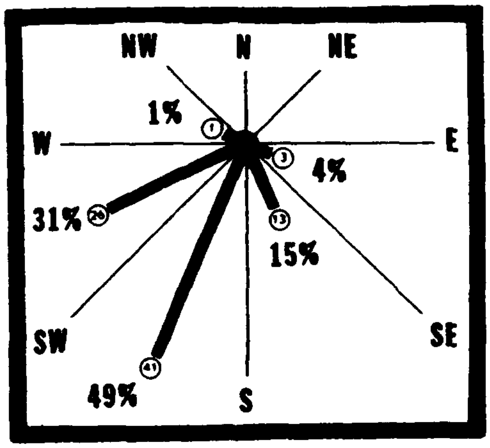

Figure V-21. Directions from which tropical cyclones entered threat area during the period 1947-1974. Numbers circled indicate the number of tropical cyclones that entered from each octant. This is expressed as a percentage adjacent to the circled number.

Table V-4 indicates that of the 84 tropical cyclones that posed a "threat" to the Numazu Operating Area during the years 1947-1974, 46% passed to the east of Numazu, 42% passed to the west and 12% passed in the immediate vicinity (within 20 n mi) of the area. The apparent majority of the "threat" tropical cyclones passing to the west or in the immediate vicinity implies that the Numazu Operating Area is placed quite often in the right or "dangerous" semicircle where the winds and seas are more intense.

Table V-4. "Threat" tropical cyclone passage relative to Numazu (1947-1974).

TRACK RELATIVE TO NUMAZU	JUN	JUL	AUG	SEP	OCT	TOTAL
Passed east of Numazu	3	3	13	12	8	39
Passed west of Numazu	2	7	12	11	3	35
Passed in the immediate vicinity of Numazu	1	1	3	4	1	10

Figures V-22 through V-26 represent an analysis of the estimated "threat" probability for any tropical cyclone as it approaches the Numazu Operating Area. The solid lines represent the probability of a system within an isoline coming within 180 n mi of the Numazu Operating Area. The dashed lines represent the approximate time in days for a system to reach Numazu based on typical speeds of movement of tropical cyclones affecting Numazu (Table V-5). For example, in Figure V-22, a tropical cyclone located at 27°N, 140°E has a 60% probability of passing within 180 n mi of the Numazu Operating Area and it will reach Numazu in about one day.

Table V-5. Average tropical cyclone speed of movement (kt) per 5-degree latitude band for tropical cyclones affecting the Numazu Operating Area for June-October.

LATITUDE BAND	JUN	JUL	AUG	SEP	OCT	AVERAGE
30 - 35 N	23	15	13	20	28	19.8
25 - 30	17	12	11	14	21	15.0
20 - 25	13	10	11	11	13	11.6
15 - 20	10	10	10	11	12	10.6

The speeds in Table V-5 were derived by considering that as tropical cyclones recurve, their forward speed characteristically, but not always, slows during the recurvature period. It should be expected that the system will subsequently accelerate rapidly toward the north or northeast. Speeds of 20 to 30 kt are common and speeds as great as 50 kt have been observed.

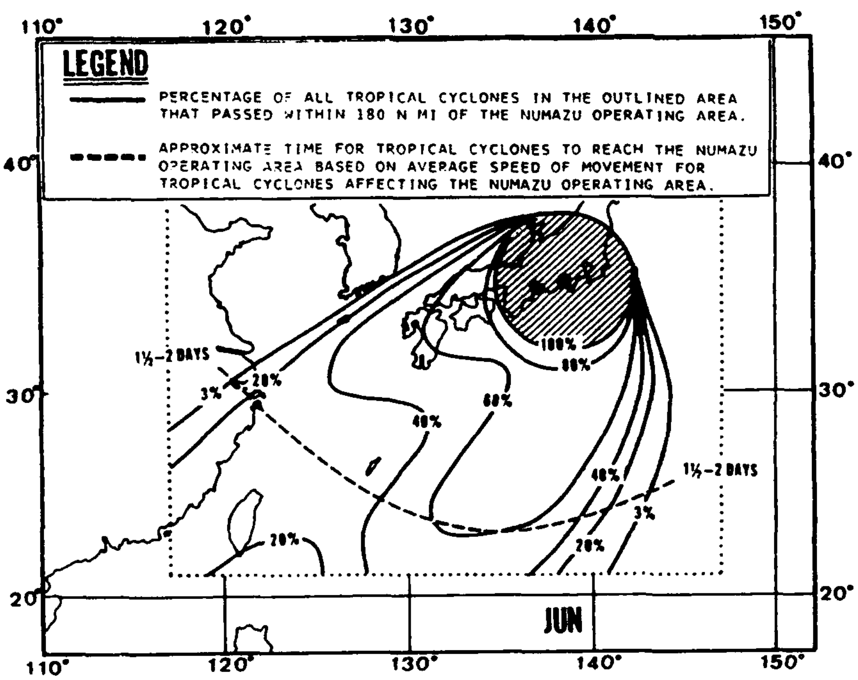

Figure V-22. Probability that a tropical cyclone will pass within 180 n mi of Numazu (shaded area) in June. (Based on data from 1947-1974.)

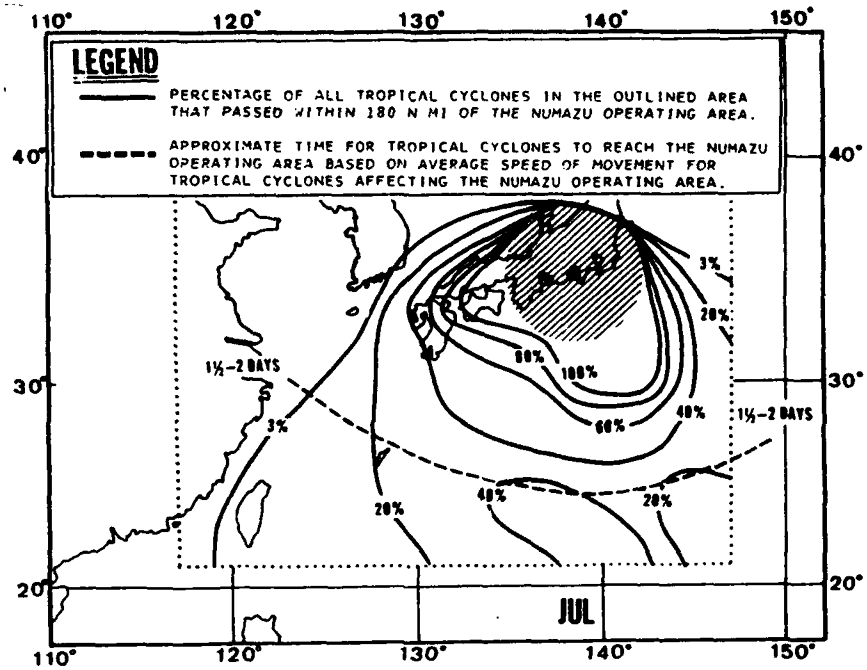

Figure V-23. Probability that a tropical cyclone will pass within 180 n mi of Numazu (shaded area) in July. (Based on data from 1947-1974.)

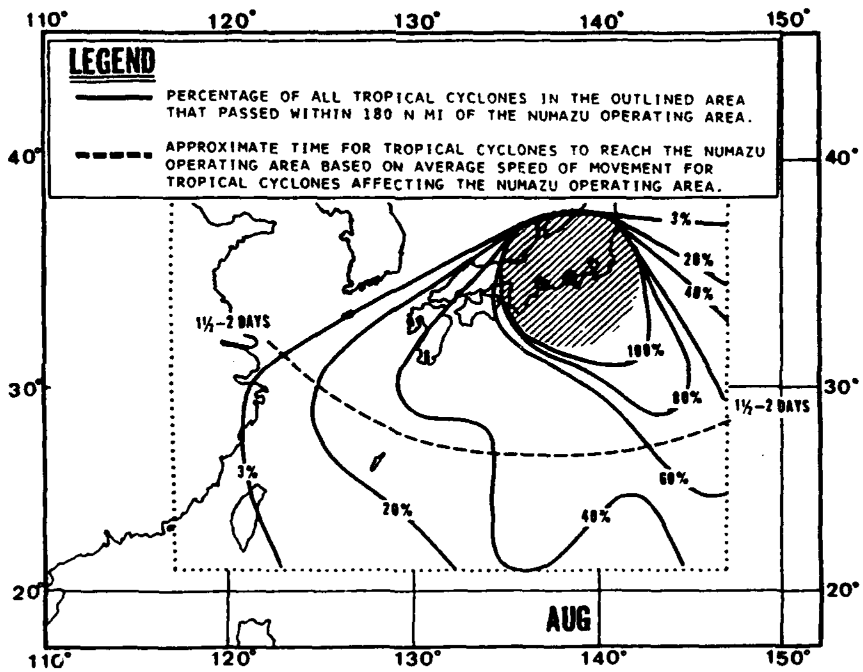

Figure V-24. Probability that a tropical cyclone will pass within 180 n mi of Numazu (shaded area) in August. (Based on data from 1947-1974.)

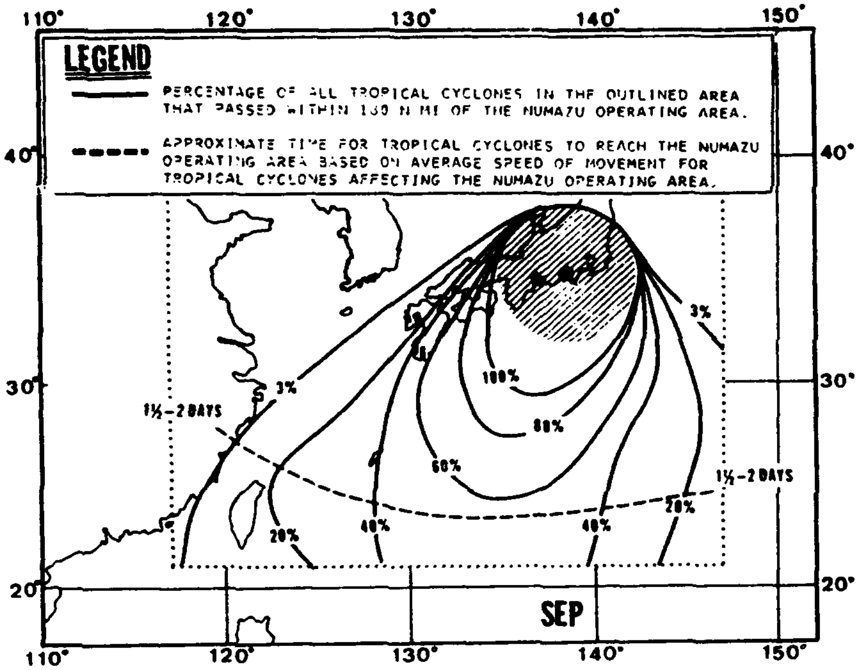

Figure V-25. Probability that a tropical cyclone will pass within 180 n mi of Numazu (shaded area) in September. (Based on data from 1947-1974.)

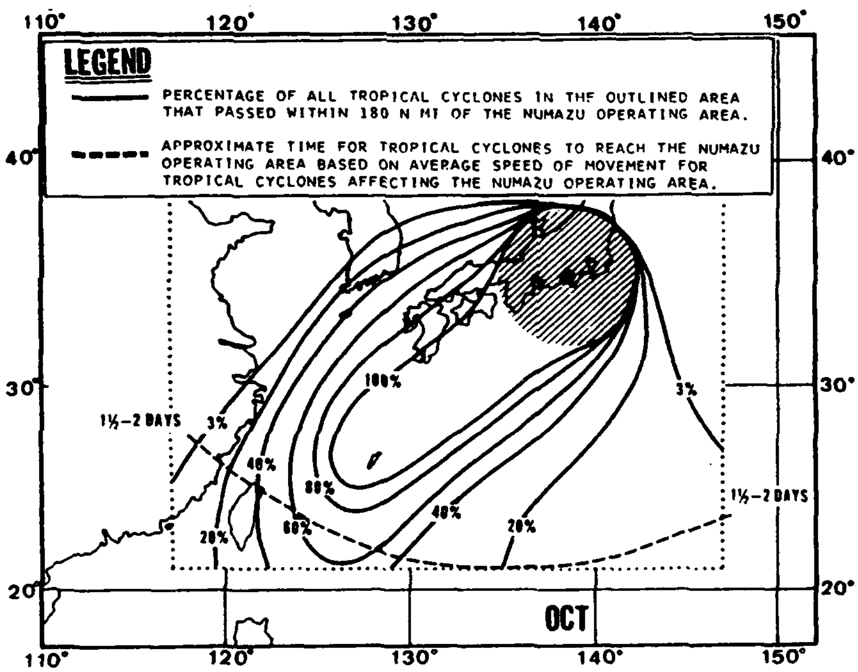

Figure V-26. Probability that a tropical cyclone will pass within 180 n mi of Numazu (shaded area) in October. (Based on data from 1947-1974.)

3.2.2 Wind And Topographical Effects

A total of 50 tropical cyclones passed within 180 n mi of the Numazu Operating Area in the 19-year period 1956-1974 during the months June-October, or about 2.6 per year.[9] Table V-6 groups the 50 tropical cyclones by strong (≥22 kt) and gale force (≥34 kt) wind intensities (based on hourly wind data) that they produced at Mishima.[10] Tropical cyclone activity within 180 n mi of the Numazu Operating Area is at a maximum during the months of August and September and these individual monthly values are also shown.

Table V-6. Extent to which tropical cyclones affected the Numazu Operating Area during the period June-October, 1956-1974 and for the individual months of August and September.

	JUN-OCT	AUG	SEP
Number of tropical cyclones that passed within 180 n mi of the Numazu Operating Area	50	20	16
Number of tropical cyclones resulting in strong (≥22 kt) winds in the Numazu Operating Area	39 (78%)	14 (70%)	15 (94%)
Number of tropical cyclones resulting in gale force (≥34 kt) winds in the Numazu Operating Area	25 (50%)	10 (50%)	10 (63%)

It can be discerned from Table V-6 that 25 (50%) of the total 50 tropical cyclones for the period June-October (1947-1974) resulted in winds of 34 kt or greater at Mishima. However, note that of the 16 tropical cyclones in September, 10 (63%) of these resulted in winds of 34 kt or greater.

The observation station at Mishima is located approximately 3 n mi northeast of the city of Numazu. The wind instrument is located on top of the station in a residential section of the city. There is no appreciable difference in the elevation of the station and that of Numazu, both being located in a flat coastal plain lying between the mountainous ridge running south into the Izu Peninsula and Fujiyama to the northwest. The observed wind is fairly representative of that at the Numazu Harbor where the observation station had been

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[9] From Chin (1972) for years 1956-1970 and from Annual Typhoon Reports for years 1971-1974 (FWC/JTWC, 1971-1974).

[10] Data provided by the Japanese Meteorological Agency weather station located at Mishima, 3 n mi inland from the Numazu Harbor (see Figure V-19).

previously located. However, during the period 1964-1973, the highest recorded wind gust in Numazu was 97 kt on 25 September 1966 while at Mishima the wind gust was recorded at 82 kt (also the highest recorded during the period). This southeasterly gust was attributed to Typhoon Ida which passed 30 n mi to the west of Numazu on 25 September 1966. During this particular typhoon, sustained winds were recorded in excess of 34 kt for 5 hours.

Winds in Suruga Bay are greatly influenced by the surrounding topography and geographical features of the bay itself. The extent of this influence is dictated by the direction of approach of the storm and the passage relative to the Numazu Operating Area. From an analysis of the tropical cyclone tracks that affected Numazu, it is apparent that tropical cyclones that result in gale force winds or greater at Mishima can pass to the east or west of Mishima or in some instances the center of the storm passes over the immediate area. The basic difference between the passages is the direction of the resulting winds in the area.

If the tropical cyclone passes to the west of the Numazu Operating Area, the winds will be predominantly from the southwest. For a passage to the west, the storm must necessarily cross the mountain ranges of Honshu. An example of this was Typhoon Vera (September 1959) which had a CPA of 110 n mi to the northwest of Mishima. The typhoon pounded the area with gusts of 68 kt from the southwest and sustained gale force winds for a 7-hour period.

If the tropical cyclone passes to the east of Mishima, the path will generally be over water and the winds will be primarily northeasterly. An example of this was Typhoon Ida (September 1958) which had a CPA of 30 n mi to the southeast of Mishima. As a result, the area experienced gusts of 64 kt from the north-northeast.

Occasionally, a tropical cyclone will pass in the vicinity of Suruga Bay. In the 28-year period (1947-1974), ten tropical cyclones tracked in such a manner with 7 of them bringing gale force winds to the area. Under such circumstances there is no discernable pattern of a prevailing direction from which the strongest winds originate. Nor is the proximity of a storm's center indicative of force. Of the 10 tropical cyclones tracked, the maximum wind gust recorded ranged from 20 kt to 85 kt.

Figure V-27 shows the position of "threat" tropical cyclone centers when strong winds ($\geq$22 kt) were first and last recorded at Mishima. A number of storms gave Mishima $\geq$22 kt winds when they were 300 n mi from the city with a predominant number of occurrences to the south and east of the Numazu Operating Area. Note also that strong winds were still being generated by a few storms when the storm centers were as far north as the island of Hokkaido. Figure V-28 shows tropical cyclone center positions when gale force ($\geq$34 kt) winds were first and last recorded at Mishima. It can be ascertained from this figure that winds $\geq$34 kt generally do not begin until the storm is about 180 n mi away. Notice the preponderance of storms that generate gale force winds are south-southeast and northwest from Mishima and that those storm centers that track to the northwest of the area produce gale force winds of longer duration.

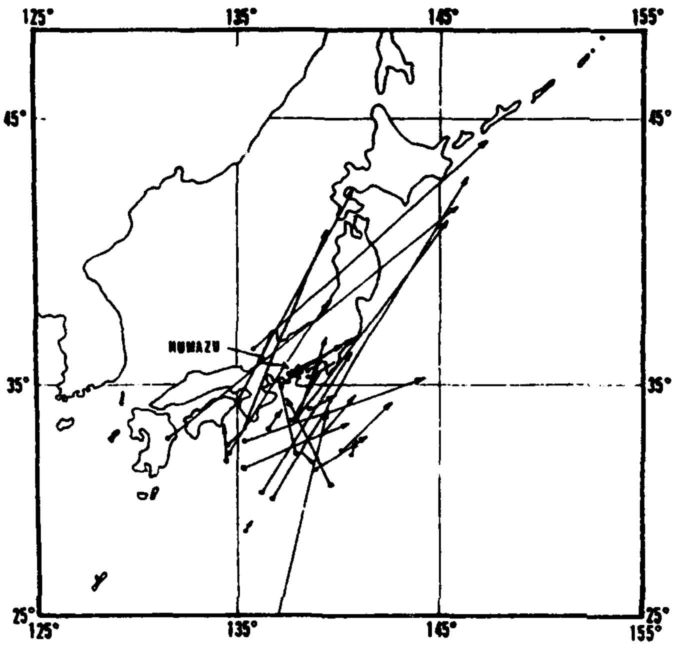

Figure V-27. Positions of 39 tropical cyclone centers when winds $\geq$22 kt first and last occurred at Mishima. (Based on hourly data for the months June-October during the years 1956-1974.)

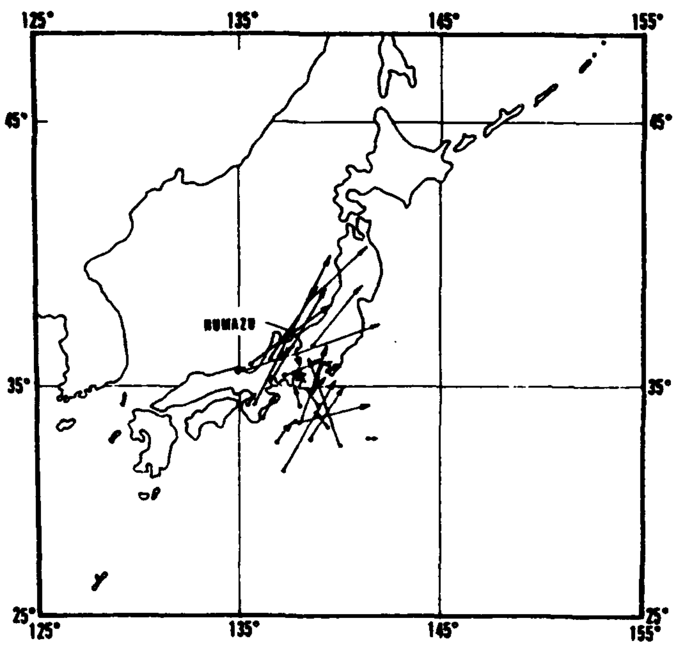

Figure V-28. Positions of 25 tropical cyclone centers when winds $\geq$34 kt first and last occurred at Mishima. (Based on hourly data for the months June-October during the years 1956-1974.)

3.2.3 Wind And Swell Wave Action

The combination of the extreme depth and geographical orientation of Suruga Bay makes the area susceptable to extreme wave action -- often on short notice. Because of the depth of the bay, wave activity in the open areas of the bay is to be considered similar to that of the open ocean (under certain circumstances). Incoming wind and swell wave energy does not begin to come under the shoaling effect until it reaches the extreme northern reaches of the bay.

The northeast-southwest geographical orientation of Suruga Bay makes it extremely vulnerable to the wind and wave condition of the ocean and provides an unimpeded region for winds from the southwest quadrant to flow. The Numazu Operating Area is located in the northern reaches of the bay in extremely deep water and fully exposed to the aforementioned southwesterly flow of wind. The result is that the operating area is placed at the focal point of a considerable amount of incoming wave energy -- produced both locally and at great distances.

The beach along the northern side of the bay can be considered steep and is composed of pea gravel. From Figure V-19 it can be seen that the bottom profile drops off rapidly to over 200 m in less than 1 n mi. The Japanese government has built a massive sea wall (approximately 50 ft high) that stretches along the entire northern coast of Suruga Bay and on the southwestern flank of the Numazu Harbor.

Maximum wave action generated by winds will occur when tropical cyclones pass to the west of the Numazu Operating Area. The resultant winds from the southwestern quadrant will flow unimpeded the entire length of the Suruga Bay, and depending on the size of the storm and the area over which the generating wind blows (fetch), produce wave heights typically associated with such winds encountered in the open ocean.

For tropical cyclones passing to the east, as approximately 46% have done in the 28-year period 1947-1974, the effects of wind produced waves will be lessened by the northeasterly flow of winds interacting with the mountains of the Izu Peninsula. Under such circumstances however, wind waves generated over the shorter fetch will be of the high frequency type -- usually steep with a short time interval between successive crests.

Swell waves are characterized by long, smooth undulations of the sea surface. These waves result from storms located at great distances from the coast and the time between successive crests may be quite large. Such waves seldom, if ever, break in deep water as in Suruga Bay and unless very high usually do not affect small craft operations while they are operating in the deep water. They do, of course, cause rolling and pitching of large vessels. However, swell waves are important in that upon reaching shallow water the wave height increases markedly, perhaps by a factor of two or more. Thus when they reach a depth shallow enough to break, they can give rise to immense surf which may cause damage or destruction to small craft or harbor installations.

Since Suruga Bay opens to the southwest, it is exposed to swells arising from the tropical cyclone generating area in the lower latitudes. These swells with their incumbent high energy approach the coast at high speeds and in the case of a large offshore disturbance such as a typhoon, the swell will ordinarily arrive before the disturbance. This situation could hamper a ship's efforts in attempting to reach a typhoon haven ahead of the storm.

The two types of waves, wind and swell waves, usually exist simultaneously at any time in the open waters of Suruga Bay. Often times the swell are completely obscured by the wind waves generated by local wind conditions. It is only near the shoreline in the Numazu Operating Area, where the swell begins to peak to greater heights, is the observer made aware of their presence. In this area, where critical wave conditions result from swell generated by storms occurring at considerable distances, local wind conditions may be of little value in determining significant wave and surf characteristics. A consideration of the orientation of isobars on a weather map will reflect large scale wind patterns and permit an estimate of the extent of the generation area and, consequently, the length of the fetch and the direction of wave propagation.

Table V-7 is an example of Fleet Numerical Weather Central's Wave Refraction/Surf Prediction based on the bottom topography of the Numazu Operating Area, direction of the incoming wave energy, and the period of the wave. The result is a "surf coefficient" that is dependent on the angle of incidence of the wave energy ray with respect to the beach. This surf coefficient is the equivalent to the ratio of the shallow water wave height and the deep water wave height. With this coefficient, an observer located in the deeper water of the operating area can estimate the height of waves passing his location and apply the surf coefficient to determine the height of the surf at the beach. For example, if a wave from the southwest with a height estimated to be 5 ft high in the deeper water and a period (measured crest to crest) of 10 sec, the surf height would range from 5 ft to 10 ft with an average of 7 ft. It should be noted that independent studies have found that the average period of typhoon generated waves is approximately 8-12 sec.

Table V-7. "Surf coefficients" determined by wave period and direction of wave energy. Resultant coefficients reflect the range of the coefficients with the average in parenthesis.

Direction of Wave Energy	Wave Period (crest to crest) Sec.									
	6	8	10	12	14	16	18	20	22	24
SOUTH	1.1-2.5 (1.3)	1.1-2.7 (1.5)	1.1-2.0 (1.5)	1.0-2.1 (1.5)	1.2-2.5 (1.6)	1.3-2.4 (1.8)	1.4-3.3 (2.1)	1.5-3.1 (2.1)	1.0-4.1 (2.2)	1.0-5.1 (2.4)
SOUTHWEST	0.9-1.7 (1.3)	1.0-2.0 (1.3)	1.0-2.0 (1.4)	1.2-2.2 (1.6)	1.1-2.5 (1.7)	1.3-2.6 (1.9)	1.4-2.5 (1.9)	1.5-2.9 (2.1)	1.4-3.0 (2.1)	1.5-3.0 (2.1)

Because of its geographical configuration, the above indicates that surf conditions near Numazu may be affected by distant storms that pass to the south or southwest, even though they may pose no threat to the Numazu Operating Area or show tendency of recurving. The swell generated by these and other storms travel at speeds (kt) of three times their crest-to-crest period. (That is, a swell with a period of 12 sec will progress outward from the generating area at 36 kt.) Eventually the "family" of swell separates with the longer period swell outdistancing the shorter periods. Decay rates of swell energy varies according to the size of the generating area and strength of the wind over the fetch. Typical tropical cyclones of typhoon intensity can generate sufficient energy such that swell from these storms can be felt at distances of 800-1000 n mi from the center of the generating area. Thus, a typhoon hitting Taiwan can result in high surf at Numazu.

3.2.4 Storm Surge and Tides

Storm surges result when a tropical cyclone crosses a coastline. They are caused by an interaction between wind stress on the water, the sharp drop in atmospheric pressure, and the shallowness of the harbor or bay.

Ships operating in Suruga Bay should not normally notice such a surge due to the extreme depths of the bay. More evident would be the wind generated waves and swells originating from the tropical cyclone system itself.

Tidal ranges near the Numazu Harbor area are quite small -- less than 2 ft for maximum ranges. Therefore, any surge associated with a tropical cyclone would tend to have a significant effect close to the harbor entrance where the water depth becomes shallower (approximately 45 fathoms).

For a more detailed discussion on the effects of tropical cyclones on Numazu, see Wixom, 1975.

3.3 THE DECISION TO EVADE OR REMAIN AT NUMAZU

3.3.1 Evasion Rationale

The responsibility for overall coordination of action to be taken by naval activities in the Numazu Operating Area has been assigned to Commander, Fleet Activities, Yokosuka.[11] The Naval Weather Service Facility, Yokosuka issues the local area forecasts for Numazu upon request.

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[11] Storm/typhoon doctrine and coordination procedures for naval forces operating in the COMNAVFORJAPAN area of responsibility has been established by COMNAVFORJAPAN INST 3140.1 series. For general information on tropical cyclone warnings the reader is referred to paragraphs 6 and 7 of Chapter I.

The commander must recognize the inherent dangers that exist when exposed to the possibility of hazardous weather while operating in the Numazu Operating Area. By proper utilization of meteorological products, especially the FWC/JTWC Tropical Cyclone Warnings, and a basic understanding of weather, the commander will be able to act in the best interest of his unit and to complete his mission when the unfavorable weather subsides. The following time table (in conjunction with Figures V-29 to V-33) has been set up to aid in these actions. The orientation of the threat axis in these Figures was derived by considering the general direction from which the tropical cyclones approached to within 180 n mi of the Numazu Operating Area. The time in days to reach the Numazu Operating Area was based on average speeds of movement of tropical cyclones affecting Numazu.

1. An existing tropical cyclone moves into or development takes place in Area A with long range forecast movement toward the Numazu Operating Area (recall that about 40% of all tropical storms and typhoons recurve):

   a. Review material condition of ship.

   b. Plot FWC/JTWC warnings and construct the danger area (see paragraphs 6 and 7 of Chapter I). Reconstruct the danger area for each new warning.

2. Tropical cyclone enters Area B with forecast movement toward the Numazu Operating Area (recall that prior to recurvature, tropical cyclones tend to slow in their forward motion and after recurvature, accelerate rapidly):

   a. Consideration should be given to ceasing operations and departing Suruga Bay. Sea state rather than wind conditions may be the governing factor at this stage.

   b. Continue plot of FWC/JTWC warnings.

   c. Prepare the ship for heavy weather. Ship should be alert for large long period swell and heavy surf.

3. Tropical cyclone enters Area C and is moving toward the Numazu Operating Area:

   a. The decision to evade the typhoon by departing the area for Yokosuka or other known typhoon havens in the Tokyo Bay area or evasion at sea must be made.

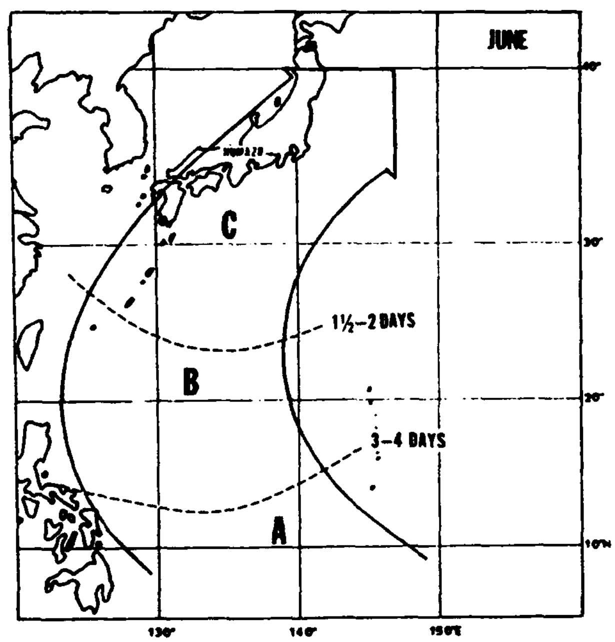

Figure V-29. Tropical cyclone threat axis for the Numazu Operating Area for the month of June.

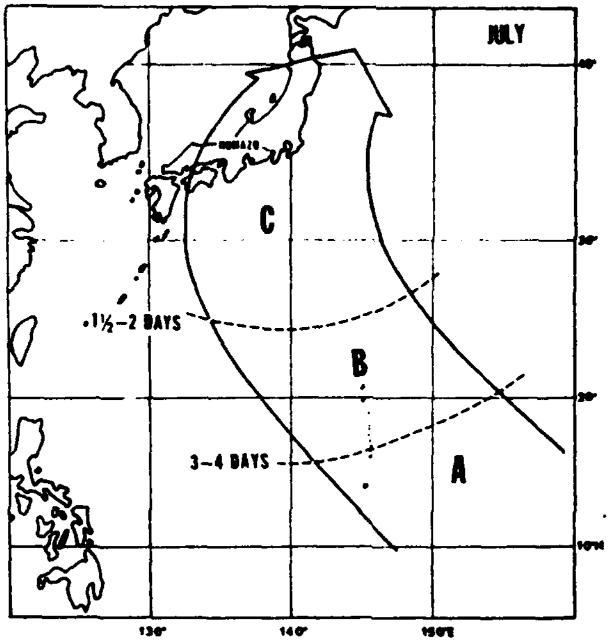

Figure V-30. Tropical cyclone threat axis for the Numazu Operating Area for the month of July.

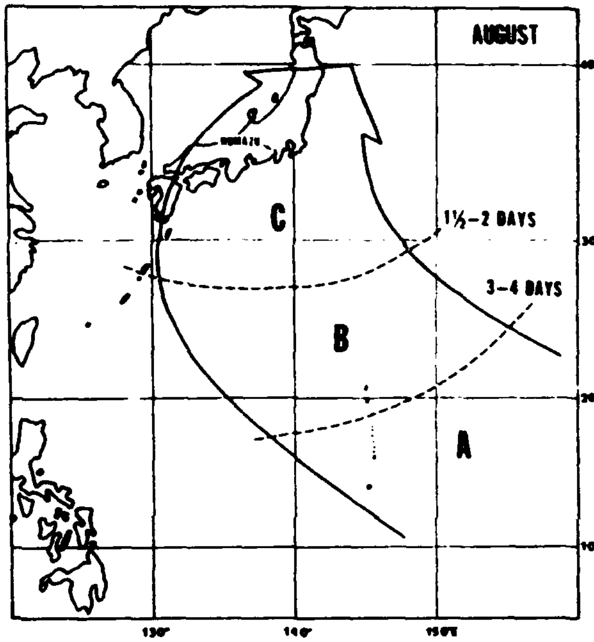

Figure V-31. Tropical cyclone threat axis for the Numazu Operating Area for the month of August.

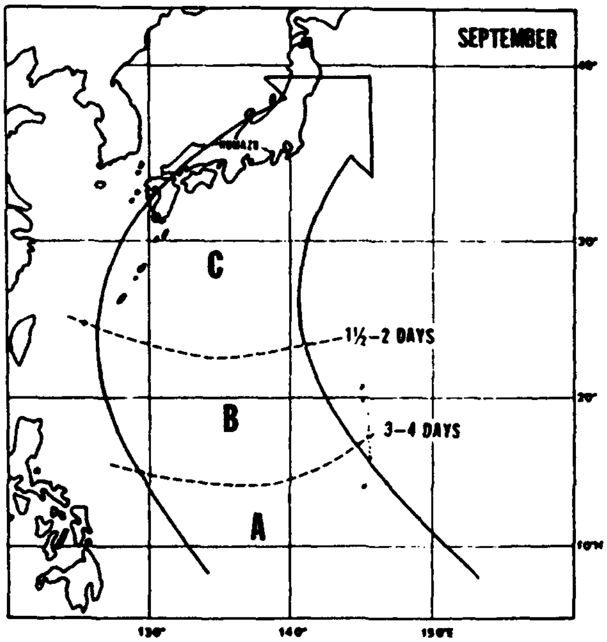

Figure V-32. Tropical cyclone threat axis for the Numazu Operating Area for the month of September.

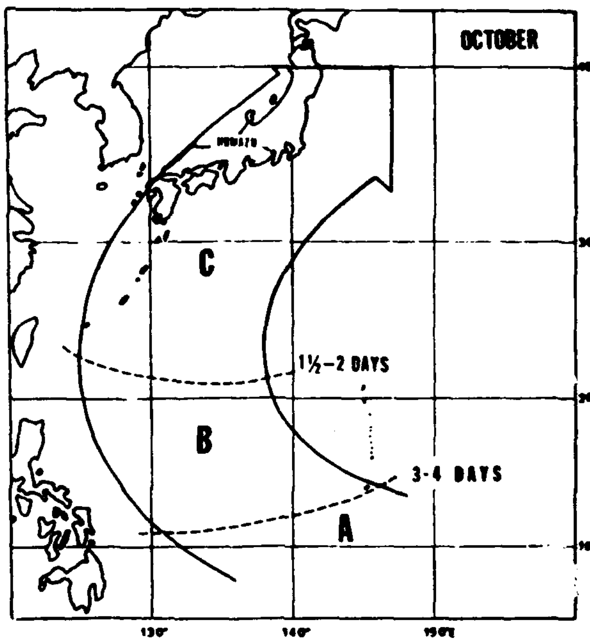

Figure V-33. Tropical cyclone threat axis for the Numazu Operating Area for the month of October.

3.3.2 Evasion To Yokosuka

The port of Yokosuka has been evaluated as an excellent typhoon haven for all sizes and types of vessels. In general, due to the geographical location, surrouding topographical features and harbor construction, the hazardous effects of wind and sea from a typhoon are greatly reduced. However, if crowded conditions exist within the port, which would reduce availability of pierside facilities, a Commanding Officer may elect to evade the typhoon at sea or anchor in Tokyo Bay.

3.3.3 Evasion In Tokyo Bay

Japanese Maritime Self Defense Force ships in the past have anchored in Tateyama Bay for typhoon passage to the east of Tokyo Bay. They also make use of Kisarazu Harbor (see Figure V-1).

Merchant vessels have, at times, depending on the direction of the tropical storm or typhoon CPA, anchored in the following areas:[12]

(1) Tropical cyclone passage to the east or south of Tokyo Bay: anchor in Chiba Harbor or Kisarazu Harbor.

(2) Tropical cyclone passage to the west or north of Tokyo Bay: anchor in Kaneda Bay.

Vessels carrying a dangerous cargo must anchor as directed by the Japanese Maritime Safety Office.

Ships requiring a pilot to transit the Uraga Suido Traffic Route may be unable to secure pilot services if winds are greater than about 35 kt because pilots embark and debark from small motor launches.

3.3.4 Evasion At Sea

The widely held doctrine of evasion at sea rather than remaining in port for the single purpose of minimizing typhoon related damage is not generally recommended if the ship can reach Yokosuka. However, if putting to sea is desirous, each tropical storm or typhoon must be considered as differing from those preceding it. The accompanying weather situation must be fully understood. To establish one technique or rule to avoid the danger area is not practical.

In general, the effects of sea/swell generated by a tropical cyclone may reduce the speed of advance (SOA), thereby increasing the time required to reach the open sea (see Paragraph 5, Chapter I). If a ship is caught in the sea/swell pattern ahead of a tropical cyclone, in particular an intense tropical storm or typhoon, the SOA may be reduced to the point that the ship will be unable to maneuver to clear the danger area.

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[12] See Defense Mapping Agency Hydrographic Center charts H.O. 97151 and H.O. 97143.

If the typhoon is forecast to follow a recurving track, with a CPA to the east of Numazu, then a course downsea/downwind, in the left or navigable semicircle may be advisable.

Any course to the north along the east coast of Honshu (north of Tokyo Bay) is considered unwise. The possibility of being overrun exists if the storm accelerates and/or turns suddenly to the north. The average speed of advance in the higher latitudes (30°-40°N) of tropical cyclones is about 25 kt; however, they have been tracked as fast as 50 kt. Typhoon wind intensities tend to decrease as the system moves into the northern latitudes but, nevertheless, can be quite destructive.

Remaining in the northern regions of Suruga Bay and riding out the storm should only be considered if the certainty of the typhoon's passage well to the east of the area can be ascertained. Some degree of protection may be offered by the mountains along the eastern side of the bay protecting the area from the northeasterly flow around the cyclone's center. Additionally, the sea state will not be as destructive because the fetch will not be as great for the northeasterly wind as it would be for a southwesterly wind.

4. IWAKUNI AND KURE

SUMMARY

The conclusions reached by this study are first that Kure Harbor is a favorable typhoon "haven" for all ships; and second, Iwakuni Harbor, although not recommended as a "haven," has easily accessible anchorages close by which are considered safe during typhoon passage. These conclusions are based on the following:

1. The location and topography of the entire Iwakuni/Kure area significantly reduces the effects of winds attending tropical cyclones.

2. Anchor holding in the designated anchorage areas is rated as excellent.

3. Surge effect is almost negligible and wave heights are not severe in the designated anchorage areas.

4. Port services and repair facilities at Kure (also available to ships at Iwakuni) are among the best in all of Japan.

5. Conversations with local harbor and meteorology officials.

4.1 LOCATION AND TOPOGRAPHY OF IWAKUNI AND KURE AND THEIR EFFECTS ON TROPICAL CYCLONES

4.1.1 General

The mountainous terrain of the islands of Honshu, Kyushu and Shikoku, with elevations exceeding 3000 ft, would lead one to expect that the winds of a tropical cyclone would be greatly reduced before reaching the Hiroshima Bay region. This is, in fact, the case when storms pass either to the west or the east of the bay region.

When storms pass to the west, the wind will normally be reduced 35-50% while storms passing to the east will usually have their winds reduced approximately 60%. Also it appears that southerly winds coming through the Bongo Straits and Inland Sea have the path of least resistance into the Hiroshima Bay area. Generally this would be the case when a storm passes to the west. Further, a very strong storm passing directly through the Bongo Straits would probably give the worst conditions in the Hiroshima Bay region.

4.1.2 Hiroshima Bay Region

Hiroshima Bay is that portion of the Inland Sea of Japan associated with the city of Hiroshima. The area of Hiroshima Bay was covered by air mining during World War II. Channels have been swept by both U.S. and Japanese mine sweepers. Ships negotiating Hiroshima Bay should remain in the swept areas listed in the HYDROPACS and DAPAC (see H.O. 110, Sec. (6-52)-(6-61), and H.O. Chart 97267).

As seen in Figures V-34 and V-35, Iwakuni is located on the western side of the bay in a relatively flat, open area while Kure is embedded in a region of mountains and mountainous islands with almost complete protection from all directions.

Oshima Island, located in south Hiroshima Bay, and the numerous smaller islands offer effective barriers to winds and seas from the south. They also are responsible for the almost negligible surge and relatively moderate seas in the bay with southerly winds. The lee side of any of the larger islands in the bay area provide substantial protection from both wind

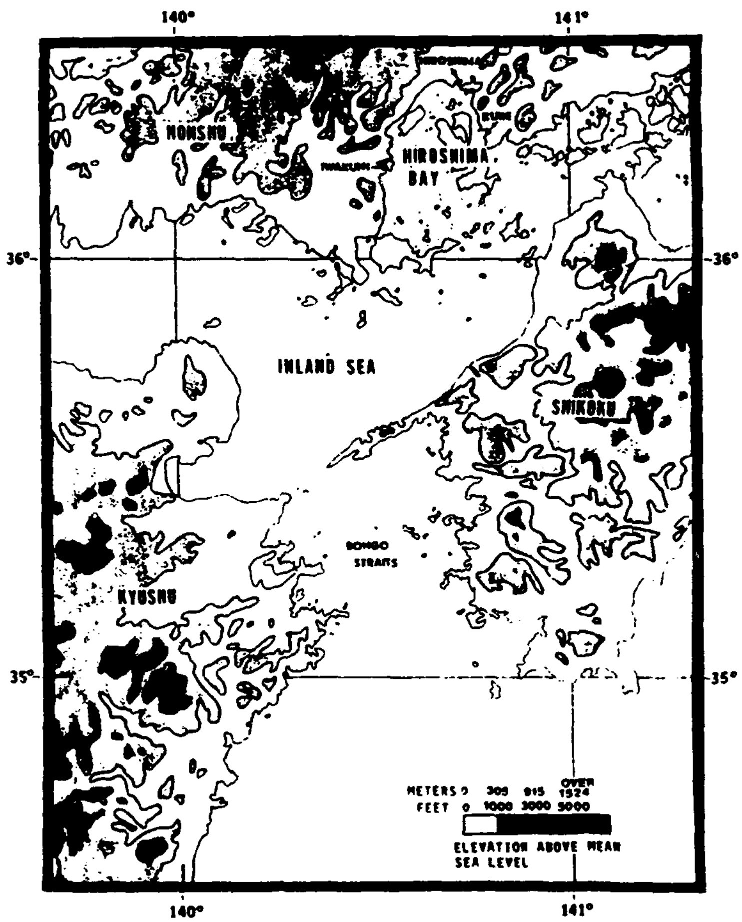

Figure V-34. Hiroshima Bay relative to the main Japanese islands of Honshu, Kyushu and Shikoku.

and sea. However, draft and the allowable radius of swing must be considered when choosing a refuge. Additionally, many of the islands, both large and small, have commercial oyster beds on their northern sides. Destruction of these beds by foreign flag vessels while seeking refuge should be a major consideration of ship captains so as to eliminate, to the greatest degree possible, the straining of relations with local fishermen and authorities.

Area A depicted in Figure V-35 is free from all the complications listed above and gives excellent protection from the wind and sea, particularly from the south and the west (storm passage to the west). The depth is about 60 ft with a mud bottom characterized by good holding. There should be no problem of crowding by other ships or traffic. Area A would also give, for larger vessels, good protection from the wind and sea when the winds are from the east and northeast (storm passage to the east). It might be prudent for small boats to journey to Area D when winds north or east are expected. Area C of Figure V-35 has all the good qualities of Area A and would provide excellent protection when the winds are from the north and east (storm passage to the east). The one drawback to Area C is a relatively shallow depth of approximately 25 ft at its center. Area B in Figure V-35 is a region of strong winds and strong currents and thus should be avoided.

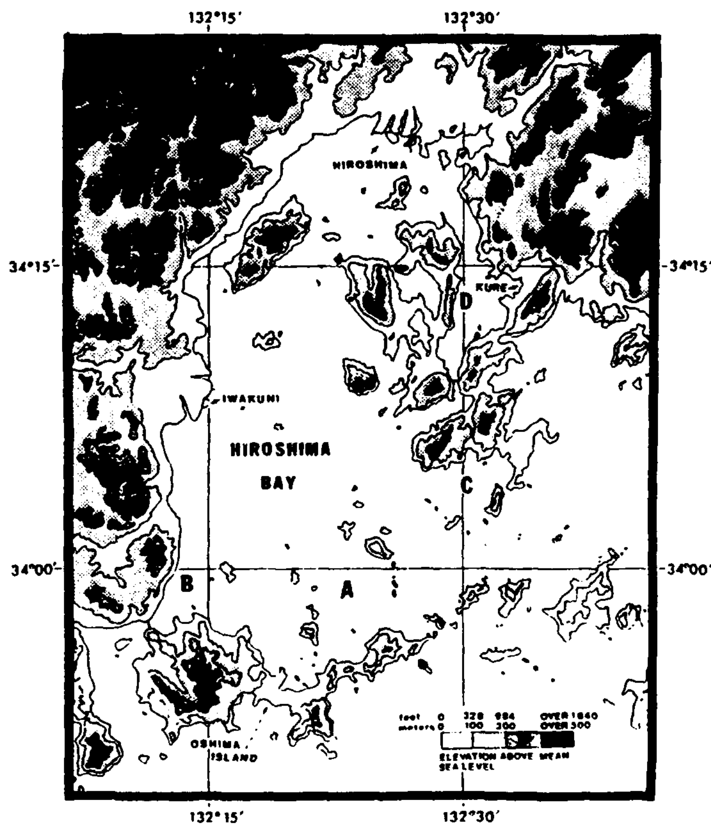

Figure V-35. Hiroshima Bay region.

4.1.3 Iwakuni

The port of Iwakuni (commercial) and the military harbor are sometimes mistakenly considered one and the same. The latter, operated by the United States Marine Corps Air Station, is located about three miles south of the commercial port (see Figure V-36).

The military port is small in size, has limited facilities, and a minimum depth of 18 feet at its single pier. The harbor is enclosed by a rocky breakwater which is partially covered at high water. The entrance to the harbor is safe for deep draft vessels for a period of only two hours before and after high tides (LST's have clearance at all times). Harbor entrance depth is reduced to two fathoms during low tide.

Four anchorages are available in the outer harbor area with 13 fathoms at low water.

Due to the relative openness of Iwakuni, neither the harbor nor the anchorages are recommended as preferred locations during tropical cyclone passage. Areas A, C, and D (in Kure Harbor), shown in Figure V-35, are the locations recommended.

4.1.4 Kure

Kure Harbor (see Figures V-35 and V-37), is located in the eastern sector of Hiroshima Bay and is literally landlocked by mountainous terrain, some of which exceed 360 meters (1181 feet) in height. To the north and east the mountains are highest, while to the west the maximum height of the islands ranges from 120 to 240 meters (394-787 feet). Islands to the south and southwest reach heights greater than 360 meters (1181 feet). These mountains are a formidable barrier to strong winds and accompanying seas. However, as can be seen from Figure V-35, the ridge lines north of Kure are aligned along a northeast-southwest axis so that one could expect the harbor to experience its strongest winds from the northeast (tropical cyclone passage to the east). Area D in the outer harbor (Figures V-35 and V-37), is the "typhoon anchorage" suggested for large vessels by Kure Harbor authorities. Area D is extremely well protected from westerly winds and would appear to be most open to northerly winds. The mud bottom, ranging from 18-22 meters (60-72 feet) in depth, is characterized by good holding. Smaller vessels usually utilize the shelter of the various coves found around the periphery of the harbor area or remain at pierside.

The weather office is located in the inner harbor as shown in Figure V-37. The winds recorded should be representative of those in the inner harbor but most probably are not representative of the winds in Area D. When the winds are from the north or south, Area D would probably experience higher winds than the inner harbor. When the winds are from the west Area D should experience lighter winds than the inner harbor. However, regardless of wind direction or speed, Area D has been utilized and praised for its security and proclaimed as the best location for large vessels at Kure.

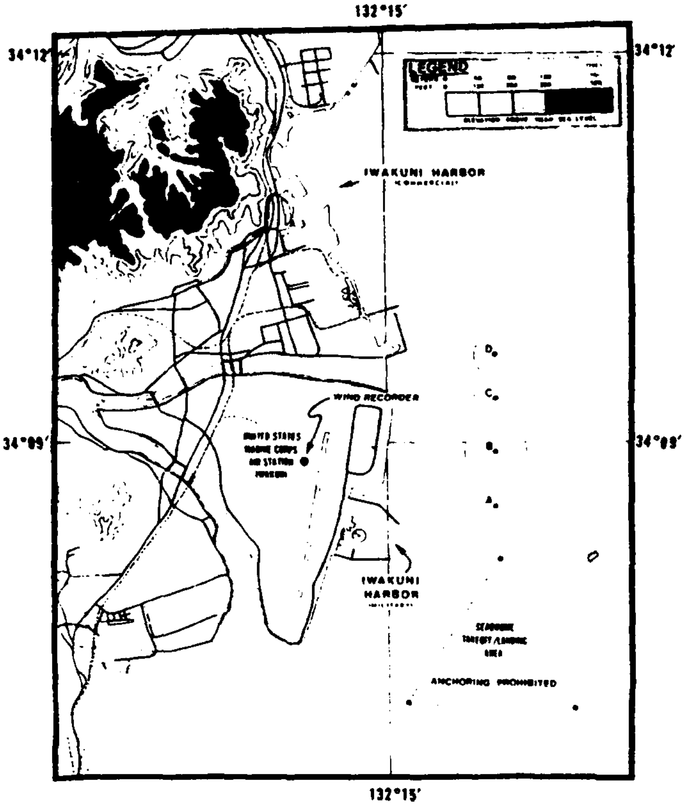

Figure V-36. Iwakuni Harbor

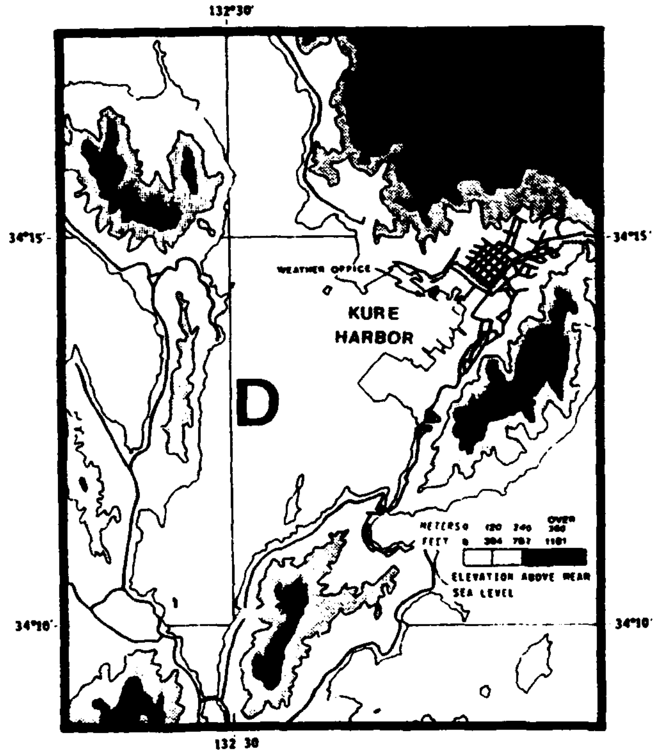

Figure V-37. Kure Harbor

There are six mooring buoys available within the inner harbor as listed in the navigation publications. The Japanese Maritime Self Defense Force (JMSDF) maintains control over a number of other buoys in the inner harbor. Their use must be coordinated through the JMSDF.

Excellent dry docks and repair facilities are available at Kure with a large part of the waterfront area being occupied by the docks and buildings of Ishikawajima-Harima Heavy Industries, LTD (IHI). IHI has the capacity to handle and repair ships over 100,000 tons.

The excellent anchorages, docks and repair facilities coupled with the exceptional protection from winds and seas accompanying tropical cyclones has given Kure the reputation of being one of the best, if not the best, typhoon havens in all of Japan. This reputation and abundance of facilities has in the past lured many ships both large and small to seek refuge in Kure, thus presenting the harbor with its only notable problem -- that of crowding. It should be noted that there have been no incidents related to crowding at Kure since records have been kept; however, the potential is there when a large number of vessels is present.

4.2 TROPICAL CYCLONES AFFECTING IWAKUNI AND KURE

4.2.1 Tropical Cyclone Climatology For Iwakuni And Kure

Tropical cyclones which affect Iwakuni and Kure generally form in an area bounded by the latitudes 5N and 30N between longitudes 120E and 165E. The latitudinal boundaries shift poleward in the summer months and equatorward in winter in response to seasonal changes of the synoptic environment.

It is possible for tropical cyclones to form during any month or season; however, those affecting the Japanese Islands, and hence, Iwakuni and Kure, are confined for the most part to the spring through fall months, with late summer and early fall being the most likely period for an occurrence.

For this study the period June-October 1947-1972 was investigated.[13] During this period 74 tropical cyclones passed within 180 n mi of Iwakuni and Kure and are defined as "threats." Figure V-38 gives the frequency distribution of threat occurrences by 5-day groupings through the five month period. Note in Figure V-38 that August and September are the preferred months for storms affecting the Iwakuni/Kure area. Notice also in Figure V-38 that a majority of the storms affecting Iwakuni and Kure are of the recurving variety.

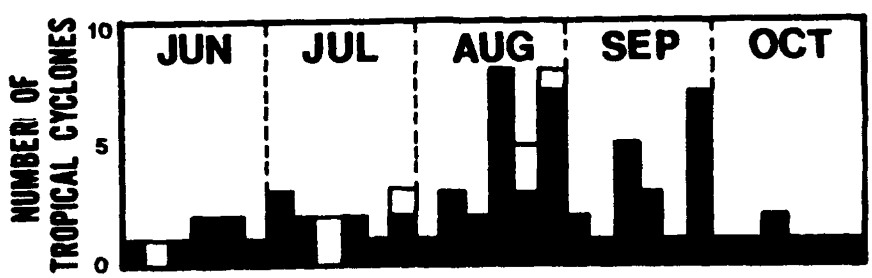

Figure V-38. Frequency distribution of the number of tropical cyclones that passed within 180 n mi of Iwakuni and Kure. Subtotals are based on 5-day periods for tropical cyclones that occurred during 1947-1972. Out of a total of 74 storms, 67 (91%) were recurvers (had a northeasterly direction of motion at the closest point of approach) and are indicated by the shading.

Figure V-41 illustrates the "threat" tropical cyclones according to the compass octant from which they entered the 180 n mi radius threat area. The circled numbers indicate the total that entered from an individual octant. The adjacent numbers express this as a percentage. It is evident that the majority of tropical cyclones (56%) entered the threat area from a sector extending from the south-southwest.

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[13]From Chin (1972) for years 1947-1970, and from Annual Typhoon Reports for the years 1971-1972 (FWC/JTWC, 1971 and 1972).

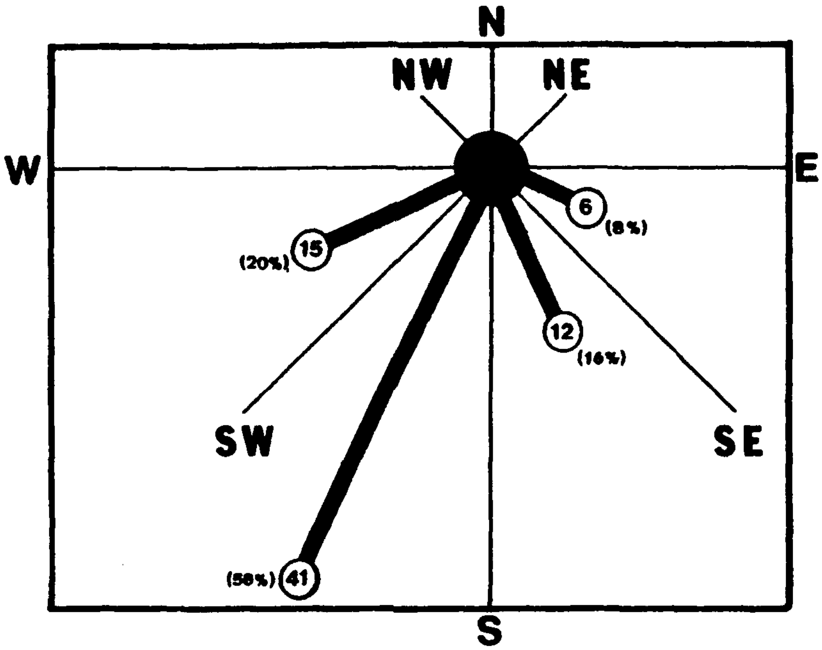

Figure V-39. Direction of approach to Iwakuni and Kure of the tropical cyclones (1947-1972) that passed within 180 n mi of Iwakuni and Kure. Circled numbers indicate the number that approached from each octant. The number in parenthesis is the percentage of total sample (74) that approached from that octant.

Table V-8 lists the average speeds of movement for tropical cyclones which affected Iwakuni/Kure for the months of June through October. The information presented in Table V-8 was used in the preparation of Figures V-40 through V-44.

Table V-8. Average climatological speeds of movement of tropical cyclones (kt) by 5-degree latitude bands for the months of June-October for the tropical cyclones affecting Iwakuni and Kure.

LATITUDE BAND (N)	AVERAGE FORWARD SPEED OF MOVEMENT (KT)					AVERAGE OF THE 5-MONTHS (KT)
	JUN	JUL	AUG	SEP	OCT	
30-35 N	25	13	12	20	17	17.4
25-30	17	11	9	15	14	13.2
20-25	12	11	10	11	12	11.0
15-20	10	10	10	11	11	10.4

IWAKUNI/KURE

Figures V-40 to V-44 represent an analysis of the probability of a tropical cyclone passing within 180 n mi of Iwakuni and Kure. The solid lines of Figures V-40 to V-44 represent the "percent threat" for any storm location. The dashed lines represent approximate approach times to Iwakuni/Kure computed from the average tropical cyclone speed of movement for June-October for tropical cyclones affecting Iwakuni/Kure (Table V-8). As an example, in Figure V-40 a storm located at 128E and 23N has a 40% probability of passing within 180 n mi of Iwakuni and Kure, and it could hit Iwakuni/Kure in 1-1/2 to 2 days.

Note the significant shift in the direction from which the "threat" tropical cyclones approach Iwakuni/Kure in Figures V-40 to V-44. In June the "threat" is generally from the southwest; whereas, in July and August, it is from the south and southeast. During September and October the threat is generally out of the south and southwest. Note that the majority of the storms make their approach from the south and southwest indicating that they have undergone recurvature and are therefore beginning to weaken even before reaching Japan. This weakening coupled with the mountainous topography surrounding the Hiroshima Bay region accounts for substantially reduced winds associated with tropical cyclones. It must be kept in mind that although the effects of storms are reduced quite effectively, destructive winds can and may occur in the Bay Region with any tropical cyclone.

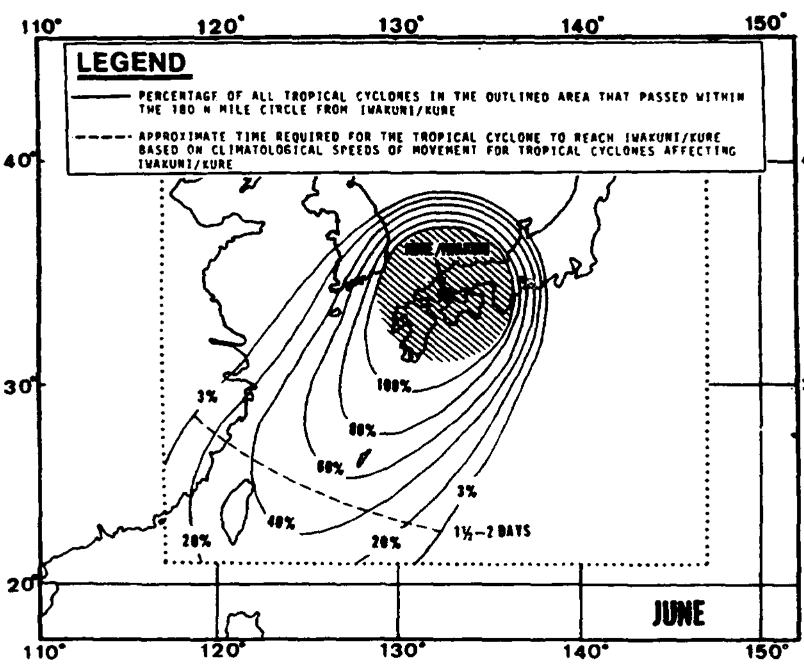

Figure V-40. Probability that a tropical cyclone will pass within 180 n mi of Iwakuni/Kure for the month of June. (Based on data from 1947-1972.)

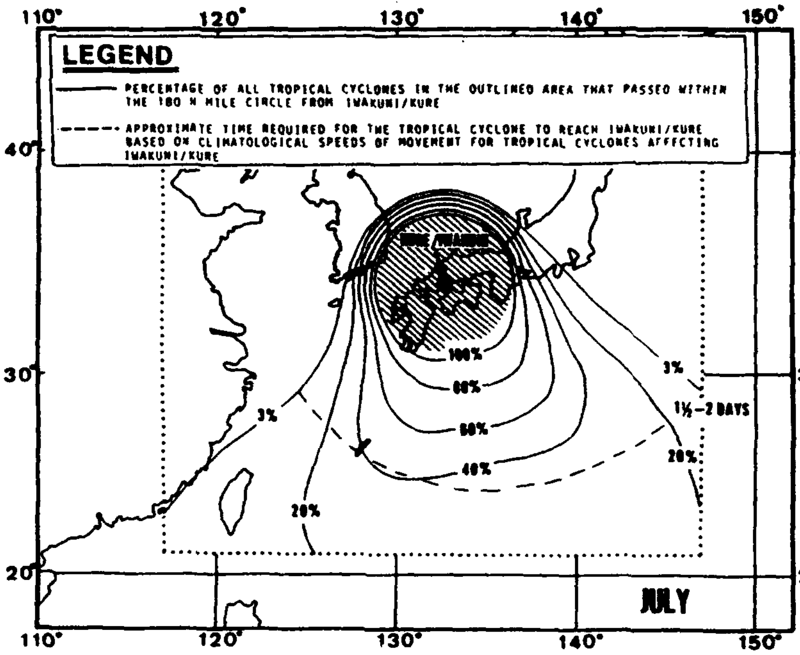

Figure V-41. Probability that a tropical cyclone will pass within 180 n mi of Iwakuni/Kure for the month of July. (Based on data from 1947-1972.)

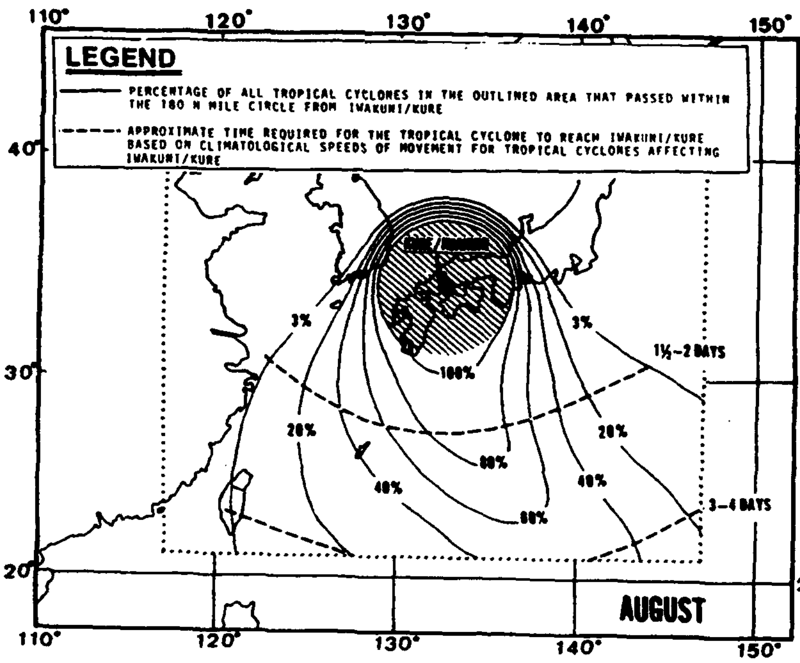

Figure V-42. Probability that a tropical cyclone will pass within 180 n mi of Iwakuni/Kure for the month of August. (Based on data from 1947-1972.)

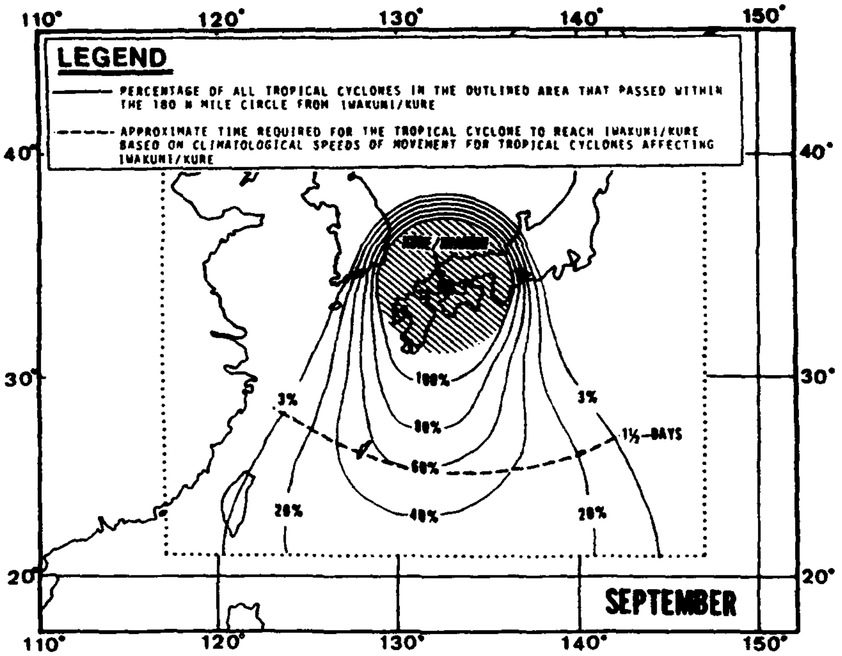

Figure V-43. Probability that a tropical cyclone will pass within 180 n mi of Iwakuni/Kure for the month of September. (Based on data from 1947-1972.)

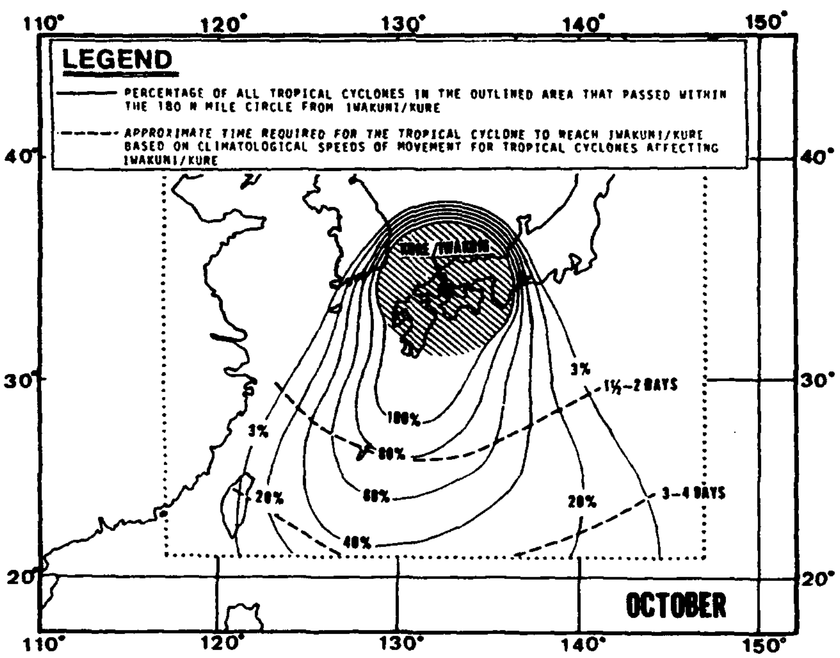

Figure V-44. Probability that a tropical cyclone will pass within 180 n mi of Iwakuni/Kure for the month of October. (Based on data from 1947-1972.)

4.2.2 Tropical Cyclones Affecting Iwakuni

During the June-October period in the 18 years 1955-1973 (excluding 1958), a total of 53 tropical cyclones or an average of 3 tropical cyclones per year have passed within 180 n mi of Iwakuni (and Kure). The largest number that occurred in any single year was 4 (1955, '59, '62, '68, and '71). Table V-9 groups the 53 storms according to their effects at Iwakuni. It can be seen in Table V-9 that of the total of 53 storms, 14 (26%) resulted in winds of 22 kt or greater and only 6 (11%) gave gale force winds.

Table V-9. Extent to which tropical cyclones affected Iwakuni, June through October, 1955-1973 (excluding 1958) (based on hourly wind observations).

Number of tropical cyclones that passed within 180 n mi of Iwakuni	53
Number of tropical cyclones that resulted in winds greater than or equal to 22 kt	14 (26%)
Number of tropical cyclones that resulted in winds greater than or equal to 34 kt	6 (11%)

The strongest sustained winds observed at Iwakuni associated with tropical cyclones were two 45-kt occurrences in 1955. It should be noted that stronger winds have been attributed to extratropical systems in the winter months.

Figure V-45 illustrates the positions of the 14 tropical cyclone centers previously mentioned when 22-kt winds first and last occurred at Iwakuni.

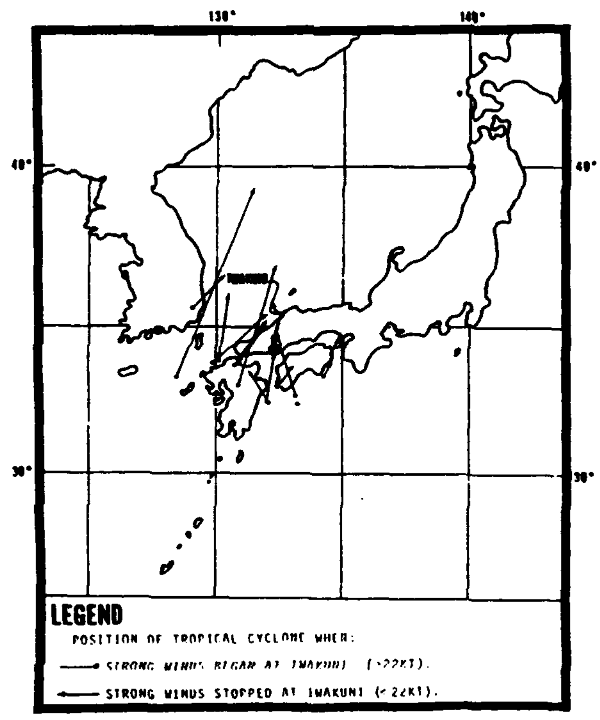

Figure V-45. Position of tropical cyclone centers when winds ≥22 kt first and last occured at Iwakuni. (Based on data from 1955-1973, excluding 1958.)

Figure V-46 illustrates the storm locations when winds first and last exceeded 33 kt. Of the 53 tropical cyclones which approached within 180 n mi of Iwakuni (and Kure), 33 (63%) were observed to pass to the east, 19 (36%) to the west, and one directly over the harbor area (1970). These observations, coupled with Figure V-45 and V-46, indicate a bias for storms passing west of and within 120 n mi of Iwakuni to be those most likely to give strong winds up to and exceeding gale force. The length of the line segments in Figures V-45 and V-46 also present a rough estimate of wind duration of Iwakuni. For the most part the line segments of Figure V-46 represent less than 100 n mi which suggests that a tropical cyclone moving with a speed of 25 kt would give gale force winds at Iwakuni for less than 4 hours.

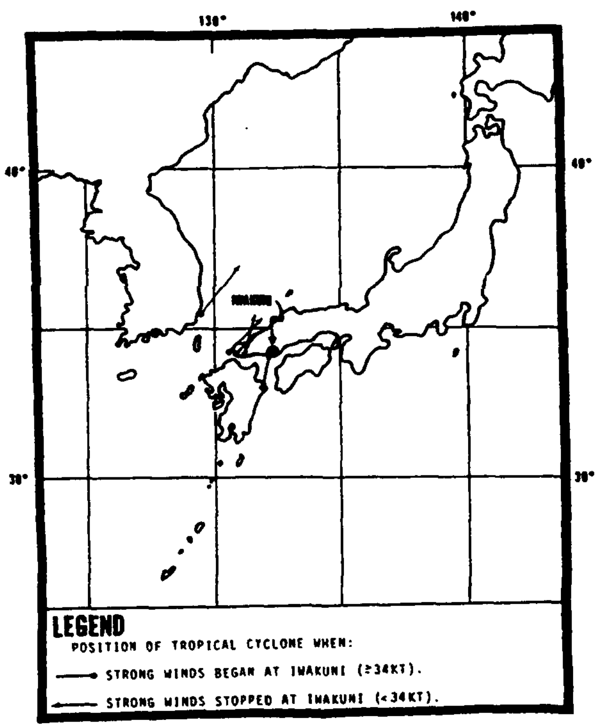

Figure V-46. Position of tropical cyclone centers when winds greater than or equal to 34 kt first and last occurred at Iwakuni. (Based on data from 1955-1973, excluding 1958.)

Due to the counterclockwise rotation of tropical cyclones in the Northern Hemisphere, those storms passing to the west of Iwakuni can be expected to give southerly winds shifting to westerly. If the storm passes to the south and east, southeasterly winds would first be experienced, followed by easterly and/or northerly winds.

4.2.3 Wave Action In Hiroshima Bay (Iwakuni)

Table V-10 lists the significant wave heights which could be observed at the Iwakuni Harbor anchorages (Anchorage A-D of Figure V-36), and Areas A and C (Figure V-35) with various wind speeds and directions. Notice in Table V-10 that the maximum wave heights at the Iwakuni Harbor anchorages (A through D) will occur when the winds are from the south (storm passage to the west), while Areas A and C will have waves 7 ft or less. Also notice in Table V-10 that winds from the north give the highest waves in Area A and winds from the west give the highest waves in Area C.

Table V-10. Significant wave heights ($\bar{H}$ 1/3) in ft that could be expected at the Iwakuni anchorages (A-D of Figure V-36), and Areas A and C (Figure V-35) with various wind speeds and directions. X indicates negligible wave heights (less than 4 ft).

WIND (KT)	IWAKUNI ANCHORAGES				AREA A				AREA C			
	N	S	E	W	N	S	E	W	N	S	E	W
35 kt	4.0 ft	5.0	4.0	X	6.0	X	X	X	X	X	X	4.5
45	5.0	6.5	5.5	X	7.0	5.0	5.5	5.5	X	5.0	X	6.5
55	6.5	9.0	6.0	X	9.5	6.0	6.5	6.5	X	6.0	4	8.5
65	8.5	11.0	7.0	X	10.5	6.5	7.0	7.0	5	7.0	5	10.0

4.2.4 Storm Surge in Hiroshima Bay (Iwakuni)

Storm surge may be defined as an abnormal rise of the sea along a shore as the result of winds and pressure drop associated with a storm. These surges are most pronounced along the south coast of the Japanese island chain where the bays are open to the Pacific Ocean.

Due to its sheltered position within the Inland Sea, the numerous islands (notably Oshima Island to the south), and the fact that winds are significantly reduced before reaching the Hiroshima Bay area, storm surge is negligible. These points were emphasized quite strongly in conversations with local harbor and weather authorities. Records are not kept on storm surge in Hiroshima Bay and no significant damage or incident has been attributed to this phenomenon.

4.2.5 Tropical Cyclones Affecting Kure

During the June-October periods in the 18 years 1955-1972, a total of 53 tropical cyclones or an average of 3 tropical cyclones per year passed within 180 n mi of Kure. The largest number that occurred in any single year was 4 (1955, '59, '62, '68, and '71). Table V-11 groups the 53 storms according to their effects on Kure. It can be seen in Table V-11 that of the total of 53 storms, 24 (45%) resulted in winds greater than or equal to 22 kt and only 6 (11%) gave winds greater than or equal to 34 kt.

Table V-11. Extent to which tropical cyclones affected Kure, June through October, 1955-1972.

Number of tropical storms that passed within 180 n mi of Kure	53
Number of tropical cyclones that resulted in winds greater than or equal to 22 kt	24 (45%)
Number of tropical cyclones that resulted in winds greater than or equal to 34 kt	6 (11%)

Figure V-47 shows the positions of the tropical cyclone centers when winds first and last exceeded 21 kt at Kure. Figure V-48 illustrates the storm centers when the winds first and last exceeded 33 kt. As noted earlier, out of the total of 53 tropical cyclones approaching within 180 n mi of Kure (and Iwakuni) during the period investigated, most passed to the east (approximately 63%) with one occurrence of a storm passing directly over the harbor area -- Typhoon Anita in 1970.

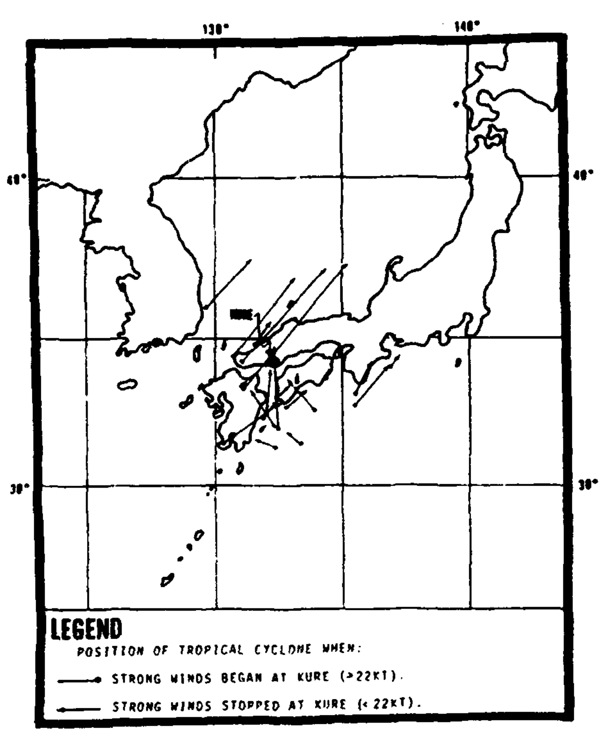

Figure V-47. Position of tropical cyclone centers when winds greater than or equal to 22 kt first and last occurred at Kure. (Based on data from 1955-1972.)

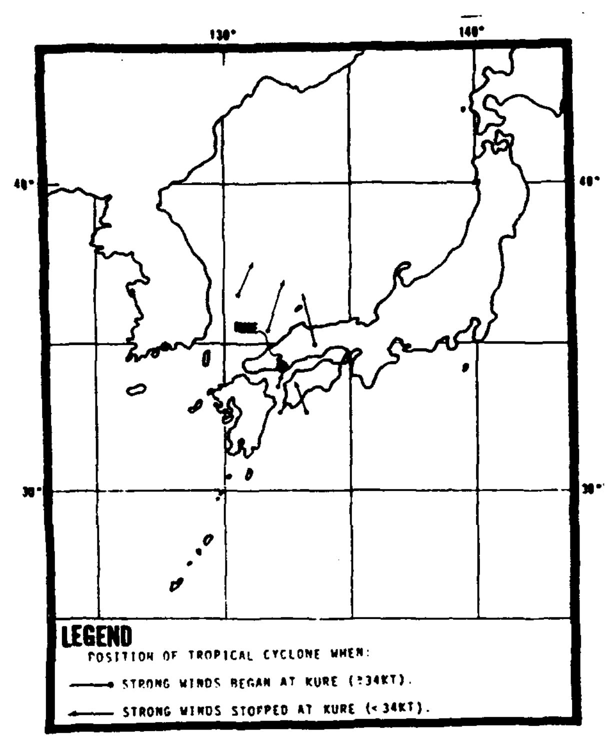

Figure V-48. Position of tropical cyclone centers when winds greater than or equal to 34 kt first and last occurred at Kure. (Based on data from 1955-1972.)

It can be seen in Figures V-47 and V-48 that the storm centers must be north of 31N before winds exceeding 22 kt and north of 32N before gale force winds are observed at Kure. Figure V-47 also suggests that storms passing to the west may have a longer duration of winds in the 22-33 kt range, than storms which pass to the east.

The strongest winds recorded at Kure that could be associated with a tropical cyclone in the period 1937-1972 were in 1970, when Typhoon Anita passed directly over the city. The maximum sustained winds recorded were 51 kt from the northeast. It should be noted that stronger winds have been attributed to extratropical systems in the winter months.

4.2.6 Wave Action In Kure Harbor

Table V-12 lists the significant wave heights which could be observed in Area D at Kure (see Figures V-35 and V-37) with winds of various speeds and directions. Observe in Table V-12 that the maximum significant wave heights will occur when winds are from the north. Wave action in the inner harbor should be less than that in Area D.

Table V-12. Significant wave heights ($\bar{H}$ 1/3 in ft) that could be expected in Area D of Kure Harbor area with wind speeds of 35, 45, 55, and 65 kt. X indicates negligible wave heights (less than 4 ft).

WIND SPEED (KT)	WIND DIRECTION			
	N	S	E	W
35	4.0 ft	X	X	X
45	5.5	X	X	X
55	6.5	4.0	4.5	X
65	7.5	5.0	5.0	X

4.2.7 Storm Surge In Kure Harbor

Storm surge is defined as an abnormal rise of the sea along a shore resulting from winds and the pressure drop associated with intense storms. Storm surge is adjudged to be negligible and hence should produce no significant damage.

For a more detailed discussion on the effects of tropical cyclones on Iwakuni and Kure, see Manning, 1975.

4.3 THE DECISION TO EVADE OR REMAIN AT PORT

4.3.1 General

There is no local heavy weather readiness procedure established for ships in port at Iwakuni and Kure. However, there are certain precautions suggested by Japanese Maritime Safety Agency officials. These suggestions plus additional conclusions for particular areas (Areas A, C, and D in Figures V-35 and V-37) form the basis for the following paragraphs.

For general information on tropical cyclone warnings, refer to paragraphs 6 and 7 of Chapter I.

4.3.2 Evasion Rationale

A most important aspect of any decision concerning heavy weather is an early appraisal of the threat posed by an individual tropical cyclone. The preparations must begin when enough time remains to allow flexibility in the evasion plan. To facilitate early action, the following time table has been devised in conjunction with Figures V-49 through V-53.

I. An existing tropical cyclone moves into, or development takes place in Area A of Figures V-49-V-53 with forecast movement toward Iwakuni/Kure.

   a. Review material condition of ship. It may be necessary to move to recommended anchorages.

   b. Reconsider any maintenance that would render the ship incapable of getting underway in 48 hr if need be, or riding out the storm at anchor.

   c. Plot FWC/JTWC, Guam warnings if issued and construct the danger area. Reconstruct the danger area for each new warning.

II. Tropical cyclone enters Area B of Figures V-49 through V-53, with forecast movement toward Iwakuni/Kure.

   a. Reconsider any maintenance that would render the ship incapable of getting underway or moving to a new anchorage prior to expected time of strong winds within the area.

   b. All ships begin planning course of action to be taken if a shift in anchorage is anticipated.

III. Tropical cyclone enters Area C of Figures V-49 through V-53 with forecast movement toward Iwakuni/Kure.

   a. Execute plans made in step II with the aid of information in the following paragraphs if the ship is in port at Iwakuni or Kure.

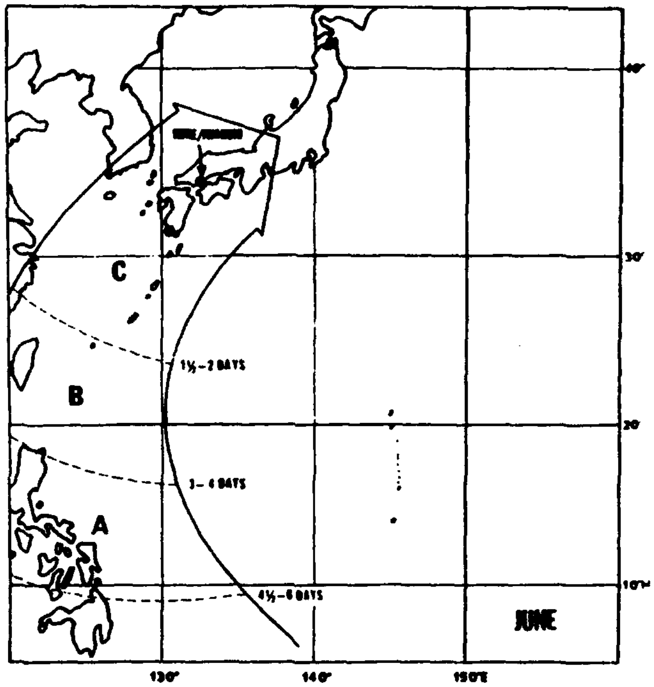

Figure V-49. Tropical cyclone threat axis for the month of June. The area within the arrow approximates a 30% or greater probability of a tropical cyclone coming within 180 n mi of Iwakuni/Kure. Approach times are based on typical speeds of movement for tropical cyclones affecting Iwakuni/Kure.

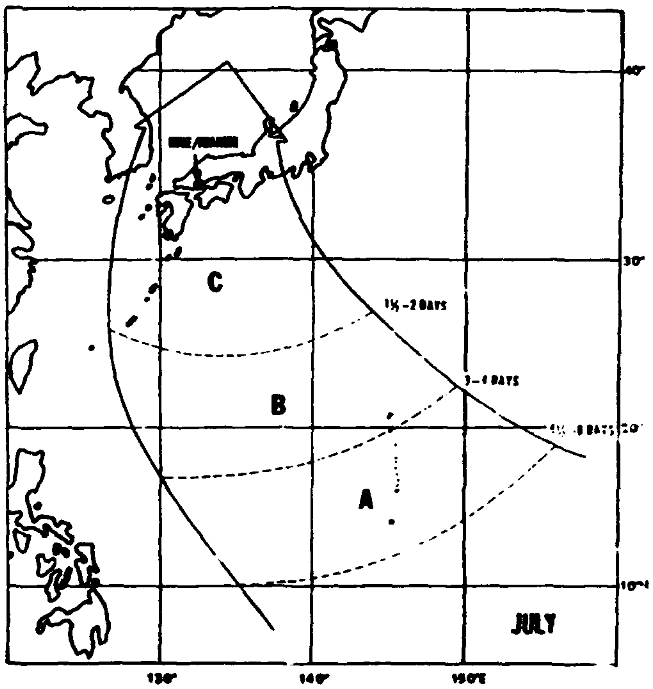

Figure V-50. Tropical cyclone threat axis for the month of July. The area within the arrow approximates a 30% or greater probability of a tropical cyclone coming within 180 n mi of Iwakuni/Kure. Approach times are based on typical speeds of movement for tropical cyclones affecting Iwakuni/Kure.

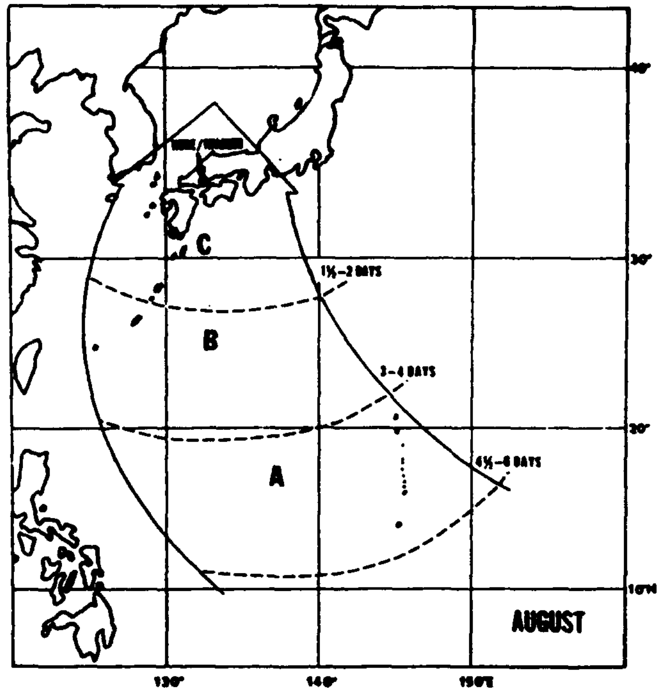

Figure V-51. Tropical cyclone threat axis for the month of August. The area within the arrow approximates a 30% or greater probability of a tropical cyclone coming within 180 n mi of Iwakuni/Kure. Approach times are based on typical speeds of movement for tropical cyclones affecting Iwakuni/Kure.

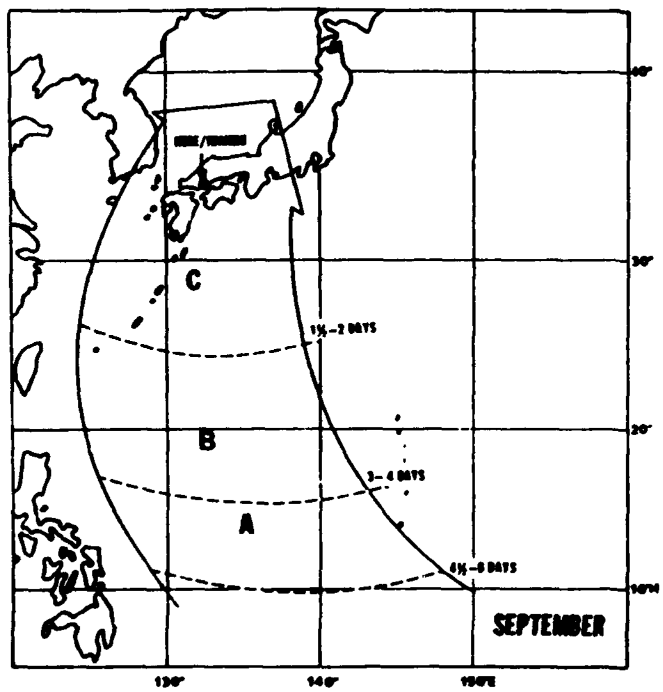

Figure V-52. Tropical cyclone threat axis for the month of September. The area within the arrow approximates a 30% or greater probability of a tropical cyclone coming within 180 n mi of Iwakuni/Kure. Approach times are based on typical speeds of movement for tropical cyclones affecting Iwakuni/Kure.

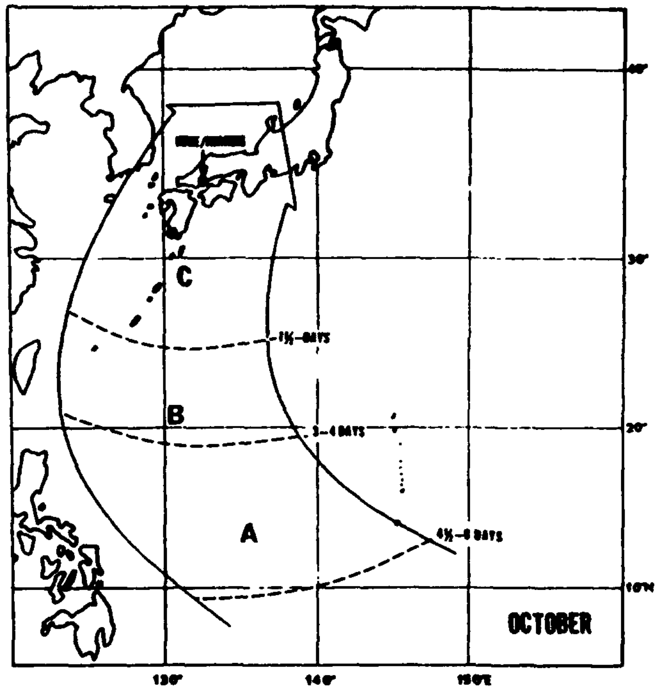

Figure V-53. Tropical cyclone threat axis for the month of October. The area within the arrow approximates a 30% or greater probability of a tropical cyclone coming within 180 n mi of Iwakuni/Kure. Approach times are based on typical speeds of movement for tropical cyclones affecting Iwakuni/Kure.

4.3.3 <u>Remaining In Port At Iwakuni/Kure</u>

Remaining in port at Iwakuni (considering Areas A and C of Figure V-35 as typhoon anchorages for Iwakuni) and Kure (considering Area D of Figures V-35 and V-37) is the recommended course of action for all ships. As stated previously, Kure is considered to be one of the best, if not the best, typhoon haven in all of Japan (crowding, however, may be a consideration). As a consequence of conversations with Kure Harbor authorities, Area D of Figures V-35 and V-37 is recommended for large vessels, including supertankers and naval combatants. Smaller vessels normally remain pierside or utilize the protection found in the various coves around the harbor.

For those ships in port at Iwakuni the recommended procedure is to move to one of the designated typhoon anchorages, either Area A or C or D (in Kure) as seen in Figures V-35 and V-37.

Ship commanders should utilize the tropical cyclone warnings issued by FWC/JTWC, Guam in conjunction with Figures V-49 to V-53 to insure a timely shift to the typhoon anchorages. Ship commanders should also determine from the warnings whether the storm is forecast to pass west of Hiroshima Bay or east of the bay. Area A should provide excellent protection with storm passage to the west and very good coverage for storms passing to the south and east. Area C should provide excellent protection from storms which pass to the east.

4.3.4 Evasion At Sea

Evasion at sea is not the recommended course of action. However, if it is desired, an evasion route to sea may be developed by the use of the FWC/JTWC warnings, Appendix I-A and Figures V-49 to V-53 of this report. In all cases, however, Optimum Track Ship Routing (OTSR) should be consulted as to the best evasion route.

There are two basic evasion tactics for ships at sea south of Japan. The most common is to place the ship south of the tropical cyclone in the left or navigable semicircle. The other is to proceed southeast or east to remain clear of the tropical cyclone track.

If a ship is in the area south of Japan and the decision is made to seek refuge in Iwakuni or Kure, then the time enroute through the Bongo Straits into Hiroshima Bay (see Figure V-34) should be considered. At speeds of 10-12 kt, an enroute time of 10-12 hours could be expected upon entering the Bongo Straits.

Another option for ships south of Japan desiring refuge in a port would be the consideration of Yokosuka, Japan -- a designated safe typhoon "haven."

For a ship in the Sea of Japan or the Korean Straits, there are also two basic evasion tactics. The most common is to place the ship in the left or navigable semicircle of the tropical cyclone. The other is to proceed further north in the Sea of Japan or north into the Yellow Sea.

In the latter case, the cooler surface water and cool air found at higher latitudes cause a weakening and ultimate dissipation of the tropical cyclone. The central winds of tropical cyclones north of 35N are generally below 64 kt. Therefore, a ship would experience less difficulty in riding out a storm at these latitudes than if it steamed south to seek the navigable semicircle and encountered winds in excess of 80 kt enroute.

If refuge in port is desired, Sasebo, Japan, a designated typhoon "haven" (for all ships except aircraft carriers) would be more easily accessible to ships in the Sea of Japan or Korean Strait, than Iwakuni or Kure.

5.0 **SASEBO**

SUMMARY

The conclusion reached in this study is that Sasebo Harbor is a favorable typhoon haven for most small and medium sized ships. Aircraft carriers and all other ships with large sail areas should be prepared to evade at sea. This conclusion is based on the following:

(1) Topography around the harbor provides excellent protection from winds out of the north or east and good protection from southerly winds. However, winds may adversely affect ships with large sail areas.

(2) The anchor holding capability in the typhoon anchorage is good.

(3) There is sufficient maneuvering room at typhoon anchorages in the outer harbor. However, aircraft carriers may be too restricted during the crowded conditions usually present in a typhoon threat situation.

(4) Specific berths in India Basin offer good mooring during strong winds. However, others do not and should be avoided.

(5) Storm surge is, in most cases, minimal. Wave motion is generally restricted by the limited fetch areas.

(6) Available port services are excellent.

5.1 LOCATION AND TOPOGRAPHY

Sasebo is located in the northwestern part of Kyushu, the southernmost of the four islands that comprise the main portion of Japan (Figure V-54). Kyushu is bordered on the southeast by the Philippine Sea, on the west by the East China Sea, and on its northwest side by the Korea (Tsushima) Strait, which connects the

East China Sea with the Sea of Japan. Kyushu is separated from the Japanese islands of Shikoku and the much larger Honshu by the Inland Sea.

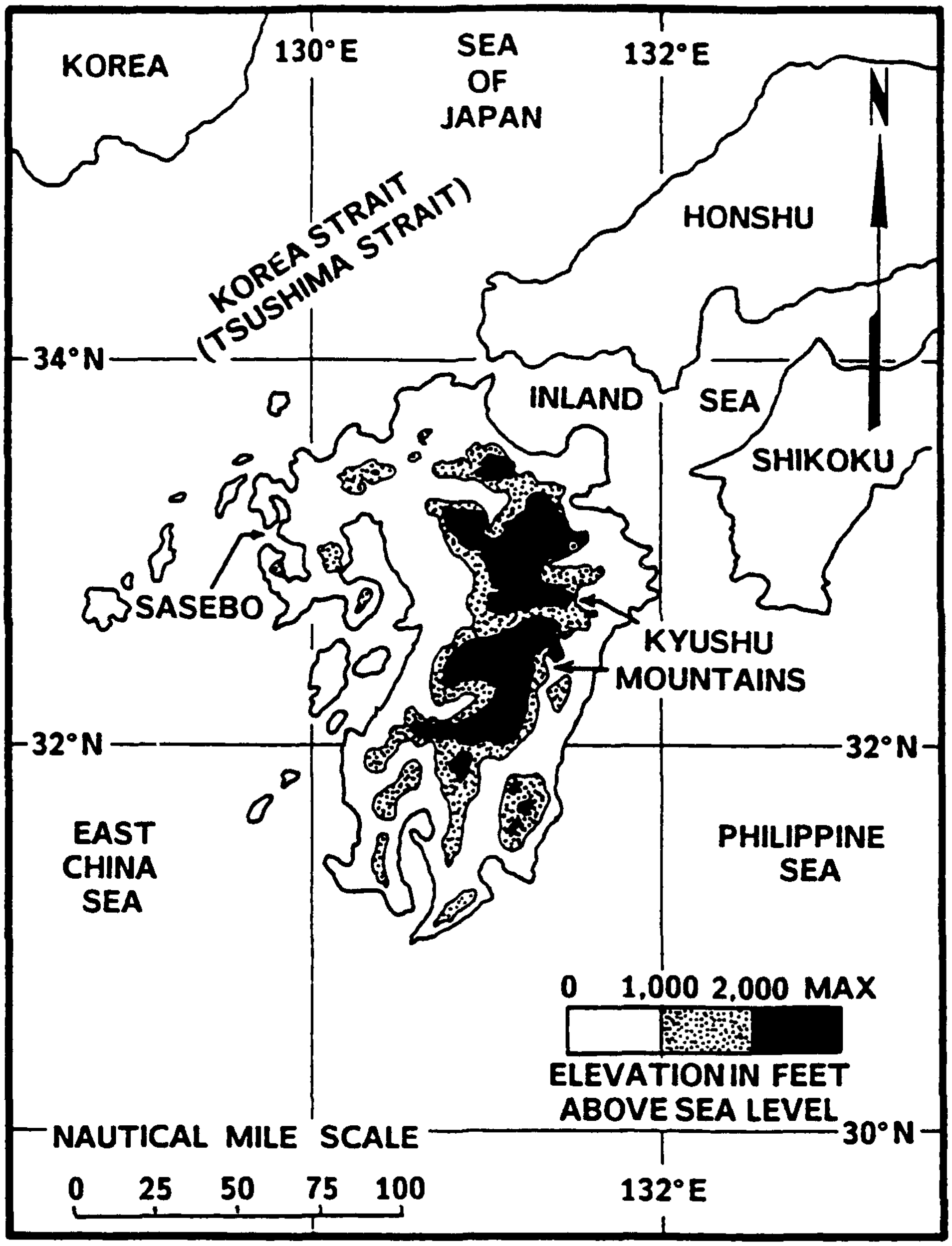

Figure V-54. Location of Sasebo on the Island of Kyushu and the island's position relative to Korea Strait, East China Sea, Philippine Sea, Inland Sea, and the other main Japanese islands of Honshu and Shikoku.

The Kyushu mountains extend from north to south through the center of the island. The topography of northwestern Kyushu is depicted in Figure V-55. Sasebo Harbor is a large, landlocked

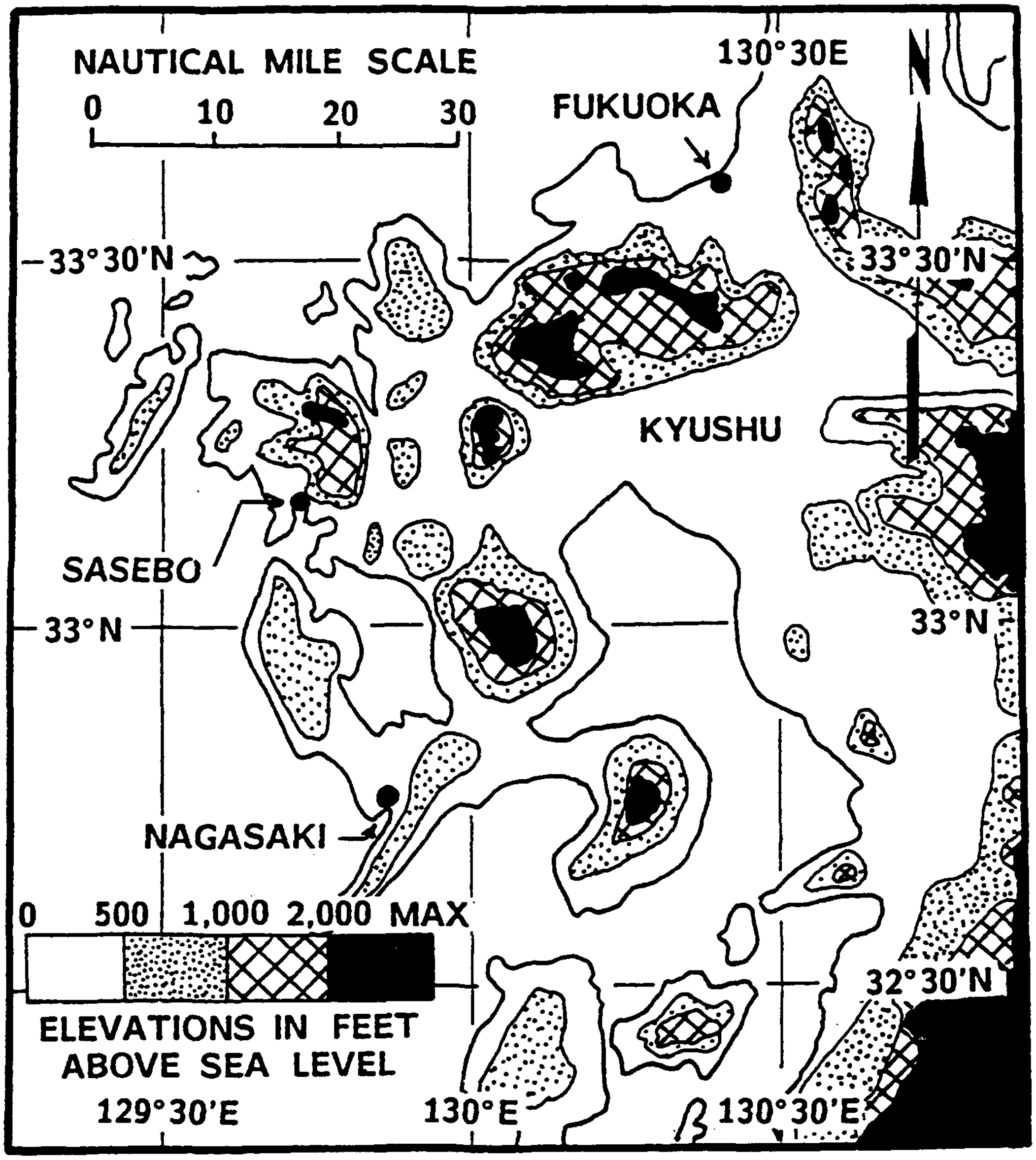

Figure V-55. Topography of northwestern Kyushu.

bay, well protected by hills and mountains on all sides. The protection is particularly evident in the inner harbor area, where hills to 787 ft (240 m) exist within 1 nm. A significant exception to the protection is a valley that lies between hills on the west side of the harbor about 1 nmi south of the entrance to India Basin near Kawanotani Cove (Figure V-56, below). The valley allows winds to funnel across the bay during periods of strong westerly flow.

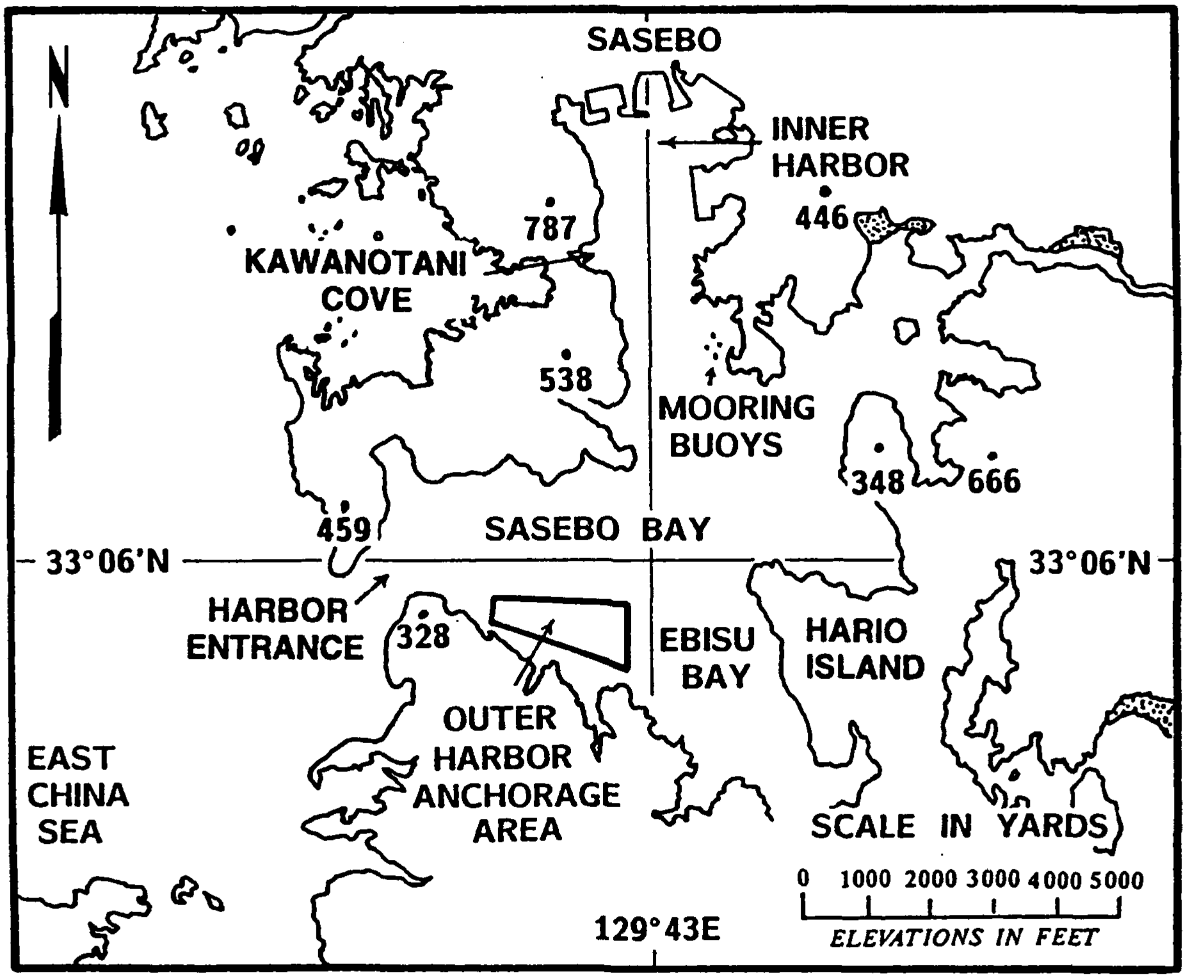

Figure V-56. Location of Sasebo Bay, outer harbor, anchorages, inner harbor, significant elevations near the harbors, and other features of the area adjacent to Naval Station, Sasebo.

5.2 SASEBO HARBOR

The port of Sasebo (33°10'N, 129°43'E), is one of two major Japanese ports frequented by U. S. Navy ships; the other is Yokosuka. Sasebo was established as a naval base in 1889. Prior to and during World War II, it was an important repair base. Since the war, it has become a major commercial and shipbuilding port. The U. S. Navy established its port facility in 1952. The inner harbor of the port is the northern extension of the outer harbor--Sasebo Bay (Figure V-56). Channel depth to the port ranges from 165 ft at the main entrance to the outer harbor, to a low of 35 ft in the inner harbor. Shallow water extends 50 yd or more offshore throughout the outer harbor and along the west side of the inner harbor. Submerged shoals extend from 75 to 100 yd from shore along the east side of the entire harbor.

Currents within the inner and outer harbors vary widely with the tidal flow. Those within 2 nmi of the inner harbor generally are less than 0.3 kt regardless of the stage of the tide. At low tide velocities approach 2 kt in the area 4 to 4.5 nmi south of the inner harbor (east of the main anchorage area near Ebisu Bay), and over 1 kt near the western entrance to the outer harbor. However, currents are generally not so strong as to hinder navigation. There is no record of a tsunami affecting the harbor.

Figure V-57 shows the location of India and Juliet Basins in the inner harbor. India Basin is used by large vessels, while Juliet Basin is utilized by harbor craft.

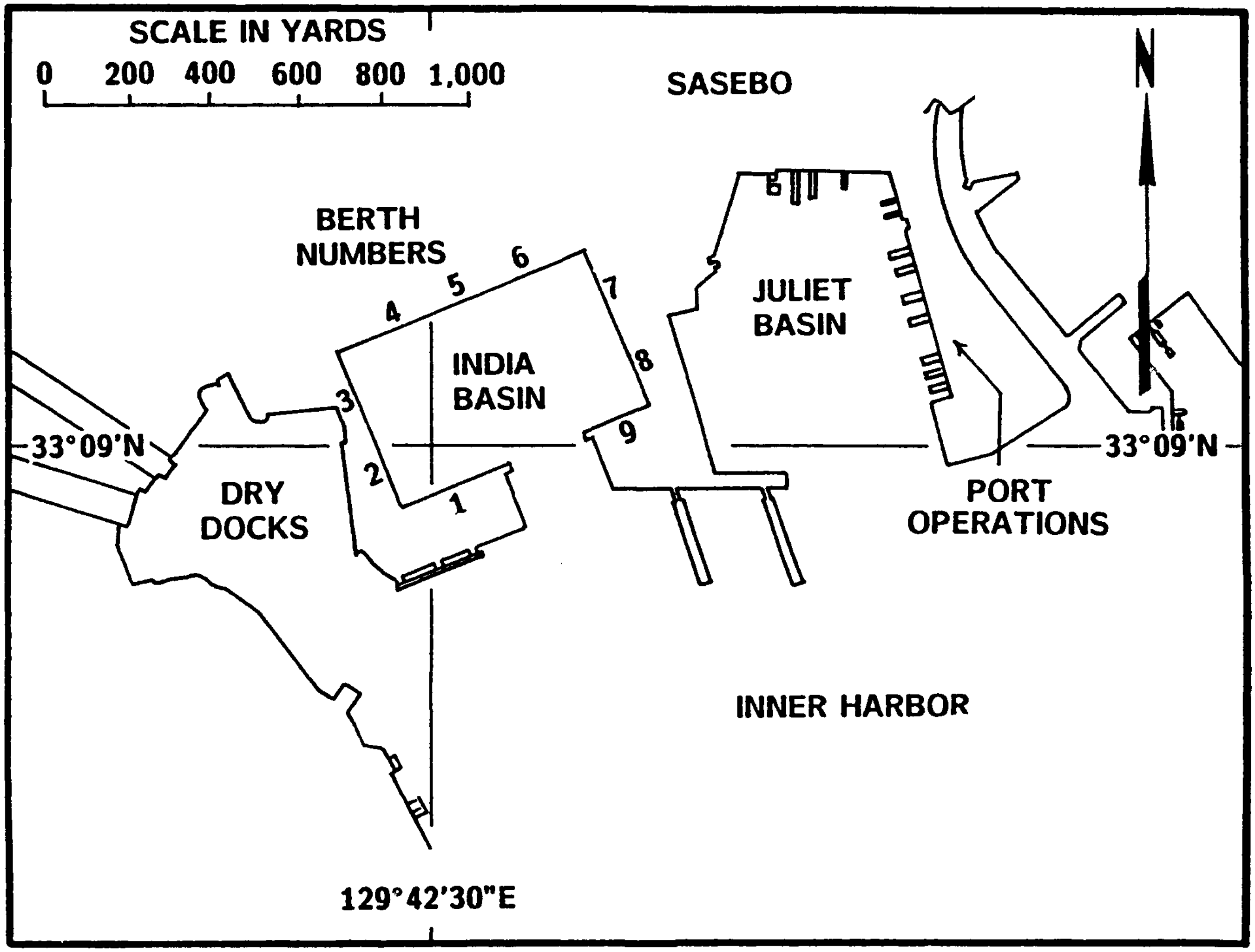

Figure V-57. Configuration of India and Juliet Basins.

5.4 HARBOR FACILITIES

India Basin, with a 552 ft (168 m) wide entrance, can berth several large ships alongside. Table V-13 lists specifications for the individual berths.

Table V-13. Berth specifications for India Basin.

BERTH	LENGTH	DEPTH AT PIERSIDE	MAX SHIP'S LENGTH
INDIA #1	839 FT	31 FT	700 FT
INDIA #2	598 FT	31 FT	850 FT
INDIA #3	598 FT	31 FT	
INDIA #4	630 FT	31 FT	1,000 FT
INDIA #5	630 FT	32 FT	
INDIA #6	630 FT	30 FT	550 FT
INDIA #7	598 FT	34 FT	850 FT
INDIA #8	598 FT	28 FT	
INDIA #9	499 FT	32 FT	450 FT

In addition to India Basin there are seven fueling piers, numerous mooring buoys with capacities up to 30,000 tons, and anchorages in the bay. A large ship yard with two dry docks and heavy lift cranes is located west of India Basin, so major hull and machinery repair work can also be accomplished at the port.

The outer harbor (Figure V-56) provides numerous anchorages with excellent holding strength on a mud and sand bottom. Typhoon anchorages are located in the vicinity of Ebisu Bay where protection is offered by the surrounding hills of Hario Island. There is a wrecked ship with 39 ft of water over the highest point located near the anchorage. It poses an anchor fouling problem for ships that anchor too close. Ships using the anchorage should check with port personnel prior to anchoring.

5.5 TROPICAL CYCLONES AFFECTING SASEBO

5.5.1 Tropical Cyclone Climatology for Sasebo

Tropical cyclones which affect Japan generally form in the area bounded by 5°N to 30°N and 120°E to 165°E. The latitudinal boundaries shift poleward during the summer months and then equatorward in winter in response to the seasonal changes of the synoptic environment.

For the purpose of this study, any tropical storm or typhoon approaching within 180 nmi of Sasebo is considered to represent a threat to the port. Table V-14 contains a descriptive history of all tropical storms and typhoons passing within 180 nmi of Sasebo during the 47-year period 1945-1991. All of the tropical cyclone statistics used in this report for storms passing within 180 nmi of Sasebo are based on the SAIC generated data set used to compile Table V-14.

The primary tropical cyclone season for Sasebo is from May to October, although historically they have occurred in all months in the genesis area described in a preceding paragraph. As shown in Table V-15, only 1 tropical cyclone passing within 180 nmi of Sasebo occurred during May in any year since 1945, and it was not of typhoon strength at CPA. No storms have passed within 180 nmi of Sasebo during the months of November through April since 1945. Table V-15 also shows the motion history of the 108 storms that passed within 180 nmi of Sasebo during the 47-year period 1945 through 1991. The average heading and speed of tropical storms and typhoons passing within 180 nmi of Sasebo was 020° 19 kt at CPA.

Table V-14. Descriptive history of the 108 tropical storms and typhoons passing within 180 nmi of Sasebo during the 47-year period 1945-1991.

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAXIMUM WIND AT STORM CENTER	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
1	OPAL	1945	JUL	20	6	60	146 (SE)	053/27.9
2	EVA	1945	AUG	3	9	43	135 (W)	357/30.1
3	SUSAN	1945	AUG	27	14	58*	175 (E)	360/10.0
4	IDA	1945	SEP	17	18	65	178 (SE)	046/25.8
5	LOUISE	1945	OCT	10	23	57	111 (SE)	051/17.5
6	JANIE	1946	JUL	29	7	83	107 (SE)	035/12.1
7	LILLY	1946	AUG	19	8	58*	69 (W)	350/ 5.1
8	DELLA	1949	JUN	20	2	50	61 (E)	007/35.8
9	FAYE	1949	JUL	17	4	50*	24 (E)	007/ 6.6
10	JUDITH	1949	AUG	16	8	43	10 (E)	354/10.5
11	ELSIE	1950	JUN	24	3	57	51 (NNW)	035/38.4
12	FLOSSIE	1950	JUL	19	4	33	138 (SSW)	299/ 8.5
13	GRACE	1950	JUL	20	5	50*	110 (WSW)	327/ 4.7
14	HELENE	1950	JUL	28	6	25	99 (S)	012/ 5.8
15	KEZIA	1950	SEP	13	9	54	60 (ESE)	359/26.1
16	KATE	1951	JUL	1	5	92	136 (ESE)	027/12.3
17	RUTH	1951	OCT	14	11	71	90 (SE)	045/35.6
18	DINAH	1952	JUN	23	2	62	137 (SE)	037/34.5
19	JUDY	1953	JUN	7	3	45	101 (SE)	049/33.0
20	GRACE	1954	AUG	17	4	78	63 (SE)	039/11.8
21	KATHY	1954	SEP	7	9	65	76 (E)	011/15.3
22	JUNE	1954	SEP	13	10	80	74 (ESE)	012/16.4
23	MARIE	1954	SEP	25	12	65	102 (SE)	029/46.6
24	DOT	1955	JUL	16	6	23	21 (SW)	325/21.9
25	GEORGIA	1955	JUL	29	10	28	141 (SW)	316/15.7
26	LOUISE	1955	SEP	29	15	73	72 (E)	007/21.2
27	MARGE	1955	OCT	3	16	54	107 (E)	359/19.3
28	BABS	1956	AUG	16	9	80	26 (NW)	050/20.6
29	EMMA	1956	SEP	9	12	106	55 (NW)	026/21.9
30	VIRGINIA	1957	JUN	27	5	50	28 (NW)	074/34.0
31	AGNES	1957	AUG	20	7	48*	95 (W)	004/22.1
32	BESS	1957	SEP	6	9	65	90 (SE)	046/11.3
33	ELLEN	1959	AUG	7	6	75	121 (SW)	137/ 8.0
34	SARAH	1959	SEP	16	14	103	102 (WNW)	029/23.5
35	AMY	1959	OCT	6	16	60	116 (SE)	040/21.7
36	DELLA	1960	AUG	29	16	75	172 (E)	009/16.2
37	BETTY	1961	MAY	28	6	36	136 (NNW)	061/32.8
38	HELEN	1961	AUG	2	12	35	53 (WSW)	338/12.4
39	IDA	1961	JUL	31	13	30	151 (SSE)	257/16.3
40	KATHY	1961	AUG	18	15	10*	40 (SE)	300/ 6.7
41	NANCY	1961	SEP	15	18	107	175 (ESE)	037/23.9
42	SARAH	1962	AUG	21	13	37	69 (SE)	046/11.7
43	VERA	1962	AUG	27	15	28	88 (ESE)	026/15.2
44	ROSE	1963	JUN	13	3	36	148 (ESE)	029/27.6
45	SHIRLEY	1963	JUN	19	4	58*	153 (NW)	043/29.5
46	BESS	1963	AUG	9	9	45*	78 (NE)	328/ 6.8
47	HELEN	1964	AUG	1	11	88	110 (SW)	314/ 9.7
48	KATHY	1964	AUG	23	15	68	62 (SE)	042/ 8.7
49	WILDA	1964	SEP	24	24	95	110 (SE)	042/21.0
50	DINAH	1965	JUN	19	10	43	48 (SSE)	053/26.5
51	JEAN	1965	AUG	5	16	105	40 (ESE)	026/19.0
52	WINNIE	1966	AUG	23	14	30	22 (SW)	322/10.5
53	BETTY	1966	AUG	29	16	60	174 (W)	007/ 9.0
54	DORIS	1966	SEP	9	18	40	115 (ESE)	018/17.8
55	HELEN	1966	SEP	24	22	30	113 (SE)	012/11.3
56	DOT	1967	JUL	26	9	45	169 (SSW)	300/ 8.0
57	POLLY	1968	AUG	16	7	41	78 (NW)	035/24.7
58	TRIX	1968	AUG	28	10	32	86 (SE)	041/18.3
59	DELLA	1968	SEP	24	15	45*	58 (ESE)	022/13.1
60	CORA	1969	AUG	22	9	60*	90 (SSE)	070/16.4

NOTES:
Datetimes are in UTC, winds are in knots, distances are in nautical miles. Parenthetical expression in column 8 gives bearing of storm from site at closest point of approach to site (CPA). Maximum winds are at time of CPA and did not necessarily occur at site. Asterisk (if any) after maximum wind indicates that storm was classified as a typhoon (at least 64 kts) somewhere within 180 nautical mile radius of site but not at CPA. Site location is 33.2°N, 129.7°E.

Table V-14 (continued). Descriptive history of the 108 tropical storms and typhoons passing within 180 nmi of Sasebo during the 47-year period 1945-1991.

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAXIMUM WIND AT STORM CENTER	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
61	WILDA	1970	AUG	14	8	82	20 (ESE)	035/13.3
62	ANITA	1970	AUG	21	9	87	155 (ENE)	343/18.1
63	BILLIE	1970	AUG	30	10	78	178 (W)	349/ 9.2
64	OLIVE	1971	AUG	5	19	63*	24 (E)	349/15.3
65	TRIX	1971	AUG	30	23	60*	111 (ESE)	048/ 8.4
66	TESS	1972	JUL	23	10	48*	88 (ENE)	335/19.5
67	GILDA	1974	JUL	6	9	53*	80 (NW)	032/14.1
68	POLLY	1974	SEP	1	18	60*	172 (ENE)	345/18.1
69	SHIRLEY	1974	SEP	8	21	55*	96 (SE)	055/19.6
70	PHYLLIS	1975	AUG	17	7	53*	111 (NE)	314/12.2
71	THERESE	1976	JUL	19	9	43*	20 (S)	090/ 6.0
72	ANITA	1976	JUL	24	12	26	20 (NE)	334/14.7
73	FRAN	1976	SEP	12	17	57*	18 (ESE)	027/16.8
74	AMY	1977	AUG	23	9	40	96 (SSW)	099/12.0
75	POLLY	1978	JUN	20	3	33	2 (ESE)	063/18.2
76	WENDY	1978	AUG	2	8	42	27 (ESE)	025/16.9
77	CARMEN	1978	AUG	19	11	35	166 (WNW)	015/19.7
78	IRMA	1978	SEP	15	18	47	20 (NW)	062/17.8
79	KEN	1979	SEP	3	15	48	113 (ESE)	031/13.7
80	OWEN	1979	SEP	30	19	68	160 (SE)	040/21.1
81	TIP	1979	OCT	18	23	73	179 (SE)	039/35.7
82	ORCHID	1980	SEP	11	17	60*	79 (ESE)	011/29.6
83	WYNNE	1980	OCT	13	23	89	161 (SSE)	065/23.7
84	JUNE	1981	JUN	22	5	30	42 (SW)	070/18.6
85	OGDEN	1981	JUL	31	10	40	24 (SSW)	297/15.6
86	ELLIS	1982	AUG	26	14	62*	119 (E)	005/17.4
87	KEN	1982	SEP	24	20	66	139 (E)	005/21.5
88	FORREST	1983	SEP	28	11	63*	17 (S)	076/30.2
89	ED	1984	JUL	29	7	95	173 (SSW)	284/11.6
90	HOLLY	1984	AUG	21	11	61*	73 (NW)	040/15.0
91	KIT	1985	AUG	8	8	83	131 (SSW)	301/ 7.9
92	ODESSA	1985	AUG	31	12	48*	16 (NW)	028/20.0
93	PAT	1985	AUG	31	13	85	19 (E)	002/23.5
94	BRENDA	1985	OCT	5	20	65	95 (WNW)	042/25.9
95	NANCY	1986	JUN	24	5	47	55 (NW)	033/30.2
96	ROGER	1986	JUL	17	8	50	143 (SE)	048/19.6
97	THELMA	1987	JUL	15	5	72	143 (WNW)	016/26.1
98	DINAH	1987	AUG	30	11	75	72 (NW)	034/29.8
99	ELLIS	1989	JUN	24	6	35	49 (ESE)	011/30.5
100	JUDY	1989	JUL	28	11	65	38 (SW)	322/10.9
101	WAYNE	1989	SEP	19	25	65	127 (SSE)	064/26.8
102	ZOLA	1990	AUG	22	14	89	130 (E)	003/21.2
103	GENE	1990	SEP	29	21	78	140 (SE)	053/13.7
104	HATTIE	1990	OCT	7	22	56	146 (SE)	052/18.3
105	CAITLIN	1991	JUL	29	9	80	66 (WNW)	033/15.5
106	GLADYS	1991	AUG	22	14	45	44 (WSW)	341/ 9.7
107	KINNA	1991	SEP	13	19	80	27 (E)	036/28.0
108	MIREILLE	1991	SEP	27	21	93	18 (SSW)	036/39.8

NOTES:
Datetimes are in UTC, winds are in knots, distances are in nautical miles. Parenthetical expression in column 8 gives bearing of storm from site at closest point of approach to site (CPA). Maximum winds are at time of CPA and did not necessarily occur at site. Asterisk (if any) after maximum wind indicates that storm was classified as a typhoon (at least 64 kts) somewhere within 180 nautical mile radius of site but not at CPA. Site location is 33.2°N, 129.7°E.

Table V-15. Frequency of motion of tropical storms and typhoons passing within 180 nmi of Sasebo during the 47-year period 1945-1991.

Total number of storms passing within 180 n mi	0	0	0	0	1	12	21	39	27	8	0	0	108
Number of storms having at least typhoon intensity at CPA	0	0	0	0	0	0	6	14	16	4	0	0	40
Number of storms less than typhoon intensity at CPA	0	0	0	0	1	12	15	25	11	4	0	0	68
Average heading (degs) towards which storms were moving at CPA	---	---	---	---	*	041	341	010	031	042	---	---	020
Average storm speed (knots) at CPA	---	---	---	---	*	30	14	15	22	25	---	---	19
Month when storm was at CPA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR

** indicates insufficient storms for average direction and speed computations.*

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It should be noted that the monthly average storm speed at CPA given in Table V-15 is relatively high, especially for the storms occurring in June. As shown in Figures A-1 through A-24, most June tropical cyclones that follow a track that will place the storm close to Sasebo recurve near between 20°N and 30°N before accelerating to the northeast. Because Sasebo is north of the normal latitudinal recurvature range, most storms passing within 180 nmi of the port have already recurved and many are moving northeastward and accelerating when they are at their CPA.

During the 47-year period from 1945 through 1991 there were 108 tropical storms and typhoons that met the 180 nmi threat criterion for Sasebo, an average of about 2.3 per year. Figure V-58 shows the monthly distribution of the 108 storms by 7-day periods when each storm was at its CPA to Sasebo. The period of peak activity extends from mid-July through September, but a secondary peak of tropical storm activity occurs during the last half of June.

A yearly chronology of tropical storms and typhoons that passed within 180 nmi of Sasebo during the 47-period 1945-1991 is presented in Figure V-59.

Figure V-60 presents a graphical depiction of the number of tropical cyclones versus CPA. The storm classification is based on the maximum wind near the storm center while that center was within 180 nmi of Sasebo, not necessarily at CPA. The sloping lines represent mathematical fits to the data points for the various intensity classifications. The average radii of maximum wind for 34, 100, and 140 kt tropical cyclones at Sasebo are 27.5, 25.9 and 23.0 nmi, respectively.

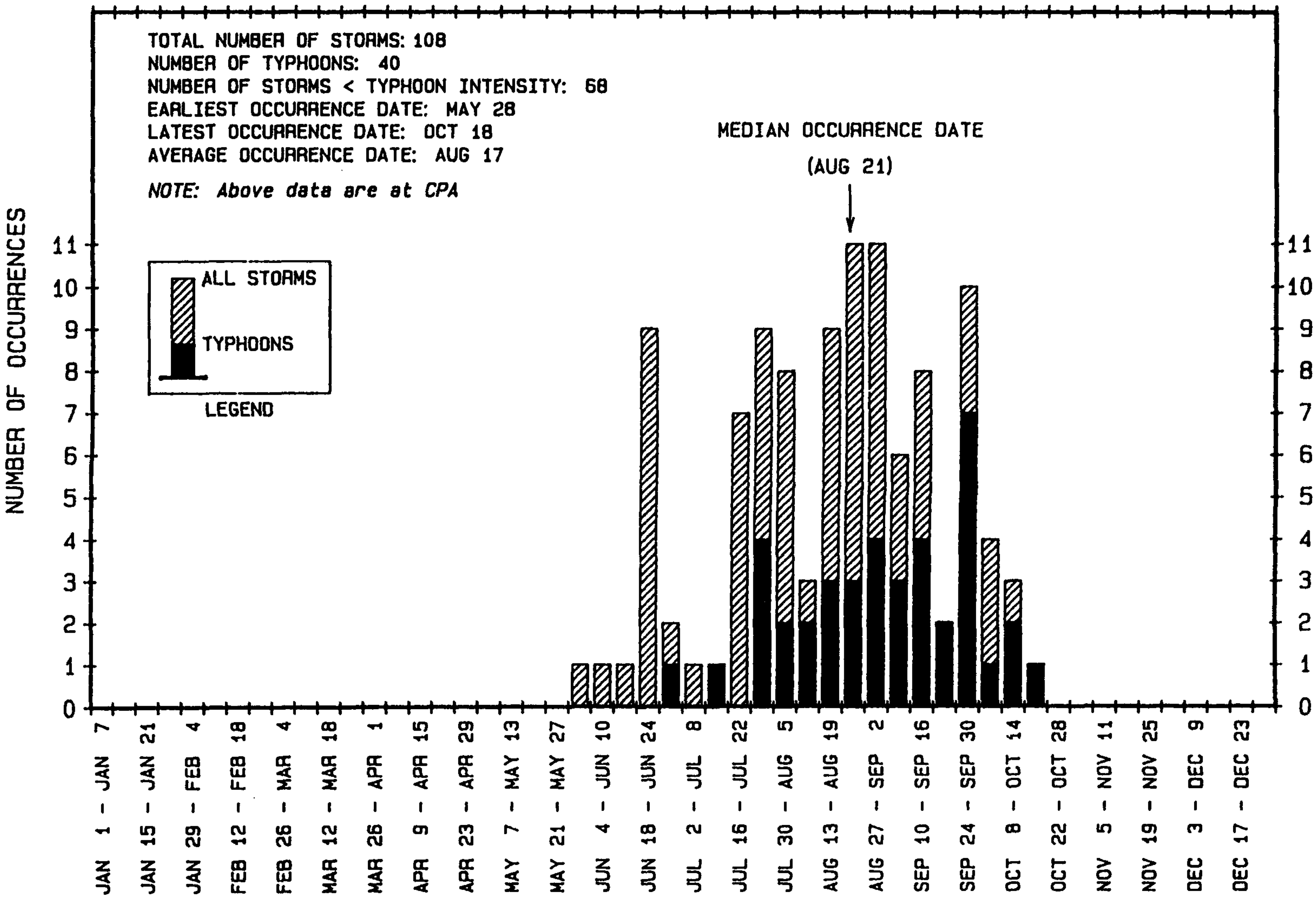

Figure V-58. Monthly distribution of the 108 tropical storms and typhoons passing within 180 nmi of Sasebo during the 47-year period 1945-1991.

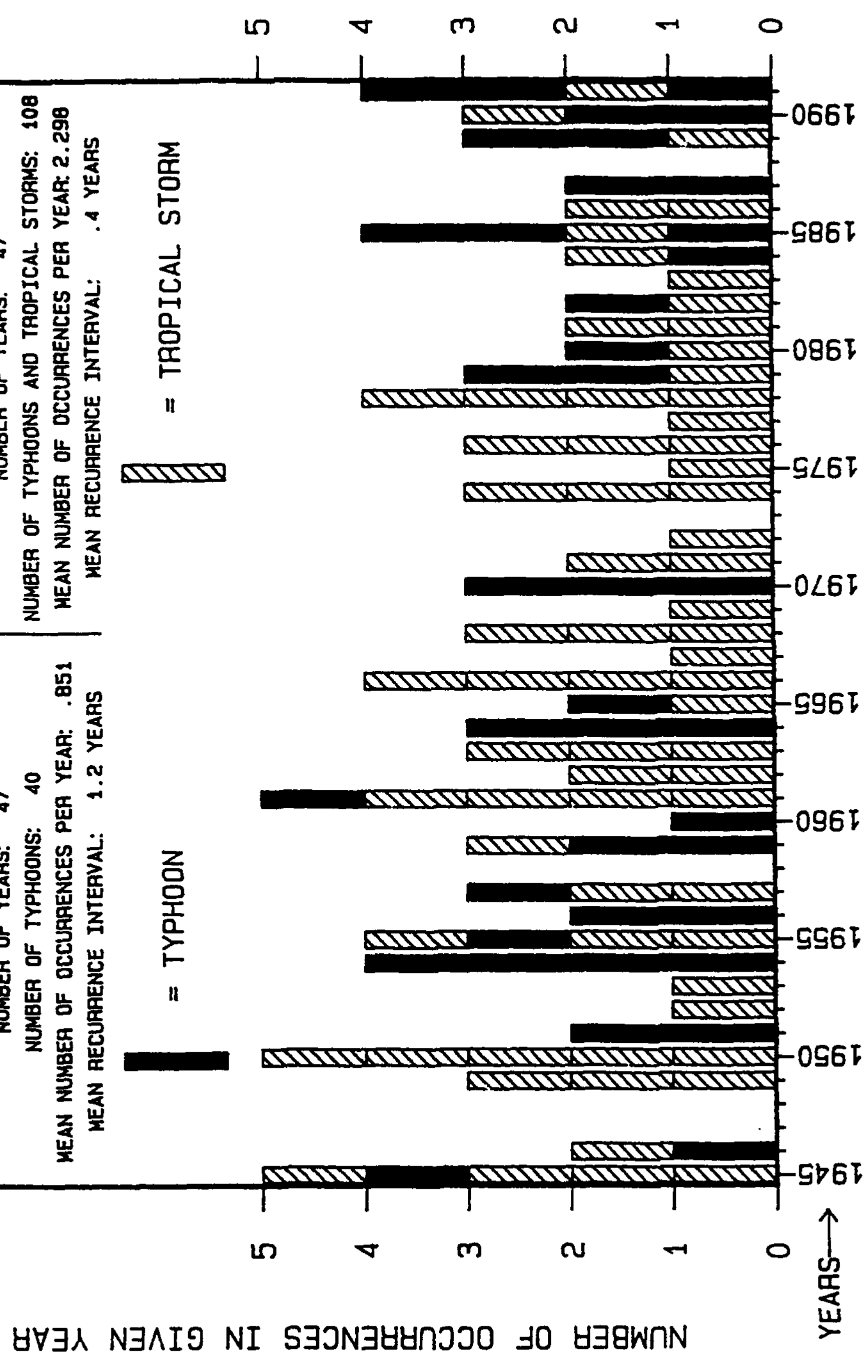

Figure V-59. Chronology of the 108 tropical storms and typhoons passing within 180 nmi of Sasebo during the 47-year period 1945-1991. Storm intensity is determined at time of closest point of approach (CPA) to Sasebo.

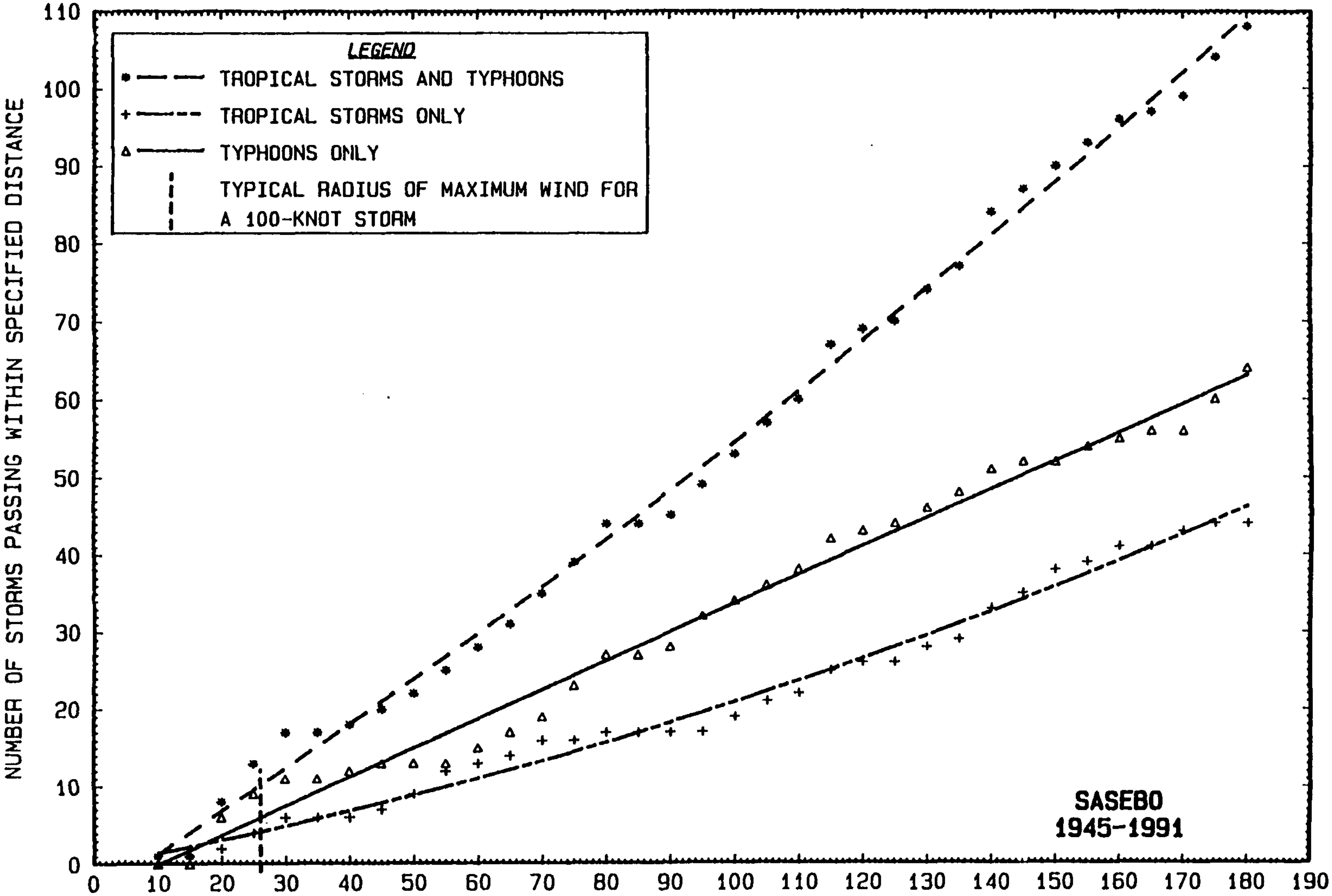

Figure V-60. Number of tropical cyclones passing at various distances from Sasebo over the 47-year period of record. Tropical storm or typhoon classification is based on maximum wind near storm center while that center was within 180 nmi of Sasebo, and not necessarily at CPA. Sloping lines represent mathematical fit to data points. Average radii of maximum wind for 34, 100, and 140 kt storms at Sasebo are 27.5, 25.9, and 23.0 nmi, respectively.

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Figure V-61 depicts, on an 8-point compass, the octants from which the 108 tropical cyclones in the data set approached Sasebo. It should be noted that the approach direction is determined at CPA, and may not represent the initial approach direction of the tropical storm or typhoon toward Sasebo. As can be seen in the figure, over 75% of the tropical cyclones were moving from the southwest or south when they were at their CPA.

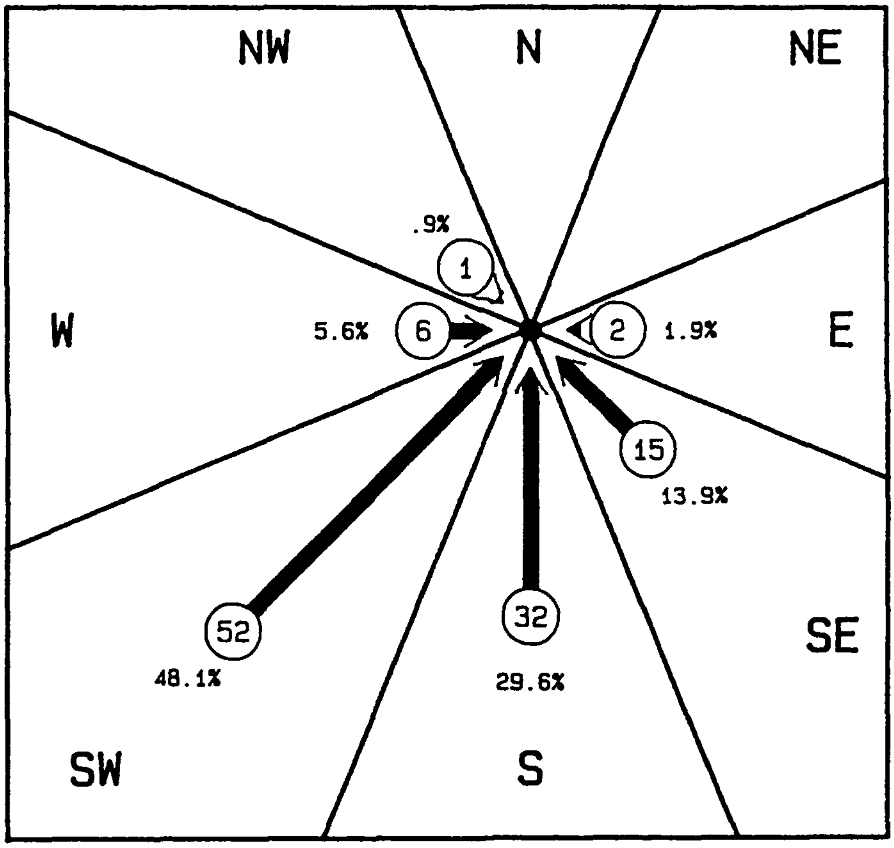

Figure V-61. Directions of approach for the 108 tropical cyclones passing within 180 nmi of Sasebo during the 47-year period of record. Length of directional arrow is proportional to the number of storms given in the circles of each octant. Approach directions are determined at CPA.

Figures V-62 through V-65 provide information on the probability of remote tropical storms and/or typhoons passing within 180 nmi of Sasebo and average time to CPA. The solid lines represent a 'percent threat' for any tropical cyclone location within the area depicted. The heavy dashed lines represent the approximate time in days for a system to reach Sasebo. For example, in Figure V-62, during the month of July a tropical cyclone located at 20°N 140°E has approximately a 40% probability of passing within 180 nmi of Sasebo and will reach Sasebo in about 4-1/2 to 6 days.

A comparison of the preceding figures reveals some differences in threat axes according to the time of year. During July and August the threat axes extend south-southeastward from Sasebo through approximately 20°N 145°E into the more tropical latitudes. By September, the axis near Sasebo extends south-southwestward to about 25°N 127°E before turning southeastward to an area near 10°N 155°E. The axis for the period October through June closely approximates that of September, extending southwestward across the east China Sea to a position just east of Taiwan before turning southeastward into the lower latitudes.

5.5.2 Wind and Topographical Effects

A total of 39 tropical cyclones approached within 180 nmi of Sasebo in the 17-year period from 1975-1991. Of the 39 tropical cyclones, 10 (26%) resulted in sustained strong winds (≥22 kt) and only 2 (5%) resulted in sustained gale force winds (≥34 kt).

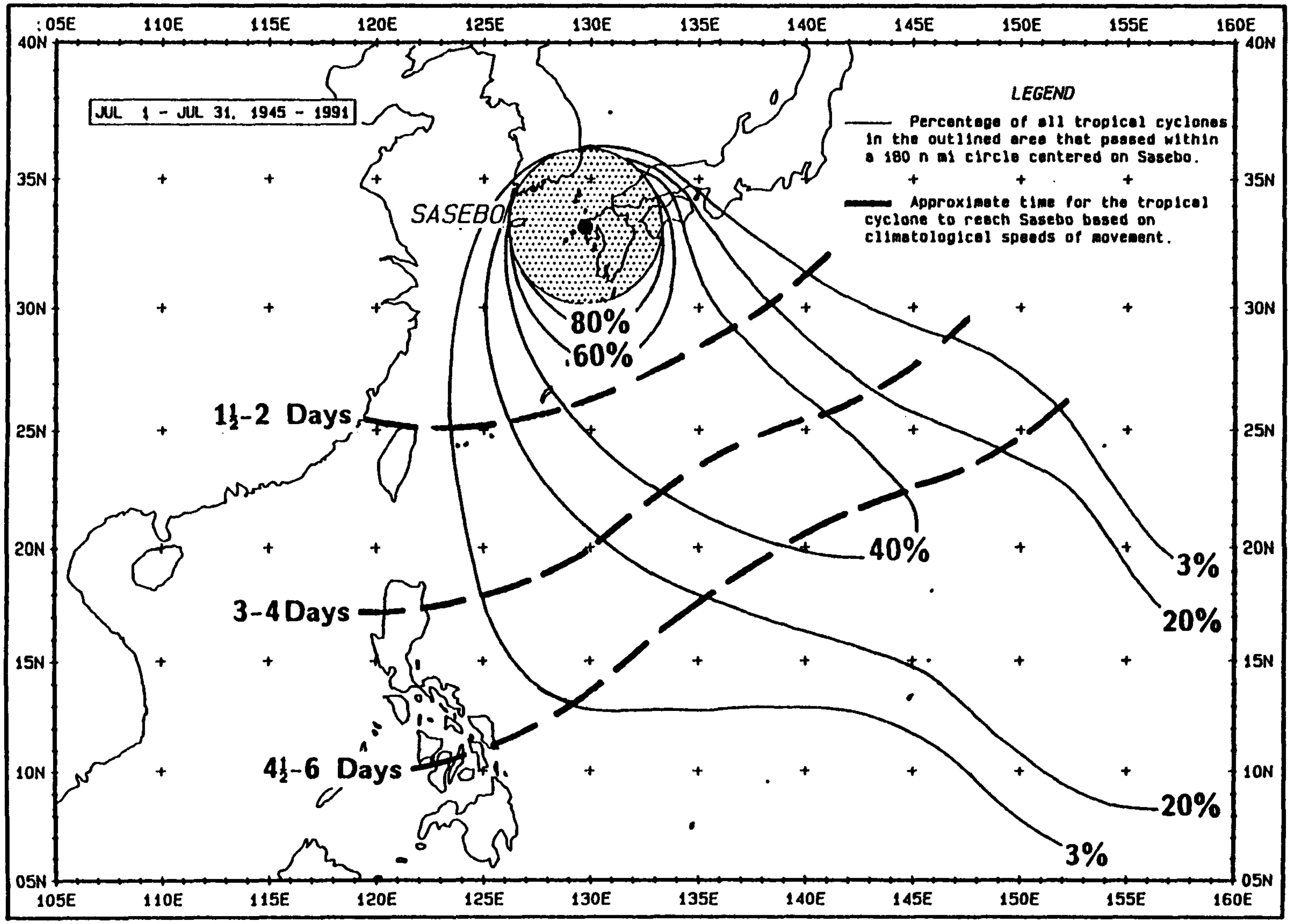

Figure V-62. Probability that a tropical storm or hurricane will pass within 180 nmi of Sasebo (circle), and approximate time to closest point of approach, during July (based on data from 1945-1991).

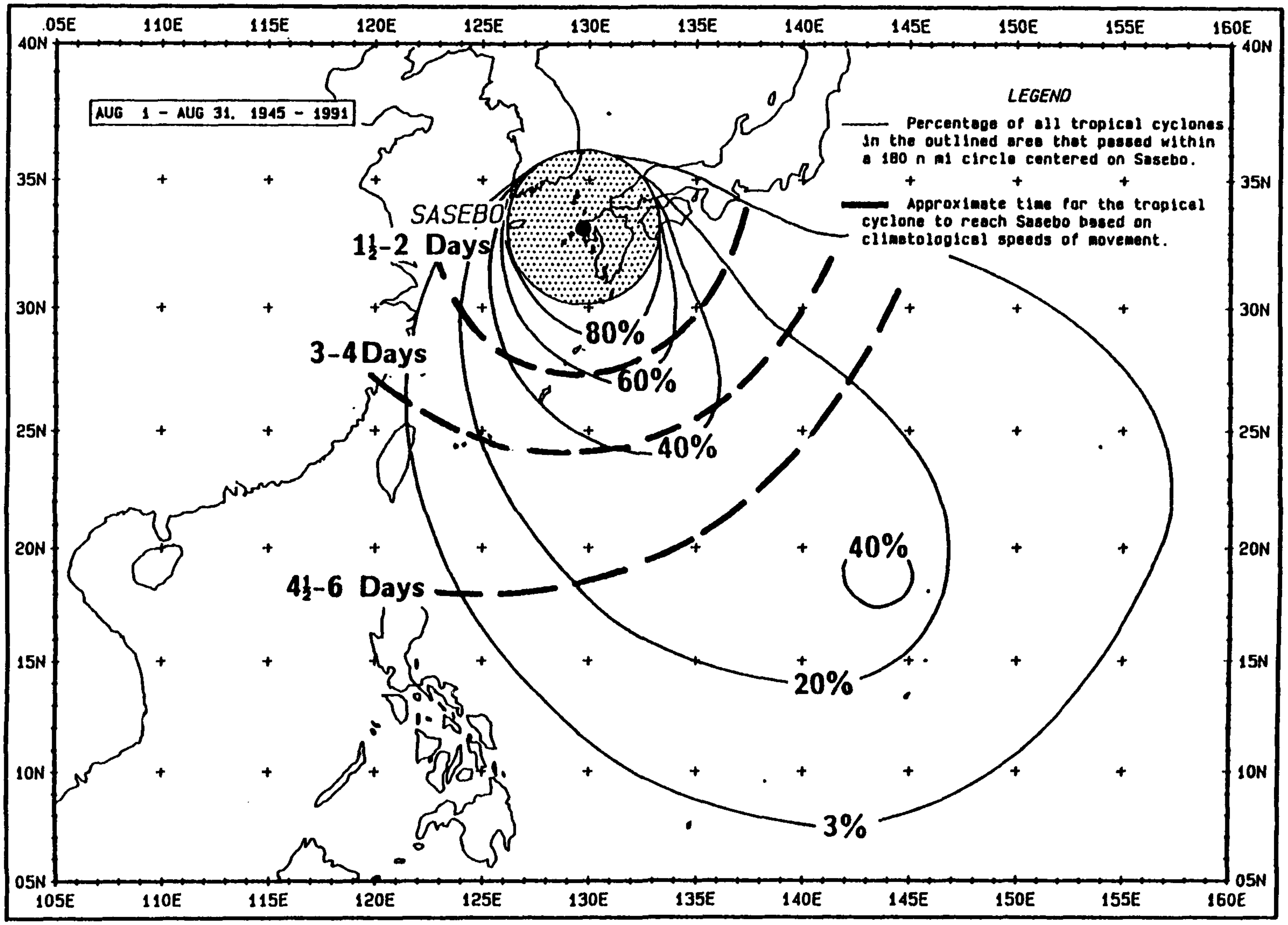

Figure V-63. Probability that a tropical storm or hurricane will pass within 180 nmi of Sasebo (circle), and approximate time to closest point of approach, during August (based on data from 1945-1991).

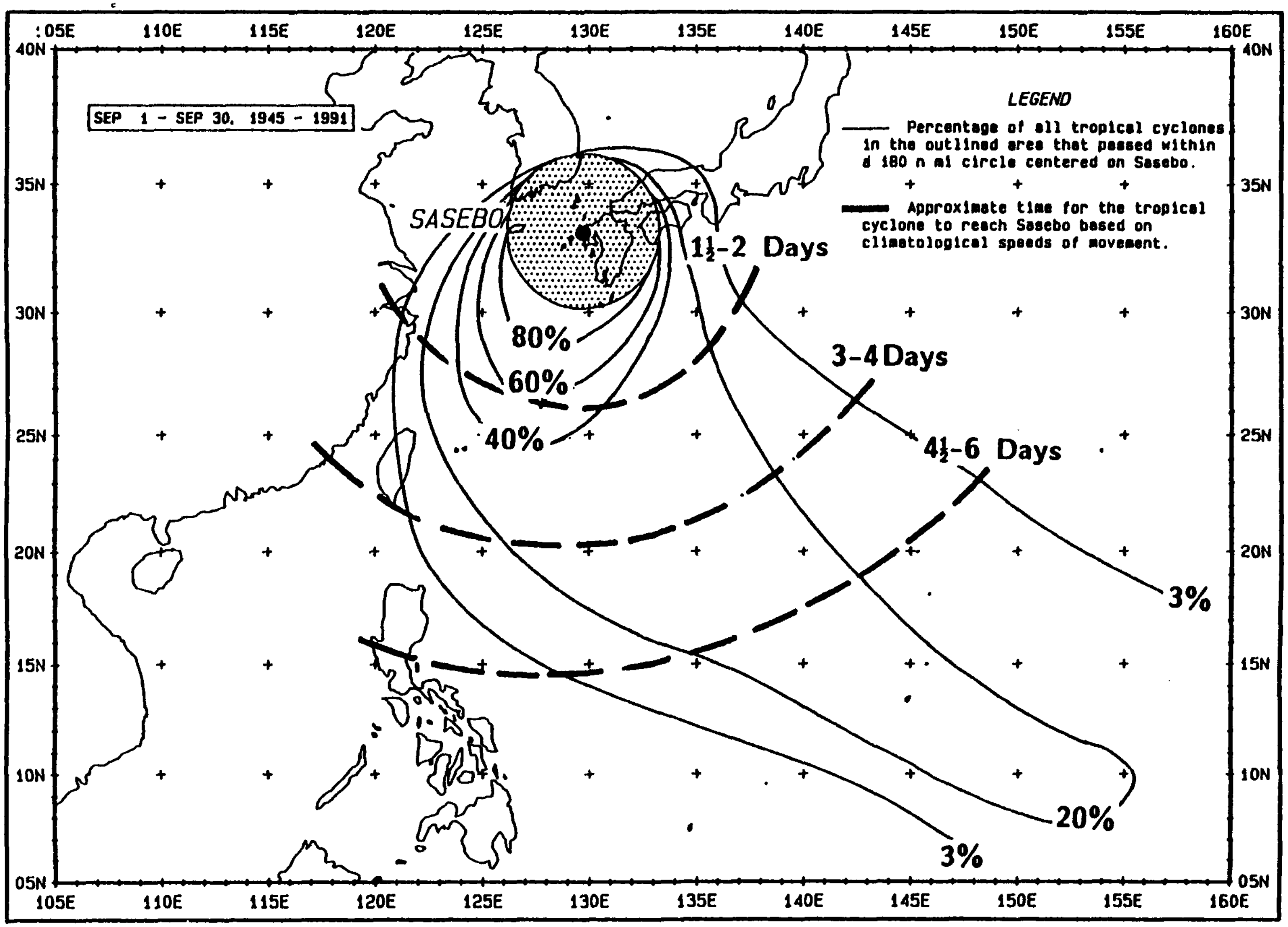

Figure V-64. Probability that a tropical storm or hurricane will pass within 180 nmi of Sasebo (circle), and approximate time to closest point of approach, during September (based on data from 1945-1991).

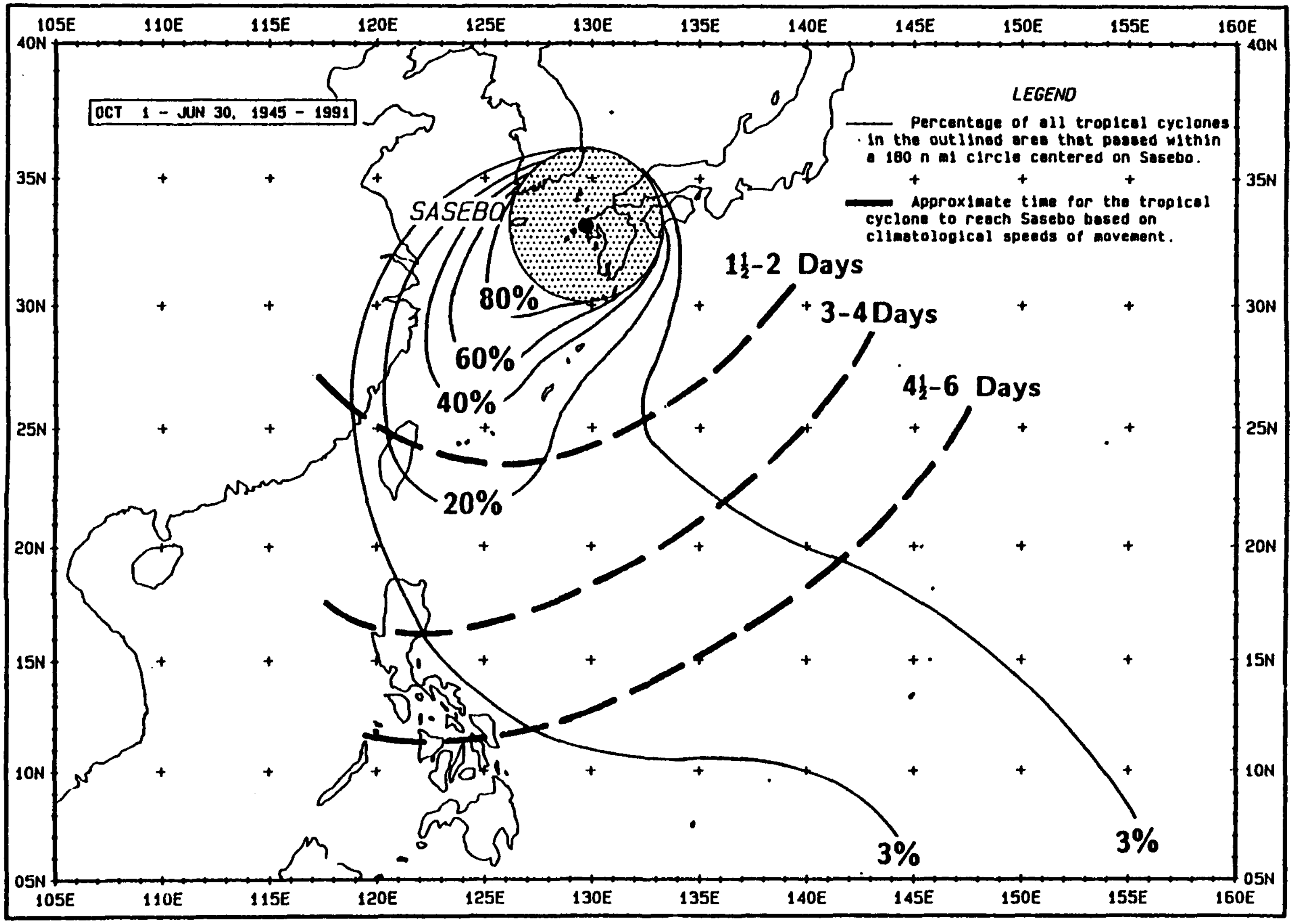

Figure V-65. Probability that a tropical storm or hurricane will pass within 180 nmi of Sasebo (circle), and approximate time to closest point of approach, during the period October through June (based on data from 1945-1991).

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An analysis of the tracks of the tropical cyclones that produced winds of ≥22 kt or ≥34 kt at Sasebo shows that storms that pass east or west of Sasebo produce essentially the same wind threat. Of the storms cited in the previous paragraph as causing strong or gale force winds, one-half passed east of Sasebo and one-half passed to the west. Other factors must be considered, however. If the tropical cyclone path is to the east across Kyushu, the storm will lose some of its intensity over land. Additionally, the Kyushu mountains and local topography (see Figures V-54 and V-55) will provide protection from the winds of the tropical cyclone. The winds that reach the port will have a strong northerly component, and wave motion in and near India and Juliet Basins will be minimal.

An early 1970's visit to Sasebo and subsequent analysis of the tropical cyclone threat to the port produced the following conclusions.

1. All U. S. Naval vessels considered Sasebo Harbor a safe typhoon haven during the passage of Typhoon Bess east of the harbor. (Typhoon Bess had a CPA of 78 nmi northeast of Sasebo, with center winds of 45 kt.) No damage was reported by any of the ships.

2. Winds reported by ships in the harbor (maximum of 48 kt) tended to be higher than those reported by land based units. Ships in the southern part of the harbor at typhoon anchorage reported winds near the maximum while ships in the northern part of the harbor reported winds close to 40 kt.

3. The use of a second anchor dropped under foot to reduce yawing, and steaming to the anchor/mooring buoy to reduce the strain on the chain, are highly recommended.

4. The wet drydocks may provide shelter for smaller ships. (Note: Late 1992 discussions with port personnel largely negated this recommendation due to the "step down" sides of the drydocks, and the danger of holing a hull if the ship should have any lateral motion while in the dry dock.)

In the case of a tropical cyclone passing west of Sasebo, the path is primarily over water. It is evident that the protection offered by topography to the south and west is much less than to the north and east of Sasebo. In addition, tropical cyclone passage to the west places Sasebo in the "dangerous" right hand semicircle, thus subjecting the harbor to higher wind velocities. The passage of Typhoon Gilda in July 1974 is cited as an example. Gilda had a CPA of 80 nmi northwest of Sasebo, with a center wind of 53 kt, and produced winds of 45 kt as compared to winds of 38 kt with Typhoon Bess (cited above) which passed to the east. The following conclusions were reached as a result of the storm.

1. U. S. Naval vessels involved, considered Sasebo Harbor as a safe typhoon haven during Typhoon Gilda's passage west of Sasebo.

2. India Basin, berths 8 and 9 (see Figure V-57) can be used as a shelter from a typhoon passing to the west of Sasebo. Maximum seas reported in India Basin during Gilda's passage were 5 ft confused. However, see Sections 5.5.4 and 5.6.1 below for more recent views on the safety of the berths during typhoon passage.

3. All radars should be used under conditions of restricted visibility to obtain accurate fixes.

It must be pointed out that all of the wind data evaluations cited in this report are based on the assumption that the "threat" tropical cyclone was solely responsible for the winds produced at Sasebo. This assumption does not take into account other extratropical synoptic features existing at the time which could "bias" the winds observed at Sasebo.

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Also, all or a portion of the hourly wind data analyzed during the 17-year period may have originated with the Japanese Weather Bureau.[1] Since the anemometer of their station does not extend above a hill just south of the station, the southerly winds used may be less than those experienced by ships in the harbor.

Figure V-66 shows the track segments of the 10 "threat" tropical cyclone centers when sustained strong winds (≥22 kt) were first and last recorded at Sasebo.

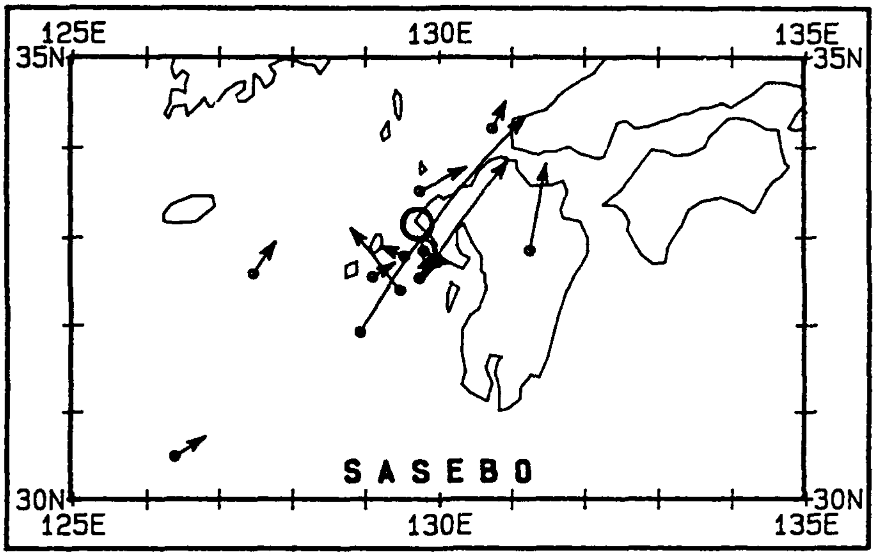

Figure V-66. Track segments of the 10 tropical storms or typhoons causing sustained winds of at least 22 kt at Sasebo during the 17-year period 1975-1991.

[1]Observational data were provided by Naval Oceanography Command Detachment, Asheville, NC.

Figure V-67 shows the 2 tropical cyclone track segments when sustained gale force (≥34 kt) winds were first and last recorded at Sasebo.

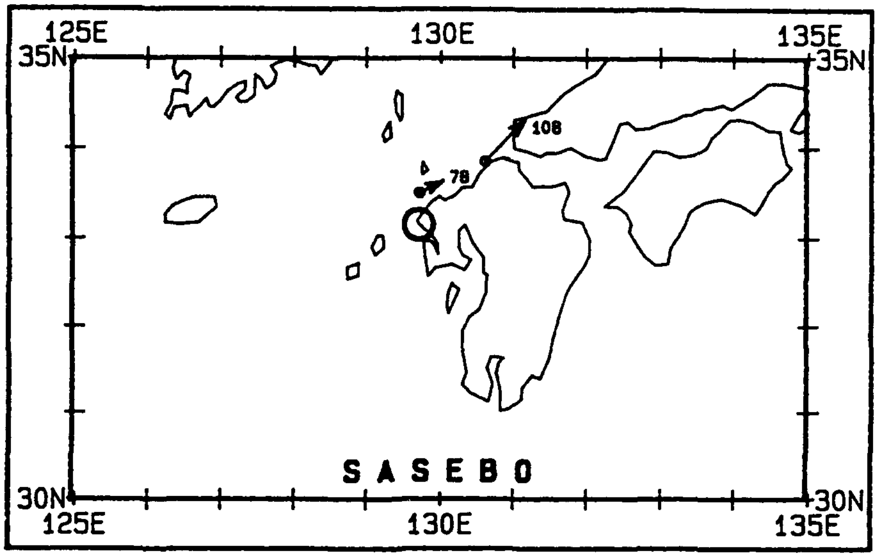

Figure V-67. Track segment of the 2 tropical storms or typhoons causing sustained winds of at least 34 kt at Sasebo during the 17-year period 1975-1991.

In examining Figures V-66 and V-67, it must be understood that there may be a bias in the wind observations used in constructing the figures (southerly winds associated with tropical cyclone passage to the west may not be as readily detected as northerly winds associated with tropical cyclone passage to the east due to the hill south of the Japanese Weather Bureau recording station).

The most severe threat to the harbor occurs when a tropical cyclone approaches from the southwest and passes west of Sasebo, within 50 nmi or so. In this case, the elevations of Hario Island (see Figure V-56) serve as a good wind barrier for ships at typhoon anchorage at Ebisu Bay. When tropical cyclones pass to the east of Sasebo, the elevated terrain to the north and east of the harbor provide excellent protection (see Figure V-55). In this case, maximum winds can be expected from the north. For a more complete description of the effects of tropical cyclones on Sasebo Harbor, See Rudolph, 1975.

5.5.3 Local Weather Conditions

The data contained in Table V-16 has been selected from observations recorded at Sasebo during the passage of the tropical cyclones listed in the table. It should be noted that no record of observations is available during the period 1945 through 1974.

Table V-16. Center data and related weather associated with selected tropical cyclone passages within 180 nmi of Sasebo during the period 1975-1991. No observational data are available for the period 1945-1974.

TYPHOON DATA				RELATED LOCAL WEATHER	
DATE (NAME)	MVMT DIR/SOA (KT)	DIR/CPA FM STAT (NMI)	CNTR WIND (KT)	MAX WIND & GUSTS (KT)	COMMENTS
78/09/15 IRMA	062/18	314/20	47	SSW 36G63	THUNDERSHOWER
80/09/11 ORCHID	011/30	103/79	60	NNW 23G40	RAINSHOWERS
80/07/31 OGDEN	297/16	208/24	40	NE 25G39	RAINSHOWERS
85/08/31 PAT	002/24	081/19	85	W 25+59	RAINSHOWERS
87/08/30 DINAH	034/30	315/72	75	E 25	HEAVY RAIN
89/07/28 JUDY	322/11	224/38	65	E 27G54	RAINSHOWERS
91/09/27 MIRIELLE	036/40	192/18	93	E 29G70 SHIFTING TO NW 34	RAINSHOWERS

5.5.4 Wave Action

Sasebo Harbor experiences its highest waves when a typhoon passes to the west since this places Sasebo in the right or "dangerous" semicircle of the typhoon. The greater relative wind (wind velocity plus storm movement) in this area generates higher waves. Because the shape of the harbor reduces the fetch, the effects of the typhoon-related sea is minimized. However, India Basin is constructed so that northerly moving waves pass through the basin entrance, reflect off of the face of the north quay wall (berths 4, 5, and 6) and impact ships moored to berths 1 and 9. The impact on ships moored to berths 1 and 9 can be significant.

The maximum wave heights that can be expected with typhoon strength winds (≥64 kt) are given in Table V-17.[2]

Table V-17. Maximum wave heights that can be expected with typhoon strength winds (≥64 kt) in vicinity of India Basin and the typhoon anchorage.

SITUATION	AREA JUST SOUTH OF INDIA BASIN	TYPHOON ANCHORAGE (VICINITY OF EBISU BAY)
Winds generally from the north (tropical cyclone passage east of Sasebo.	4 feet	8 feet
Winds generally from the south (tropical cyclone passage west of Sasebo.	7 feet	5 feet

[2]Based on forecasting curves for shallow-water waves from U. S. Army Coastal Engineering Research Center, 1973: "Shore Protection Manual (Volume 1)."

5.5.5 Storm Surge and Tides

A rise in water level may occur when a tropical cyclone crosses a coastline; the phenomenon is known as storm surge. Storm surge may be visualized as a raised dome of water, moving with the storm, and centered a few miles to the right of its path. Storm surge is caused by wind stress on the water surface and the effects of atmospheric pressure reduction. Also, tides may act to either increase or decrease this rise in water level.

The storm surge effect is most evident in the shallow waters of large inland bays opening southward along the south coast of Japan (from Miyazaki, 1974). The height of the storm surge in a given port on a south facing coast is dependent on the tropical cyclone track. If the track is to the west of the port, the peak surge will be large; the opposite is true for a track to the east of the port.

Of 10 tropical cyclones which passed to the west of Sasebo over a 5-year period, the maximum tidal height over the normal tide was 1.3 feet. Since the tidal range for Sasebo Harbor is 10 to 12 feet, this relatively small storm surge would be significant only if it coincided with a high spring tide and large waves. These three factors did coincide in July 1974 with the passage of Typhoon Gilda (CPA of 80 nmi west-northwest of Sasebo). Large amounts of water were forced over the southern walls in both Juliet and India Basins. However, even under these extreme conditions, India Basin was considered a "safe, adequate haven" by the commanding officer of USS SACRAMENTO (AOE-1) berthed at India Basin berths 7 and 8 during Typhoon Gilda's passage.

5.6 THE DECISION TO EVADE OR REMAIN IN PORT

5.6.1 Remaining in Port

Commander Fleet Activities Sasebo Instruction 5000.1 (series) makes the following statements pertinent to the use of Sasebo as a typhoon haven: "Given the local topography Sasebo is a typhoon haven for all but aircraft carriers. Evasion sorties must be commenced early because of the restricted waters near Sasebo. Ordinarily SOPA will not order a general sortie from the harbor. Harbor craft including towing and salvage ships are much safer in port."

During the 1992 discussions with harbor personnel, it was strongly emphasized that ships with large sail areas, such as LPD's, LHA's, LPA's, LKA's, etc., and AEGIS ships are not safe in India Basin during strong southerly winds. It was also recommended that ships moored to berths 4, 5, or 6 should get underway if a storm were forecast to pass west of the harbor. Similarly, berths 1 & 9 are not desirable due to wave reflection. Ships moored to berths 7 and/or 8 may be able to stay if the forecast winds are northerly (storm passing south/east of Sasebo). The adjacent Fleet Gym would provide a limited wind break, and most of the wind force would be along the longitudinal axis of the ship.

To assist in preparation for the threat posed by an approaching tropical cyclone the following time/action sequence aid, to be used in conjunction with Figures V-68 to V-71, is provided.

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I. An existing tropical cyclone moves into or development takes place in Area A with long range forecast movement toward Sasebo:

a. Review material condition of ship.

b. Reconsider any maintenance activities scheduled to exceed 48 hours.

c. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

II. Tropical cyclone enters Area B with forecast movement toward Sasebo:

a. Reconsider all maintenance activities scheduled to exceed 24 hours.

b. Anticipate Tropical Cyclone Condition III.

c. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

III. Tropical cyclone has entered Area C and is moving toward the Sasebo area:

a. Be prepared to move to a typhoon anchorage.

b. Review availability of tugs and pusherboats.

c. Ensure sufficient power is available to counter high winds and seas by steaming to the anchor. (See paragraph 5, Chapter I.)

d. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

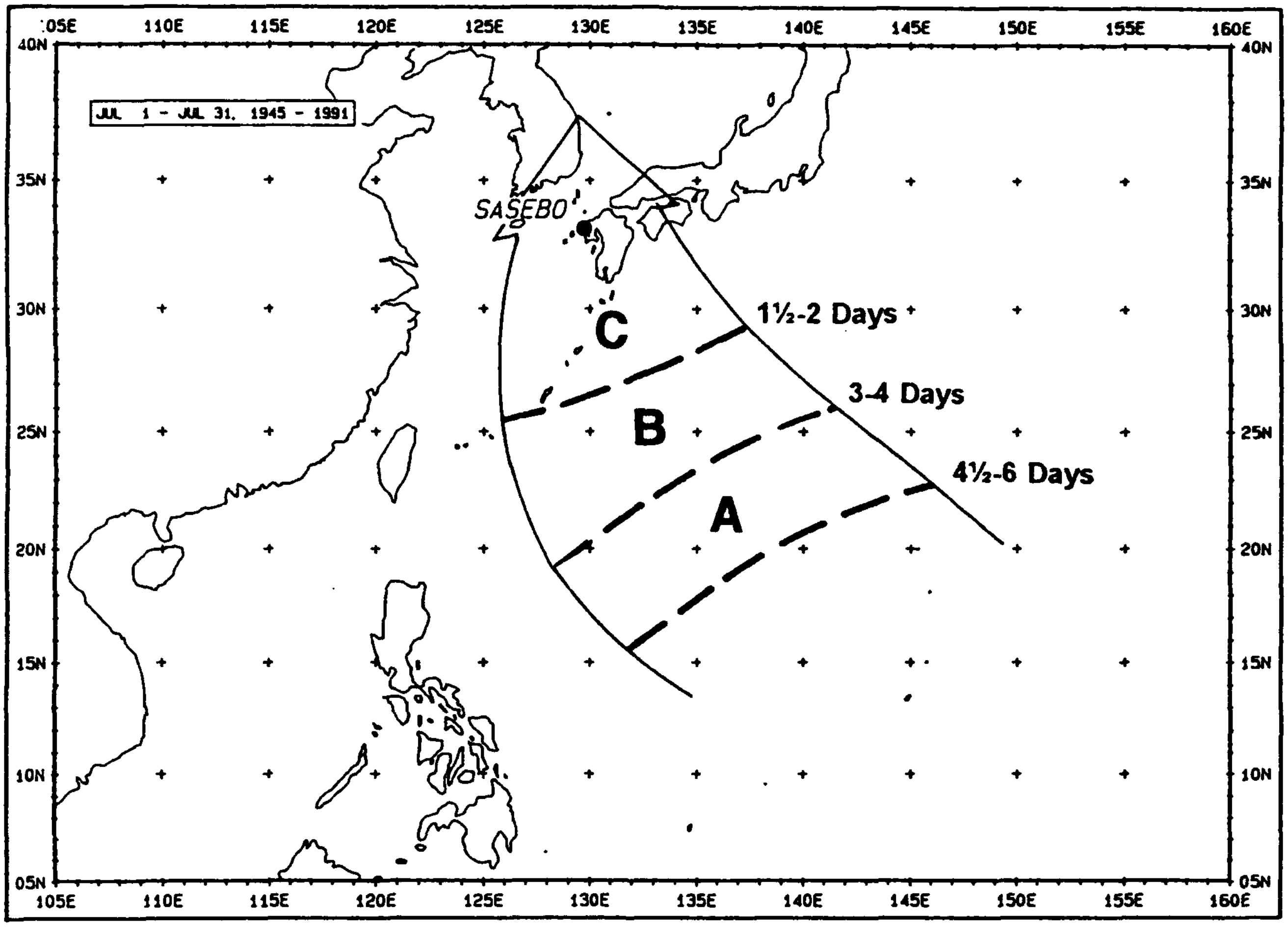

Figure V-68. Tropical cyclone threat axis for Sasebo for July. The area within the limits of the arrow approximates a 50% or greater probability of a tropical cyclone coming within 180 nmi of Sasebo.

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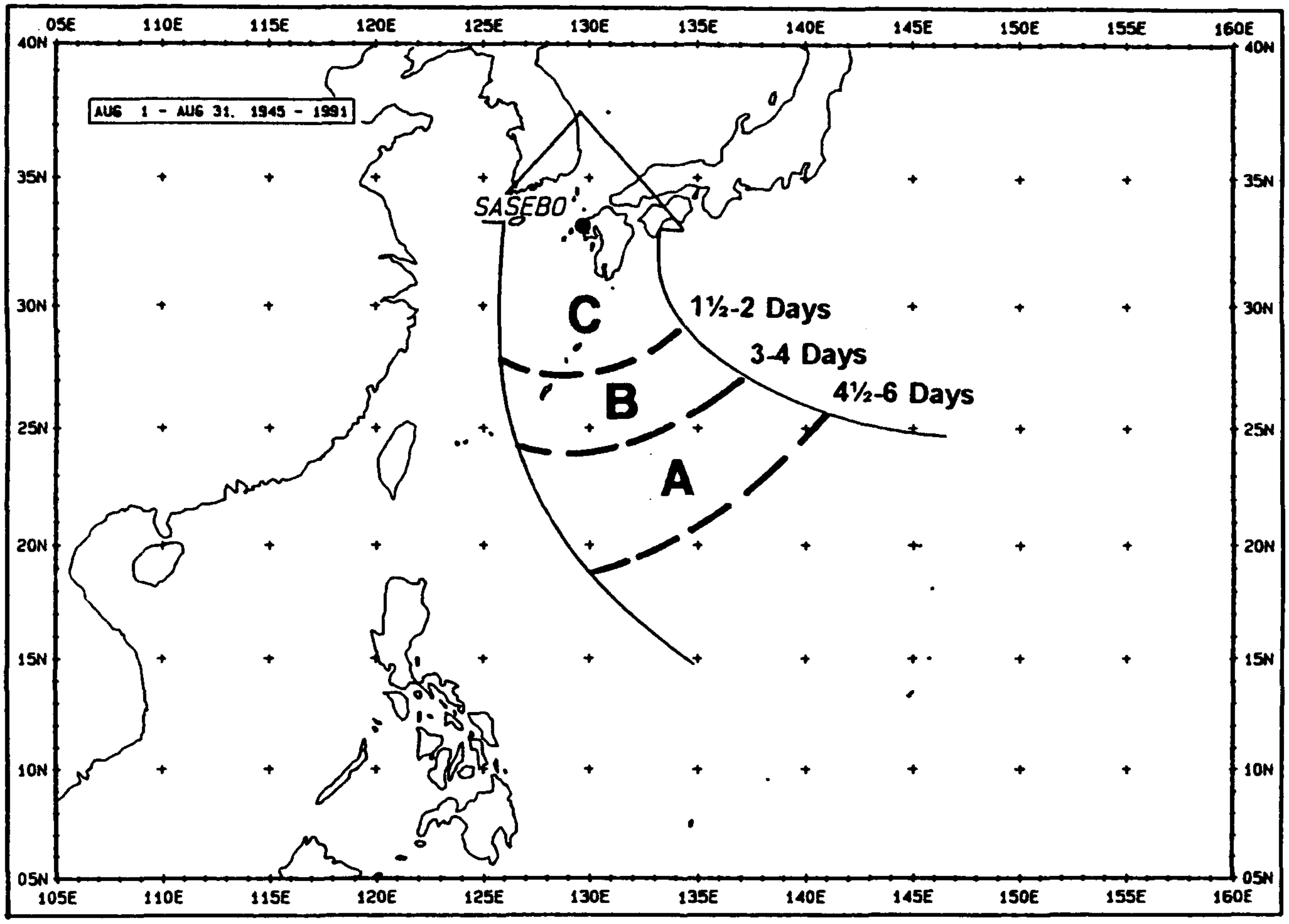

Figure V-69. Tropical cyclone threat axis for Sasebo for August. The area within the limits of the arrow approximates a 50% or greater probability of a tropical cyclone coming within 180 nmi of Sasebo.

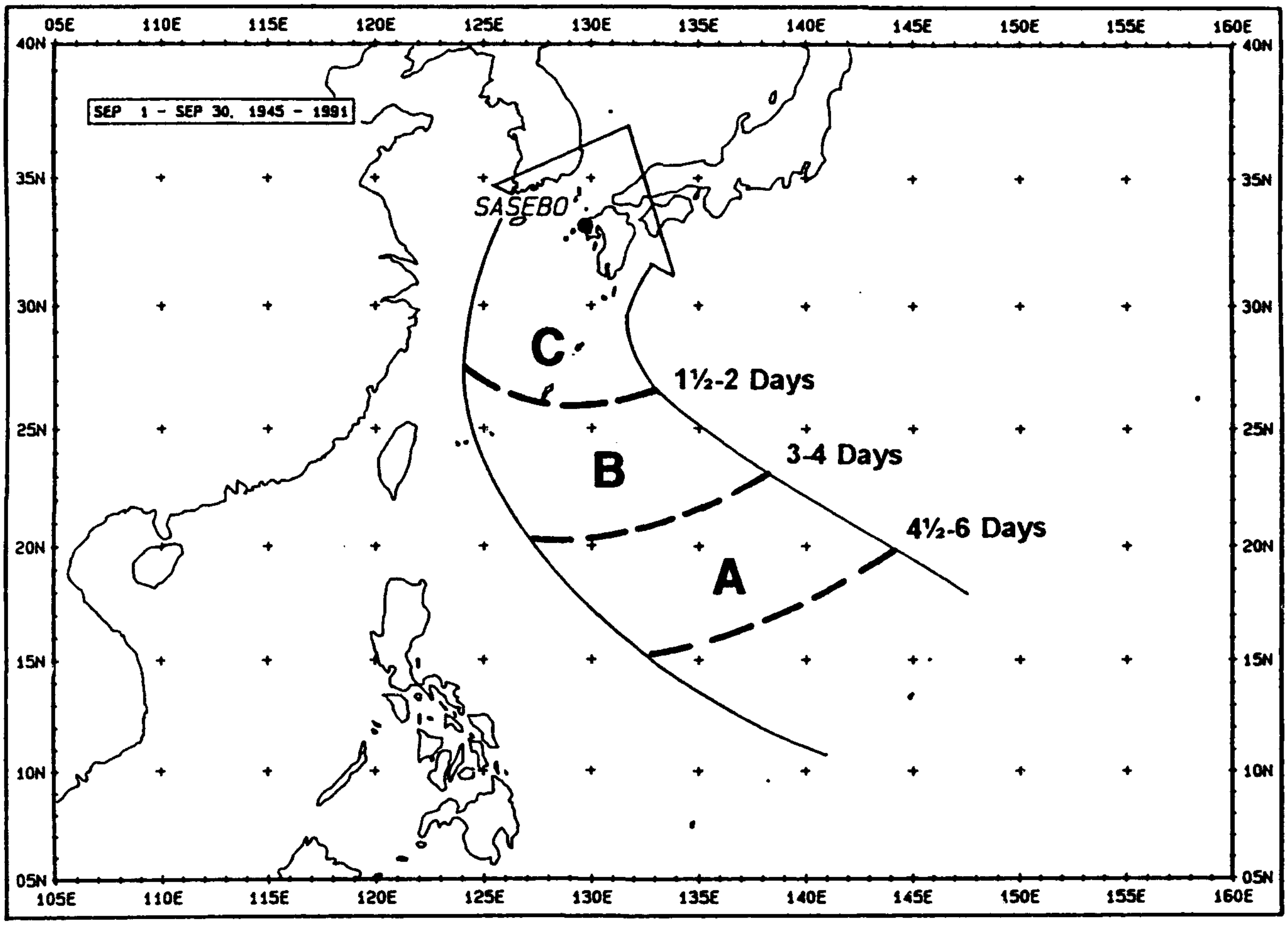

Figure V-70. Tropical cyclone threat axis for Sasebo for September. The area within the limits of the arrow approximates a 50% or greater probability of a tropical cyclone coming within 180 nmi of Sasebo.

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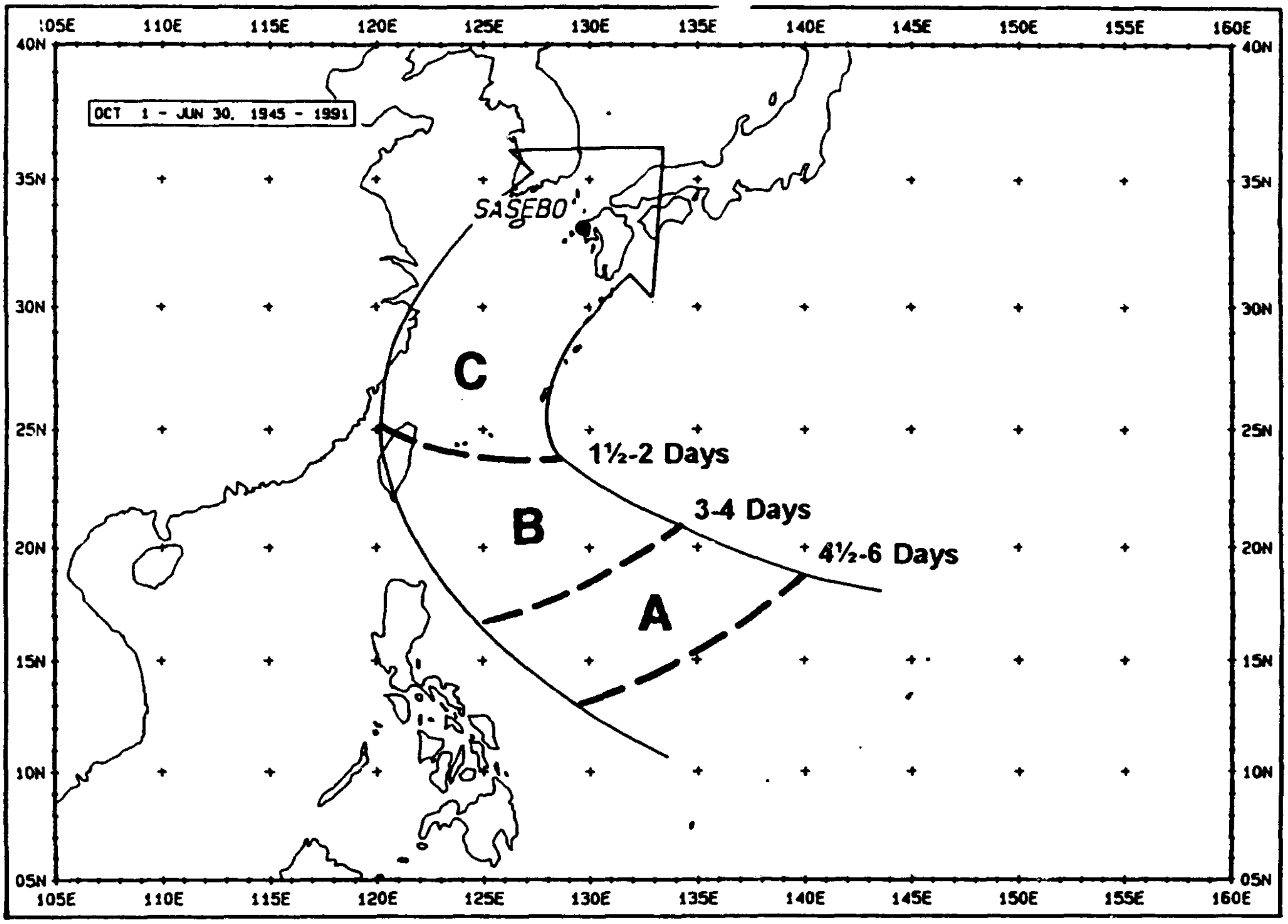

Figure V-71. Tropical cyclone threat axis for Sasebo for the period 1 October through 30 June. The area within the limits of the arrow approximates a 50% or greater probability of a tropical cyclone coming within 180 nmi of Sasebo.

Even though utilization of the typhoon anchorages in the southern part of the harbor is the preferred action, and although most harbor personnel advise against it, several commanding officers have noted in the past that India Basin, especially berths 8 and 9, is suitable for larger ships during the passage of a typhoon. Wet drydocks west of India Basin have been thought to provide excellent shelter for small ships (MSC, ATF, etc.), but harbor personnel state that such use is not recommended during high winds because the drydocks have step-down sides, and excessive ship motion could hole a ship's hull.

There have been a few instances where ships have incurred damage from or were placed in hazardous situations by a typhoon while at Sasebo. The following is a brief summary of the most significant events.

I. In 1991, USS St. Louis was moored cold iron at Pier #1. A typhoon moved through the area, causing strong southerly winds at India Basin. Although she had full moorings and two 3,000 hp tugs under full power were pushing her onto the pier (southward), the wind forced St. Louis off the pier, straining her moorings. It is felt by experienced harbor personnel that a large freighter, moored on the opposite side of the quay, acted as a wind break and was instrumental in preventing USS St. Louis from parting her moorings.

II. Also in 1991, USS Dubuque (LPD-8) dragged anchor while anchored in the south (quarantine) anchorage even though she was steaming to the anchor with turns for 10 kt. She picked up and attempted to re-anchor several times with the same result. The ship finally anchored in the channel and held.

III. Typhoon Diana destroyed the seawall adjacent to Port Operations on the east side of Juliet Basin with 6-8 ft seas in 1987. During that same storm (see below) USS Dubuque was damaged in India Basin. Southerly winds forced water over the road at the end of Juliet Basin.

IV. Also during Typhoon Diana in 1987, USS Dubuque suffered hull damage (holing) during high winds (strongest was 75 kt) while moored to berths 4, 5 and 6 against rigid camels, and pulled a 50-ton bollard off the pier. Harbor personnel state that the hull damage resulted from the use of rigid camels instead of the more flexible "Yokohama" fenders.

There is only a limited supply of "Yokohama" fenders available for use at Sasebo. As of November 1992, the following were on hand:

Number	Size	Owner
2	15′ x 30′	FLEACTS Sasebo
2	15′ x 30′	NSD Yokosuka Det Sasebo
2	11′ x 36′	SUBGRU 7
5	6′ x 15′	NSD Yokosuka Det Sasebo

There is concern by harbor personnel that "Yokohama" fenders may tend to jump on the docks during high waves. To reduce that danger, the fenders should be partially flooded to get them lower in the water. Thirty tons of water will lower a 15′ x 30′ fender about 1/3 into the water. (Note: SUBGRU 7′s two 11′ x 36′ fenders cannot be flooded.)

5.6.2 Moving to Anchorage

Vessels with large sail areas (LPD's, LHA's, LPA's, LKA's, etc., and AEGIS ships) should not remain in India Basin when strong winds are forecast. Anchoring is a possibility if the storm is forecast to pass east of Sasebo, but harbor crowding may make departure difficult if a later decision were made to leave the anchorage.

5.6.3 Evasion at Sea

Evasion at sea is recommended for all vessels with large sail areas, especially if a typhoon is forecast to pass west of Sasebo. In considering any evasion option it must be remembered that tropical cyclones are notoriously difficult to accurately forecast, especially during the recurvature phase, and the 48-hour forecast error may exceed 200 nmi. Consequently, the storm may be closer to or farther from Sasebo than the forecast indicates, or to the right or left of the forecast track. Since the waters near Sasebo Harbor are restricted and evasion options are limited once open sea is reached, a sortie must commence early, certainly no later than the setting of Typhoon Condition III--typhoon force winds possible within 48 hours. To facilitate early action, the following timetable aid (to be used in conjunction with Figures V-68 to V-71) is provided:

I. An existing tropical cyclone moves into or development takes place in Area A with forecast movement toward Sasebo:

a. Review material condition of ship. A sortie may be desirable 2-4 days hence. Begin planning course of action to be taken in case of sortie.

b. Reconsider any maintenance that would render the ship incapable of getting underway within 48 hours.

II. Tropical cyclone enters Area B with forecast movement toward Sasebo:

a. Execute sortie plans made in previous steps. Sortie should be completed before storm enters Area C.

III. Tropical cyclone enters Area C moving toward Sasebo.

a. If sortie was not accomplished by this time, evasion is no longer recommended. Prepare to move to typhoon anchorage.

b. Ensure sufficient power is available to counter high winds and seas by steaming to the anchor.

c. Ensure sufficient tugs are available to make the move to the typhoon anchorage.

Evasion routes at sea may be developed by the use of the NOCC/JTWC Guam tropical cyclone warnings (see paragraphs 6 and 7 of Chapter I), and Appendix A (the mean tropical cyclone tracks, track limits, and average speed of movements) for the month of interest in conjunction with Figures V-68 to V-71 (tropical cyclone threat axes and approach times to Sasebo). In each specific case, Optimum Track Ship Routing (OTSR) should be consulted for the best evasion route.

There are two basic evasion tactics. The most common is to place the ship south of the tropical cyclone in the navigable semicircle. The other is to proceed north into the Yellow Sea or Sea of Japan.

In the latter case, the cooler surface water and cool air found at higher latitudes cause tropical cyclones to lose their tropical characteristics, with a resultant weakening and ultimate dissipation of the tropical cyclone. Therefore, a ship would experience less difficulty in riding out a storm at these latitudes than if it steamed south to seek the navigable semicircle and encountered winds in excess of 80 kt enroute. Caution is necessary; even though a circulation has lost its tropical identity, storm force winds are still possible.

Port Visit Information

November 1992: NRL Meteorologists CDR R. G. Handlers, USN, and Mr. L. Phegley, and SAIC Meteorologist Mr. R. D. Gilmore met with COMFLEACTS Sasebo Operations and Port Services personnel LT L. M. Calloway, QMC E. F. Jackson, Mr. K. Fuchigami, and Mr. Y. Totoki, JMSDF officers LCDR Sakai and LTJG Taniyama, Mr. Ichitsubo, Sasebo Port Operations Officer, and Captain A. Hanba, Master Harbor Pilot to obtain much of the information contained in this report.

6. KAGOSHIMA

SUMMARY

The conclusion reached in this study is that Kagoshima Harbor is not a safe harbor during the passage of an intense tropical cyclone. The key factors in reaching this conclusion are:

1. Due to the size and shape of Kagoshima Bay and surrounding land masses, the harbor provides little shelter from wind and seas. (During the period 1947-74, the highest recorded wind gust in Kagoshima was 100 kt due to Typhoon Louise (29 September 1955). This typhoon passed 30 n mi to the west of Kagoshima and contributed 5 hours of gale force winds.)

2. Wave action induced by gale force winds can be quite dangerous.

3. The holding action of the bottom in the harbor area is considered very poor under adverse weather conditions.

4. The restricted nature of the anchorage itself would give a commanding officer little reaction time in the event the anchor began to drag.

This conclusion is in full agreement with the Kagoshima Harbor authorities and the Japanese Maritime Safety Agency concerning ships that are anchored.

It is recommended that commanding officers and masters of vessels take early evasion action commensurate with operational constraints. For U. S. Navy or contracted DOD vessels, it is recommended that Sasebo or Hiroshima Bay be given priority consideration as typhoon havens. If evasion at sea is more desirable, it is recommended that the ship be placed in the Yellow Sea or Sea of Japan where effects from the typhoon will be considerably lessened.

6.1 GEOGRAPHICAL LOCATION

Kagoshima Harbor is located on the western side in the northern region of Kagoshima Bay. The bay itself cuts into the southern tip of Kyushu Island for a distance of 45 n mi (see Figure V-54).

A dominant feature in the vicinity of Kagoshima Harbor is Sakurajima, an active volcano which rises out of the bay to a height of 3655 ft, about 2 n mi from the harbor facilities. Figure V-72 shows the general features of the region around Kagoshima Bay.

Also located in the vicinity is the largest crude oil terminal in the world at Kiire, 14 n mi south of Kagoshima City. This man-made facility handles in excess of 500 vessels a year with berths for 500,000 DWT tankers.

6.2 KAGOSHIMA HARBOR

Kagoshima Harbor is located at 31° 35'N, 130° 34'E and is one of the principal ports in Kyushu. It is primarily an exporting port for agricultural and light industrial products. Additionally, it is a terminal point for auto/ passenger ferry boats operating between Japan and Okinawa. On occasion, the U.S. Navy utilizes the city as a liberty port.

The harbor facilities in the Kagoshima port area consist of numerous "ports" that have been constructed to provide specialized services for various industries. These ports stretch southward from the central city area for approximately 10 n mi. Figure V-73 depicts some of these "ports" servicing Kagoshima City. It should be noted that as newer facilities are built or planned, they will be designed to accommodate the larger vessels that are currently being built. For example, at the newer port at Taniyama No. 2 (not shown), the south berth is approximately 4300 ft long with a design depth of 43 ft., while at an older port, Shinkoh Harbor further to the north, the longest berth is approximately 850 ft with a limiting depth of about 25 ft.

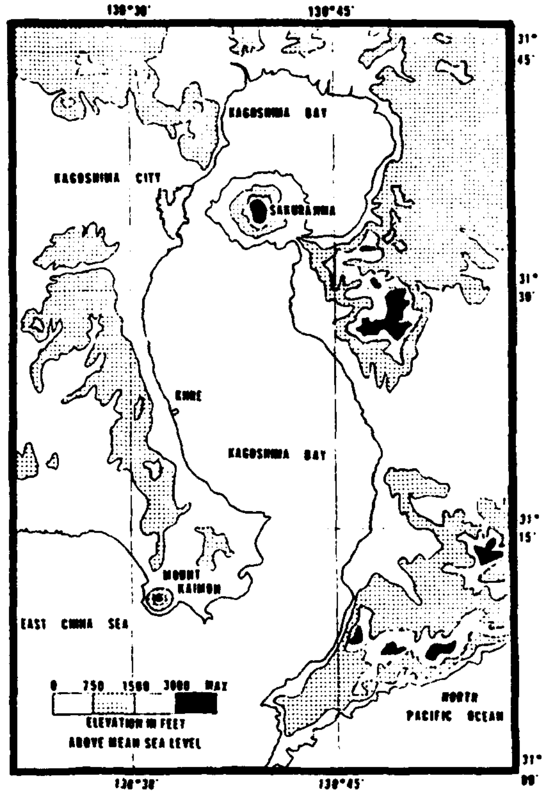

Figure V-72. Kagoshima Bay.

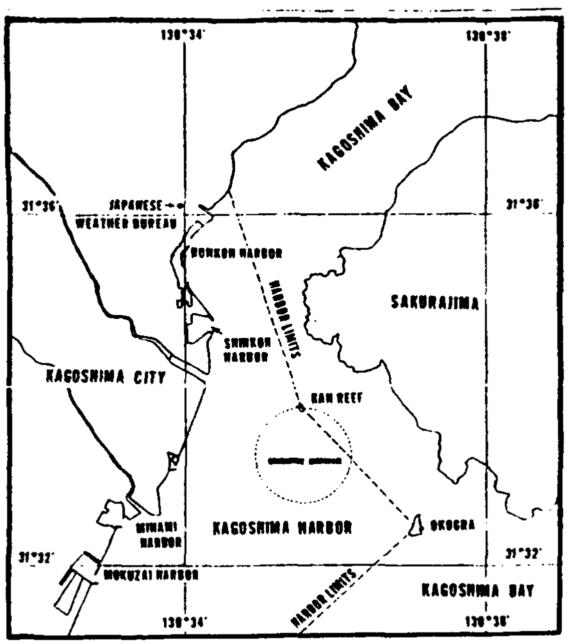

Figure V-73. Kagoshima Harbor.

Currents in the harbor area flow at a speed of about 2 kt when the tide is setting south in the area between Kagoshima City and Sakurajima. These currents result from rising and ebbing tides and are not considered hazardous to navigation. There is no known record of a tsunami ("tidal wave") affecting the harbor.

The outer harbor has numerous anchorages with poor holding strength (fine to coarse sand and shale). There are no safe typhoon anchorages in the area. (Refer to Port Directories of U. S. Pacific Fleet and Military Sealift Command for details on additional port and harbor facilities.)

6.3 TOPOGRAPHY

Kagoshima Bay is a large bay opening to the extreme southern tip of Kyushu. At its widest point, at about 31° 20'N, it is 12.5 n mi wide. The north-south distance is approximately 45 n mi. Except for Sakurajima, there are no other significant topographic features breaking the expanse of the bay itself. Figure V-72 shows the topographic features of Kagoshima Bay and its surroundings.

Sakurajima, an active volcano, is situated in the northern reaches of the bay. During the last significant eruption, it connected itself with the eastern shore of the bay. Current activity is limited to releasing considerable amounts of smoke and ash. It should be noted that this volcano and others on the island of Kyushu from time to time "rumble" as a reminder of their activeness. While Sakurajima does offer the harbor and anchorage protection from winds and rough seas generated by local weather conditions, it can also compound the adverse effects of heavy weather when the area comes under the influence of a tropical cyclone or other storms of equal size or intensity. Sakurajima and the mountains on the western side of the bay present a significant topographical feature that could influence northeasterly winds and produce a localized funneling and strengthening of the winds affecting the harbor area.

A mountain ridge that rises to 4080 ft lies along the eastern side of the bay. To the west of Kagoshima Bay is the aforementioned mountain ridge rising to nearly 2000 ft that gradually becomes rolling foothills and low lying areas to the south with Mount Kaimon rising from the southern tip of Kyushu at the western entrance to the bay.

6.4 TROPICAL CYCLONES AFFECTING KAGOSHIMA

6.4.1 <u>Tropical Cyclone Climatology For Kagoshima</u>

Climatology indicates that the island of Kyushu has been affected by tropical cyclones from April through December. The majority, however, that pose a threat to Kagoshima (any tropical cyclone approaching within 180 n mi of Kagoshima Harbor is defined as a "threat" for the purpose of this study) occur during the months of June-October. Figure V-74 gives the frequency distribution during the months of "threat" occurrences by 5-day periods. This summary is based on data for the 28-year period, 1947-1974. Note that the maximum number occur during August and September.[17]

Figure V-75 depicts, on an 8-point compass, the "threat" tropical cyclones according to the octant from which they approached Kagoshima. The circled numbers indicate the total that approached from an individual octant. The count for an octant of approach includes both recurving and non-recurving tropical cyclones. (See paragraphs 3 of Chapter I for a description of recurving tropical cyclones.) Note that a majority of these approach from the south-southeast and south-southwestern octants. A more detailed inspection of the 85 tracks revealed that 20 (22%) did not recurve prior to passing the closest point of approach to Kagoshima.

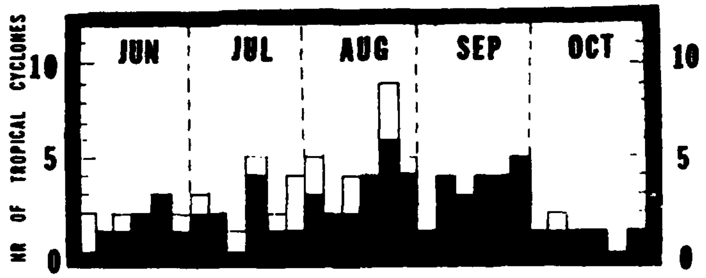

Figure V-74. Frequency of tropical cyclones that passed within 180 n mi of Kagoshima. Subtotals are based on 5-day periods for tropical cyclones that occurred during 1947-1974. Shaded area indicates recurving tropical cyclones per 5-day period (that is, had a northeasterly direction of motion at CPA).

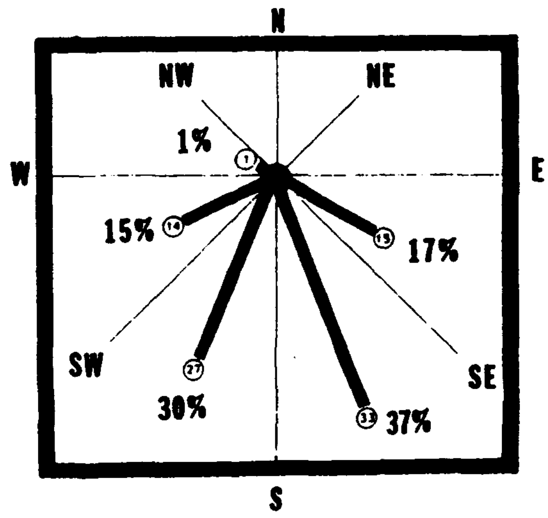

Figure V-75. Directions from which tropical cyclones entered threat area (a 180 n mi radius circle centered at Kagoshima) during the period May-November, 1947-1974. Numbers circled indicate the number of tropical cyclones that entered from each octant. This is expressed as a percentage adjacent to the circled number.

[17] A total of 90 tropical cyclones passed within 180 n mi of Kagoshima during the May-November period for the years 1947-1974. Eighty-five (94%) of these tropical cyclones passed within 180 n mi during the 5 months June-October, and the remaining 5 passed in the months of May and November.

KAGOSHIMA

Table V-18 indicates that, of the 85 tropical cyclones that posed a threat to Kagoshima during the years 1947-1974 (June-October), 53% passed to the east of Kagoshima, 36% passed to the west and 11% passed in the immediate vicinity of the port. The fact that the majority of the "threat" tropical cyclones pass to the east, implies that Kagoshima is placed more often in the left or "navigable" semicircle where the wind and seas are less intense.

Table V-18. "Threat" tropical cyclone passage relative to Kagoshima (1947-1974).

TRACK RELATIVE TO KAGOSHIMA	JUN	JUL	AUG	SEP	OCT	TOTAL
Passed east of Kagoshima	5	10	10	15	5	45
Passed west of Kagoshima	7	7	13	3	1	31
Passed in the immediate vicinity of Kagoshima	0	0	6	3	0	9

Figures V-76 to V-80 represent an analysis of the estimated probability for any tropical cyclone approaching within 180 n mi of Kagoshima. The solid lines represent the probability of coming within 180 n mi of Kagoshima for any storm location. The dashed lines represent the approximate time in days for a system to reach Kagoshima, computed from typical speeds of movement for tropical cyclones affecting Kagoshima (Table V-19). For example, in Figure V-76, a tropical cyclone located at 25°N, 130°E has a 60% probability of passing within 180 n mi of Kagoshima and it will reach Kagoshima in about 1 1/2-2 days.

Note the significant shift in direction from which tropical cyclones approach the Kagoshima area (Figures V-76 to 80). In June the "threat" is generally from the southwest whereas, in July and August it is more to the south and southeast, then becomes more southerly in September, and then south to southwesterly in October.

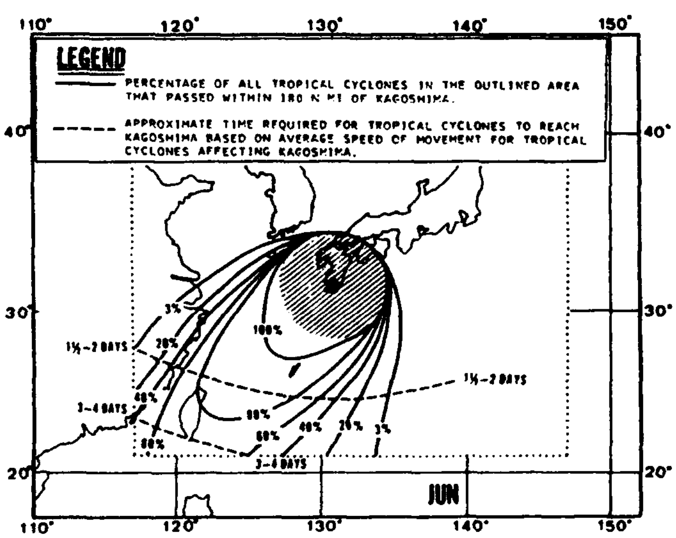

Figure V-76. Probability that a tropical cyclone will pass within 180 n mi of Kagoshima (shaded area) for the month of June. (Based on data from 1947-1974.)

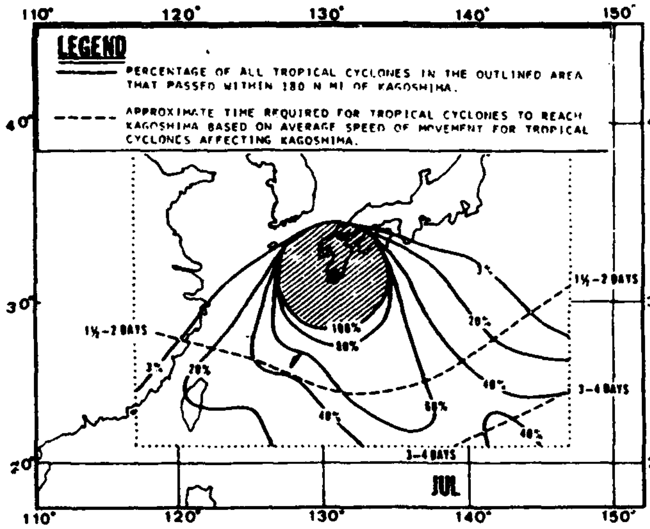

Figure V-77. Probability that a tropical cyclone will pass within 180 n mi of Kagoshima (shaded area) for the month of July. (Based on data from 1947-1974.)

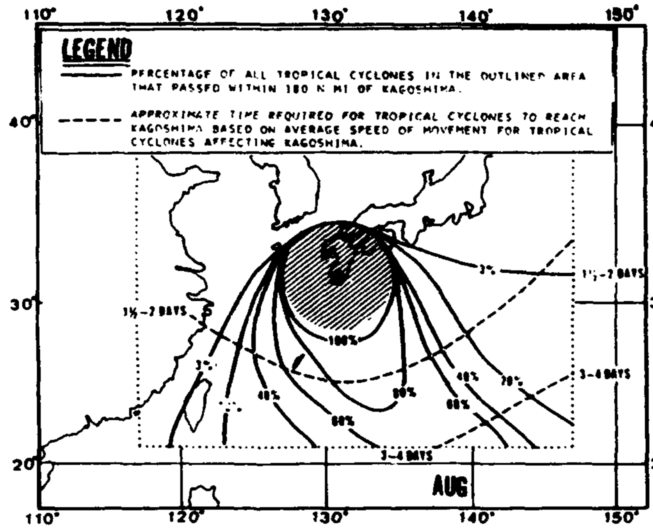

Figure V-78. Probability that a tropical cyclone will pass within 180 n mi of Kagoshima (shaded area) for the month of August. (Based on data from 1947-1974.)

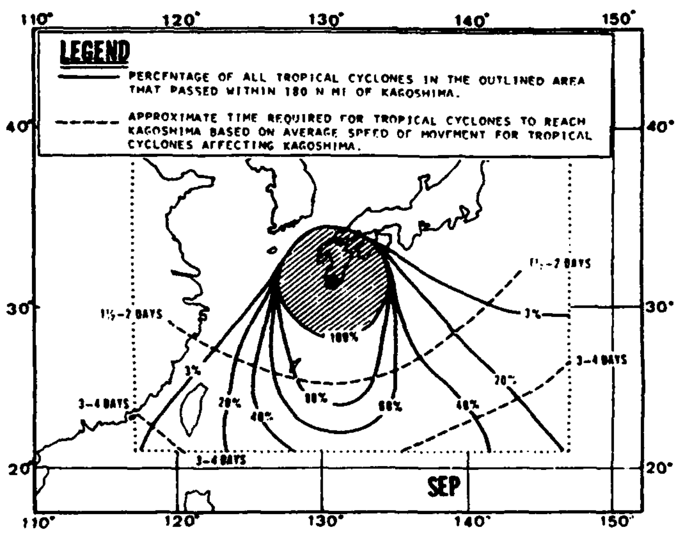

Figure V-79. Probability that a tropical cyclone will pass within 180 n mi of Kagoshima (shaded area) for the month of September. (Based on data from 1947-1974.)

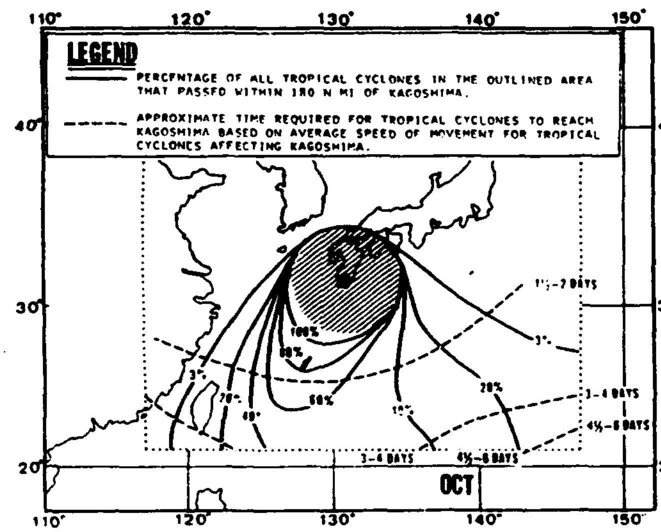

Figure V-80. Probability that a tropical cyclone will pass within 180 n mi of Kagoshima (shaded area) for the month of October. (Based on data from 1947-1974.)

Table V-19. Average tropical cyclone speed of movement (kt) per 5-degree latitude band for tropical cyclones affecting Kagoshima for June-October.

LATITUDE BAND	JUN	JUL	AUG	SEP	OCT	AVERAGE
30-35N	25	13	13	18	18	17.4
25-30	18	12	10	14	15	13.8
20-25	11	11	10	12	13	11.4
15-20	10	10	10	11	11	10.4

5.4.2 Wind And Topographic Effect

A total of 54 tropical cyclones approached within 180 n mi of Kagoshima in the 19-year period 1956-1974 during the months June-October,[18] or about 3.1 a year. Table V-20 groups the tropical cyclones by strong (≥22 kt) and gale force (≥34 kt) wind intensities (based on hourly wind data) that they produced at Kagoshima.[19] Tropical cyclone activity in the Kagoshima area is maximal during the months of August and September and these individual monthly values are also shown.

Table V-20. Extent to which tropical cyclones affected the Kagoshima area during the period June-October, 1956-1974, and for the individual months of August and September.

	JUN-OCT	AUG	SEP
Number of tropical cyclones that passed within 180 n mi of Kagoshima	54	22	13
Number of tropical cyclones resulting in strong (≥22 kt) winds at Kagoshima	43(80%)	16 (73%)	10 (77%)
Number of tropical cyclones resulting in gale force (≥34 kt) winds at Kagoshima	21 (39%)	10 (45%)	4 (31%)

It can be discerned from Table V-20 that 21 (39%) of the total 54 tropical cyclones for the period June-October (1956-1974) resulted in winds of 34 kt or greater at Kagoshima. However, of 22 tropical cyclones tracked in August, 10 (45%) resulted in winds of 34 kt or greater.

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[18] From Chin (1972) for years 1956-1970 and from Annual Typhoon Reports for years 1971-1974 (FWC/JTWC, Guam, 1971-1974).

[19] Data provided by the Japanese Meteorological Agency weather station located at Kagoshima.

An observation station for the Japanese Meteorological Agency is located in the downtown area of Kagoshima near the harbor facilities (see Figure V-73). The wind instrument is located on top of the station in such a manner as to be unobstructed from any nearby buildings or trees. During the period 1947-1974, the highest recorded wind gust in Kagoshima was 100 kt on 29 September 1955. This easterly gust was attributed to Typhoon Louise which passed 30 n mi to the west of Kagoshima on 29 September 1955. The duration of gale force wind (excess of 33 kt) was 5 hours during this storm.

Winds in Kagoshima Bay are significantly influenced by the surrounding topography and the geographical features of the bay itself. The extent of this influence is dependent on the direction of approach of the storm and the passage relative to the Kagoshima area. From an analysis of the tropical cyclones that affected Kagoshima it is apparent that tropical cyclones that result in gale force winds at Kagoshima can pass to the east or west of Kagoshima or in some instances the center of the storm passes over the immediate area. The basic difference in effect is the direction and strength of the resultant wind in the area.

If the tropical cyclone passes to the east of Kagoshima, the path will generally be over water and the winds will be primarily northeasterly. While there will be some interaction with the Kyushu Mountains (see Figure V-54) to decrease the intensity of the winds, local topography becomes significant in its effect on northeasterly winds. The mountains on the northwestern side of the bay that rise to nearly 2000 ft and Sakurajima which rises to 3655 ft tend to direct and funnel winds from the northeastern quadrant into the narrow region of the Kagoshima Harbor area as can be seen in Figures V-72 and V-73. An example of this was Typhoon Helen which had a CPA of 40 n mi to the east-southeast of Kagoshima on 24 September 1966. During this particular typhoon, wind gusts were recorded up to 78 kt from the northeast.

In the case of tropical cyclones passing to the west of Kagoshima, the path is also over water in its approach to the area, thus retaining much of its strength before striking Kyushu. From Figures V-54 and V-72 it is evident that the protection offered by surrounding topography is of little assistance in decreasing the intensity of the storm as it makes its first encounter with land. The long broad expanse of Kagoshima Bay allows practically uninterrupted flow from the southeastern quadrant. These factors, in addition to the bay being placed in the "dangerous" semicircle, makes a western passage extremely dangerous. An example of this case was Typhoon Babs which had a CPA of 150 n mi to the west-northwest of Kagoshima on 16 August 1956. Typhoon Babs produced wind gusts of up to 72 kt from the south-southeast.

Figures V-81 through V-83 show the average maximum wind gust associated with the tropical cyclones studied, and the direction from which it originated as recorded at Kagoshima during the period 1947-1974. An evaluation of these figures show that winds from tropical cyclones passing to the west come primarily from the southeasterly direction and tend to be more intense than those from tracks of storms passing to the east. In those cases, the winds may come from any direction but for the most part come from the northeast or northwest. Occasionally, a tropical cyclone will pass in the immediate vicinity of Kagoshima. In the period 1947-1974, ten such storms tracked in such a manner with all but one producing gale force winds or stronger. Under such circumstances, there is no discernible pattern as to prevailing direction from which the strongest winds originate. The proximity of the storm's center when passing in the immediate vicinity, however, is indicative of force. Of the 10 tropical cyclones studied, the average maximum wind gust was 58 kt.

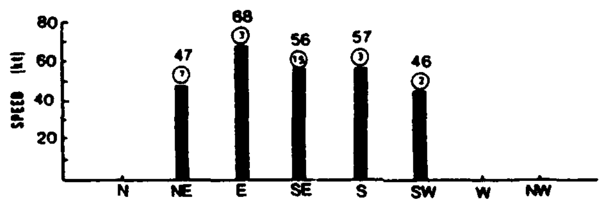

Figure V-81. Average maximum wind gust and direction of winds originating from tropical cyclones passing within 180 n mi to the west of Kagoshima. (Numbers circled indicate total number of tropical cyclones producing winds from the direction indicated.)

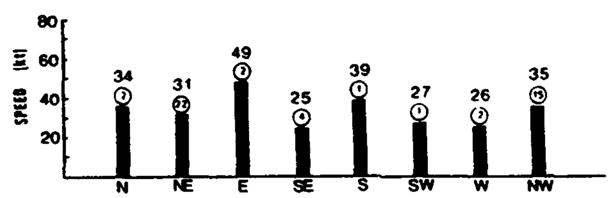

Figure V-82. Average maximum wind gust and direction of winds originating from tropical cyclones passing within 180 n mi to the east of Kagoshima.

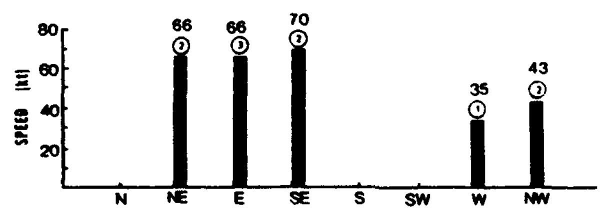

Figure V-83. Average maximum wind gust and direction of winds originating from tropical cyclones passing in the immediate vicinity (within 20 n mi) of Kagoshima.

Figure V-84 shows the position of "threat" tropical cyclone centers when strong winds (≥22 kt) were first and last recorded at Kagoshima. A number of storms gave Kagoshima ≥22 kt winds when they were 300 n mi to the south of the city. Figure V-85 shows tropical cyclone center positions when gale force (≥34 kt) winds were first and last recorded at Kagoshima. It can be ascertained from this figure that winds ≥34 kt generally do not begin until the storm is about 180 n mi away. Notice the preponderance of storms that generate strong or gale force winds originate to the south and west of Kagoshima and that no gale force winds occurred when the storms moved north of 34°N.

The most severe threat to the harbor occurs when a tropical cyclone approaches from the southwest and passes west of Kagoshima within 50 n mi. In this case, winds will flow from the southeast unimpeded the entire length of Kagoshima Bay focusing on the narrow harbor area.

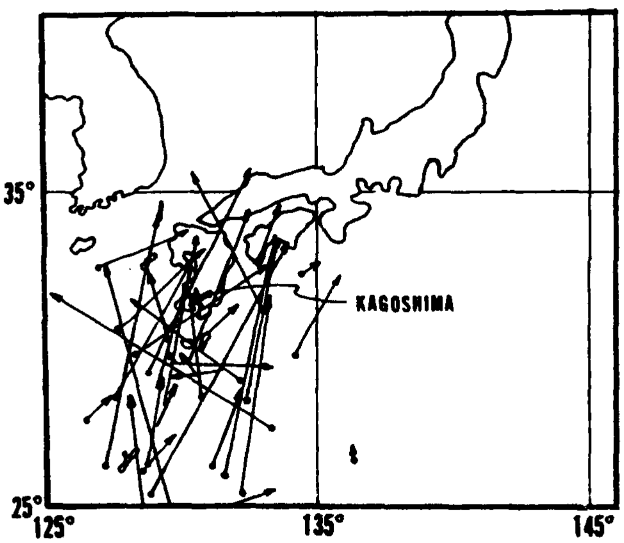

Figure V-84. Positions of 43 tropical cyclone centers when winds ≥22 kt first and last occurred at Kagoshima. (Based on hourly data for the months June-October during the years 1956-1974.)

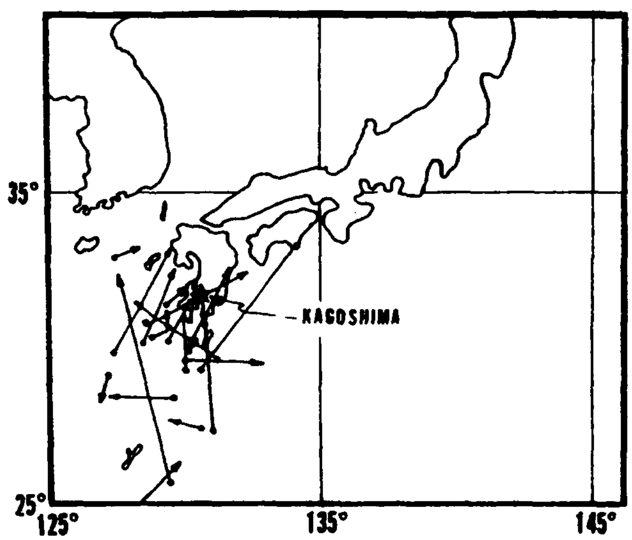

Figure V-85. Positions of 21 tropical cyclone centers when winds ≥34 kt first and last occurred at Kagoshima. (Based on hourly wind data for the months June-October during the years 1956-1974.)

6.4.3 Wave Action

The geographical location of Kagoshima Harbor is such that regardless of whether a tropical cyclone passes east or west of the port, ships anchored in the outer harbor area will experience considerable wave action. Tropical cyclones passing to the east will generate winds from the northeastern quadrant. In this area there is an unbroken fetch of 12 n mi in the northern portion of Kagoshima Bay. In a similar manner, the fetch to the south-southeast of the harbor is approximately 28 n mi over which winds generated by a tropical cyclone passing to the west can flow unimpeded.

Table V-21 shows the wind speed required to generate various wave heights in Kagoshima Harbor based on the direction and length of fetch that the wind blows over.[20]

Table V-21a. Fetch limits (n mi) by direction from Kagoshima Harbor (Honkoh Harbor area).

NE	ENE	E	ESE	SE	SSE
12	3	1.8	1.5	10.2	28.2

Table V-21b. Wind speed (kt) required to obtain indicated wave heights (m) at Kagoshima Harbor (Honkoh Harbor area) by wind direction.

RESULTANT WAVE HEIGHT (meters)	WIND DIRECTION					
	NE	ENE	E	ESE	SE	SSE
0 - 0.5	12.6	20.0	24.0	26.0	13.0	10.0
0.6 - 1.0	22.2	36.0	23.6	46.8	23.0	17.0
1.1 - 1.5	31.6	50.0	60.0	64.0	32.6	24.0
1.6 - 2.0	40.6	64.0	-	-	42.0	30.6
2.1 - 3.0	56.0	-	-	-	58.0	42.0
3.1 - 5.0	-	-	-	-	-	-

[20] From a 10-year study of wind effects on Kagoshima Harbor (1960-1969) prepared by the Japanese Meteorological Agency for the Kagoshima Prefecture government.

During the same period of study that produced Table V-21, additional data shows the frequency distribution of wave height as can be seen in Table V-22.

Table V-22. Frequency of wave height occurrences at Kagoshima Harbor occurring over the 10-year period 1960-1969 (from a Japanese Meteorological Agency study).

WAVE HEIGHT (meters)	NUMBER	PERCENTAGE
0 - 0.5	3015	82.5
0.6 - 1.0	572	15.7
1.1 - 1.5	56	1.5
1.6 - 2.0	7	.2
2.1 - 3.0	3	.1
3.1 - 5.0	1	-
TOTAL	3654	100.0

It should be noted that these tables reflect weather conditions that occurred throughout the entire year for 10 complete years, and included 35 tropical cyclones.

Because of the configuration of the entrance to Kagoshima Bay, swell generated by the storm centers is effectively intercepted. Thus the sea state inside the bay and in the Kagoshima Harbor area is dependent solely on local wind conditions.

6.4.4 Storm Surge

Storm surge may be defined as an abnormal rise of the sea along a shore as the result of the winds of a storm and the pressure drop. The piling up of water on a coast ahead of a tropical storm or typhoon is more apparent in the dangerous semicircle, the region of most intense winds. Kagoshima Harbor is in the dangerous semicircle when a tropical cyclone passes to the west of the area. The surge effect is most evident in the shallow waters of large inland bays that open to the south (Miyazaki, 1974).

Conversations with officials of the Kagoshima Harbor Office and Japanese Maritime Safety Agency indicate that the harbor area is not adversely affected by storm surges.

6.5 THE DECISION TO EVADE OR REMAIN IN PORT

6.5.1 Evasion Rationale

Because of the threat of high winds associated with tropical cyclones and the extremely poor holding quality of the bottom (sand and shale) in the anchorage, Kagoshima Harbor IS NOT CONSIDERED A SAFE TYPHOON HAVEN. Commanding Officers and Masters of vessels must recognize the inherent dangers that exist when exposed to hazardous weather and remaining at an anchorage which has known poor holding qualities.

(At the Nippon Oil Staging Terminal located at Kiire, all pumping from oil tankers is ceased when sustained winds reach 30 kt. When sustained winds reach gale force intensity, ship's masters are advised to leave the terminal and depart the area, preferably to the open sea.)[21]

Figures V-86 through V-90 show the tropical cyclone threat axis for Kagoshima from June-October. The area of the arrows represent approximately a 30% or greater probability of a tropical cyclone coming within 180 n mi of Kagoshima.

For general information on tropical cyclone warnings the reader is referred to paragraphs 6 and 7 of Chapter I.

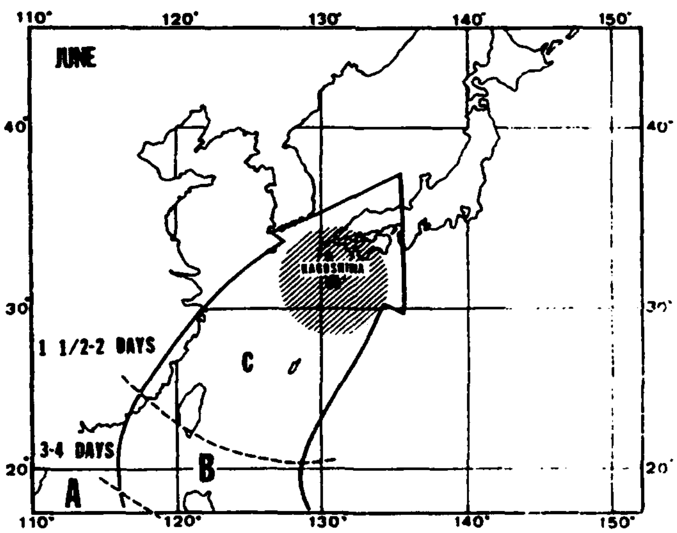

Figure V-86. Tropical cyclone threat axis for Kagoshima for the month of June. Approach times to Kagoshima are based on typical speeds of movement for tropical cyclones affecting Kagoshima.

[21]Based on a conversation with the port captain at Kiire.

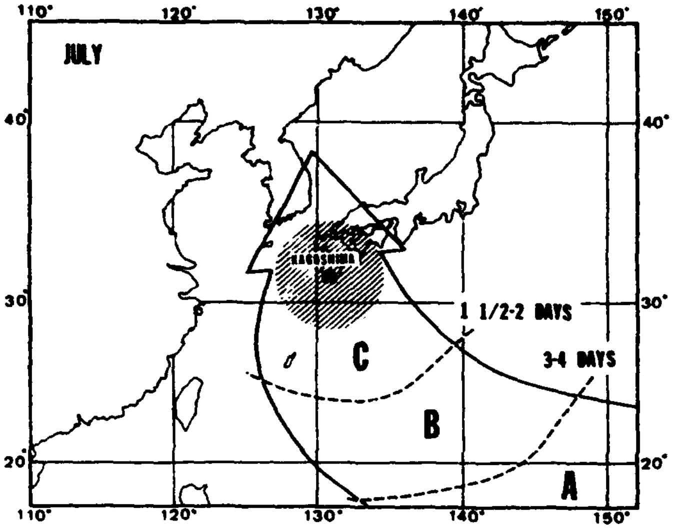

Figure V-87. Tropical cyclone threat axis for Kagoshima for the month of July. Approach times to Kagoshima are based on typical speeds of movement for tropical cyclones affecting Kagoshima.

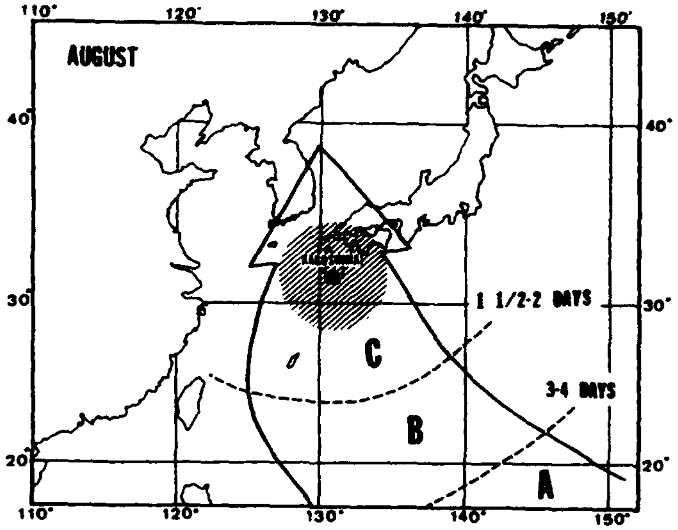

Figure V-88. Tropical cyclone threat axis for Kagoshima for the month of August. Approach times to Kagoshima are based on typical speeds of movement for tropical cyclones affecting Kagoshima.

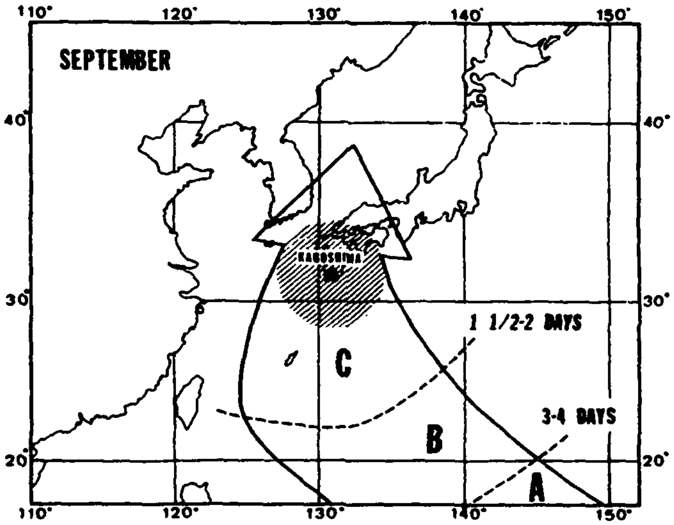

Figure V-89. Tropical cyclone threat axis for Kagoshima for the month of September. Approach times to Kagoshima are based on typical speeds of movement for tropical cyclones affecting Kagoshima.

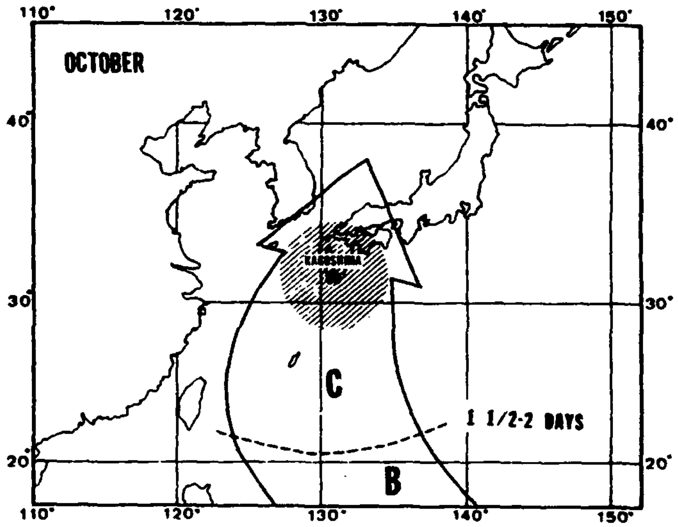

Figure V-90. Tropical cyclone threat axis for Kagoshima for the month of October. Approach times to Kagoshima are based on typical speeds of movement for tropical cyclones affecting Kagoshima.

6.5.2 Evasion

In the southern part of Japan there are two areas that have been evaluated as typhoon havens -- Sasebo in northwestern Kyushu (Rudolph, 1975), and the Kure/Iwakuni area in Hiroshima Bay (Manning, 1975). (Sasebo Harbor is considered an excellent haven but only for vessels smaller than aircraft carriers.)

Since transit time, whether it be to another port or to sea, may be lengthy, evasion must commence early. To facilitate early action, the following time table (in conjunction with Figures V-86 to V-90) has been constructed.

1. An existing tropical cyclone moves into or development takes place in Area A with forecast movement toward Kyushu:

   a. Review material condition of ship. Evasion may be desirable 2-4 days hence. Begin planning course of action to be taken in case of increasing threat.

   b. Reconsider any maintenance that would render the ship incapable of getting underway within 48 hours.

2. Tropical cyclone enters Area B with forecast movement toward Kagoshima:

   a. Execute evasion plans made in previous steps. Evasion should be completed before storm enters Area C. If evasion is to be made to Sasebo, approximately one-half day's steaming time, the commanding officer may elect to delay execution of evasion plans accordingly.

3. Tropical cyclone enters Area C moving toward Kagoshima:

   a. If evasion is not accomplished by this time, evasion from Kagoshima Bay is no longer recommended. If the decision to remain at anchor is made, ensure sufficient power is made available to counter high winds and seas by steaming to the anchor (see paragraphs 5 of Chapter I).

   b. Another course of action would be to get way on the ship, and place the ship's head into the wind and sea (see paragraph 5, Chapter I). Since Kagoshima Bay is large, and with few exceptions deep, the ship can be placed in various locations in the bay to reduce the fetch and thereby reduce the effects of wave action. Movement into the southwestern part of the bay would tend to offset the effects of southeasterly winds. It is not recommended that a ship be placed in the northern regions of Kagoshima Bay, north of Sakurajima, due to the restrictive nature of the area and the shallow water in the middle of this region. (It should be noted that of all the tropical cyclones studied, the longest duration of gale force winds at Kagoshima was 5 hours.)

Evasion routes at sea may be developed by the use of the warnings received from FWC/JTWC and Appendix 1-A (the mean tropical cyclone tracks, track limits, and average speed of movements for the months June-October) in conjunction with Figures V-86 to V-90 (tropical cyclone threat axis and approach times to Kagoshima for the months June-October). In all cases, Optimum Track Ship Routing (OTSR) should be consulted as to the best evasion route. Ships whose ultimate destination is the eastern Pacific may want to consider evading to Yokosuka in south central Honshu (Graff, 1975).

In general, the effects of sea/swell generated by a tropical cyclone may reduce the speed of advance (SOA) thereby increasing the time required to reach the open sea (see paragraph 5, Chapter I). If a ship is caught in the sea/swell pattern ahead of an intense tropical storm or typhoon, the SOA may be reduced to the point that the ship will be unable to maneuver to clear the danger area.

There are two basic evasion tactics. The most common among civilian shipping companies is to place the ship south of the tropical cyclone in the navigable semicircle. The other is to proceed north into the Yellow Sea or Sea of Japan.

In the latter case, the cooler surface water and cool air found at higher latitudes cause a weakening and ultimate dissipation of the tropical cyclone. Therefore, a ship should experience less difficulty in riding out a storm at these latitudes than if it steamed south to seek the navigable semicircle and encountered winds in excess of 80 kt enroute.

7. BUCKNER BAY, OKINAWA

SUMMARY

The conclusion reached by this study is that Buckner Bay is not considered to be a haven during typhoon conditions. The lack of extensive protection from wind due to the relatively low topography of the surrounding land mass and the exposure of ships to wind and seas with any easterly component severely limits Buckner Bay as a storm refuge.

It is recommended that all Navy ships capable take action to evade at sea when typhoon conditions threaten Buckner Bay.

7.1 LOCATION

Okinawa is the principal island in the Ryukyu Islands chain which extends in an arc from off the northeastern coast of Taiwan to the southern end of Kyushu. This chain of islands forms the southeastern boundary of the East China Sea. Okinawa is located 350 n mi south of Kyushu or approximately in the middle of the Ryukyu Island chain.

Oriented roughly northeast to southwest, Okinawa is 58 n mi long and 2.6 to 17 n mi wide. The northern part of the island is rugged, mountainous, and wooded, with few inhabitants and very little cultivated land. The southern part consists of hills and plateaus, is highly cultivated and thickly settled. The topography of Okinawa is depicted in Figure V-91.

A detailed study of the coast and harbors of Okinawa and specific comments on navigation aids and coastal features near Buckner Bay and Naha, is included in H.O. Pub. 156, Sailing Directions (Enroute) for Japan, sector 20.

7.2 BUCKNER BAY HARBOR

The main entrance to Buckner Bay is Tatsu Guchi, located between Ufu Bishi and Tsuken Shima (see Figure V-92). The navigable width of this channel is almost 2 n mi. The second entrance, Kudaka Kuchi, is a little less than 1/2 n mi wide and is located south of Kudaka Shima.

There are numerous anchorages available throughout the bay in a sand, mud and shell bottom. The greater part of Buckner Bay has been wire dragged to a depth of 11 fathoms. Pier area is available at White Beach, the principal facility serving the U.S. Navy.

7.3 TOPOGRAPHY

Figure V-92 depicts the topography of the land masses surrounding Buckner Bay. It is evident that there is virtually no wind protection afforded by topography for winds from east-southeast to south-southwest.

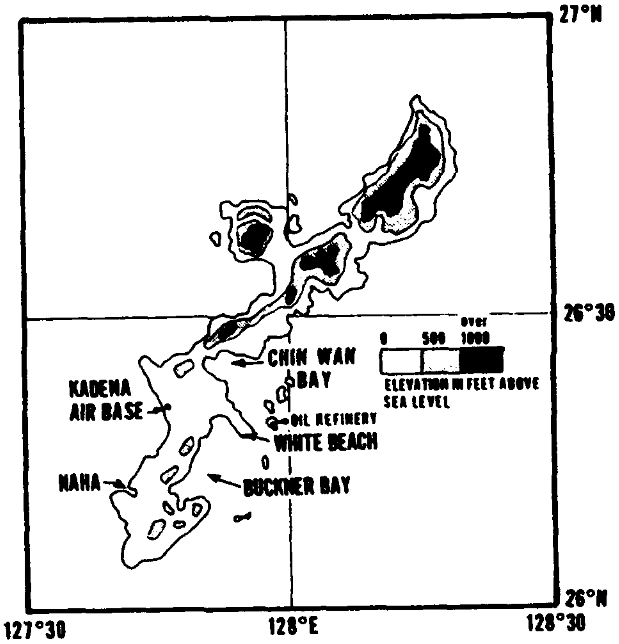

Figure V-91. Topography of Okinawa

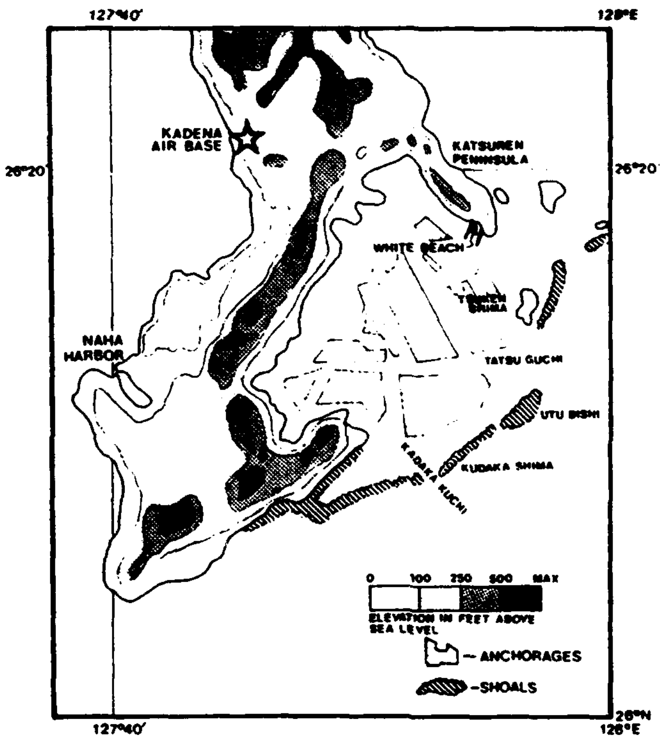

Figure V-92. Southern Okinawa

7.4 HARBOR FACILITIES

There are two piers at White Beach (see Figure V-93). The older of the two, Pier Bravo is an asphalt-surfaced causeway connecting to a steel pier reinforced with concrete. A newer pier, the Navy Pier located east of pier Bravo is used primarily by U. S. Navy vessels while part of pier Bravo is used by the Japanese Maritime Self Defense Force. Information as to pier length and alongside depth can be obtained from the appropriate Port Directory. There are no mooring buoys located within Buckner Bay.

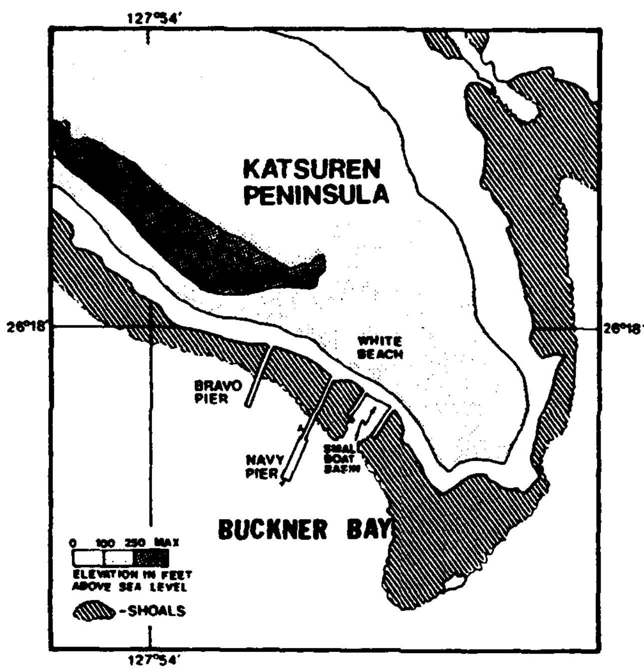

Figure V-93. Pier area of White Beach.

Buckner Bay does not have a tug/pilot available. If tug/pilot assistance is required it must come from Naha Harbor (6 tugs available) or the oil refinery (4 tugs available) located at Kinmu Bay (see Figure V-91). When threatened by a typhoon these tugs will undoubtedly be used first at their primary location before rendering assistance to ships in Buckner Bay. The Port Services Officer at White Beach does have four LCM-6 type pusher boats available which could be of some use during an emergency.

Buckner Bay is not a logistics support port. However, fuel oil, fresh water, and food can be obtained in limited quantities.

7.5 TROPICAL CYCLONES AFFECTING BUCKNER BAY

7.5.1 Tropical Cyclone Climatology For Buckner Bay/Naha Harbors

The climatology of tropical cyclones for Buckner Bay and Naha Harbors are combined here since the two harbors are less than 13 n mi apart. The midpoint of a line between the two harbors was used for the following climatology. For purposes of this study, any tr. ical cyclone that entered a 180 n mi circle radially outward from this midpoint was considered to be a threat to Buckner Bay/Naha Harbor and designated as a "threat" tropical cyclone.

Tropical cyclones can occur during any month of the year in the western North Pacific area. However, the majority of those that pose a threat to Buckner Bay/Naha occur during the months of May-December. Climatological records indicate that during this period Okinawa is either within or closely adjacent to the mean tropical cyclone track (see Appendix 1-A) and therefore has the dubious distinction of being located in the middle of "Typhoon Alley."

The peak "threat" period for Buckner Bay/Naha extends from July through September. This is indicated in Figure V-94 which depicts the monthly summary by 5-day periods of tropical cyclone occurrences and is based on data from May-December, 1947-1973. During this 27-year period, 115 tropical cyclones "threatened" Buckner Bay/Naha, for an average of approximately four tropical cyclones per year. August is the peak "threat" period (27%) followed by July and September. Only 5% of the "threat" tropical cyclones occurred during May and December. Figure V-94 also indicates that almost half of the "threat" tropical cyclones are "recurvers" (had a northeasterly component of motion at their closest point of approach to Buckner Bay/Naha after an initial northwestward component of motion).

Figure V-95 displays the "threat" tropical cyclones according to the compass octant from which they approached Buckner Bay/Naha. The circled numbers indicate the total that entered from an individual octant. The adjacent numbers express this as a percentage. It is evident that 60% of the "threat" tropical cyclones entered the threat area from a sector extending from SW to SE.

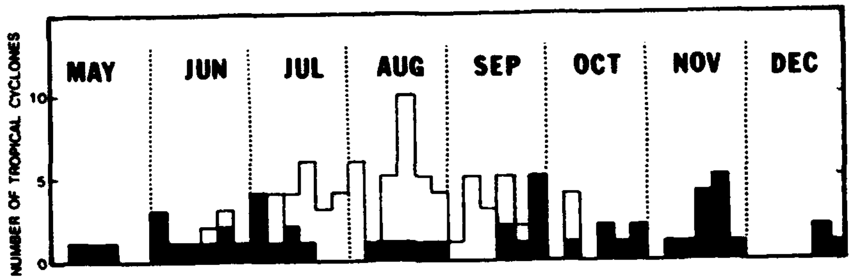

Figure V-94. Frequency distribution of the number of tropical cyclones that passed within 180 n mi of Buckner Bay/Naha. Subtotals are based on 5-day periods, for tropical cyclones that occurred during 1947-1973. The shaded area indicates the number of recurving tropical cyclones per 5-day period (northeasterly direction of motion at their closest point of approach to Buckner Bay/Naha after an initial northwesterly direction of motion).

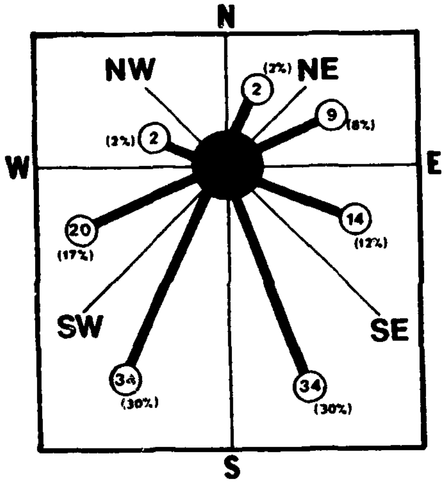

Figure V-95. Directions from which tropical cyclones entered threat area (a 180 n mi radius circle centered at the middle of a line between Buckner Bay and Naha during the period May-December, 1947-1973. Numbers circled indicate the number of tropical cyclones that entered from each octant. This is expressed as a percentage adjacent to the circled number.

Table V-23 indicates that, out of the 115 "threat" tropical cyclones during May-December, 1947-1973, 57 passed the midpoint of a line connecting Buckner Bay/Naha to the east and 58 passed to the west. Therefore, the chance of having a "threat" tropical cyclone pass to the west or east of Buckner Bay/Naha during the typhoon season is equal. However, it is interesting to note that during June, July, and September, the majority of "threat" tropical cyclones pass to the west of Buckner Bay/Naha, while during May, August, October, November, and December the likelihood of having a tropical cyclone pass to the east of Buckner Bay/Naha is greater.

Table V-23. "Threat tropical cyclone passage relative to the midpoint of a line between Buckner Bay and Naha.

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Passed east of midpoint	3	2	7	18	9	6	9	3	57
Passed west of midpoint	0	9	18	13	12	3	3	0	58

BUCKNER BAY, OKINAWA

Figures V-96 to V-103 represent analyses of the probability of any tropical cyclone approaching within 180 n mi of Buckner Bay/Naha for May through December, respectively. The solid lines represent the "percent threat" for any storm location. The dashed lines represent approximate approach times to Buckner Bay/Naha, computed from average tropical cyclone speeds of movement for tropical cyclones affecting Buckner Bay/Naha during May-December (speeds of movement were derived from climatological data (U.S. NWSED, Asheville, 1973). For example, a tropical cyclone located at 20N/119E in May has a 40% probability of coming within 180 n mi of Buckner Bay/Naha and it can hit Buckner Bay/Naha in about 1½-2 days (see Figure V-96).

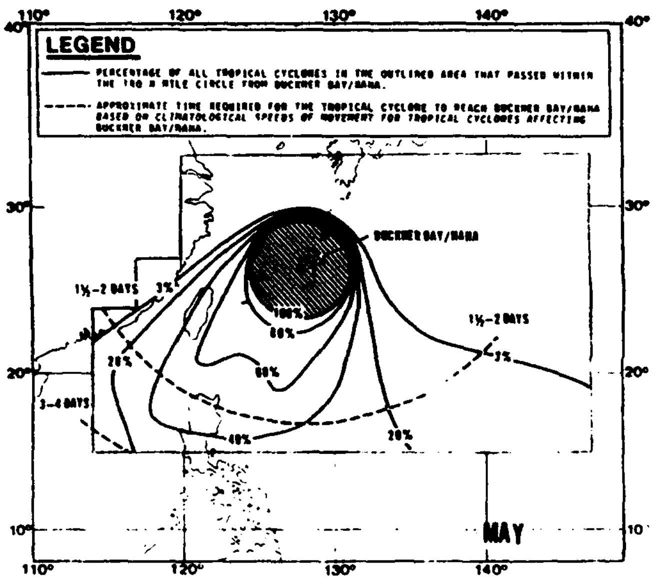

Figure V-96

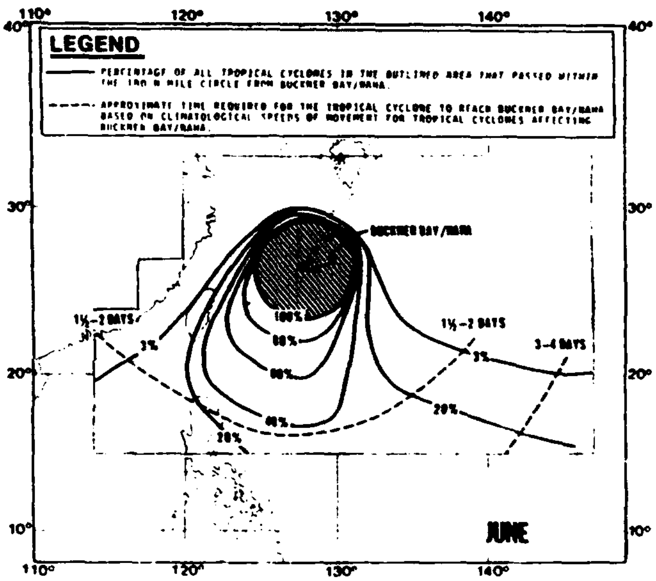

Figure V-97

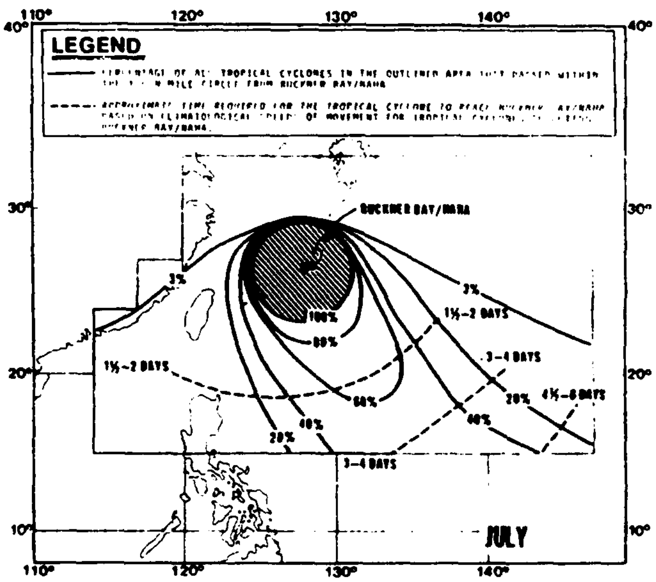

Figure V-98

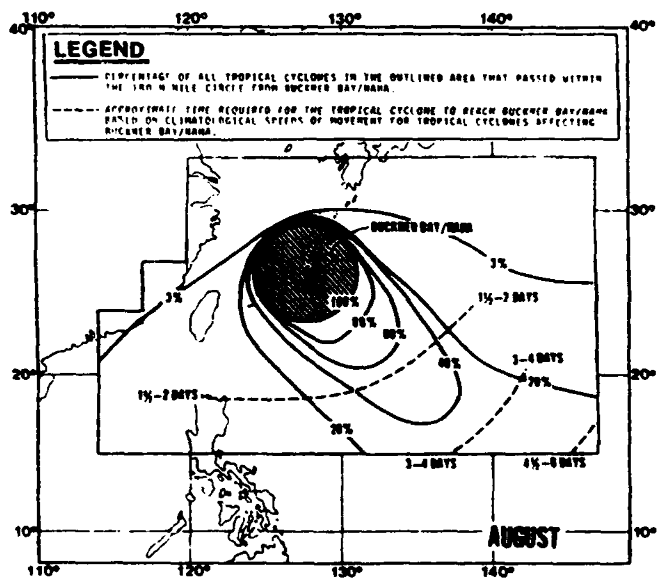

Figure V-99

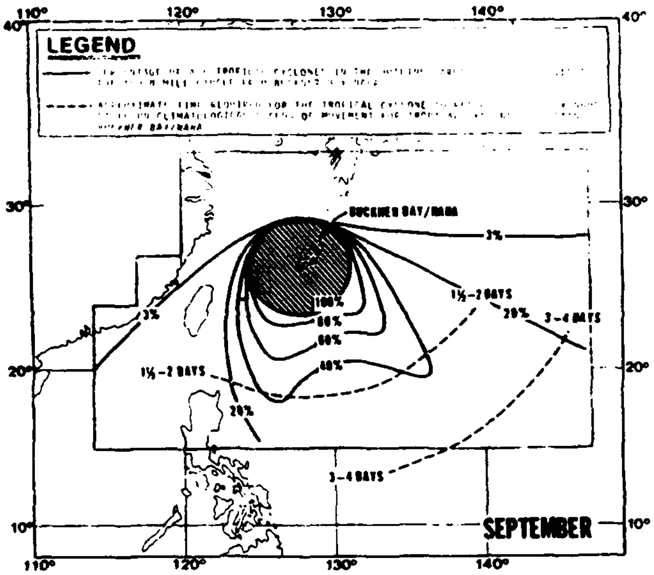

Figure V-100

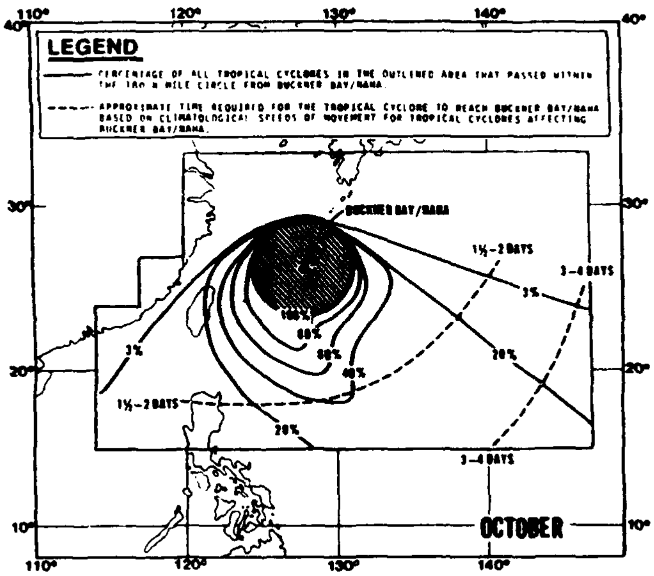

Figure V-101

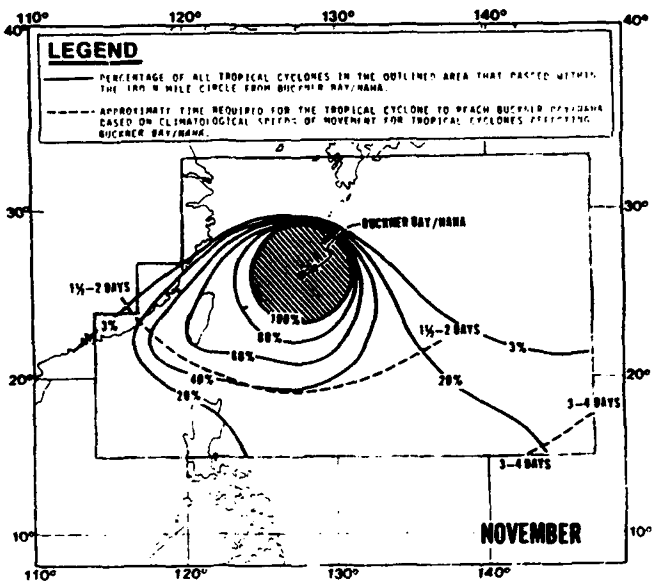

Figure V-102

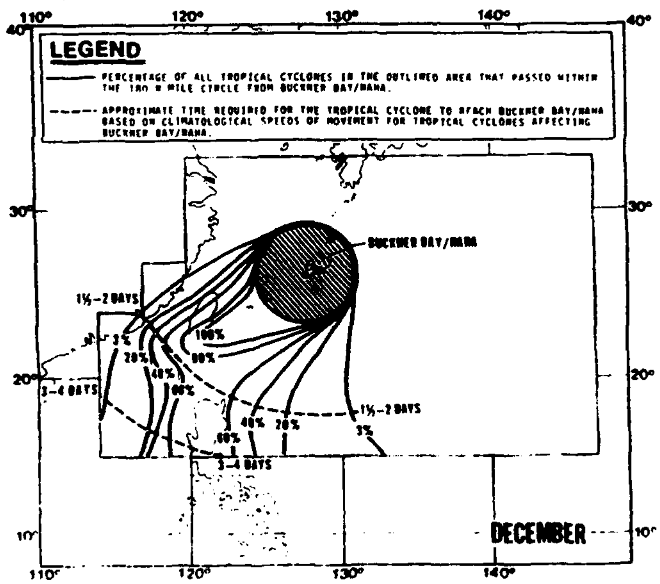

Figure V-103

Note the significant shift in direction from which "threat" tropical cyclones approach Buckner Bay/Naha (Figures V-96 to V-103). In May, June, November, and December the "threat" is generally from the southwest, whereas in July-October the "threat" is generally from the south to southeast.

The average speeds of movement of tropical cyclones affecting Buckner Bay/Naha are presented in Table V-24.

Table V-24. Listing of May-December average climatological speeds of tropical cyclones affecting Buckner Bay/Naha by 5-degree latitude bands.

Latitude Band (°N)	Average Forward Speed of Movement (kt)								Average of the 8 Months (kt)
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
20-35	15	14	11	11	13	13	18	13	13.5
15-20	11	13	10	10	11	12	13	10	11.2
10-15	10	10	9	9	10	12	12	9	10.1

7.5.2 Wind And Topographical Effects

Based on topographical considerations, strong winds can be expected from a sector extending from the east to the south since little topographic protection is available from these directions (see Figures V-92 and V-93).

To determine the extent to which "threat" tropical cyclones produced strong winds (≥22 kt) or gale force winds (≥34 kt) in Buckner Bay, the wind observations from Kadena Air Base (26°21'N, 127°45'E) were analyzed for the period May-December, 1947-1972. Figure V-92 shows the location of Kadena Air Base and surrounding topography. It must be noted that winds generally from the east and south will be 10-20% stronger in Buckner Bay than at Kadena Air Base due to the local topography. In addition, winds generally from the west will be 10-20% less at Buckner Bay than the winds recorded at Kadena Air Base. This "bias" must be kept in mind in the following paragraphs.

Table V-25 groups the 110 tropical cyclones that "threatened" Buckner Bay during the 26-year period, May-December, 1947-1972 according to the extent to which they affected Buckner Bay. Approximately two thirds of the tropical cyclones that came within 180 n mi of Okinawa produced ≥22 kt winds at Kadena and one third produced gale force winds or greater (≥34 kt).

Table V-25. Extent to which "threat" tropical cyclones affected Buckner Bay during May-December, 1947-1972.

Number of tropical cyclones that "threatened" Buckner Bay	110	%
Number of "threat" tropical cyclones resulting in strong (≥22 kt) winds in Buckner Bay	75	68%
Number of "threat" tropical cyclones resulting in gale force (≥34 kt) winds in Buckner Bay	38	34%

From an analysis of the "threat" tropical cyclone tracks that affected Buckner Bay the following is apparent: (1) Gale force winds resulting from a "threat" tropical cyclone occurred in each month during June-December and (2) August had the greatest number of "threat" tropical cyclones which produced gale force winds in Buckner Bay.

Figure V-104 shows the positions of "threat" tropical cyclone centers when strong winds (≥22 kt) first began and ended at Buckner Bay. It is apparent that "threat" tropical cyclones as far south as 21-22N and as far north as 30N can produce strong winds at Buckner Bay.

Figure V-105 shows tropical cyclone center positions when gale force (≥34 kt) winds were first and last experienced at Buckner Bay. It can be seen that gale force winds (≥34 kt) generally do not begin until the "threat" tropical cyclone is at a latitude of 24N to 25N. Also, the almost symmetric distribution of arrows indicates that Okinawa's topography has little effect in reducing the intensity of the winds produced by the "threat" tropical cyclone.

For a more detailed discussion on the effects of tropical cyclones on Okinawa, see Rudolph, et al., 1975.

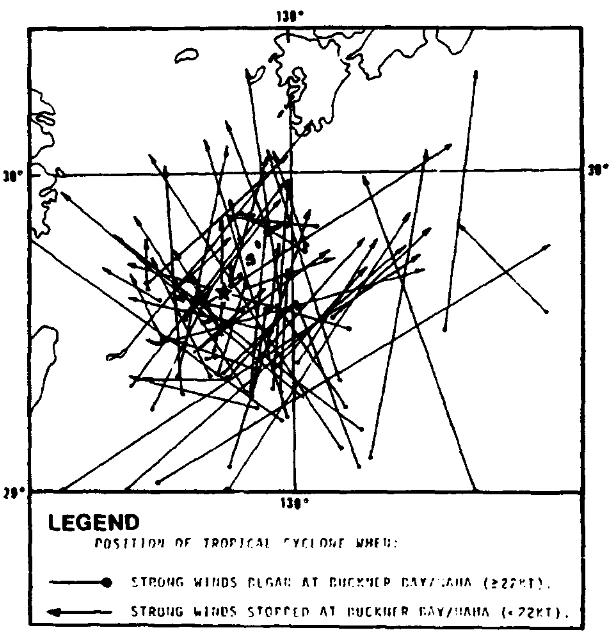

Figure V-104. Positions of tropical cyclone centers when ≥22 kt winds first and last occurred at Buckner Bay/Naha. (Based on May-December data from the years 1947-1972.)

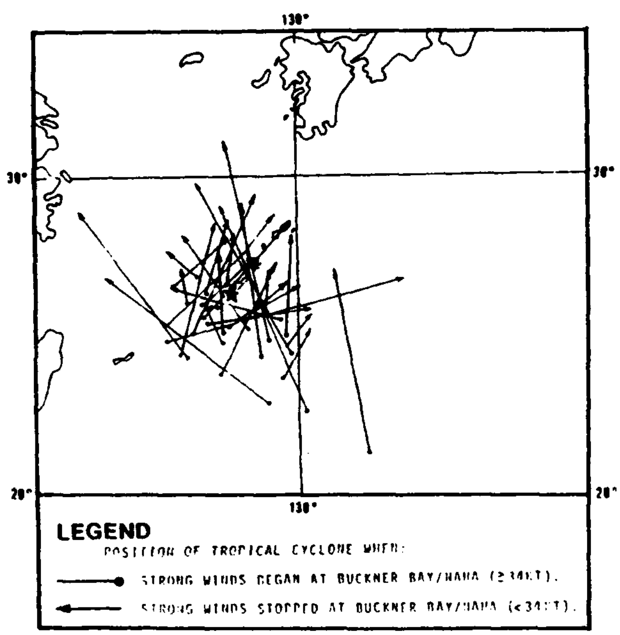

Figure V-105. Positions of tropical cyclone centers when ≥34 kt winds first and last occurred at Buckner Bay/Naha. (Based on May-December data from the years 1947-1972.)

7.5.3 Wave Action

The wave heights that can be expected with typhoon strength winds (≥64 kt) in Buckner Bay are presented as Table V-26.

Table V-26. Wave heights that can be expected with typhoon strength winds (≥64 kt) in Buckner Bay (based on research conducted by the U.S. Naval Oceanography Office.

	White Beach	Middle of Bay
Winds generally from the north (tropical cyclone passage east of Buckner Bay)	4 ft	6 ft
Winds generally from the south (tropical cyclone passage west of Buckner Bay)	20 ft	16 ft

Heights of up to 20 ft can be expected from a typhoon passing within 20 n mi to the west of Buckner Bay. The resulting southerly winds generate waves which are virtually unopposed before reaching White Beach, although the coral reefs and islands surrounding Buckner Bay offer some resistance.

7.5.4 Storm Surge And Tides

When a tropical cyclone crosses a coastline, a rise in water level may occur. This is caused by wind stress on the water surface and effects of atmospheric pressure reduction. For storms approaching Okinawa from the south, this surge effect will be maximum in bays which open to the south and east if the harbor is located in the dangerous semicircle.

According to statistical information gathered by the U.S. Naval Oceanographic Office, a maximum storm surge of 7.8 ft can be expected. Generally some flooding is associated with typhoons approaching from the east. The maximum tide at Buckner Bay is 5.7 ft.

7.6 THE DECISION TO EVADE OR REMAIN IN PORT

7.6.1 General

The responsibility for overall coordination of action to be taken by Naval activities on Okinawa has been assigned to the Commanding General, Marine Corps Base, Camp Butler. The established procedures in the event hazardous weather is expected is contained in SOPA (OKINAWA) INSTRUCTION 5000.1 (series). Storm/typhoon doctrine and coordination procedures for naval forces operating in the COMNAVFORJAPAN area of responsibility has been established by COMNAVFORJAPAN INST 3140.1J (series).

For general information about tropical cyclone warnings the reader is referred to paragraphs 6 and 7 of Chapter I.

7.6.2 Remaining In Port

Remaining in Buckner Bay when threatened by a typhoon is not the recommended course of action for the following reasons:

(1) There is almost no protection available in the bay for winds with an easterly or southerly component.

(2) Sea states up to 20 ft are possible in Buckner Bay.

(3) A storm surge is experienced when a typhoon approaches. This surge may be in excess of 7 ft.

(4) Ships moored at the White Beach piers may not have tug services available to get underway if needed.

6.6.3 Evasion

Evasion from Buckner Bay when threatened by a typhoon is the recommended course of action for all ships to follow. Figures V-106 to V-113 portray the tropical threat axes for Buckner Bay/Naha for the months of May-December, respectively. Approach times are based on average climatological speeds of movement for tropical cyclones affecting Buckner Bay/Naha.

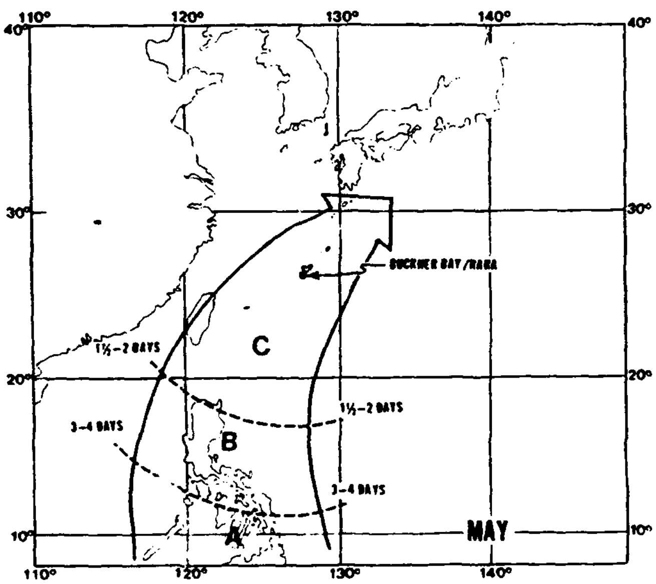

Figure V-106. MAY

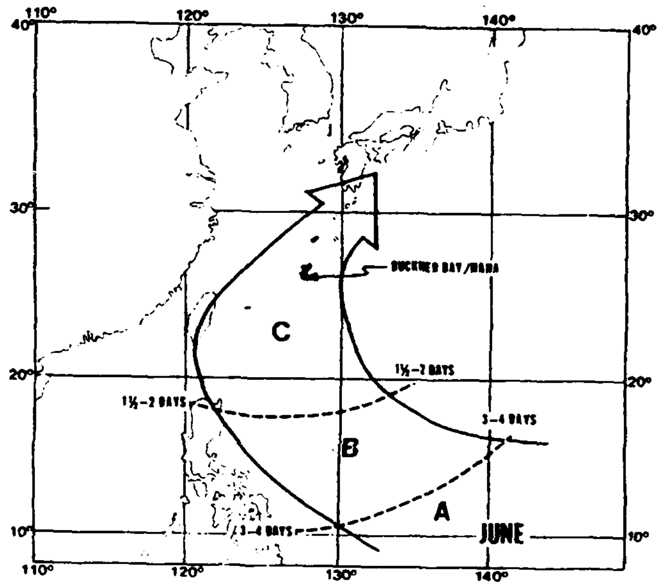

Figure V-107. JUNE

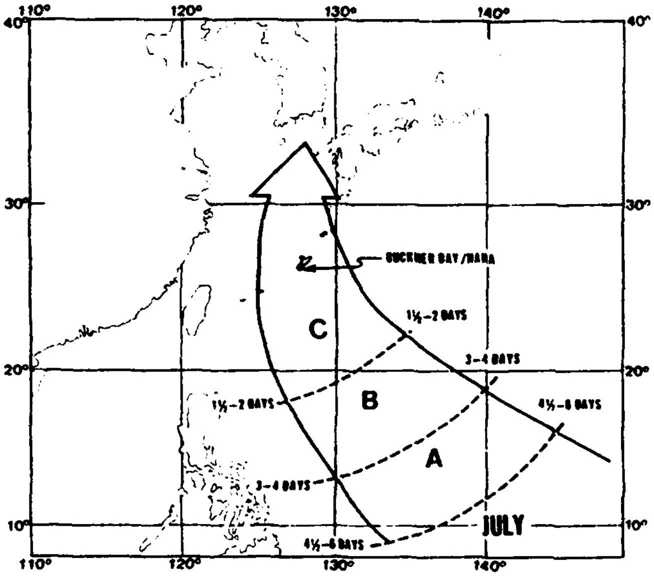

Figure V-108. JULY

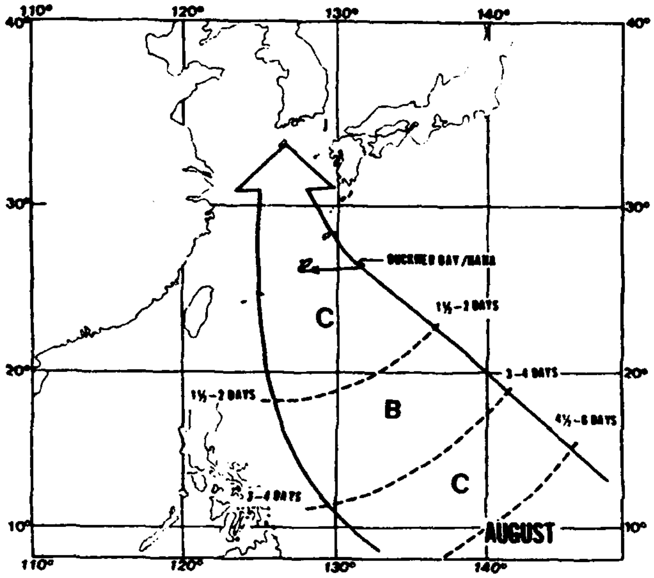

Figure V-109. AUGUST

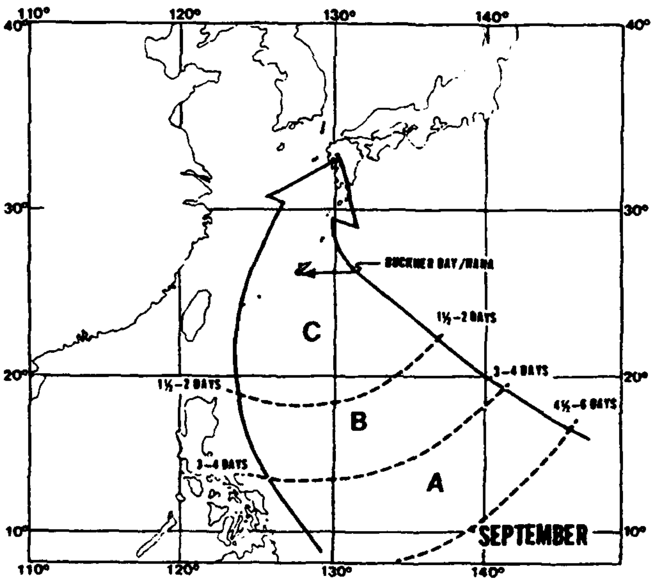

Figure V-110. SEPTEMBER

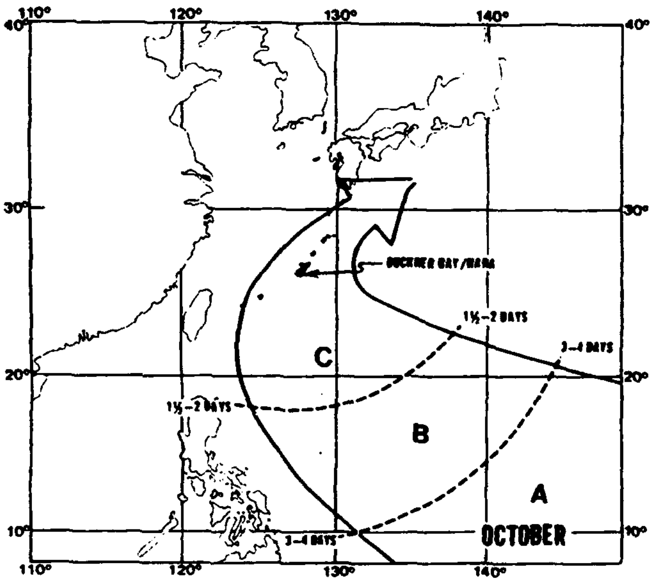

Figure V-111. OCTOBER

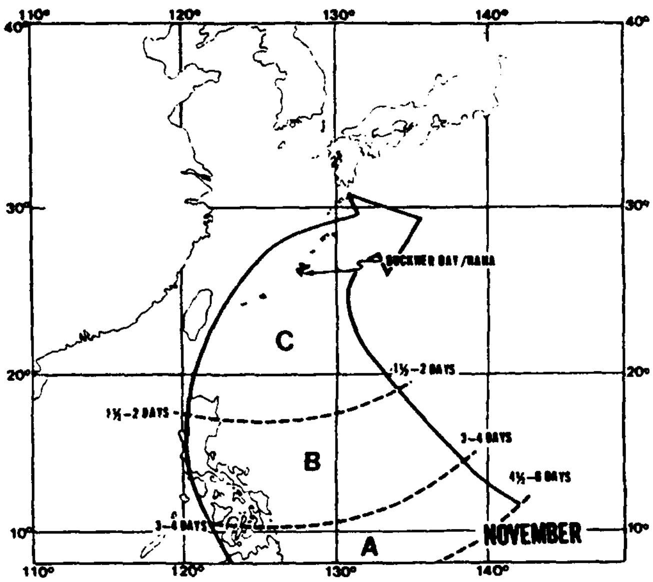

Figure V-112. NOVEMBER

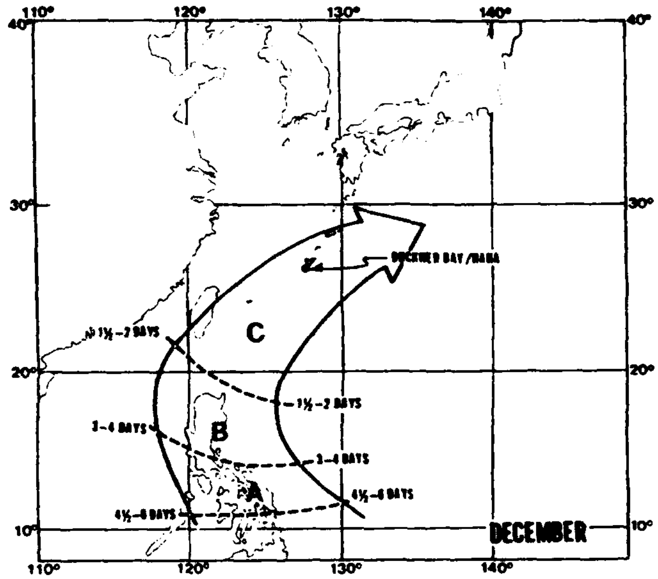

Figure V-113. DECEMBER

To correctly assess the threat posed by an approaching tropical cyclone, the following timetable incorporating Figures V-106 to V-113 has been constructed for this purpose.

I. An existing tropical cyclone moves into, or development takes place in, Area A with forecast movement toward Okinawa.

   a. Review material condition of ship. A sortie may be desirable 2-4 days hence.

   b. Reconsider any maintenance that would render the ship incapable of getting underway within 48 hours.

   c. Plot FWC/JTWC, Guam warnings and construct the danger area. Reconstruct the danger area for each new warning.

II. Tropical cyclone enters Area B moving toward Buckner Bay/Naha.

   a. All ships begin planning course of action to be taken if sortie should be ordered.

   b. Reconsider any maintenance that would render the ship incapable of getting underway within 24 hours.

   c. Anticipate Storm/Typhoon Condition III.

III. Tropical cyclone enters Area C moving toward Buckner Bay/Naha.

   a. Execute sortie plan made in previous step.

   b. Anticipate Storm/Typhoon Conditions II and I.

Whatever evasion decision is made, the following general comments should be considered.

1. When departing Buckner Bay/Naha Harbor, ample time should be given to combat the heavy sea condition likely to be encountered at the entrance to Buckner Bay/Naha Harbor.

2. Crossing ahead of a typhoon should be accomplished well in advance. Heavy swells may be encountered ahead of an advancing typhoon long before the occurrence of strong winds. Such swells may decrease a ship's maneuverability and speed of advance, preventing avoidance of the typhoon (see Chapter I, paragraph 5).

3. At certain times of the year, particularly in the peak typhoon season, the possibility exists that two or more tropical cyclones will be present at one time. This will greatly complicate any evasion planning and execution.

4. A looping tropical cyclone can cause a false sense of security as evading ships attempt to return. A looping storm after initial passage can return and cause as high or higher winds/seas upon its return.

7.6.4 Evasion Techniques

The final decision involving evasion of a tropical storm rests with the commanding officer of the vessel involved. One of the more successful Pacific Ocean evasion techniques involves running downwind and downsea relative to the typhoon in order to reach a latitude south of the storm and be located in the navigable semicircle. The success of this method depends upon almost continuous reconnaissance coverage and the relatively slow movement and gradual expansion of the initially small area affected by severe winds which is characteristic of typhoons at low latitudes.

For a ship in or near Buckner Bay/Naha the following evasion routes for the more common threat situations (depicted in Figure V-114) are suggested.

1. Tropical cyclone is forecast to pass east of Buckner Bay/Naha (Figure V-114 (a)).

   Evasion should be to the southwest. This allows the ship to gain a latitude south of the storm center in the safe semicircle.

2. Tropical cyclone is forecast to pass west of Buckner Bay/Naha (Figure V-114 (b)).

   Evasion should be to the east-southeast. This provides ample maneuvering room and allows course modification to the east or north as the storm movement/intensity varies. A WORD OF CAUTION -- the ship is operating in the dangerous semicircle and wind and sea will be between bow and beam and may adversely affect the ship speed (see Chapter I, paragraph 5). Sufficient separation from the storm center must be maintained to stay outside the 30-kt wind radius.

3. Tropical cyclone is forecast to recurve and pass south of Buckner Bay/Naha (Figure V-114 (c)).

   Evasion should be to the north or northwest. This will place the ship in the safe semicircle and also make available a second option -- to proceed to Sasebo Harbor, a typhoon haven for all but the largest of ships (Rudolph, 1975).

4. Tropical cyclone is forecast to recurve and pass north of Buckner Bay/Naha (Figure V-114 (d)).

   Evasion should be to the east-southeast. This will provide ample maneuvering room and place the ship south of the tropical cyclone. A WORD OF CAUTION -- the ship will be operating in the dangerous semicircle and ships speed may be reduced significantly (see Chapter I, paragraph 5).

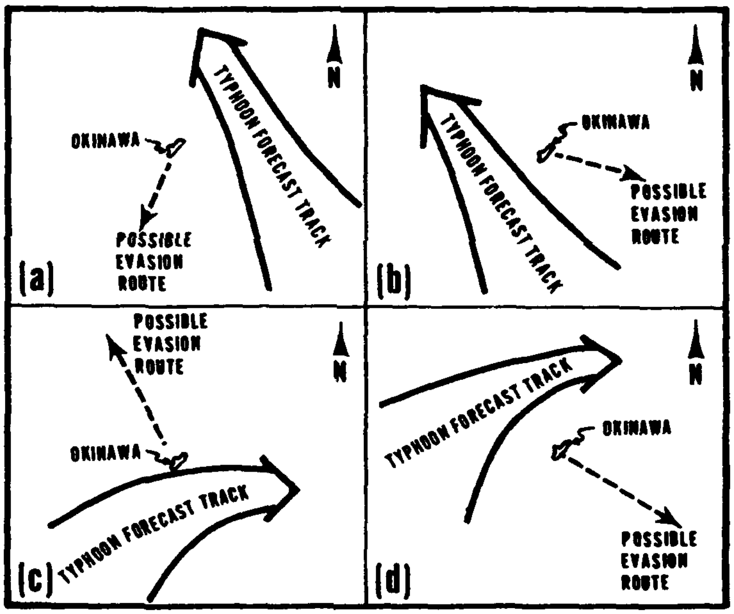

Figure V-114. Common typhoon threat situations experienced at Buckner Bay/Naha and possible evasion routes.

Since the general movement of tropical cyclones varies from month to month, the appropriate information presented in Figures V-96 to V-103 (percent "threat" lines), Figures V-106 to V-113 ("threat" axis diagrams) and Appendix 1-A (the mean monthly tropical cyclone tracks, track limits and average speeds of movement), in conjunction with the warnings issued by FWC/JTWC Guam, should all be used in developing a viable evasion route.

8. NAHA, OKINAWA

SUMMARY

The conclusion reached in this study is that Naha Harbor is a poor haven during typhoon conditions. The key factors in reaching this conclusion were:

1. Lack of sheltered berths.
2. The threat of other vessels adrift in the confined harbor.
3. High sea states within the harbor area for winds of 25 kt and greater.
4. Poor anchor holding action of the harbor bottom.

It is recommended that all U.S. Navy ships capable take action to evade at sea when typhoon conditions threaten Naha, Okinawa.

8.1 LOCATION

Naha, the principal port of Okinawa, is located on the southwestern coast of the island at 26°13'N, 127°41'E. Refer to paragraph 7.1 of Chapter V.

8.2 NAHA HARBOR

Naha Harbor consists of an outer harbor, with outer and inner anchorages, and two inner harbors (Figure V-115). The main inner harbor (Naha Ko) is used by ocean-going vessels with a draft up to 31.5 ft, while the new inner harbor is used by coastal vessels under 3,000 tons.

Figure V-116 depicts the main inner harbor which is divided into a commercial area (northern part) and an Army area (southern part) which has eight piers. The commercial wharfs are letter designated A through L. Piers A-D and J-L are "small craft" piers while pier E is not used.

The inner and outer anchorages are not individually charted and several sunken wrecks within the anchorages are hazards to those vessels lacking local knowledge. The anchorages are exposed to wind and sea and the bottom is considered very poor holding ground.

The tidal range in the harbor is about 6 ft while mean currents do not exceed 2.5 kt.

8.3 TOPOGRAPHY

Figure V-92 indicates that Naha Harbor is unprotected to the northwest but receives some protection from hills less than 250 ft to the north and south. More protection is available to the east.

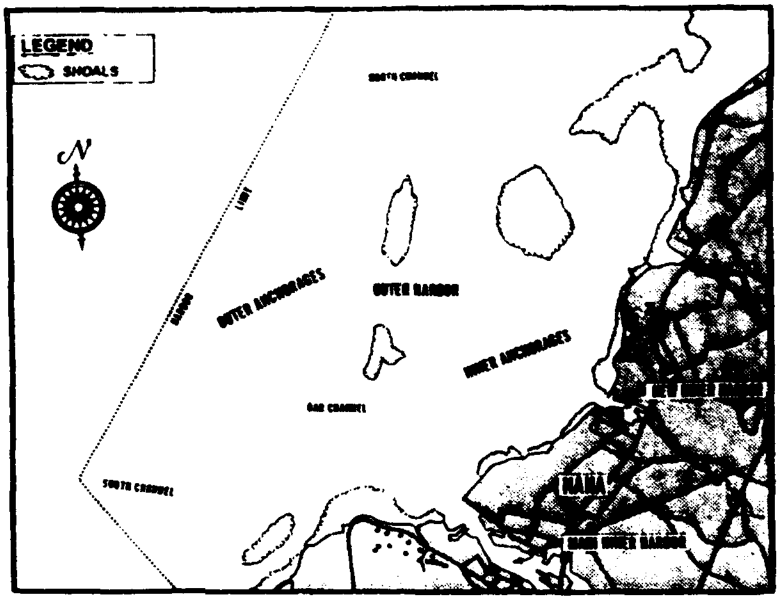

Figure V-115. Naha Harbor.

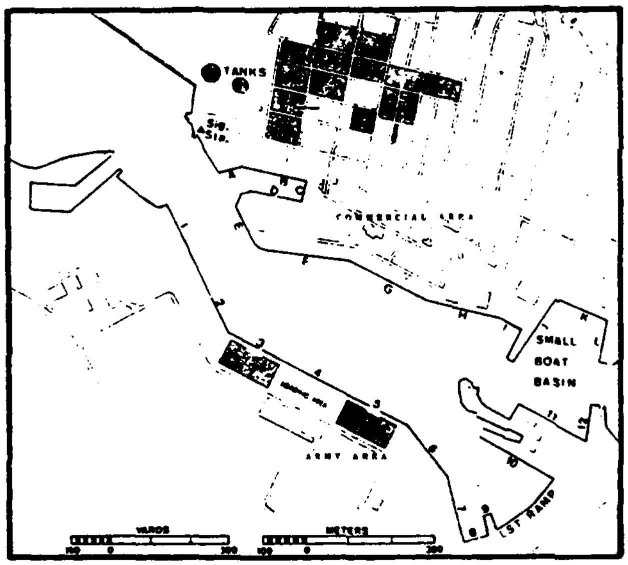

Figure V-116. Naha main inner harbor (Naha Ko).

8.4 HARBOR FACILITIES

The Director for Terminal Operations, 2nd Logistical Command, U.S. Army, is responsible for the operation of facilities and services in the military terminal complex of the port, while the Japanese Maritime Safety Agency (JMSA) controls the commercial complex. For a detailed description of harbor facilities available in Naha, refer to the CINCPACFLT or Far East Port Directory.

8.5 TROPICAL CYCLONES AFFECTING NAHA

8.5.1 Tropical Cyclone Climatology For Naha

Refer to paragraph 7.5.1, Chapter V for the tropical cyclone climatology of Naha.

8.5.2 Wind And Topographical Effects

Maximum winds can be expected from the northwest at Naha since the harbor opens to the ocean in this direction. Thus, tropical cyclones to the north of Okinawa are severe problems to Naha.

To determine the extent to which threat tropical cyclones produced strong winds (≥22 kt) or gale force winds (≥34 kt) in Naha Harbor, the wind observations from Kadena Air Base (26°21'N, 127°45'E) at an elevation of 152 ft were analyzed (refer to paragraph 7.5.2, Chapter V). Since both Naha Harbor and Kadena Air Base are located on Okinawa's western coastline and the surrounding topography is similar, winds recorded at Kadena Air Base are representative of wind conditions experienced in Naha Harbor.

For a more detailed discussion on the effects of tropical cyclones on Okinawa, see Rudolph, et al., 1975.

8.5.3 Wave Action

Wave action in Naha Harbor area is severe enough to halt all traffic with the onset of 25 kt or greater winds. Although ships have been moved in winds up to 50 kt during emergency conditions, wave action in the harbor can be destructive enough to necessitate clearing the port of all vessels when winds of 50 kt or greater are expected within 24 hours.

The wave heights that can be expected with typhoon strength winds (≥64 kt) in Naha Harbor are presented as Table V-27.

Table V-27. Wave heights that can be expected with typhoon strength winds (≥64 kt) in Naha's main inner and outer harbor. (Based on information from U.S. Army Coastal Engineering Research Center, 1973.)

	Main Inner Harbor	Main Outer Harbor
Winds generally from the north (tropical cyclone passage east of Naha)	8 ft	15 ft
Winds generally from the south (tropical cyclone passage west of Naha)	4 ft	12 ft

8.5.4 Storm Surge And Tides

During periods of moderate to strong northwesterly winds, a surge effect of 2-3 ft is evident in the main inner harbor. This is caused by wind stress on the water surface and the effects of atmospheric pressure reduction. When this surge effect coincides with high tide, an abnormal rise in water level occurs.

8.6 THE DECISION TO EVADE OR REMAIN IN PORT

8.6.1 General

For general information about tropical cyclone warnings the reader is referred to paragraphs 6 and 7 of Chapter I. See also paragraph 7.6.1 of Chapter V.

8.6.2 Remaining In Port

Naha is a confined, generally unsheltered harbor. The anchorages are exposed to wind and sea and the bottom is considered very poor holding ground. Several merchant ships may be present at any given time in Naha Harbor, and some of these vessels may have inadequate or poorly maintained mooring gear. As a result, it is possible for them to break loose during typhoon conditions and cause damage to other ships. As a consequence, it is recommended that U.S. Navy ships sortie when typhoon conditions threaten. If a ship is unable to get underway and evade at sea, every effort must be made to obtain a berth within Naha Ko, the main inner harbor. If such a berth cannot be obtained well in advance of the onset of heavy weather, evasion at sea is strongly recommended.

8.6.3 Evasion

Evasion from Naha Harbor when threatened by a typhoon is the recommended course of action for all ships to follow. See paragraph 7.6.3 of Chapter V for general evasion comments.

8.6.4 Evasion Techniques

Due to the proximity of Buckner Bay and Naha Harbor, the evasion techniques presented in paragraph 7.6.4 of Chapter V are applicable.

9.0 MAIZURU

SUMMARY

The conclusion reached in this study is that the Port of Maizuru, East Harbor, is a safe haven for a small to medium size vessel during the passage of a typhoon near the port; a port in which to remain if already there or one in which to seek shelter if at sea when threatened by a typhoon. This conclusion is based on the following factors.

(1) Although gale force winds are occasionally observed in the East Harbor area during the passage of a tropical cyclone, the surrounding topography significantly reduces the velocity of the strongest winds in the port area.

(2) The apparent integrity and good repair of the piers, and good holding qualities of the anchorage bottom.

(3) The reputation of the port as a typhoon haven. Local harbor personnel state that the port is a good typhoon haven, and it is used by many Japanese merchant ships and fishing boats when a typhoon threatens.

(4) Wind wave motion in the harbor is limited by a short fetch length. Open ocean waves do not reach East Harbor.

(5) The port is not susceptible to storm surge.

9.1 LOCATION AND TOPOGRAPHY

The Port of Maizuru, East Harbor, is located on the northern coast of the Japanese island of Honshu at 35°29'N 135°23'E (Figure V-117). Situated about 230 nmi west of Tokyo, the port

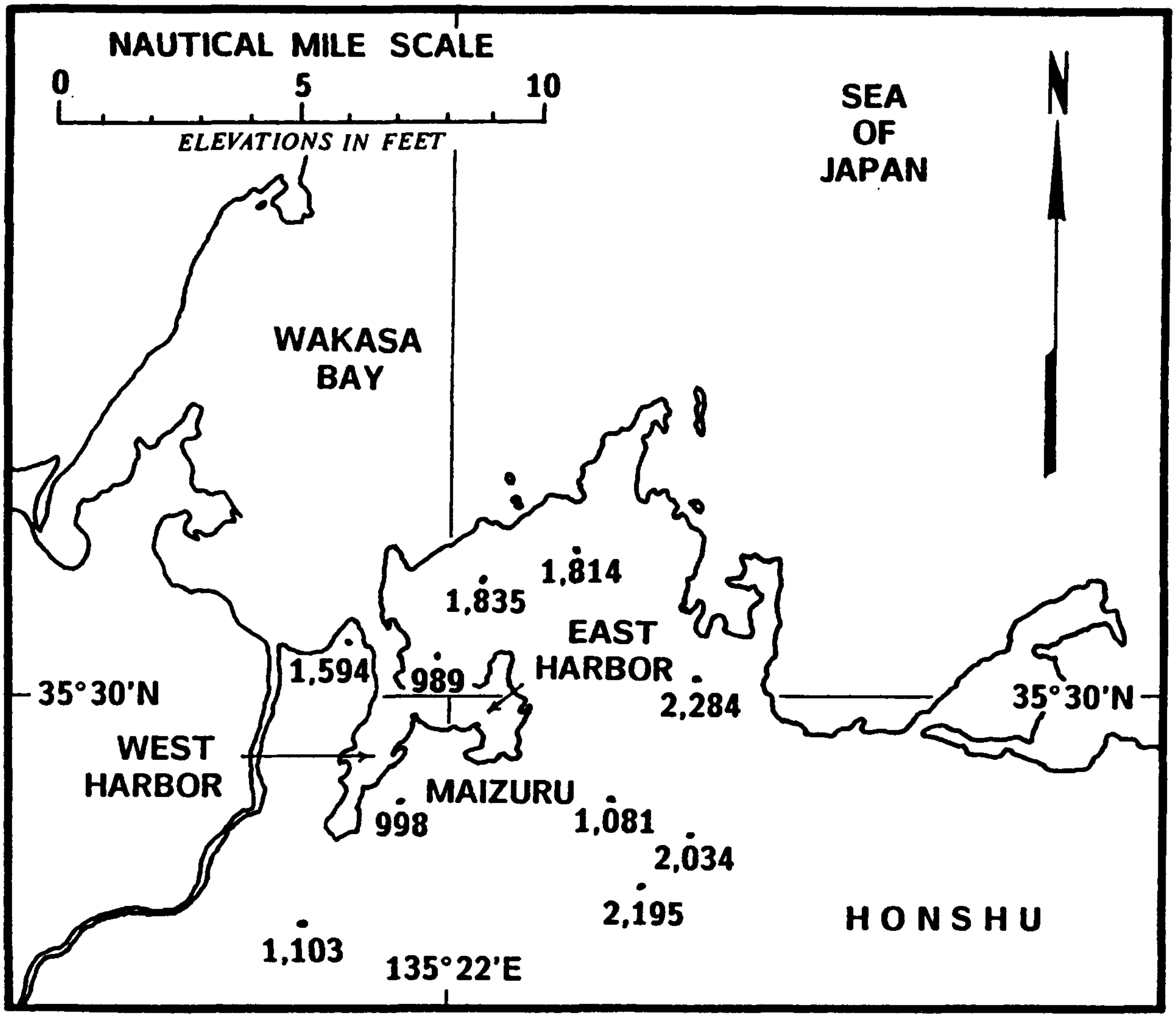

Figure V-117. Location of Maizuru in relation to the north coast of Honshu and south shore of the Sea of Japan.

is positioned at the southern end of Wakasa Bay in the southern portion of the Sea of Japan. The port is relatively small when compared to many others in Japan, but it is an important terminal for the import and export of wood and wood products.

The harbor is largely landlocked, and is surrounded by mountainous terrain that commonly exceeds 984 ft (300 m), with one peak reaching 1,835 ft (559 m) within 2 nmi of East Harbor. Other peaks exceed 2,200 ft (671 m) within 10 nmi of the port.

MAIZURU

The harbor is entered from the southern end of Wakasa Bay, via a 540 yd (494 m) wide fairway that proceeds south-southeastward to the inner harbors. The port is divided into two basins, West Harbor and East Harbor. The section of interest to U. S. Navy ships is East Harbor. West Harbor, adjacent to the town of Maizuru, is exclusively a commercial facility.

9.2 MAIZURU EAST HARBOR

The channel leading to East Harbor makes a 90° turn to the east as it passes Sambommatsu Cape then proceeds eastward for about 2 nmi as a 400 yd (366 m) wide fairway (Figure V-118). East Harbor is irregular in shape, with approximate dimensions of 1 nmi (east-west) by 2 nmi (north-south). The facilities that are of interest to U. S. Navy ships include the Japanese Maritime Self Defense Force (JMSDF) Pier in the southwest portion of the harbor just northwest of the small community of Shin-Maizuru, and the anchorages in the central part of the harbor.

Three adjacent berths, designated A-3, A-4, and A-5, lay along a quay in the southwest portion of the harbor (Figure V-119). JMSDF berth A-5 is the only one available for use by U. S. Navy ships. It is 541 ft (165 m) long, with an alongside depth reported to be 34 ft (10.3 m), although DMA Chart 95282 indicates that depths close to the quay may be as shallow as 28.2 ft (8.6 m). Because the berth is long enough to accommodate only one vessel, additional vessels will necessarily be nested unless they anchor. The pier and bollards appeared to be in excellent condition during a November 1992 visit to the port. The quay face has large, built-in rubber fenders along its length. As of November 1992, the largest U. S. Navy ship to visit the port was the USS Blue Ridge (LCC-19). Because of her 620 ft length, Blue Ridge anchored in the harbor.

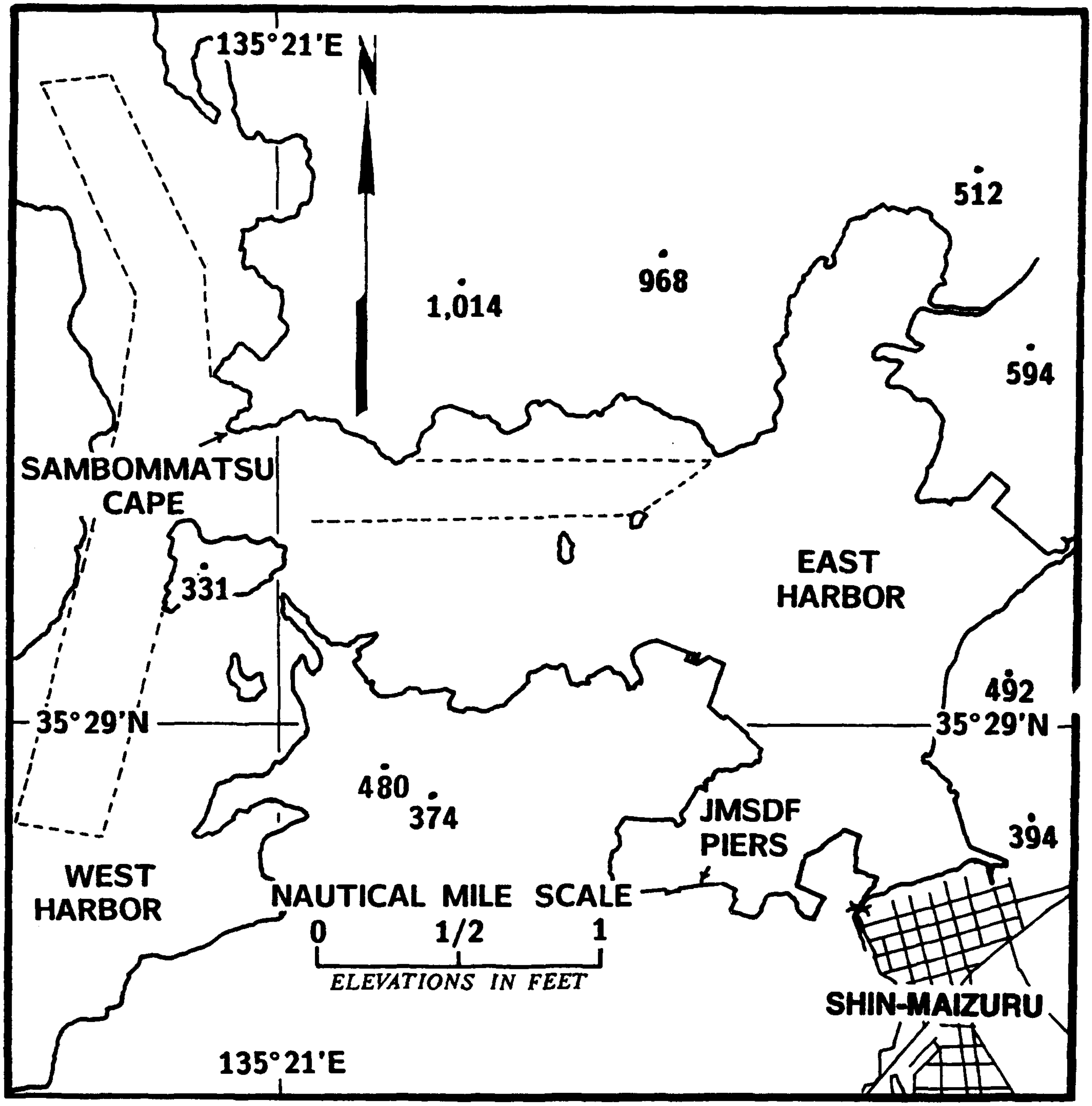

Figure V-118. Harbor entrance and East and West Harbors at Maizuru.

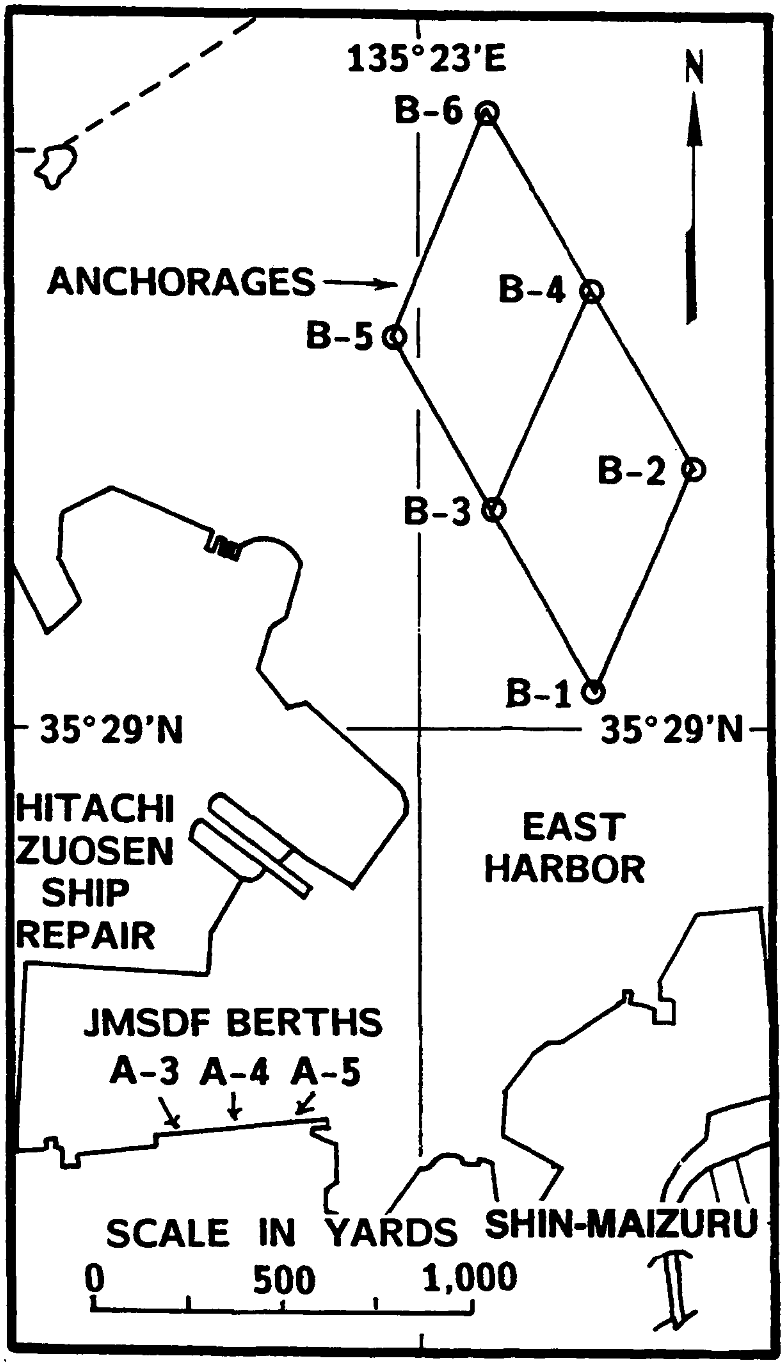

Figure V-119. East Harbor with designated anchorage locations and JMSDF berths adjacent to the small village of Shin Maizuru.

As indicated in Figure V-119, there are six anchorage positions in East Harbor. Designated as B-1 through B-6, they have a minimum of 1,640 ft (500 m) separation provided between positions. Water depths in the anchorages generally range from 40-45 ft (12-14 m). Local JMSDF personnel indicate that holding is good, but bottom type is not specified. Tug boats can be arranged by coordination with the local JMSDF office.

Other facilities in East Harbor include a civilian ship repair facility, Hitachi Zuosen, which is located across from the JMSDF pier in the southwest portion of East Harbor. See Figure V-119.

9.3 TROPICAL CYCLONES AFFECTING MAIZURU

9.3.1 Tropical Cyclone Climatology at Maizuru

Tropical cyclones which affect Japan generally form in the area bounded by 5°N to 30°N and 120°E to 165°E. The latitudinal boundaries shift poleward during the summer months and then equatorward in winter in response to the seasonal changes of the synoptic environment.

For the purpose of this study, any tropical storm or typhoon approaching within 180 nmi of Maizuru is considered to represent a threat to the port. Table V-28 contains a descriptive history of all tropical storms and typhoons passing within 180 nmi of Maizuru during the 47-year period 1945-1991. All of the tropical cyclone statistics used in this report for storms passing within 180 nmi of Maizuru are based on the SAIC generated data set used to compile Table V-28.

Table V-28. Descriptive history of the 101 tropical storms and typhoons passing within 180 nmi of Maizuru during the 47-year period 1945-1991.

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAXIMUM WIND AT STORM CENTER	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
1	OPAL	1945	JUL	20	6	53	140 (S)	075/28.8
2	RUTH	1945	AUG	25	13	52	110 (WSW)	335/11.2
3	SUSAN	1945	AUG	27	14	40	100 (W)	004/13.0
4	IDA	1945	SEP	17	18	60*	85 (SE)	047/26.0
5	KATE	1945	OCT	5	22	57	108 (ESE)	026/20.9
6	LOUISE	1945	OCT	11	23	50	65 (SE)	053/19.2
7	JANIE	1946	JUL	30	7	40*	100 (W)	357/18.1
8	GWEN	1947	AUG	6	7	82	137 (SE)	039/13.6
9	KATHLEEN	1947	SEP	15	11	60*	176 (ESE)	033/ 9.4
10	IONE	1948	SEP	16	14	85	150 (SE)	038/23.0
11	LIBBY	1948	OCT	6	17	68	155 (SSE)	058/18.8
12	AGNES	1948	NOV	19	23	58	146 (SE)	054/32.6
13	HESTER	1949	JUL	28	6	22	55 (E)	005/12.0
14	JANE	1950	SEP	3	8	70	19 (ESE)	020/23.5
15	KATE	1951	JUL	2	5	88	51 (SSE)	067/32.1
16	RUTH	1951	OCT	14	11	55	19 (ESE)	051/36.7
17	DINAH	1952	JUN	23	2	55	107 (SSE)	066/34.9
18	TESS	1953	SEP	25	15	65	97 (ESE)	031/25.7
19	GRACE	1954	AUG	18	4	42	11 (S)	056/10.8
20	KATHY	1954	SEP	7	9	50	151 (WNW)	027/25.6
21	JUNE	1954	SEP	13	10	55	171 (W)	007/24.8
22	LORNA	1954	SEP	18	11	68	129 (SSE)	059/17.4
23	MARIE	1954	SEP	26	12	65	49 (NW)	040/50.9
24	LOUISE	1955	SEP	30	15	88	167 (NW)	039/38.4
25	MARGE	1955	OCT	4	16	50	141 (WSW)	028/20.2
26	OPAL	1955	OCT	20	19	45	64 (SE)	043/41.5
27	BABS	1956	AUG	17	9	80	119 (NW)	033/24.6
28	HARRIET	1956	SEP	27	15	70	118 (SE)	052/28.0
29	VIRGINIA	1957	JUN	27	5	44	13 (S)	114/ 7.2
30	BESS	1957	SEP	7	9	50	26 (NNW)	046/36.0
31	ALICE	1958	JUL	22	9	63*	172 (SE)	039/24.1
32	FLOSSIE	1958	AUG	25	12	48*	57 (SSE)	056/18.6
33	HELEN	1958	SEP	17	14	90	171 (SE)	046/29.0
34	ELLEN	1959	AUG	8	6	58	66 (SSE)	063/16.5
35	GEORGIA	1959	AUG	13	7	78	154 (ENE)	347/35.0
36	VERA	1959	SEP	26	15	110	61 (E)	023/34.4
37	AMY	1959	OCT	7	16	50	73 (S)	079/21.7
38	VIRGINIA	1960	AUG	11	10	48*	82 (WNW)	022/17.0
39	WENDY	1960	AUG	12	11	45*	27 (WNW)	036/23.9
40	DELLA	1960	AUG	29	16	58*	96 (W)	003/24.1
41	NANCY	1961	SEP	16	18	73	29 (SE)	035/29.6
42	LOUISE	1962	JUL	27	7	35	55 (SE)	049/ 6.5
43	THELMA	1962	AUG	25	14	54*	41 (E)	358/21.0
44	ROSE	1963	JUN	13	3	35	43 (W)	027/36.0
45	DELLA	1963	AUG	28	11	78	133 (SSE)	064/12.0
46	KATHY	1964	AUG	24	15	55	29 (NW)	056/15.8
47	WILDA	1964	SEP	24	24	72	4 (WNW)	042/32.6
48	JEAN	1965	AUG	6	16	72	132 (WNW)	027/28.1
49	LUCY	1965	AUG	22	18	112	153 (SE)	036/ 7.7
50	SHIRLEY	1965	SEP	10	24	90	9 (SSW)	028/35.0
51	TRIX	1965	SEP	17	25	85	126 (SE)	036/29.3
52	VIOLA	1966	AUG	22	13	25	79 (NE)	319/18.5
53	DORIS	1966	SEP	9	18	35	67 (NW)	039/21.9
54	IDA	1966	SEP	24	23	80	148 (E)	015/34.9
55	LOUISE	1967	AUG	22	15	45	92 (SSE)	056/ 6.9
56	DINAH	1967	OCT	27	30	53	134 (E)	014/26.4
57	MARY	1968	JUL	28	4	33	150 (SW)	316/15.9
58	ALICE	1969	AUG	4	7	25	115 (S)	064/17.1
59	CORA	1969	AUG	22	9	43	73 (SE)	045/20.1
60	OLGA	1970	JUL	5	2	45*	22 (SW)	321/15.5

NOTES:
Datetimes are in UTC, winds are in knots, distances are in nautical miles. Parenthetical expression in column 8 gives bearing of storm from site at closest point of approach to site (CPA). Maximum winds are at time of CPA and did not necessarily occur at site. Asterisk (if any) after maximum wind indicates that storm was classified as a typhoon (at least 64 kts) somewhere within 180 nautical mile radius of site but not at CPA. Site location is 35.5°N, 135.4°E.

Table V-28 (continued). Descriptive history of the 101 tropical storms and typhoons passing within 180 nmi of Maizuru during the 47-year period 1945-1991.

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAXIMUM WIND AT STORM CENTER	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
61	WILDA	1970	AUG	15	8	57	106 (NW)	042/29.8
62	ANITA	1970	AUG	21	9	65	135 (WNW)	028/19.6
63	IVY	1971	JUL	7	13	47	109 (SE)	047/21.2
64	TRIX	1971	AUG	30	23	41	73 (S)	100/13.0
65	CARMEN	1971	SEP	26	28	45	76 (SSE)	045/30.0
66	PHYLLIS	1972	JUL	15	7	38	59 (E)	360/15.0
67	HELEN	1972	SEP	16	20	63*	52 (E)	020/30.9
68	ELLEN	1973	JUL	29	6	25	104 (ESE)	318/ 5.3
69	MARY	1974	AUG	26	15	50	124 (ESE)	021/30.2
70	POLLY	1974	SEP	1	18	55*	135 (WSW)	346/20.6
71	SHIRLEY	1974	SEP	9	21	22	68 (SE)	055/26.9
72	RITA	1975	AUG	22	8	60*	5 (SW)	028/17.5
73	FRAN	1976	SEP	13	17	41	154 (WNW)	033/23.7
74	KEN	1979	SEP	4	15	25	11 (N)	046/19.0
75	OWEN	1979	SEP	30	19	52	52 (SE)	050/32.3
76	TIP	1979	OCT	19	23	65	72 (SE)	049/47.6
77	ORCHID	1980	SEP	11	17	45	165 (WNW)	012/30.7
78	WYNNE	1980	OCT	14	23	78	179 (SSE)	066/34.1
79	BESS	1982	AUG	1	11	53*	86 (E)	360/34.0
80	ELLIS	1982	AUG	27	14	48	165 (W)	358/21.0
81	JUDY	1982	SEP	12	19	60*	97 (E)	001/26.1
82	KEN	1982	SEP	25	20	45	141 (W)	357/22.0
83	ABBY	1983	AUG	17	5	60*	108 (ESE)	027/ 8.5
84	BEN	1983	AUG	15	7	30	44 (ESE)	284/24.5
85	HOLLY	1984	AUG	21	11	48	153 (NW)	050/24.9
86	IRMA	1985	JUN	30	6	70	141 (SE)	048/35.9
87	ODESSA	1985	SEP	1	12	40	104 (NW)	060/23.0
88	ROGER	1986	JUL	17	8	45	163 (S)	073/21.9
89	KELLY	1987	OCT	16	20	58*	10 (W)	026/29.1
90	ELLIS	1989	JUN	24	6	35	121 (NW)	052/22.2
91	ROGER	1989	AUG	27	20	40	23 (SE)	036/22.6
92	WAYNE	1989	SEP	19	25	63*	125 (SSE)	067/36.5
93	WINONA	1990	AUG	9	12	65	144 (ESE)	028/14.7
94	ZOLA	1990	AUG	22	14	80	126 (WNW)	015/28.3
95	FLO	1990	SEP	19	20	75	68 (ESE)	029/25.1
96	GENE	1990	SEP	30	21	63*	104 (SSE)	062/26.2
97	HATTIE	1990	OCT	8	22	47	106 (SSE)	060/33.6
98	PAGE	1990	NOV	30	29	58*	118 (SE)	039/23.4
99	HARRY	1991	AUG	30	16	40	137 (SE)	035/21.3
100	KINNA	1991	SEP	14	19	63*	57 (NNW)	064/35.8
101	MIREILLE	1991	SEP	27	21	80	86 (NNW)	049/44.5

NOTES:
Datetimes are in UTC, winds are in knots, distances are in nautical miles. Parenthetical expression in column 8 gives bearing of storm from site at closest point of approach to site (CPA). Maximum winds are at time of CPA and did not necessarily occur at site. Asterisk (if any) after maximum wind indicates that storm was classified as a typhoon (at least 64 kts) somewhere within 180 nautical mile radius of site but not at CPA. Site location is 35.5°N, 135.4°E.

MAIZURU

The primary tropical cyclone season for Maizuru is from June to October, although historically they have occurred in all months in the genesis area described in the preceding paragraph. As shown in Table V-29, no tropical cyclone passing within 180 nmi of Maizuru occurred prior to June in any year since 1945. Only 2 have occurred as late as November, and neither were of typhoon strength at CPA. Table V-29 also shows the motion history of the 101 storms that passed within 180 nmi of Maizuru during the 47-year period 1945 through 1991. The average heading and speed of tropical storms and typhoons passing within 180 nmi of Maizuru was 035° at 24 kt at CPA.

It should be noted that the average storm speed at CPA given in Table V-29 is relatively high, ranging from 18 kt in July to 29 kt in October. The reason lies in the location of Maizuru. As shown in Figures A-1 through A-24, most tropical cyclones that follow a track that will place the storm close to Maizuru recurve between 20 and 30 degrees north latitude and then accelerate northeastward. Because Maizuru is north of the normal latitudinal recurvature range, most storms passing within 180 nmi of the port have already recurved and are moving northeastward and accelerating when they are at their CPA.

During the 47-year period from 1945 through 1991 there were 101 tropical storms and typhoons that met the 180 nmi threat criterion for Maizuru, an average of just over 2 per year. Figure V-120 shows the monthly distribution of the 101 storms by 7-day periods. The period of peak activity extends from mid-August through September.

Figure V-121 shows the annual distribution of tropical storms and typhoons passing within 180 nmi of Maizuru during the 47-year period 1945 through 1991. There have only been four years in that 47-year period that no tropical storms or typhoons passed within 180 nmi of Maizuru.

Table V-29. Frequency of motion of tropical storms and typhoons passing within 180 nmi of Maizuru during the 47-year period 1945-1991.

Month when storm was at CPA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Total number of storms passing within 180 n mi	0	0	0	0	0	5	12	34	36	12	2	0	101
Number of storms having at least typhoon intensity at CPA	0	0	0	0	0	1	1	9	16	3	0	0	30
Number of storms less than typhoon intensity at CPA	0	0	0	0	0	4	11	25	20	9	2	0	71
Average heading (degs) towards which storms were moving at CPA	---	---	---	---	---	060	023	028	036	046	*	---	035
Average storm speed (knots) at CPA	---	---	---	---	---	27	18	20	28	29	*	---	24

* indicates insufficient storms for average direction and speed computations.

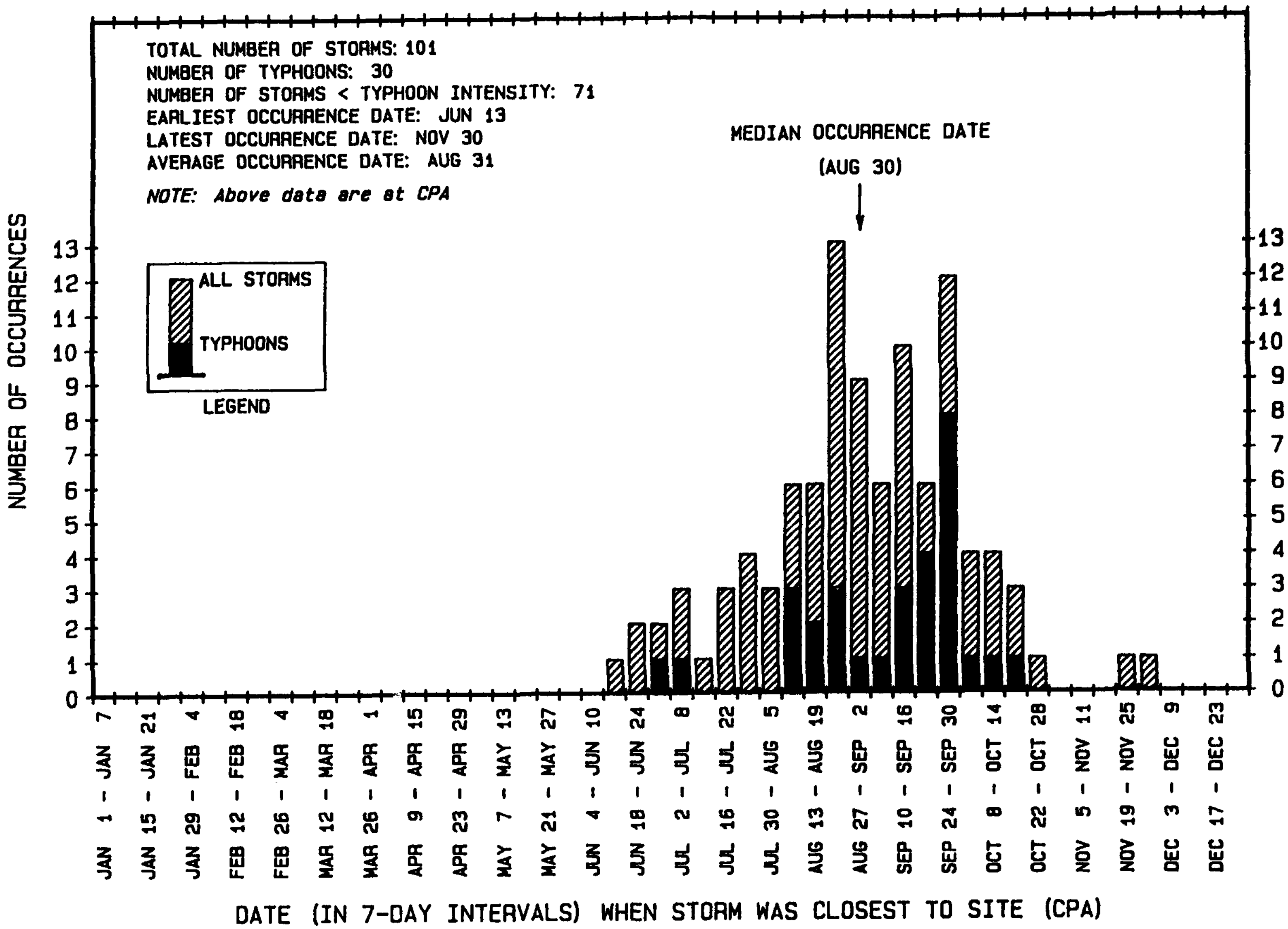

Figure V-120. Monthly distribution of all tropical storms and typhoons passing within 180 nmi of Maizuru during the 47-year period 1945-1991.

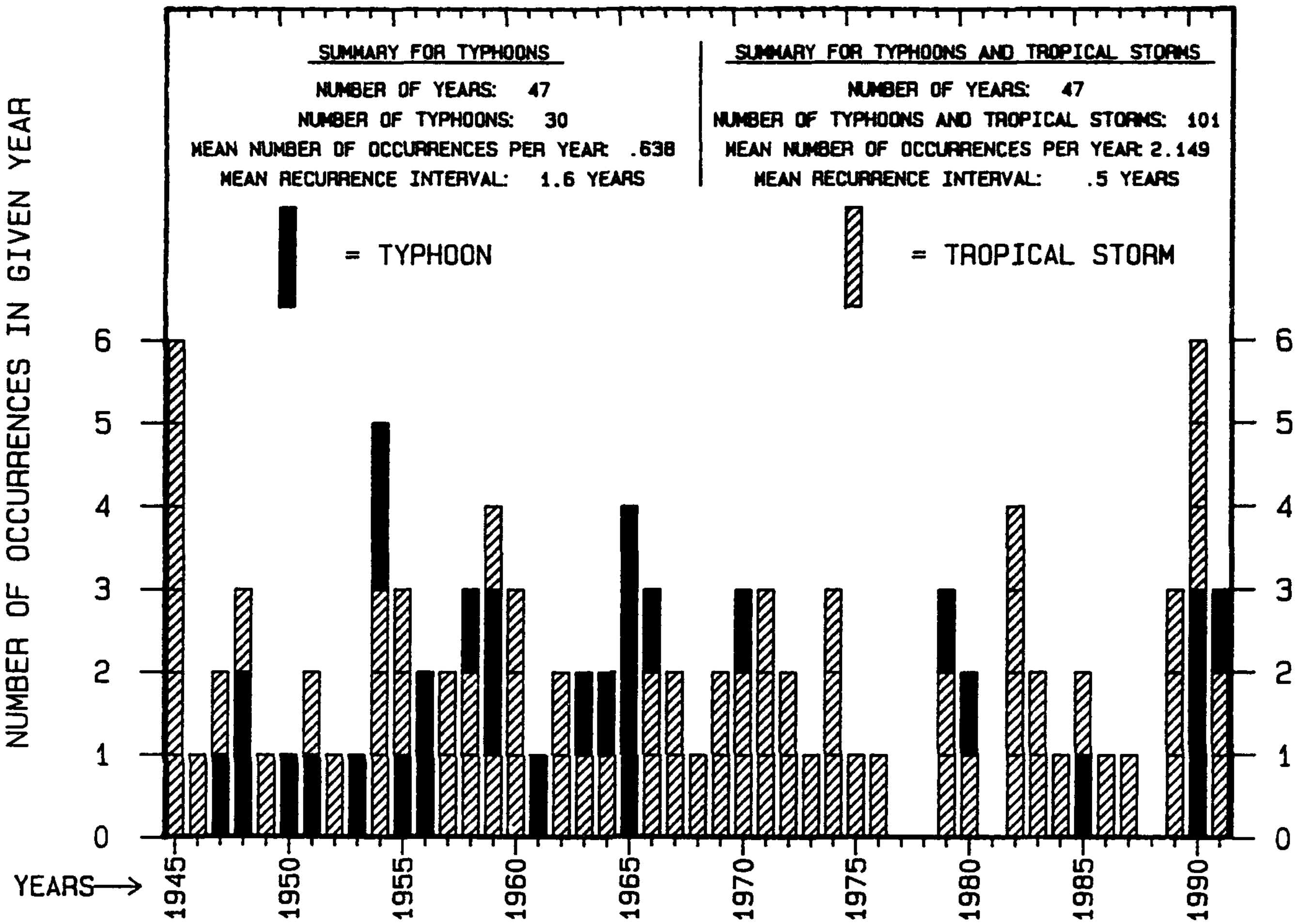

Figure V-121. Chronology of all tropical storms and typhoons passing within 180 nmi of Maizuru during the 47-year period 1945-1991. Storm intensity is determined at time of closest point of approach (CPA) to Maizuru.

Figure V-122 presents a graphical depiction of the number of tropical cyclones versus CPA. The storm classification is based on the maximum wind near the storm center while that center was within 180 nmi of Maizuru, not necessarily at CPA. The sloping lines represent mathematical fits to the data points for the various intensity classifications. The average radii of maximum wind for 34, 100, and 140 kt tropical cyclones at Maizuru are 29.8, 28.2, and 25.4 nmi, respectively.

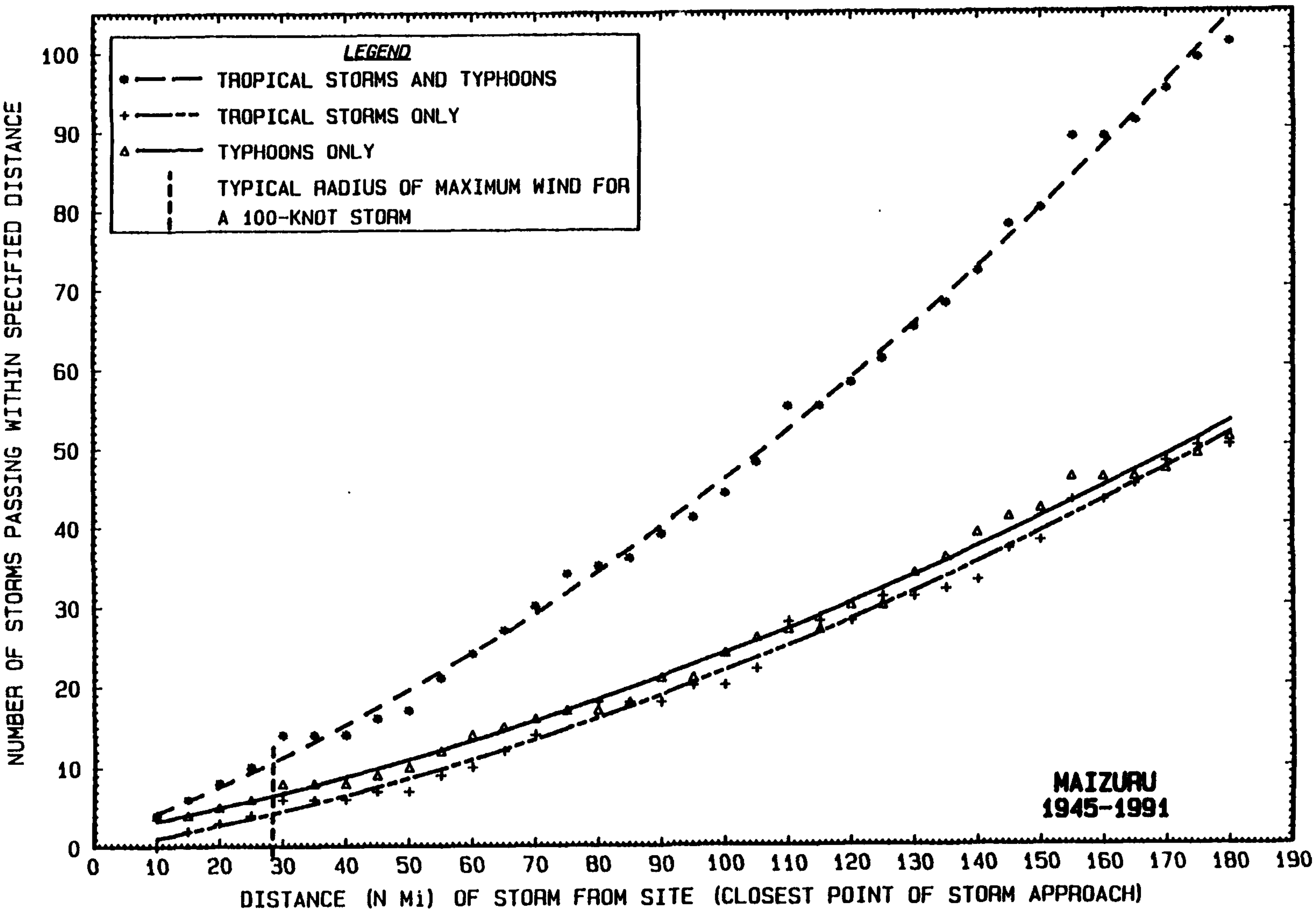

Figure V-122. Number of tropical cyclones passing at various distances from Maizuru during the 47-year period of record. Tropical storm or typhoon classification is based on maximum wind near storm center while that center was within 180 nmi of Maizuru, and not necessarily at CPA. Sloping lines represent mathematical fit to data points. Average radii of maximum wind for 34, 100, and 140 kt storms at Maizuru are 29.8, 28.2, and 25.4 nmi respectively.

Figure V-123 depicts, on an 8-point compass, the octants from which the 101 tropical cyclones in the data set approached Maizuru. As can be seen in the figure, almost 90% of the storms passing within 180 nmi of Maizuru were moving from the south or southwest. It should be noted that the approach direction is determined at CPA, and may not represent the initial approach direction of the tropical storm or typhoon toward Maizuru.

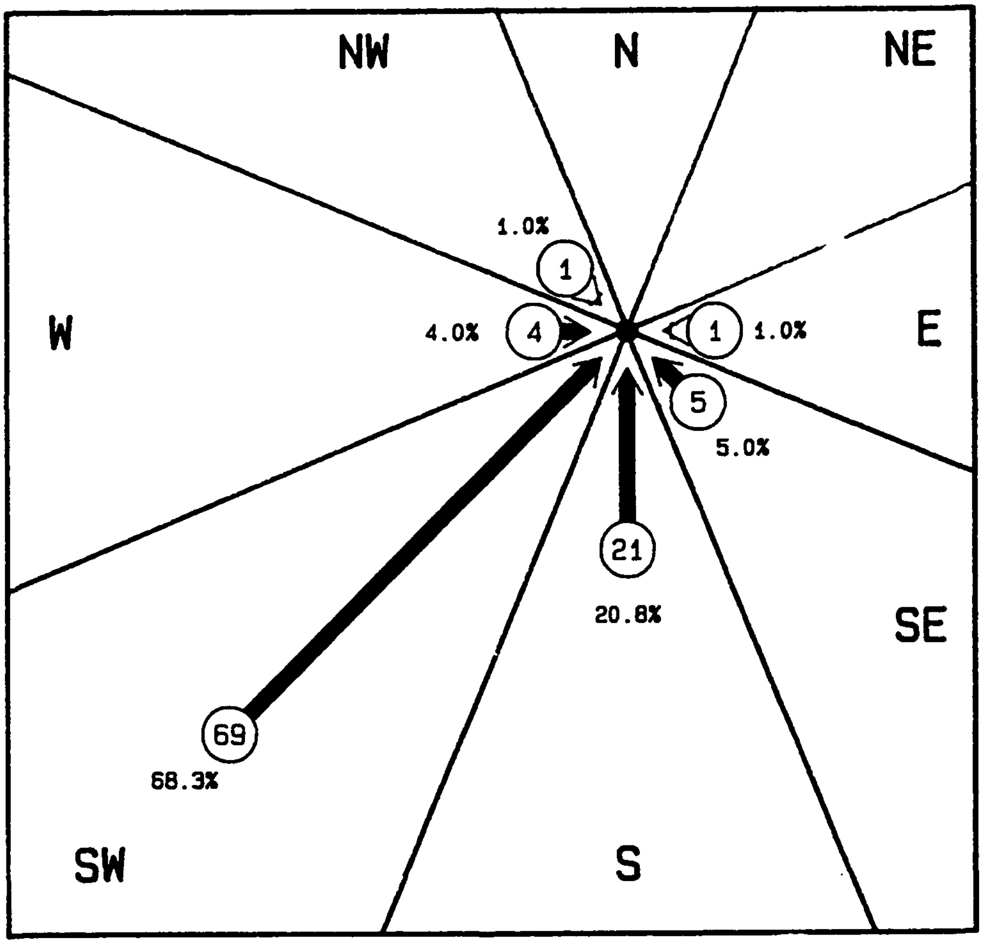

Figure V-123. Directions of approach for 101 tropical cyclones passing within 180 nmi of Maizuru during the 47-year period 1945-1991. Length of directional arrow is proportional to the number of storms given in the circles of each octant. Approach directions are determined at CPA.

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Figures V-124 through V-126 provide information on the probability of remote tropical storms and/or typhoons passing within 180 nmi of Maizuru and average time to CPA. The solid lines represent a 'percent threat' for any tropical cyclone location within the area depicted. The heavy dashed lines represent the approximate time in days for a system to reach Maizuru. For example, in Figure V-124, during the months of July and August a tropical cyclone located at 20°N 140°E has approximately a 20% probability of passing within 180 nmi of Maizuru and will reach Maizuru in about 4-1/2 to 6 days.

A comparison of the preceding figures shows some distinct differences in threat axes according to the time of year. For July and August (Figure V-124), the primary threat axis extends more-or-less southward from Maizuru to approximately 27°N before turning east-southeastward to a position near 20°N, 160°E. The September axis (Figure V-125) extends south-southwestward from Maizuru to approximately 28°N 131°E before turning southeastward to about 12°N 148°E. The threat axis for those storms forming during the least active period, October through June, extends southwestward from Maizuru to approximately 23°N 128°E before turning southeastward to more tropical latitudes.

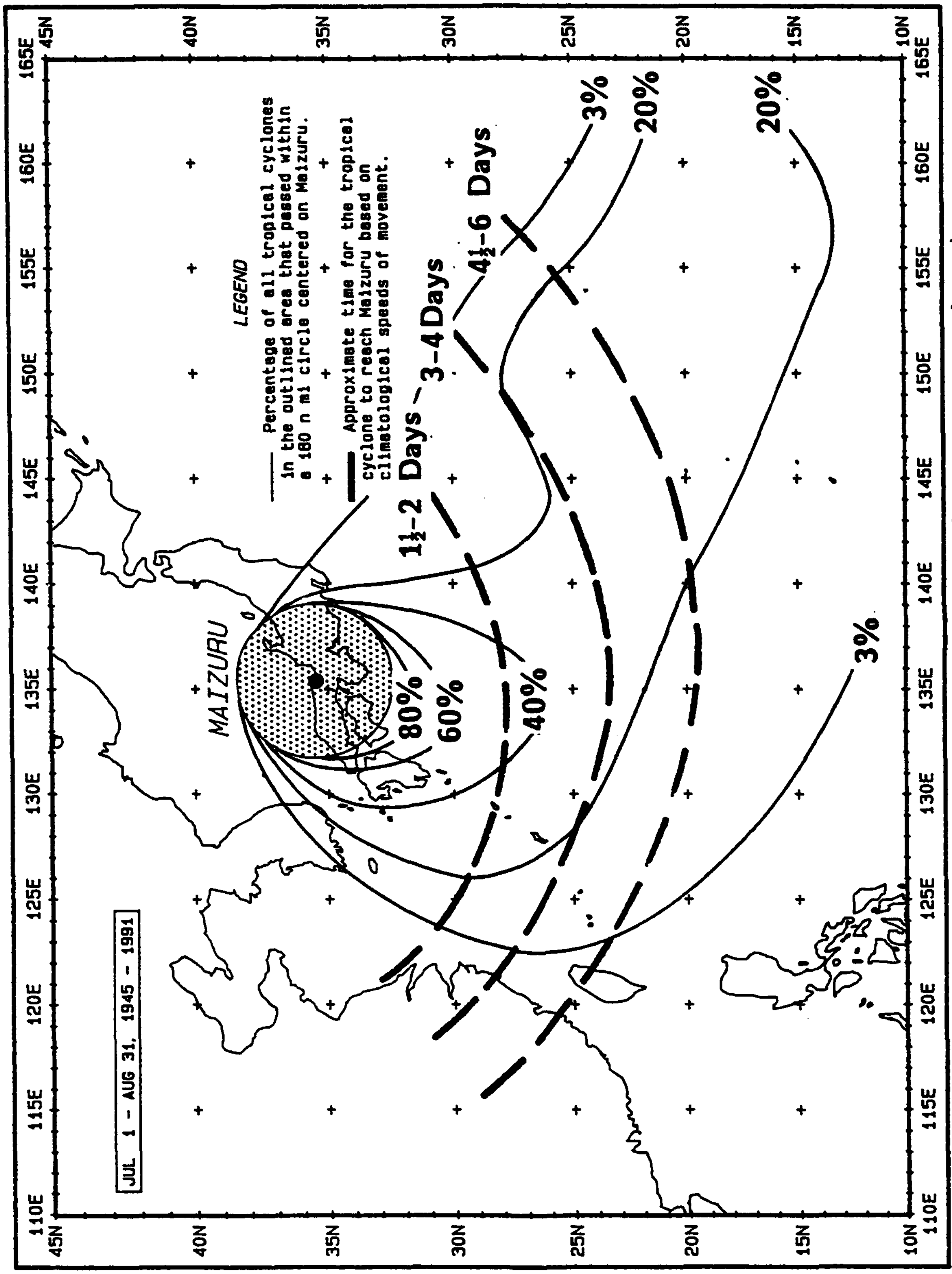

Figure V-124. Probability that a tropical storm or hurricane will pass within 180 nmi of Maizuru (circle), and approximate time to closest point of approach, during July and August (based on data from 1945-1991).

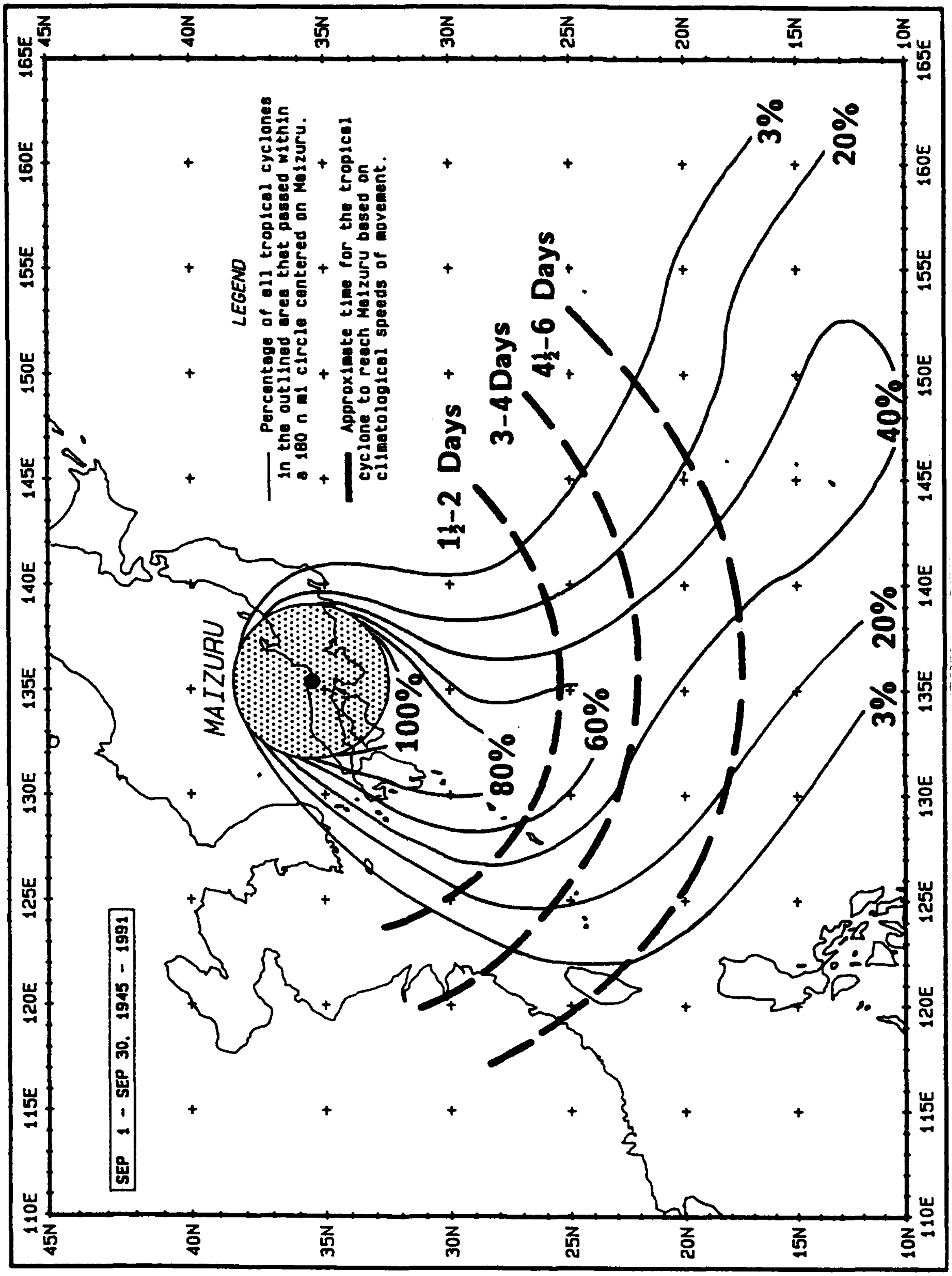

Figure V-125. Probability that a tropical storm or hurricane will pass within 180 nmi of Maizuru (circle), and approximate time to closest point of approach, during September (based on data from 1945-1991).

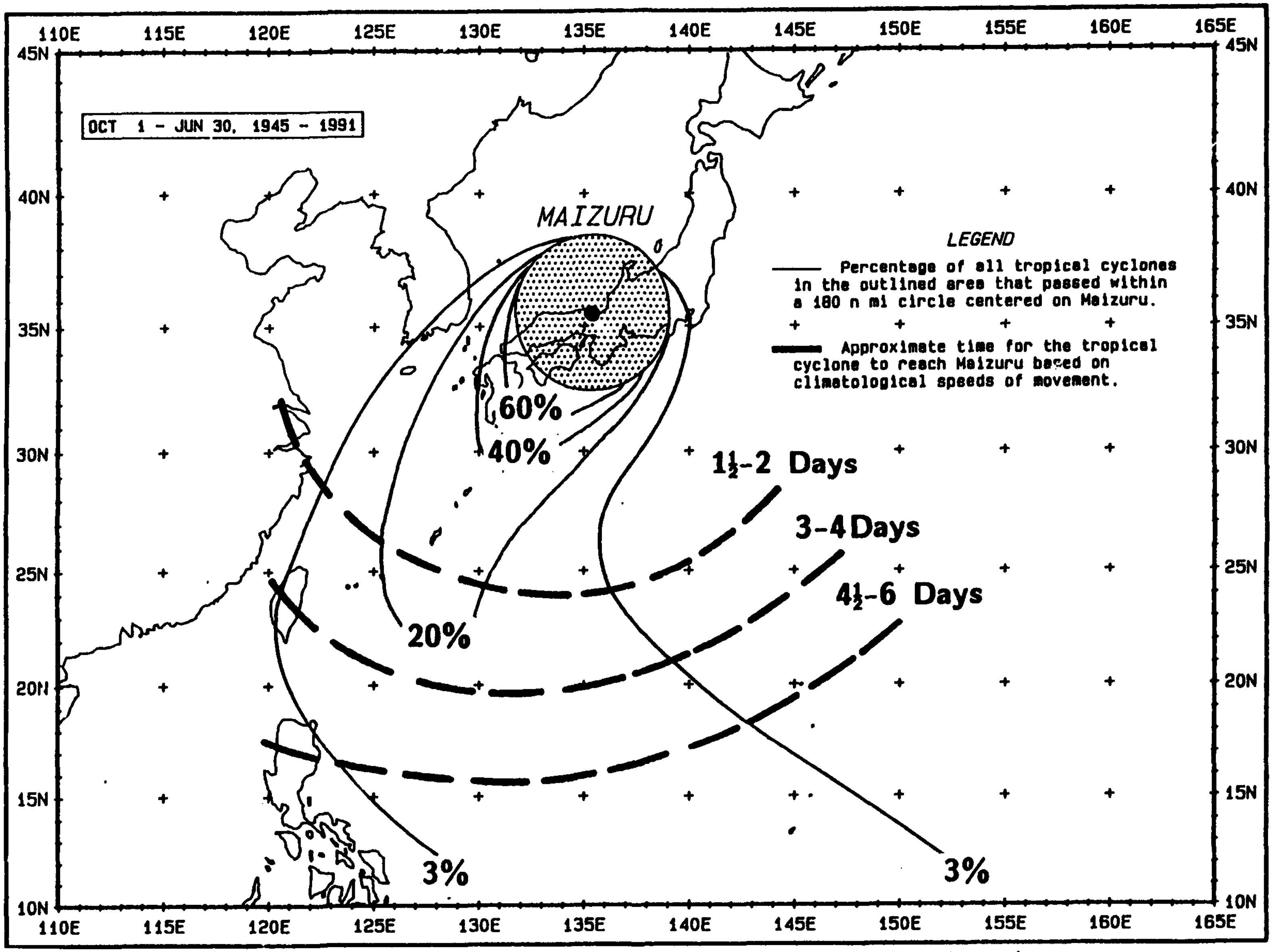

Figure V-126. Probability that a tropical storm or hurricane will pass within 180 nmi of Maizuru (circle), and approximate time to closest point of approach, during the period October through June (based on data from 1945-1991).

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Figures V-127 and V-128 show track segments of those tropical cyclones that caused sustained winds of ≥22kt and ≥34 kt at Maizuru. The figures show relatively few storms, attesting to the protection that the terrain around the port at Maizuru provides to the area. However, as discussed in Section 9.3.2

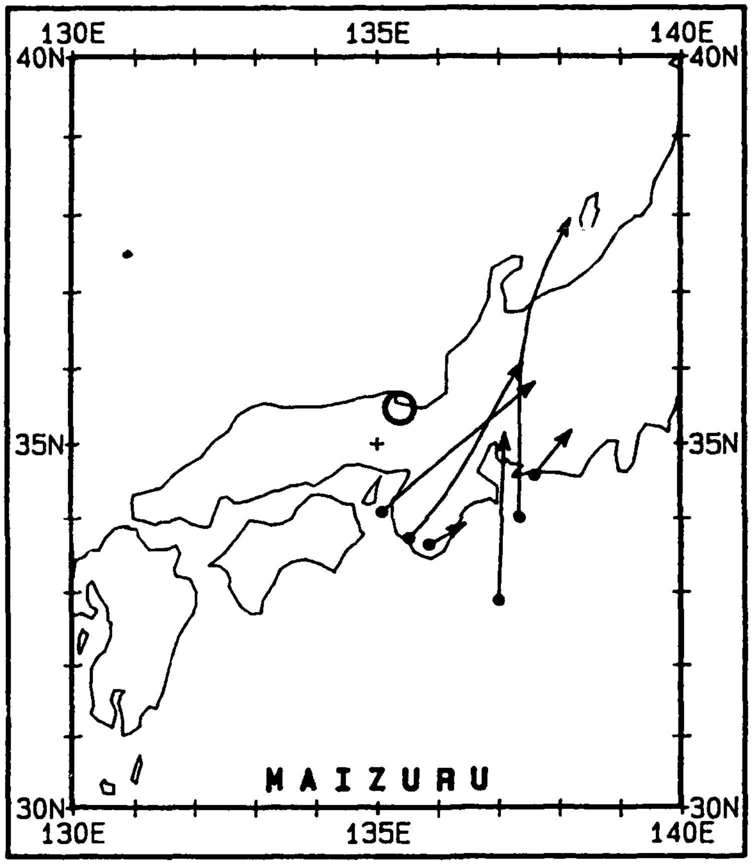

Figure V-127. Track segments of the 6 tropical storms or typhoons causing sustained winds of at least 22 kt at Maizuru during the 19-year period 1973-1991.

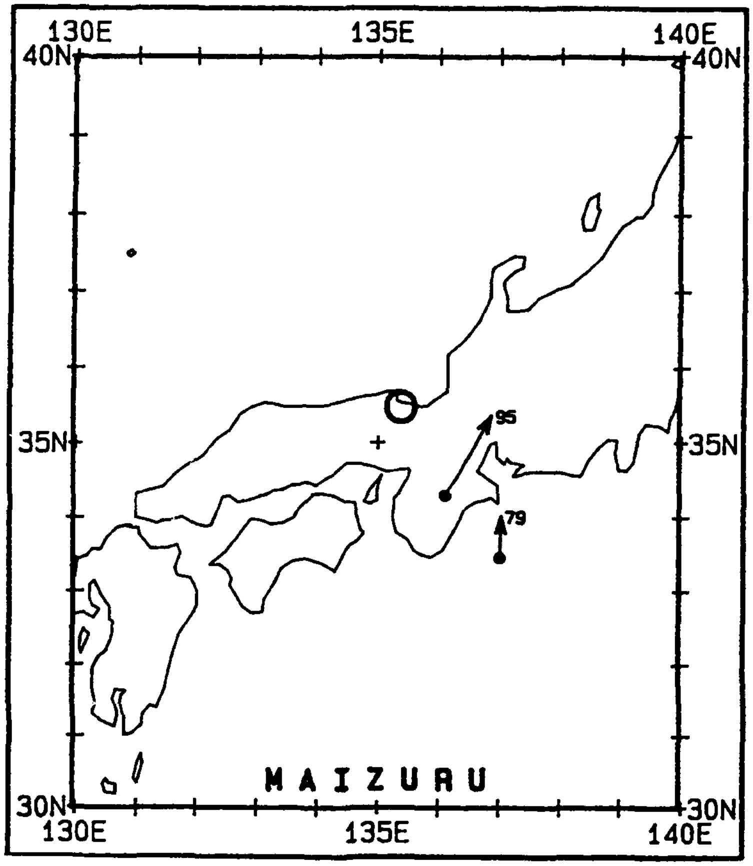

Figure V-128. Track segments of the 2 tropical storms or typhoons causing sustained winds of at least 34 kt at Maizuru during the 19-year period 1973-1991. Index numbers correspond to those given in Table V-28.

below, the exposure of the wind measuring equipment at the port may introduce a bias into the data because the equipment is more sheltered from southerly winds than northerly winds. It should be noted that all of the storms in each figure followed a track that passed east of Maizuru, resulting in northerly winds at the port.

9.3.2 Wind and Topographical Effects

The mountainous topography surrounding Maizuru greatly affects wind direction and velocity at the port. There are two valleys that may serve as channels for winds leading to the piers and anchorages. One is located north-northeast of East Harbor between peaks of 1,575 ft (480 m) and 1,824 ft (556 m), while the second is split into two valleys extending south and east from the southeast side of East Harbor. Each is oriented so that winds passing through them could reach East Harbor.

Wind measuring equipment at Maizuru is located about 150 yd south of the JMSDF piers atop the JMSDF building. Its exposure is considered by local personnel to be representative of northerly winds, but protected from and not representative of southerly winds. Local personnel state that the anchorage receives stronger winds than the pier area during periods of southerly flow, but records provided by JMSDF personnel indicate that the same may also be true for northerly winds. One case of record during a typhoon passage with the closest point of approach to be about 70 nmi southeast of Maizuru, showed peak winds at berth A-3 to be north-northeast 40 kt with gusts to 50 kt while winds at anchorage B-5 were north 50 kt. One hour later berth A-3 reported north-northeast 30 kt with gusts to 55 kt while anchorage B-5 reported north 50 kt with gusts to 88 kt.

Other records show similar differences for southeasterly winds. When a typhoon passed approximately 65 nmi northwest of Maizuru, berth A-5 experienced south-southeasterly 16 kt winds while anchorage B-2 recorded southeast 24 kt with gusts to 36 kt.

9.3.3 Local Weather Conditions

The data contained in Table V-30 has been selected from observations recorded at Maizuru during the passage of the tropical cyclones listed in the table.[1] It should be noted that no record of observations is available during the period 1945 through 1973.

Table V-30. Center data and related weather associated with selected tropical cyclone passages within 180 nmi of Maizuru during the 19-year period 1973-1991. No observational data are available for the period 1945-1972.

TYPHOON DATA				RELATED LOCAL WEATHER	
DATE (NAME)	MVMT DIR/SOA (KT)	DIR/CPA FM STAT (NMI)	CNTR WIND (KT)	MAX WIND & GUSTS (KT)	COMMENTS
79/09/30 OWEN	050/32	139/52	52	N 36	RAIN SHOWERS
82/08/01 BESS	360/34	079/86	53	N 35	RAIN SHOWERS
82/09/12 JUDY	001/26	095/26	60	NNE 33	RAIN SHOWERS
87/10/16 KELLY	026/29	281/10	58	NE 22	RAIN SHOWERS
90/09/19 FLO	029/25	114/68	75	N 43	RAIN SHOWERS
90/10/08 HATTIE	060/34	150/106	47	N 30G34	RAIN SHOWERS
90/11/30 PAGE	039/23	126/118	58	N 24	RAIN SHOWERS

Local wind conditions over the harbor area will vary from the official observation site. A few examples obtained during the port visit of 1992 are: During the passage of Typhoon Flo in September 1990, with a CPA of 68 nmi southeast of Maizuru, local records at the port showed peak winds at berth A-3 to be north-northeast 40 kt with gusts to 50 kt while winds at anchorage B-5 were north 50 kt. One hour later berth A-3 reported north-

[1]Based on hourly observations provided by Naval Oceanography Command Detachment, Asheville, NC.

northeast 30 kt with gusts to 55 kt while anchorage B-5 reported north 50 kt with gusts to 88 kt. Official records (Table V-30) reported considerably lower wind speeds.

Other records show similar differences for southeasterly winds. When an unidentified tropical cyclone passed approximately 65 nmi northwest of Maizuru, berth A-5 experienced south-southeasterly 16 kt winds while anchorage B-2 recorded southeast 24 kt with gusts to 36 kt.

9.3.4 Wave Action

The unique configuration of the port of Maizuru effectively eliminates any possibility of any significant open-ocean wave motion from reaching the East Harbor, and greatly reduces the fetch for wind-wave generation. Consequently, wave motion is not a significant problem in the harbor. According to U. S. Army Coastal Engineering Research Center (1973), with a 40 to 45 ft water depth and a fetch length of 9,000 ft, it would be possible for a 65 kt wind to generate waves of 5-6 ft in the anchorage area. The 9,000 ft fetch length is representative of the over-water distance to the middle of the harbor where the anchorage is located.

9.3.5 Storm Surge

Storm surge may be visualized as a raised dome of water, moving with the storm, and centered a few miles to the right of its path. The piling up of water on a coast ahead of a tropical storm or typhoon is more apparent in the dangerous semicircle, the region of most intense winds which is located to the right of the storm's direction of movement. The speed of the storm adds to the wind velocity generated by the mechanics of the storm itself.

The port of Maizuru is situated in an area that minimizes storm surge effects. Its location on the north coast of Honshu and the narrow entrance to both East and West Harbors make it unlikely that Maizuru will experience a damaging storm surge. Normal tidal range in the harbors is about 8 in (20 cm), with past storm related increases of only 6 in (15 cm) on top of the normal range.

9.4 THE DECISION TO EVADE OR REMAIN IN PORT

9.4.1 General

There is no U. S. Navy authority assigned to Maizuru, so decisions to evade or remain in port will necessarily be made independently by the ship's captain, in accordance with appropriate directives issued by higher authority.

9.4.2 Evasion Rationale

It is of utmost importance that the commander recognize the inherent dangers that exist when exposed to the possibility of hazardous weather. Proper utilization of meteorological products, especially the NOCC/JTWC Guam Tropical Cyclone Warnings, and a basic understanding of weather will enable the commander to act in the best interest of his unit, and complete his mission when the unfavorable weather subsides. To assist in preparation for the threat posed by an approaching tropical cyclone the following time/action sequence aid, to be used in conjunction with Figures V-129 to V-131, is provided.

I. An existing tropical cyclone moves into or development takes place in Area A with long range forecast movement toward Maizuru (recall that about 40% of all tropical storms and typhoons recurve):

a. Review material condition of ship.

b. Reconsider any maintenance that would render the ship incapable of riding out a storm or typhoon with the electrical load on ship's power, or would render the ship incapable of getting underway, if need be, within 48 hours.

c. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

II. Tropical cyclone enters Area B with forecast movement toward Maizuru (recall that prior to recurvature tropical cyclones tend to slow in their forward motion and after recurvature accelerate rapidly):

a. Reconsider any maintenance that would render the ship incapable of shifting to a berth or, if at a berth, moving to the anchorage or otherwise getting underway prior to the onset of strong winds within the harbor.

b. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

III. Tropical cyclone has entered Area C and is moving toward Maizuru:

a. Anticipate the arrival of the tropical cyclone winds and take appropriate actions.

b. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

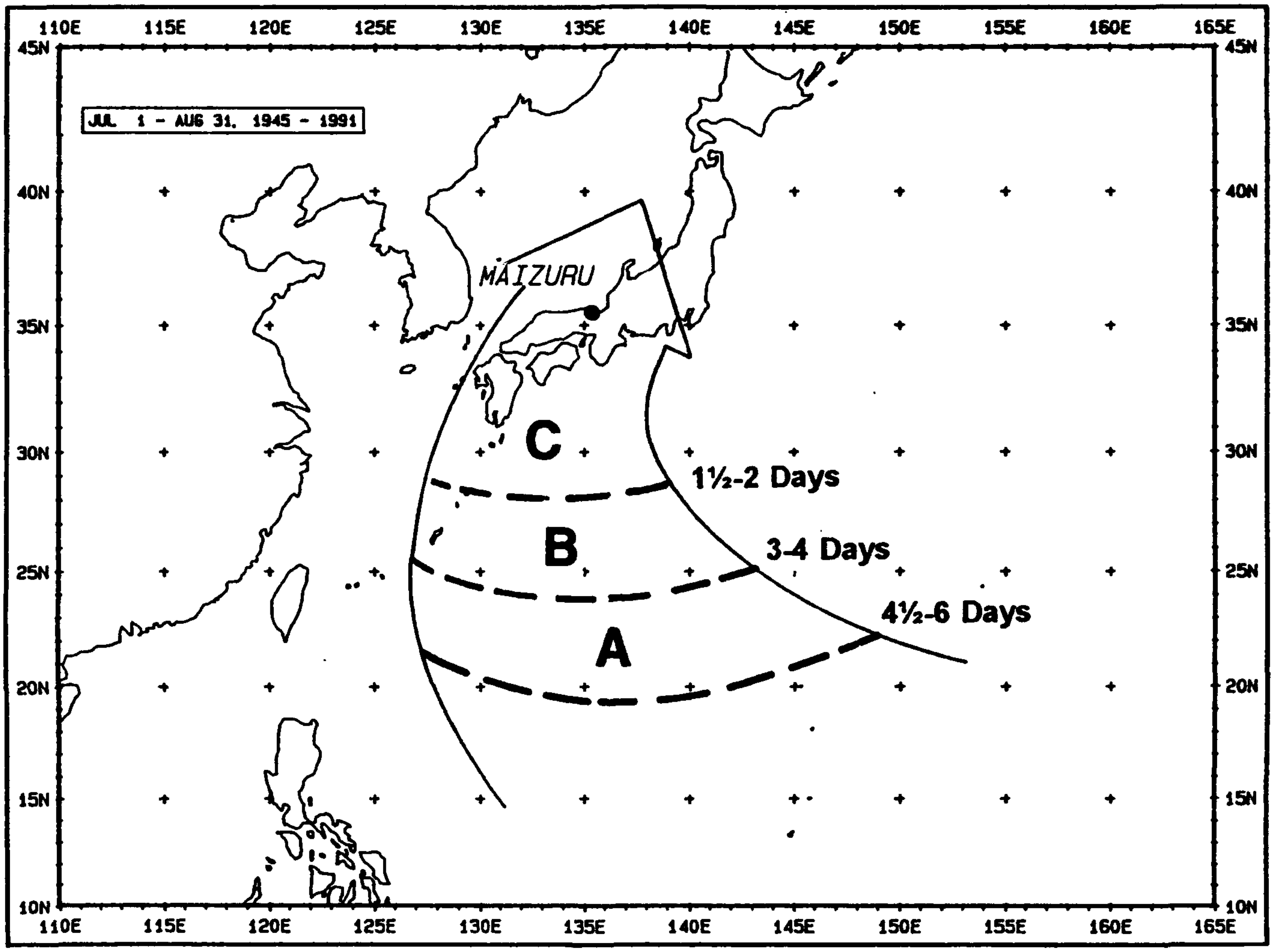

Figure V-129. Tropical cyclone threat axis for Maizuru for July and August.

MAIZURU

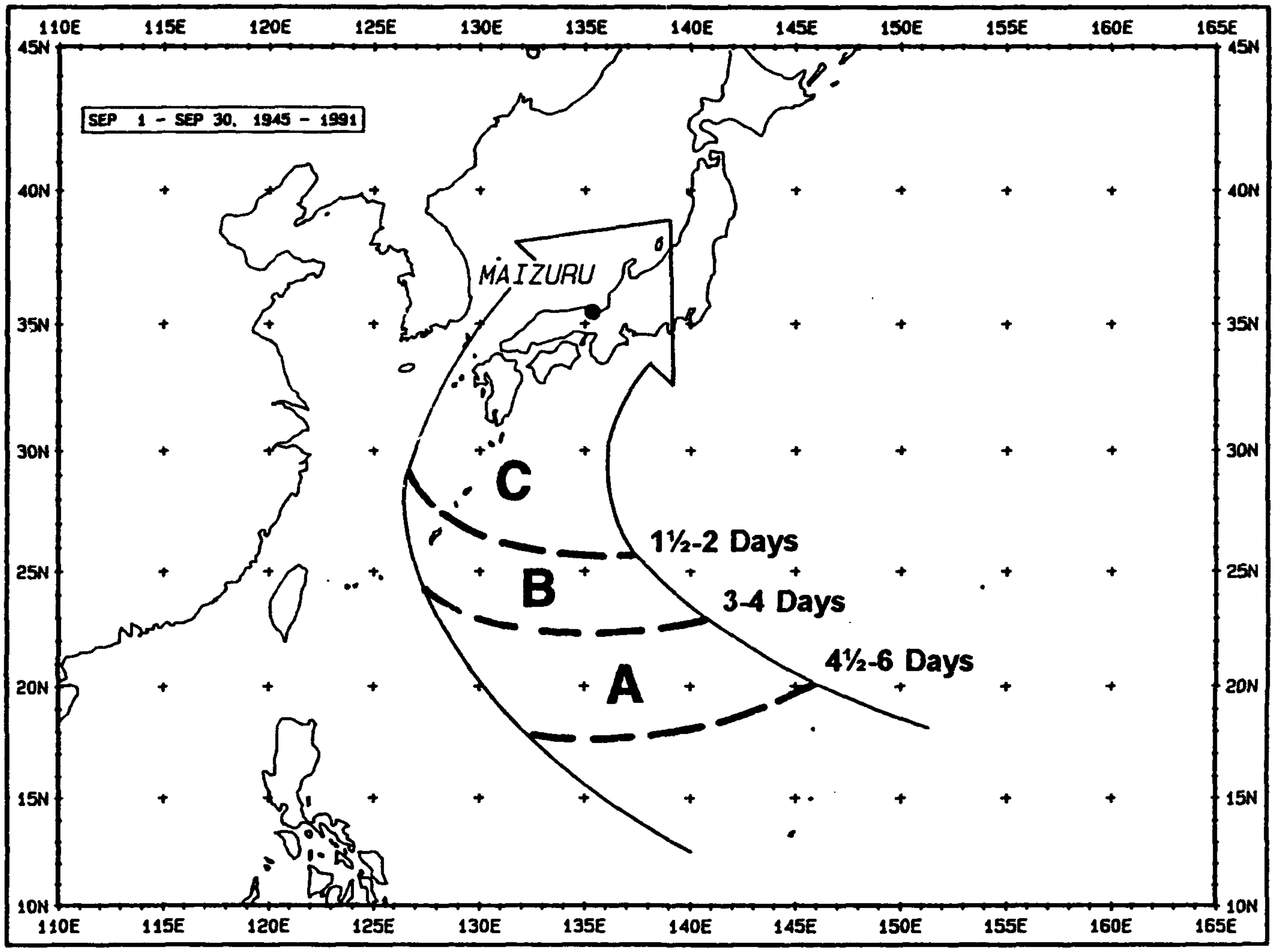

Figure V-130. Tropical cyclone threat axis for Maizuru for September.

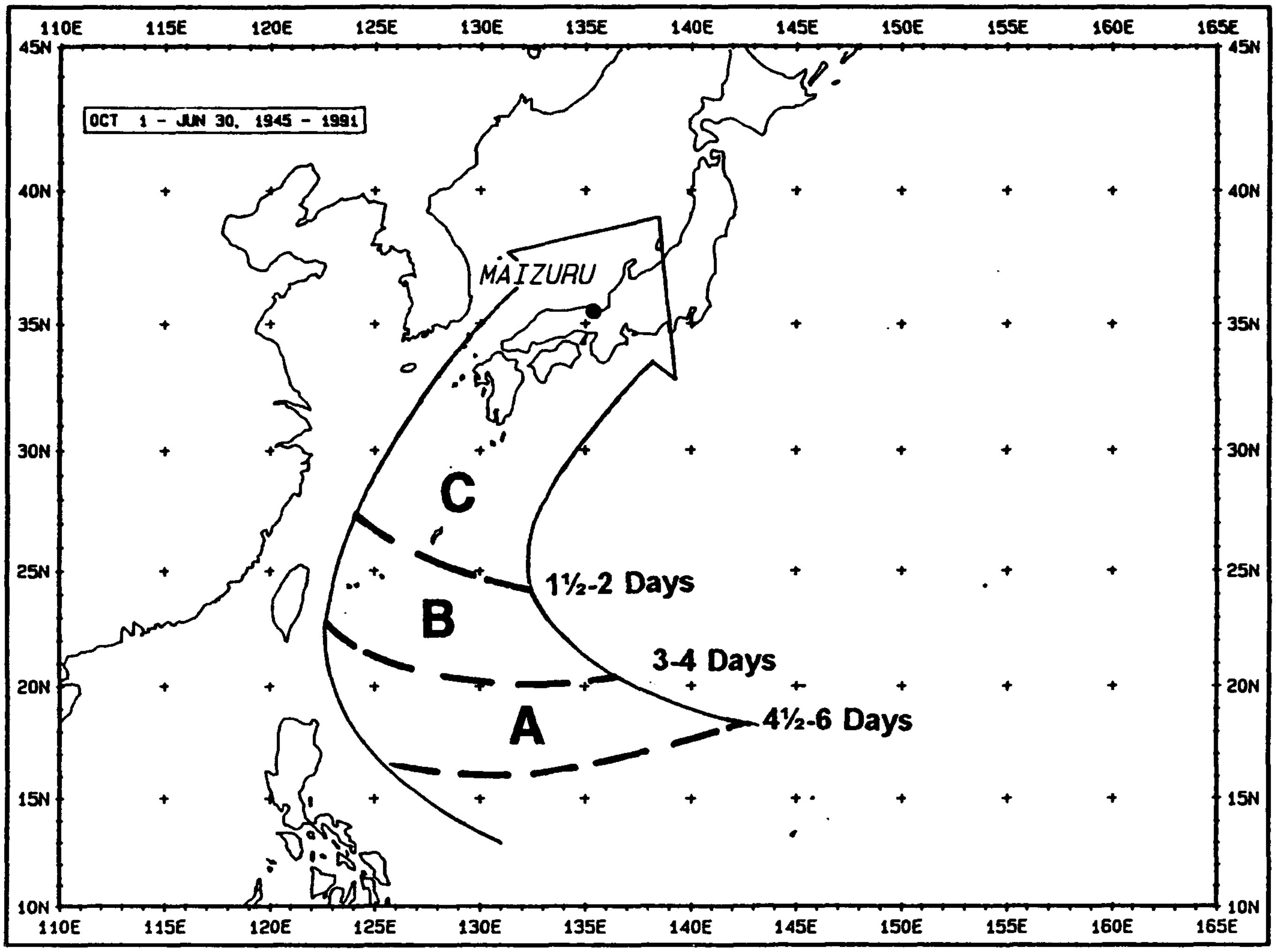

Figure V-131. Tropical cyclone threat axis for Maizuru for the period October through June.

A strong wind is the most important factor to be considered. Wave action has only limited effect in the port of Maizuru and storm surge effects are negligible.

9.4.3 Remaining in Port

The port of Maizuru is considered to be an adequate typhoon haven. Remaining in port is the recommended course of action when a tropical storm or typhoon threatens Maizuru. If more than one U. S. Navy ship is in port and berth A-5 is available, the largest vessel will be assigned to the berth and the smaller vessel(s) requiring shorter swinging room will be assigned to the anchorages.

The ship assigned to the berth should take normal precautions for high winds. Extra attention should be given to the brow and mooring lines during the passage of the storm. Ships should put out extra line and wire as deemed necessary and should be ready to tend mooring lines.

Vessels using the anchorage should have engines in standby in case they are needed to ease the strain on the chain and to keep the anchor from dragging in strong wind situations.

9.4.3 Evasion at Sea

Evasion at sea is not a recommended course of action, especially so if the tropical cyclone is forecast to pass west of Maizuru and enter the Sea of Japan. The Sea of Japan is essentially a closed basin with few evasion options and only three viable exits, including Tsushima Strait between Japan and Korea and Tsugaru Strait between the Japanese islands of Honshu and Hokkaido. The third exit, La Perouse Strait, located between Hokkaido and the Kurile Islands, is an additional 250 nmi and commensurate steaming time north of Tsugaru Strait.

If evasion is considered, evasion routes at sea may be developed by the use of the NOCC/JTWC Guam tropical cyclone warnings (see paragraphs 6 and 7 of Chapter I), Appendix A (the mean tropical cyclone tracks, track limits, and average speed of movements), and Figures V-129 to V-131 (tropical cyclone threat axis and approach times to Maizuru). In each specific case, Optimum Track Ship Routing (OTSR) should be consulted as to the best evasion route.

If a forecast track would take a tropical storm between Korea and Maizuru and ultimately into the Sea of Japan, a very early sortie would be required in order to avoid the storm's effects. Exiting the Sea of Japan via the Tsushima Strait is not an option since it may place the ship directly into the storm's track. There is no reasonable location in the Sea of Japan that would provide adequate sea room to avoid the effects of a tropical cyclone.

If a sortie were initiated well in advance of a storm's anticipated arrival, it would be possible for a ship to transit the approximate 420 nmi distance from Maizuru to the Tsugaru Strait and exit the Sea of Japan prior to the storm's arrival. However, the ship may still have to contend with the storm once the Pacific Ocean was reached. As can be seen in the preferred storm track figures in Section I, it would not be unusual for the storm to follow a track that would take it northeastward across the Sea of Japan to northern Japan. Also, it is the nature of tropical cyclones to accelerate after recurvature, and they may move at a rate that is 2 to 3 times faster than they were moving prior to recurvature. The storm track figures in Section I show that it is not uncommon for a storm to move at a 20-30 kt speed of advance (SOA), and some move faster. A late departure would hazard the ship by placing it in the potential path of the storm.

If a tropical cyclone has completed recurvature south of Japan and is already on an east or northeastward track that would place Maizuru on the relatively weaker left semicircle, it would be possible to sortie by moving west from Maizuru and exiting the Sea of Japan via the Tsushima Strait. Little would be gained by this option, however, since the storm would likely be relatively close to Maizuru by the time the recurvature was completed, and a sortie would most likely be in progress when the storm was at its closest point of approach (CPA).

Whichever option is chosen, ship captains should remember that tropical cyclones are historically unpredictable, especially in the recurvature phase. The 48-hour forecast position error may exceed 200 nmi. Consequently, the storm may be closer to or farther from Maizuru than the forecast indicates, or be right or left of its forecast track.

Port Visit Information

November 1992: NRL Meteorologists CDR R. G. Handlers, USN, and Mr. L. Phegley, and SAIC Meteorologist Mr. R. D. Gilmore met with JMSDF officers LCDR Takakua and LT Saimon to obtain much of the information included in this port evaluation.

10.0 MURORAN

SUMMARY

The conclusion reached in this study is that Muroran cannot be considered a typhoon haven. This conclusion is based on the following factors.

(1) The Sakimori area of the port, where U. S. Navy ships will likely moor, affords no protection from the full effects of strong winds.

(2) Although such occurrences have been rare, past history indicates that ships in the harbor are susceptible to damage if a particularly strong tropical cyclone should pass near the port.

Evasion at sea is the recommended course of action when a tropical cyclone approaches Muroran. Limited evasion options make an early sortie from the port the wise and safest course of action.

10.1 LOCATION AND TOPOGRAPHY

The port of Muroran is located at 42°21'N 140°58'E on the southern coast of the Japanese island of Hokkaido (Figure V-132).

Muroran Harbor is situated on the west side of and close to the end of a broadly pointed, southward extending peninsula that terminates in Chikyu Cape (Figure V-133). Muroran Harbor opens to the west into the waters of Uchiura Bay. Uchiura Bay is roughly circular in shape with an approximate 28 nmi diameter that is open southeastward to the Pacific Ocean through a 15 nmi opening between Chikyu Cape and Suna Point.

MURORAN

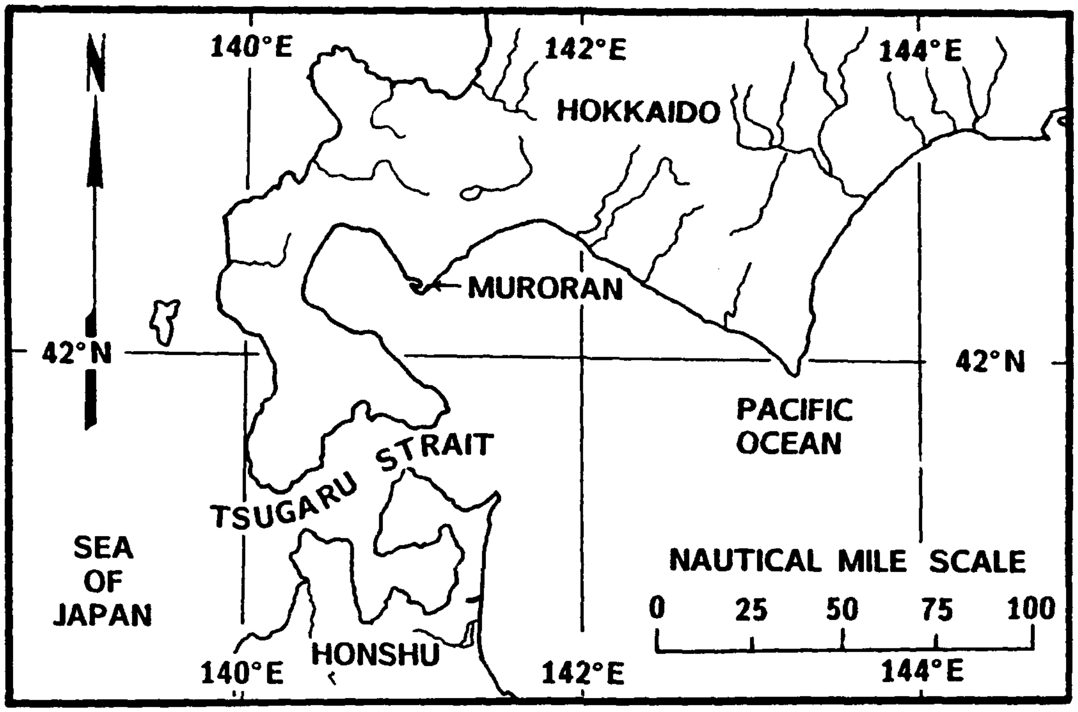

Figure V-132. Muroran location on Hokkaido south coast.

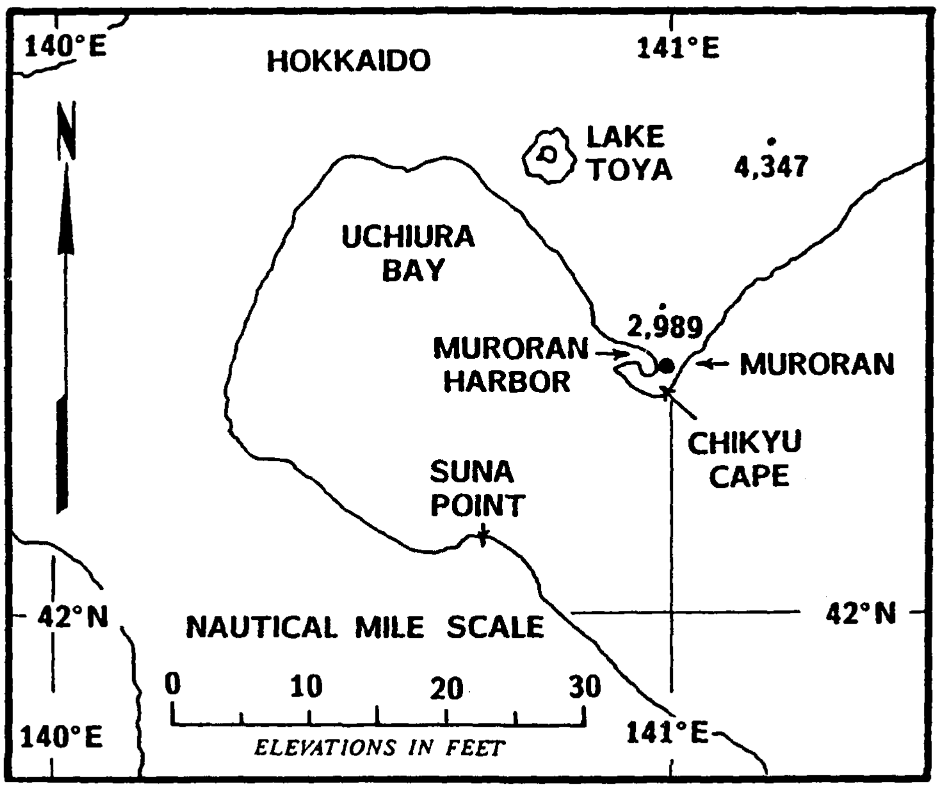

Figure V-133. Muroran harbor within Uchiura Bay.

The terrain of southern Hokkaido is mountainous. Elevations reach 2,989 ft (911 m) within 5 nmi north of the port, while some peaks reach 4,347 ft (1,325 m) less than 20 nmi to the northeast. Hills with elevations to 656 ft (200 m) are located on the small peninsula southwest of the harbor. The harbor area is open through the harbor entrance to Uchiura Bay on the west and low-lying terrain east of the port provides little protection. The terrain configuration near the port creates a natural channel for winds with westerly or easterly components.

10.2 MURORAN HARBOR

Muroran harbor is divided into three main sections: two inner divisions (Sections 1 and 2) and an outer division (Section 3). See Figure V-134. Section 3, where U. S. Navy ships will likely moor, is entered from the west via the main channel which leads through a 570 yd (521 m) opening between the outer breakwaters. Access to the inner harbors is gained through a 315 yd (288 m) wide opening between two breakwaters located about 1.35 nmi east of the outer harbor entrance. As of November 1992, a large suspension bridge was under construction across the harbor at the approximate location of the inner breakwaters. When completed, the bridge towers will be 459 ft (140 m) high and the bridge deck will have a 197 ft (60 m) vertical clearance.

The outer harbor, Section 3, is of primary interest to U. S. Navy ships. Sakimori berths 1 and 2, just east of the northern-most outer breakwater, have been assigned to and used by U. S. Navy ships during the two most recent visits (as of November 1992). Discussions with harbor personnel indicate that the same berths would likely be assigned during future visits. The same harbor personnel state that the berths are in good repair, and

MURORAN

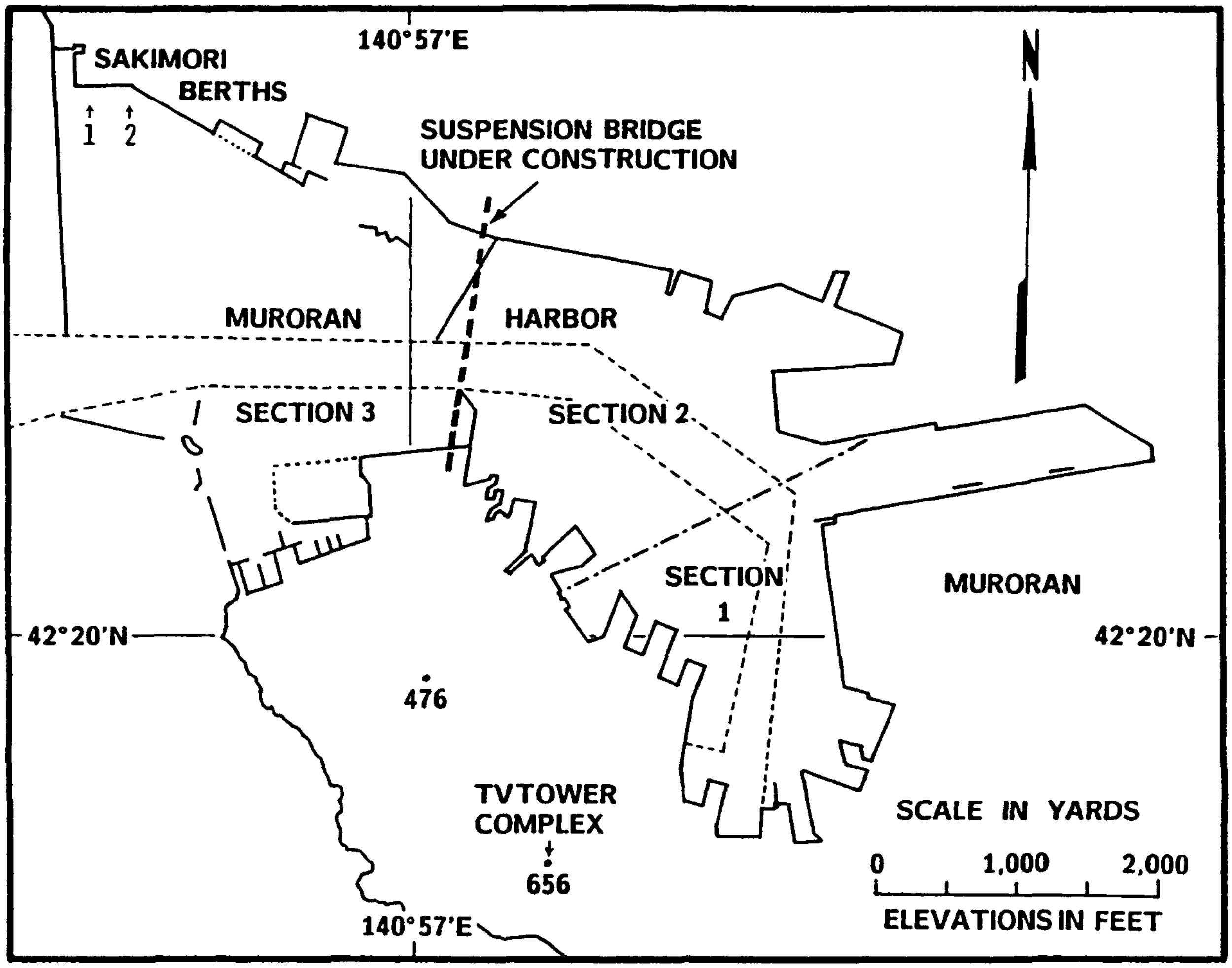

Figure V-134. Muroran harbor.

rubber fenders are attached to the face of the pier. A ship visiting the port in 1987 reported that neither steam nor electricity was available at the pier. Most of the piers in Muroran harbor are privately owned and not available for use by transient U. S. Navy ships.

The harbor channel is dredged to a depth of 54 ft (16.5 m) from the outer harbor entrance through Section 2 of the inner harbor. Water depths outside the channel are generally 33 to 49 ft (10 to 15 m) in the north part of the outer harbor and vary from 56 ft (17 m) to less than 10 m (33 ft) south of the channel. Inner harbor depths vary from 43 to 49 ft (13 to 15 m) near the channel to less than 20 ft (6 m) near many of the piers.

Tides at the port aren't significant since, according to DMA Chart 96949, the level of the spring rise is only 1.3 ft (0.4 m) above mean sea level.

According to local harbor personnel, Muroran is regarded by merchant seamen to be "the best port in Hokkaido." It is a heavy industrial port, with an ironworks, a petroleum refinery, and other similar enterprises bordering the harbor. The port has the related necessary equipment and machinery associated with such use, including several heavy-lift cranes, both mobile and fixed. The Hakodate dock company has a dry dock with a reported capacity of 28,000 DWT on the south side of inner harbor Section 2. Narasaki Shipbuilding Company has facilities to repair small vessels.

10.3 TROPICAL CYCLONES AFFECTING MURORAN

10.3.1 Tropical Cyclone Climatology at Muroran

Tropical cyclones which affect Japan generally form in the area bounded by 5°N to 30°N and 120°E to 165°E. The latitudinal boundaries shift poleward during the summer months and then equatorward in winter in response to the seasonal changes of the synoptic environment. The same genesis area is true for the storms affecting Muroran, but the northerly location of Muroran significantly reduces the number of tropical cyclones approaching within 180 nmi of the port. Many have lost or are rapidly losing their tropical characteristics and becoming extratropical by the time they reach CPA.

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For the purpose of this study, any tropical storm or typhoon approaching within 180 nmi of Muroran is considered to represent a threat to the port. Table V-31 contains a descriptive history of all tropical storms and typhoons passing within 180 nmi of Muroran during the 47-year period 1945-1991.

Table V-31. Descriptive history of the 39 tropical storms and typhoons passing within 180 nmi of Muroran during the 47-year period 1945-1991.

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAXIMUM WIND AT STORM CENTER	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
1	KITTY	1949	SEP	1	9	43	46 (WNW)	022/34.5
2	JANE	1950	SEP	3	8	43	37 (ESE)	042/29.7
3	KEZIA	1950	SEP	14	9	52	23 (S)	078/52.6
4	KAREN	1952	AUG	19	8	40	47 (N)	085/22.0
5	TESS	1953	SEP	26	15	50	123 (SE)	039/29.5
6	KATHY	1954	SEP	8	9	35	84 (NW)	030/41.9
7	MARIE	1954	SEP	26	12	62*	56 (W)	009/34.1
8	LOUISE	1955	SEP	30	15	70	15 (WNW)	051/33.9
9	BABS	1956	AUG	18	9	30	46 (WSW)	012/11.1
10	BESS	1957	SEP	7	9	38	87 (SSE)	069/36.2
11	ALICE	1958	JUL	23	9	50	73 (ESE)	032/33.8
12	GEORGIA	1959	AUG	14	7	55	176 (W)	354/37.5
13	SARAH	1959	SEP	18	14	70	23 (NNW)	044/26.2
14	VERA	1959	SEP	27	15	75	120 (SSE)	065/32.2
15	VIRGINIA	1960	AUG	12	10	63*	112 (SSE)	072/46.4
16	DELLA	1960	AUG	30	16	55	160 (WNW)	028/30.7
17	NANCY	1961	SEP	16	18	65	30 (SW)	015/58.8
18	NORA	1962	AUG	3	8	35	90 (SSW)	106/31.7
19	THELMA	1962	AUG	27	14	30	64 (SSE)	079/24.0
20	SHIRLEY	1963	JUN	20	4	46	35 (NNW)	073/21.7
21	KATHY	1964	AUG	25	15	40	146 (SSE)	074/30.3
22	WILDA	1964	SEP	25	24	43	120 (SE)	051/56.4
23	JEAN	1965	AUG	6	16	58	157 (WNW)	010/40.5
24	SHIRLEY	1965	SEP	10	24	58*	48 (WNW)	036/33.1
25	TRIX	1965	SEP	18	25	60*	78 (ESE)	032/41.7
26	IDA	1966	SEP	25	23	50	151 (SE)	046/49.6
27	DINAH	1967	OCT	28	30	48	165 (SE)	050/27.9
28	WILDA	1970	AUG	15	8	45	58 (WNW)	029/38.4
29	ANITA	1970	AUG	22	9	45	157 (W)	031/24.5
30	HELEN	1972	SEP	20	20	19	2 (E)	067/ 8.7
31	OWEN	1979	OCT	1	19	35	159 (SSE)	036/47.0
32	TIP	1979	OCT	19	23	52	178 (SE)	042/73.3
33	THAD	1981	AUG	23	15	49	22 (N)	006/49.3
34	ROGER	1989	AUG	28	20	40	18 (SE)	022/17.4
35	WINONA	1990	AUG	10	12	45	169 (SE)	042/25.9
36	ZOLA	1990	AUG	23	14	45	41 (SSE)	071/34.7
37	FLO	1990	SEP	20	20	52	169 (SSE)	065/34.9
38	PAGE	1990	DEC	1	29	45	178 (S)	010/24.2
39	MIREILLE	1991	SEP	27	21	63*	63 (SSE)	048/58.5

NOTES:
Datetimes are in UTC, winds are in knots, distances are in nautical miles. Parenthetical expression in column 8 gives bearing of storm from site at closest point of approach to site (CPA). Maximum winds are at time of CPA and did not necessarily occur at site. Asterisk (if any) after maximum wind indicates that storm was classified as a typhoon (at least 64 kts) somewhere within 180 nautical mile radius of site but not at CPA. Site location is 42.3°N, 140.9°E.

As can be noted from the table, comparatively few storms retaining tropical characteristics affect Muroran; only 39 storms approached within the 180 nmi radius of Muroran, as compared to the 115 storms that entered the 180 nmi threat radius around Yokosuka during the same period. Of the total number (39) of storms listed in the table, only 4 were of typhoon strength when at CPA to Muroran. All of the tropical cyclone statistics used in this report for storms passing within 180 nmi of Muroran are based on the SAIC generated data set used to compile Table V-31.

Historically, tropical cyclones have occurred in all months in the genesis area described in a preceding paragraph, but the primary tropical cyclone season for Muroran is more narrowly defined. As shown in Table V-32, a few tropical cyclones have affected the port as early as June and July (1 each month), and as late as December (1), but the primary tropical cyclone season for Muroran is during August and September. The same table shows the motion history of the 39 storms that passed within 180 nmi of Muroran during the 47-year period 1945 through 1991. It is interesting to note the relatively fast movement of the storms included in the table; those storms reaching CPA in September had an average speed of 39 kt while the average heading and speed of all storms entering the 180 nmi radius circle during the 47-year period was 042° at 35 kt. The fast movement is due to the influence of the upper-level westerlies as the tropical cyclone moves north and eastward toward higher latitudes.

During the 47-year period from 1945 through 1991 there were only 39 tropical storms and typhoons that met the 180 nmi threat criterion for Muroran, an average of less than one per year. Figure V-135 shows the monthly distribution of the 39 storms by 7-day periods. The period of peak activity extends from early August through September, but the occurrence of typhoon strength storms has been limited to the last 21 days of September.

Table V-32. Frequency of motion of the 39 tropical storms and typhoons passing within 180 nmi of Muroran during the 47-year period 1945-1991.

Total number of storms passing within 180 n mi	0	0	0	0	0	1	1	15	18	3	0	1	39
Number of storms having at least typhoon intensity at CPA	0	0	0	0	0	0	0	0	4	0	0	0	4
Number of storms less than typhoon intensity at CPA	0	0	0	0	0	1	1	15	14	3	0	1	35
Average heading (degs) towards which storms were moving at CPA	---	---	---	---	---	*	*	043	041	*	---	*	042
Average storm speed (knots) at CPA	---	---	---	---	---	*	*	30	39	*	---	*	35
Month when storm was at CPA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR

** indicates insufficient storms for average direction and speed computations.*

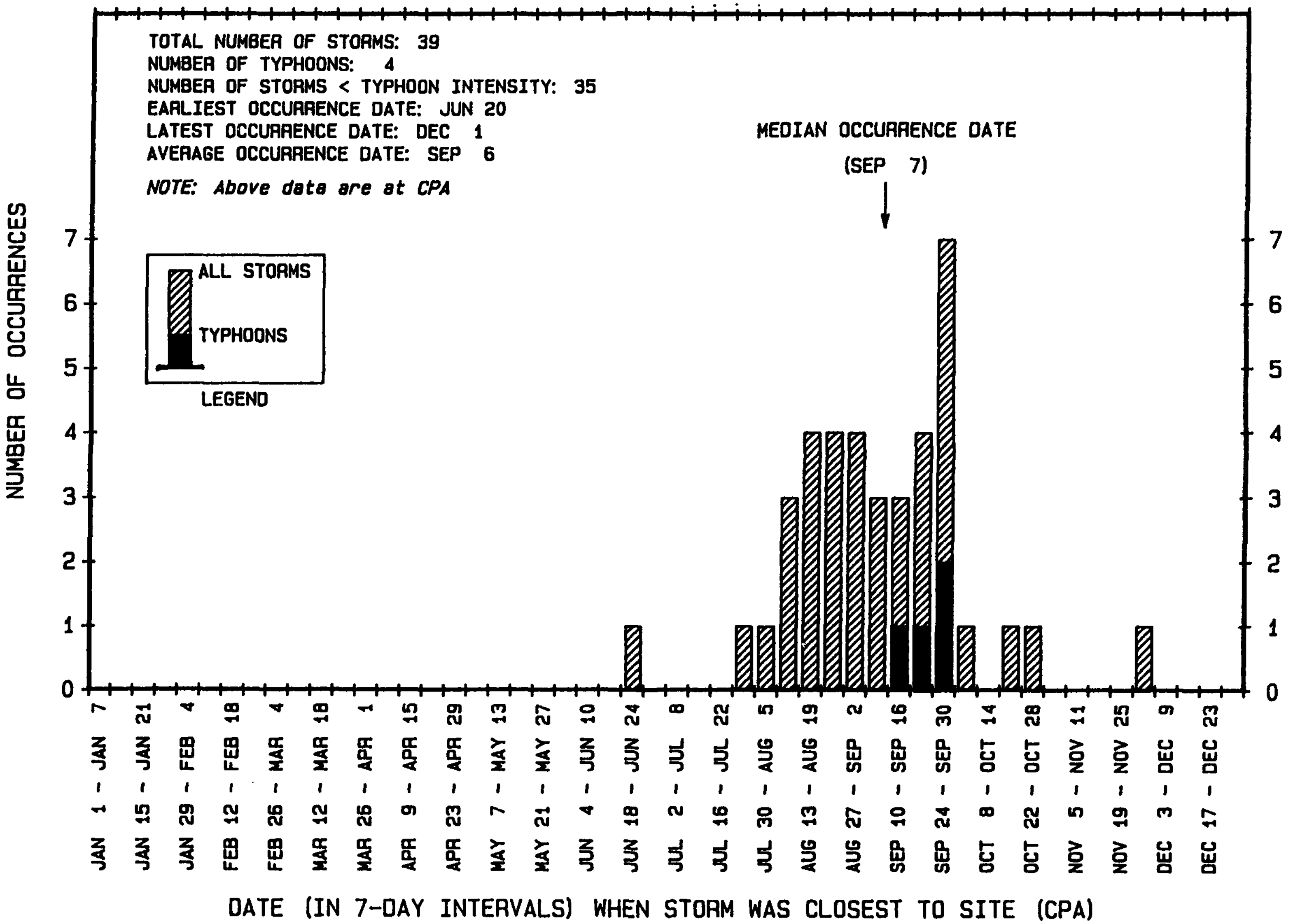

Figure V-135. Monthly distribution of the 39 tropical storms and typhoons passing within 180 nmi of Muroran during the 47-year period 1945-1991.

MURORAN

Figure V-136 shows the annual distribution of tropical storms and typhoons passing within 180 nmi of Muroran during the 47-year period 1945 through 1991. As can be seen in the figure, there were few years in the 1950's and 1960's that had no occurrences, but since the early 1970's, there have been several years when no tropical storm or typhoon approached within 180 nmi of Muroran. No typhoon strength storm affected Muroran during the 1962-1991 period.

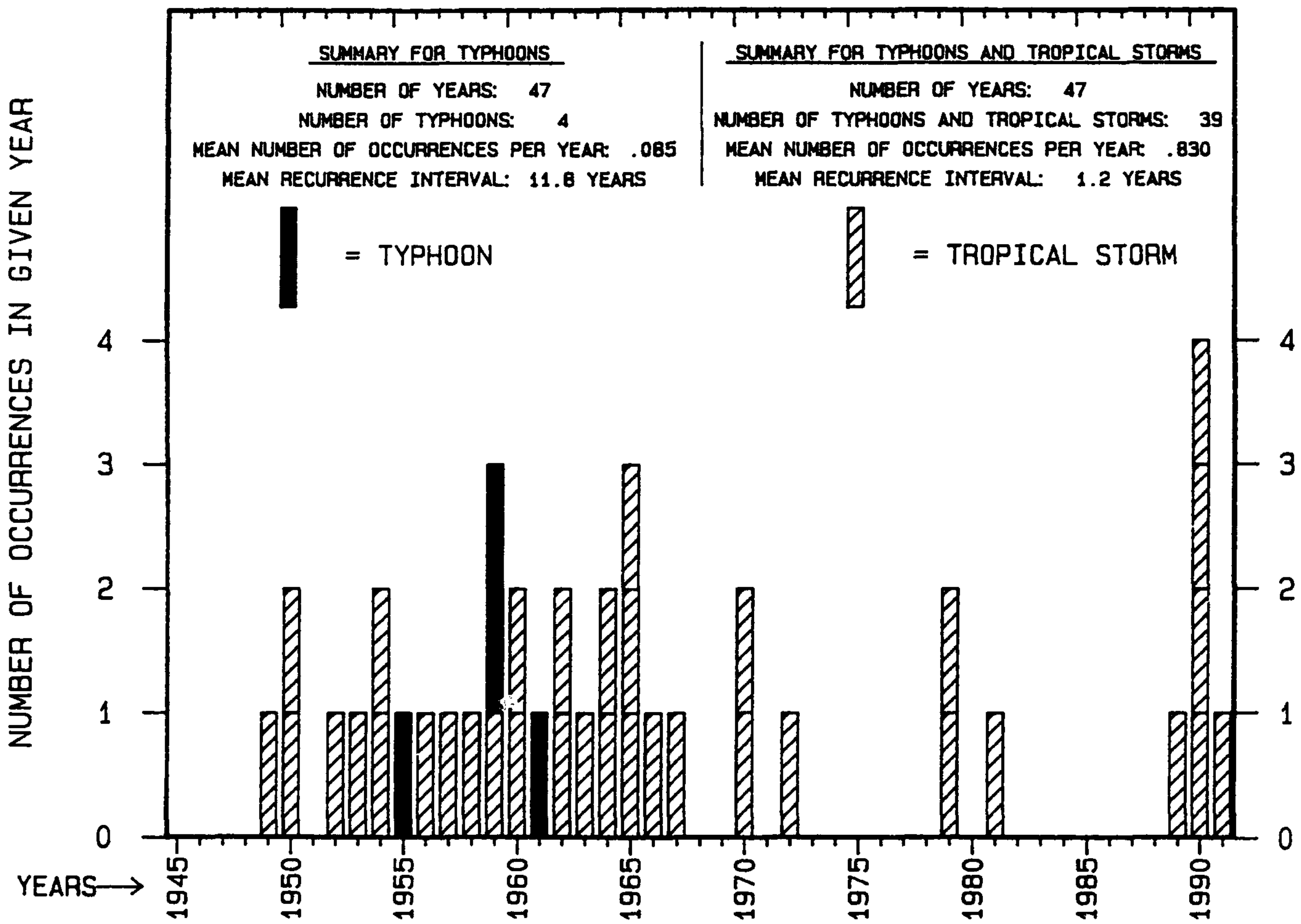

Figure V-136. Chronology of the 39 tropical storms and typhoons passing within 180 nmi of Muroran during the 47-year period 1945-1991. Storm intensity is determined at time of closest point of approach (CPA) to Muroran.

Figure V-137 presents a graphical depiction of the number of tropical cyclones versus CPA. The storm classification is based on the maximum wind near the storm center while that center was within 180 nmi of Muroran, not necessarily at CPA. The sloping lines represent mathematical fits to the data points for the various intensity classifications. The average radii of maximum wind for 34, 100, and 140 kt tropical cyclones at Muroran are 37.6, 36.0, and 33.1 nmi, respectively.

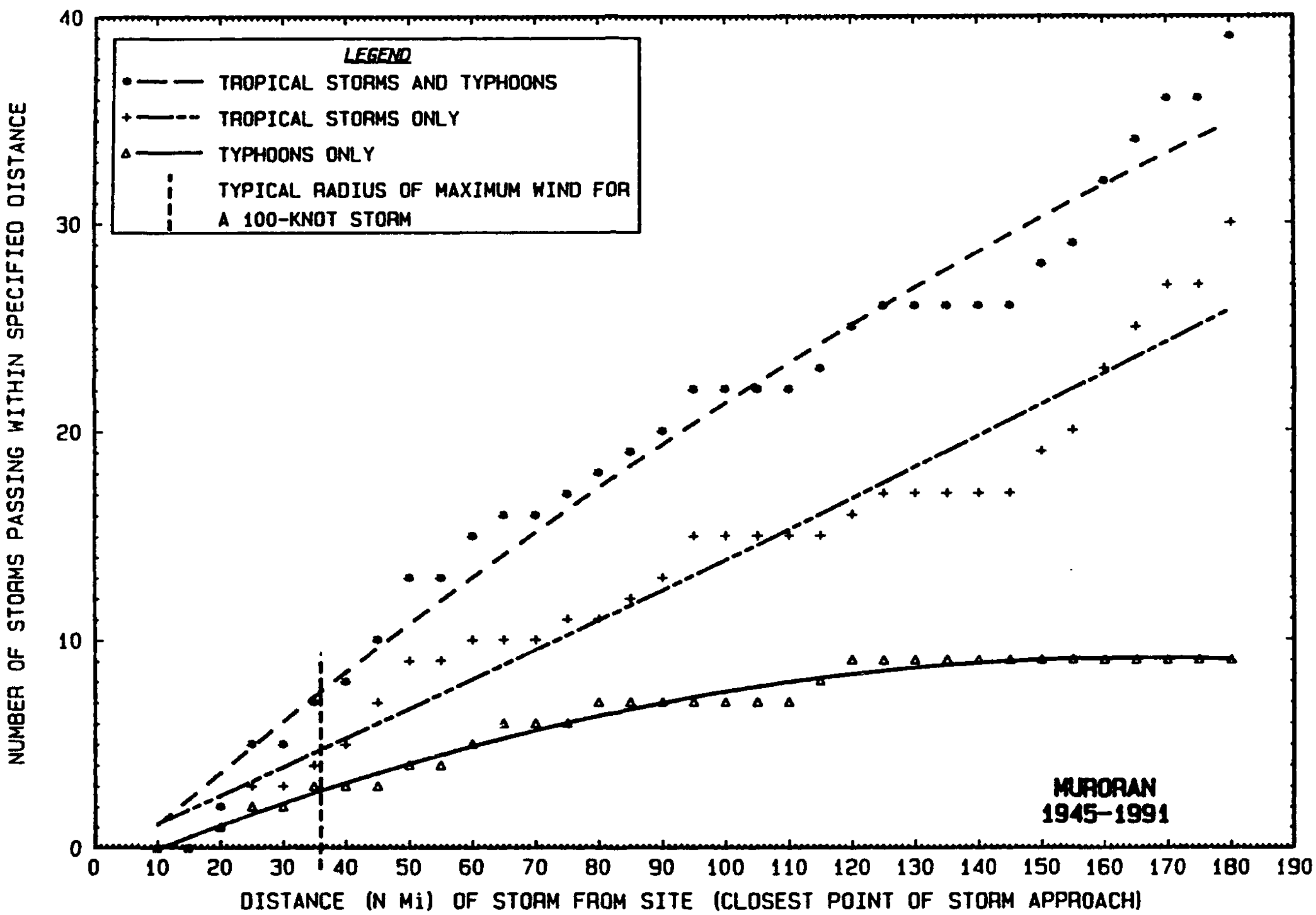

Figure V-137. Number of tropical cyclones passing at various distances from Muroran during the 47-year period of record. Tropical storm or typhoon classification is based on maximum wind near storm center while that center was within 180 nmi of Muroran, and not necessarily at CPA. Sloping lines represent mathematical fit to data points. Average radii of maximum wind for 34, 100, and 140 kt storms at Muroran are 37.6, 36.0, and 33.1 nmi respectively.

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Figure V-138 depicts, on an 8-point compass, the octants from which the 39 tropical cyclones in the data set approached Muroran. Over one-half of the storms, 21 of 39, were moving from the southwest octant. Approximately one-fourth (9 of 39) were moving from the south octant, and an equal number were moving from the west octant. It should be noted that the approach direction is determined at CPA, and may not represent the initial approach direction of the tropical storm or typhoon toward Muroran.

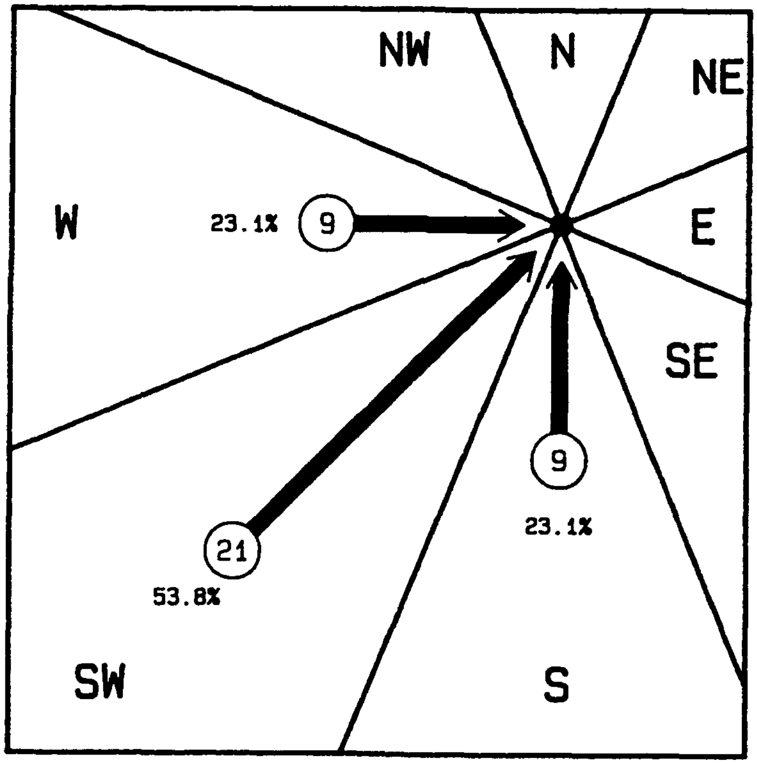

Figure V-138. Directions of approach for the 39 tropical cyclones passing within 180 nmi of Muroran during the 47-year period of record. Length of directional arrow is proportional to the number of storms given in the circles of each octant. Approach directions are determined at CPA.

Figures V-139 and V-140 provide information on the probability of remote tropical storms and/or typhoons passing within 180 nmi of Muroran and average time to CPA. The solid lines represent a 'percent threat' for any tropical cyclone location within the area depicted. The heavy dashed lines represent the approximate time in days for a system to reach Muroran. For example, in Figure V-139, during the months of July and August a tropical cyclone located at 30°N 135°E has approximately a 20% probability of passing within 180 nmi of Muroran and will reach Muroran in about 1-1/2 to 2 days.

As can be seen in the preceding figures, there is little difference in the threat axes for tropical cyclones of July and August versus all other months for Muroran. There is a slight difference in the orientation of the axes southwest of Muroran, with the July and August storms tending to approach from a more southwesterly direction. After the threat axes cross southwestern Honshu, they both tend to turn near 30°N to the south and then southeastward toward lower latitudes. Of the 39 storms in the data set used to construct the figures, 4 passed over Korea and 2 passed through Tsushima Strait between Korea and Japan before crossing the Sea of Japan and entering the 180 nmi threat radius around Muroran. The 33 others crossed the main Japanese islands of Kyushu, Shikoku and/or Honshu before approaching Muroran. The July and August storms show a stronger tendency to follow a track over the Sea of Japan, while the storms occurring during the September through June period tended to follow the western coast of Honshu or travel over the land mass of Honshu while approaching the 180 nmi threat circle.

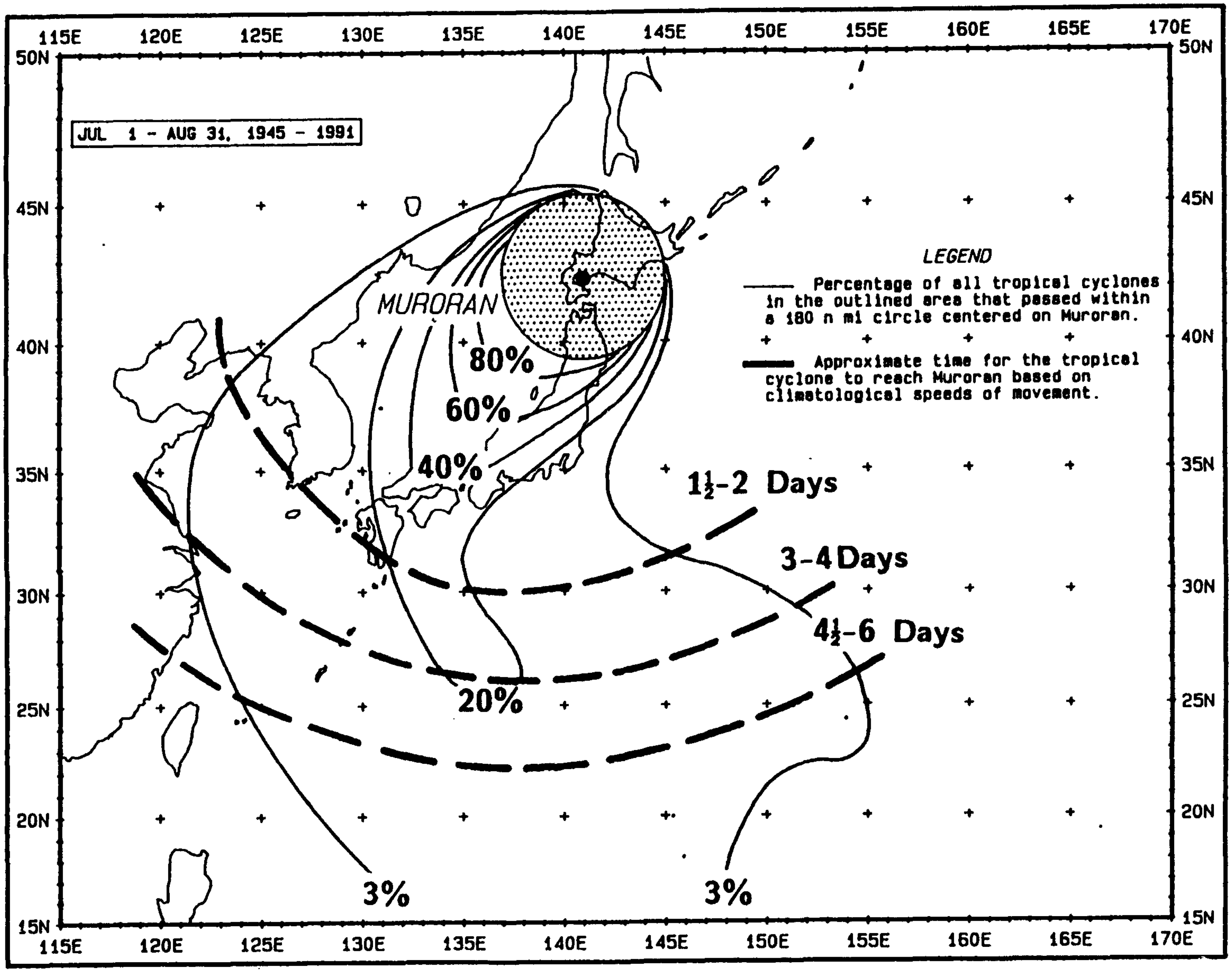

Figure V-139. Probability that a tropical storm or hurricane will pass within 180 nmi of Muroran (circle), and approximate time to closest point of approach, during July and August (based on data from 1945-1991).

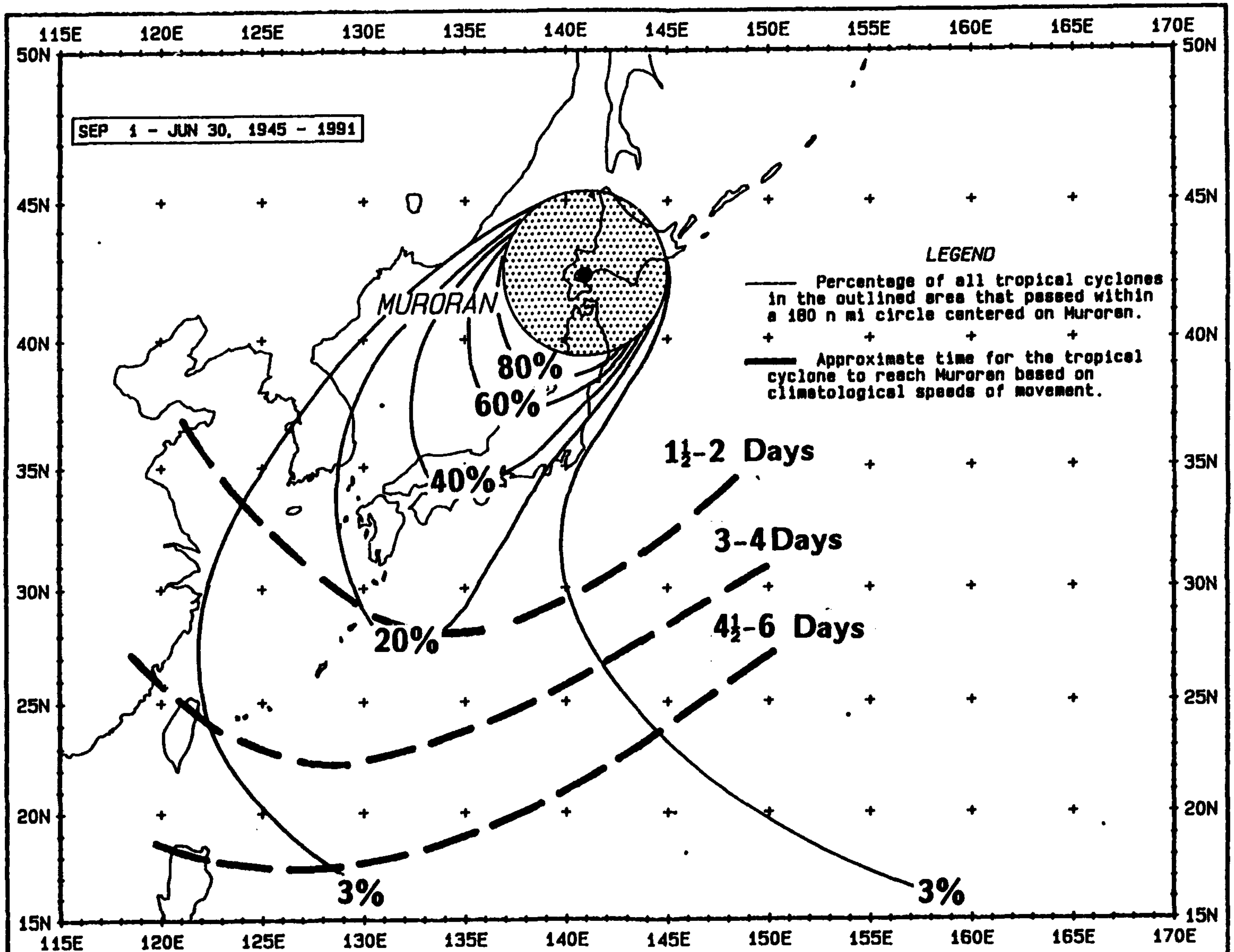

Figure V-140. Probability that a tropical storm or hurricane will pass within 180 nmi of Muroran (circle), and approximate time to closest point of approach, during the period September through June (based on data from 1945-1991).

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The track segments in Figure V-141 reflect the tropical cyclone positions when sustained winds of ≥22 kt were being experienced at Muroran. Only 3 of the 9 storms that passed within 180 nmi during the period of 1979 through 1991 resulted in sustained winds of ≥22 kt at Muroran. Note that none of the 9 storms caused sustained ≥34 kt winds at Muroran.

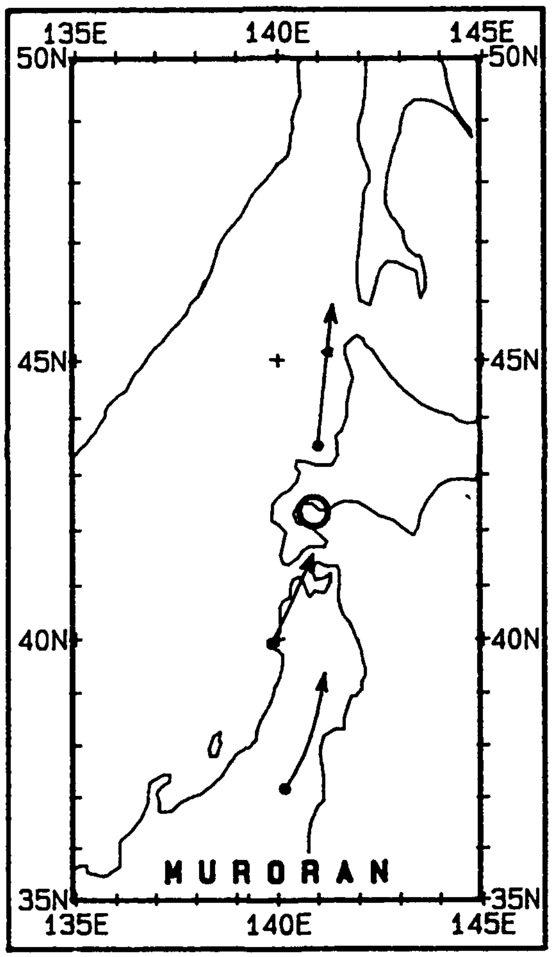

Figure V-141. Track segments of the 3 tropical storms or typhoons causing sustained winds of at least 22 kt at Muroran during the 13-year period 1979-1991.

10.3.2 Wind and Topographical Effects

Because of the adjacent topography, the port of Muroran is adversely affected primarily by winds with a strong westerly component. Post-frontal winds that follow cold frontal passage during the winter months are the primary cause of strong westerly winds. However, a tropical cyclone that followed a track that would place it close to and east or northeast of Muroran could also cause strong westerly winds at the port.

Easterly winds also reach the port. Strong easterlies are not a common occurrence, but the 2 southermost storms whose track segments are represented in Figure V-141 brought easterly winds to Muroran. If a tropical cyclone followed a track that would place it close to and south or west of Muroran, strong easterly winds could result and impact port facilities.

Northerly winds do not pose a significant threat to the port because the mountainous terrain of Hokkaido serves as an effective barrier to northerly flow. If a weather system placed Hokkaido under strong northerly flow, the wind force would be diminished, and the direction at Muroran would likely have a strong westerly or easterly component.

Although not common, strong winds from the south quadrant are possible. A review of a 20-year record of maximum recorded winds at Muroran during the period 1971-1990 revealed 5 years where the year's maximum winds came from either south (2 occurrences) or south-southwest (3 occurrences).[1] The strongest wind recorded during those five years was 46 kt (23 m/sec).

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[1]Data was taken from a list of maximum recorded winds at Muroran during the period 1971 through 1990 that was provided by Maritime Safety Agency personnel and the Captain of the Port at Muroran.

10.3.3 Local Weather Conditions

The data contained in Table V-33 has been selected from observations recorded at Muroran during the passage of the tropical cyclones listed in the table.[2] It should be noted that no record of observations is available during the period 1945 through 1978.

Table V-33. Center data and related weather associated with selected tropical cyclone passages within 180 nmi of Muroran during the 13-year period 1979-1991. No observational data are available for the period 1945-1978.

TYPHOON DATA				RELATED LOCAL WEATHER	
DATE (NAME)	MVMT DIR/SOA (KT)	DIR/CPA FM STAT (NMI)	CNTR WIND (KT)	MAXIMUM SUSTAINED WIND (KT)	COMMENTS
81/08/23 THAD	006/49	357/22	49	SW 26*	RAIN SHOWERS
89/08/28 ROGER	022/17	137/18	40	ENE 28*	RAIN SHOWERS
90/12/01 PAGE	010/24	176/178	45	ENE 24*	RAIN SHOWERS
91/09/28 MIRIELLE	048/58	109/64	60	W 28*	RAIN SHOWERS

* Wind gusts not recorded.

Substantiating the comments by Muroran harbor personnel that the strongest winds at the port are caused by extra-tropical low pressure systems and associated frontal systems rather than tropical cyclones, a review of maximum wind speeds recorded at Muroran during the years 1971-1990 contained no events that coincided with the passing of a tropical cyclone near the area.

[2]Based on hourly observations provided by Naval Oceanography Command Detachment, Asheville, NC.

10.3.4 Wave Action

Waves are not a major problem at most of the port facilities. Wave generation in Uchiura Bay is fetch limited since the bay is only about 28 nmi across. As described above, the harbor entrance is open to the west, so any easterly-moving waves that are generated in Uchiura Bay can enter the outer harbor. If the waves contained enough energy, they could also pass through the narrower entrance to the inner harbors, and impact the port facilities on the east side of harbor Section 2, and in the northern part of Section 1. The Sakimori area, where U. S. Navy ships would likely moor would not be directly impacted.

The shallow-water wave generation tables contained in U. S. Army Coastal Engineering Research Center (1973) show that a 65 kt wind could raise waves of only 3 ft at Sakimori berths 1 and 2, given a 50 ft water depth and a fetch length of 4,000 yd (the longest distance across the outer harbor).

10.3.5 Storm Surge

Storm surge may be visualized as a raised dome of water, moving with the storm, and centered a few miles to the right of its path. Storm surge is caused by wind stress on the water surface and the effects of atmospheric pressure reduction. The piling up of water on a coast ahead of a tropical storm or typhoon is more apparent in the dangerous semicircle, the region of most intense winds which is located to the right of the storm's direction of movement. The speed of the storm adds to the wind velocity generated by the mechanics of the storm itself.

The configuration of Hokkaido Island in the vicinity of the harbor makes storm surges unlikely at Muroran because the harbor opens to the west away from the open sea area of potential storm surge buildup. The typical rapid movement of storms at this latitude further minimizes the storm surge threat. According to Muroran harbor personnel, there have been no instances of significant storm surge at Muroran.

10.4 THE DECISION TO EVADE OR REMAIN IN PORT

10.4.1 General

There is no U. S. Navy authority assigned to Muroran, so decisions to evade or remain in port will necessarily be made independently by the ship's captain in accordance with appropriate directives issued by higher authority.

10.4.2 Evasion Rationale

It is of utmost importance that the commander recognize the inherent dangers that exist when exposed to the possibility of hazardous weather. Proper utilization of meteorological products, especially the NOCC/JTWC Guam Tropical Cyclone Warnings, and a basic understanding of weather will enable the commander to act in the best interest of the unit, and complete the mission when the unfavorable weather subsides. To assist in preparation for the threat posed by an approaching tropical cyclone the following time/action sequence aid, to be used in conjunction with Figures V-142 to V-143, is provided.

I. An existing tropical cyclone moves into or development takes place in Area A with long range forecast movement toward Muroran.

a. Review material condition of ship.

b. Reconsider any maintenance that would render the ship incapable of riding out a storm or typhoon with the electrical load on ship's power, or would render the ship incapable of getting underway, if need be, within 48 hours.

c. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

II. Tropical cyclone enters Area B with forecast movement toward Muroran (recall that tropical cyclones tend to accelerate rapidly after they have recurved):

a. Reconsider any maintenance that would render the ship incapable of getting underway, if need be, prior to the onset of strong winds within the harbor. If a sortie is planned, it should be initiated soon after the storm enters Area B.

b. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

III. Tropical cyclone has entered Area C and is moving toward Muroran:

a. Anticipate the arrival of the tropical cyclone winds and take appropriate actions.

b. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

MURORAN

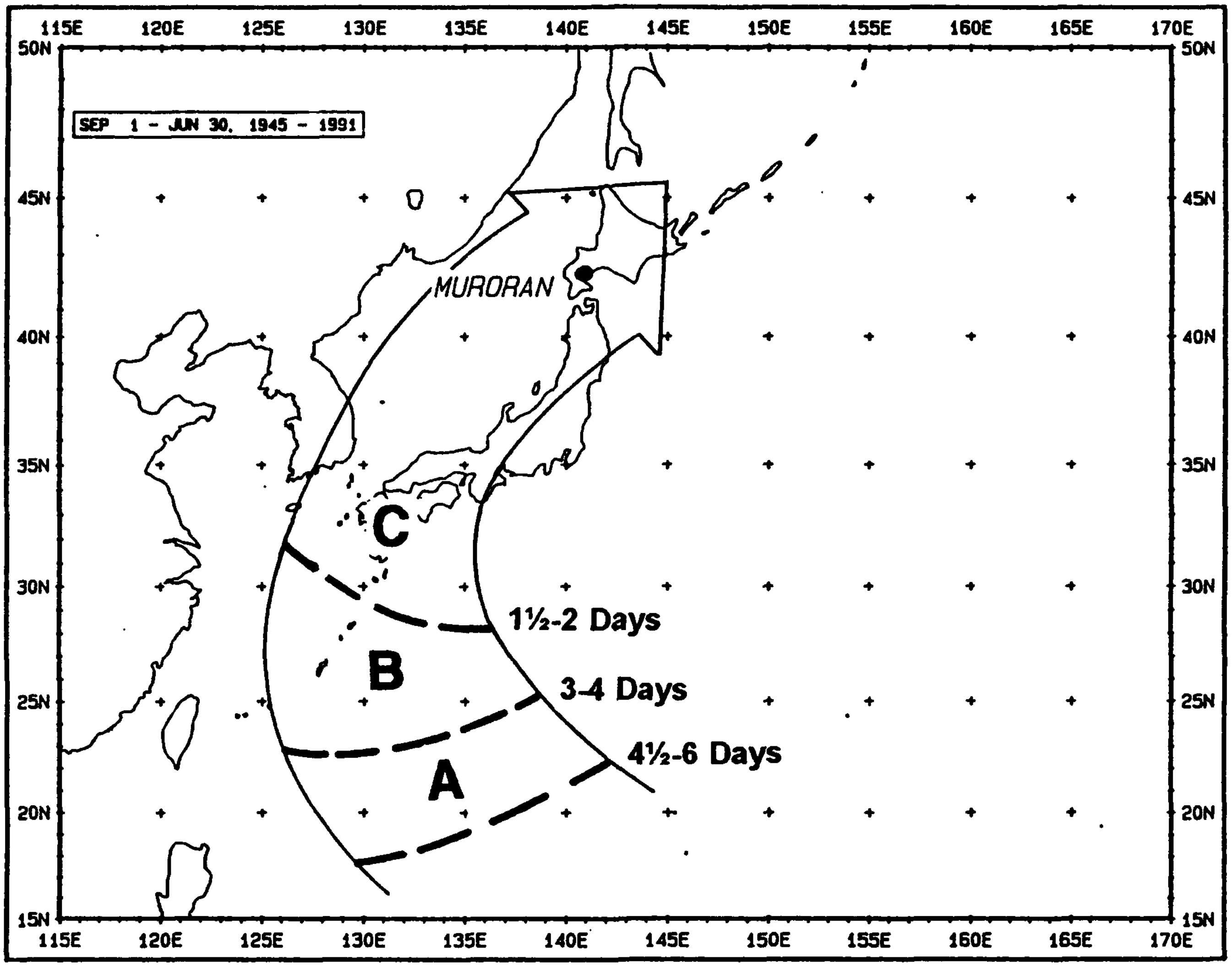

Figure V-143. Tropical cyclone threat axis for Muroran for the period September through June.

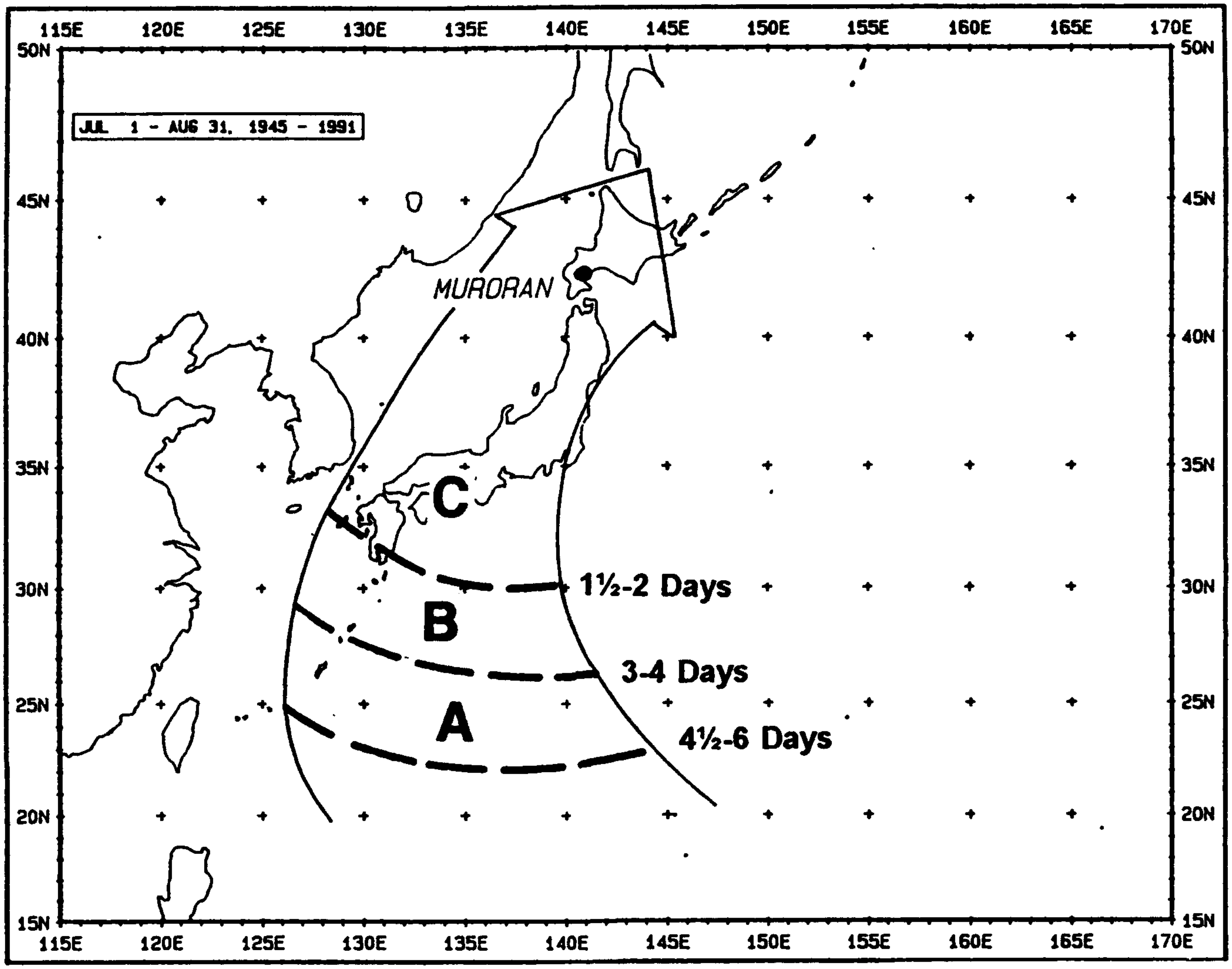

Figure V-142. Tropical cyclone threat axis for Muroran for July and August.

A s-rong wind is the most important factor to be considered. Wave action has only limited effect in the port of Muroran, especially at Sakimori berths 1 and 2, and storm surge effects are negligible.

10.4.3 Remaining in Port

As related above, harbor personnel state that merchant seamen regard Muroran to be the best port in Hokkaido. The port has successfully been used as a haven over the years by various ships, including a British ship that, according to harbor personnel, entered the port during "typhoon conditions" in 1991. Typhoon occurrence at Muroran is infrequent, but it does happen. Local harbor personnel relate an incident that occurred "about 40 years ago, when DōYamaru typhoon gave large damage to ships." Such an incident is an indication that although most storms would not pose a serious threat to ships in the port, it is possible for a particularly strong tropical cyclone to cause significant damage. There are no specifics regarding the location or size of the damaged vessels.

In consideration of the foregoing, the safest course of action would be for seaworthy ships to sortie from the port prior to the arrival of strong winds and evade at sea. If a vessel could not get underway, it should take normal precautions for high winds. The strongest forces would probably have a strong west or east component, although a strong southerly wind is possible. A southerly wind would tend to force the ship onto the pier, while easterly or westerly winds would be along the longitudinal axis of ships moored to Sakimori piers 1 and 2. Extra attention should be given to the brow and mooring lines during the passage of the storm. Ships should put out extra line and wire as deemed necessary and should be ready to tend mooring lines.

10.4.3 Evasion at Sea

Evasion at sea is considered to be the wise and safest course of action. An early sortie from the harbor will provide the captain with several evasion options that will not be available if sortie is delayed. It must be borne in mind, however, that tropical cyclones are historically unpredictable, and the 48-hour forecast position error often exceeds 200 nmi. Because of this error, a storm could be closer to (or farther from) Muroran than the forecast indicates or be right or left of the storm's forecast track. Tropical cyclones may cross the mountainous terrain of Honshu, moving from the Sea of Japan to the Pacific Ocean, and from the Pacific Ocean to the Sea of Japan. Consequently, the prudent mariner will plan ahead, sortie early, and include back-up options in his planning in case the tropical cyclone does not follow the initial forecast track.

The cooler surface water and cool air found at higher latitudes cause tropical cyclones to lose their tropical characteristics, with a resultant weakening and ultimate dissipation of the tropical cyclone. Caution is necessary, however; even though a circulation has lost it's tropical identity, it may still be accompanied by storm force (≥47 kt) winds.

Evasion routes at sea may be developed by the use of the NOCC/JTWC Guam tropical cyclone warnings (see paragraphs 6 and 7 of Chapter I), and Appendix A (the mean tropical cyclone tracks, track limits, and average speed of movements) for the month of interest in conjunction with Figures V-142 and V-143 (tropical cyclone threat axis and approach times to Muroran). In each specific case, Optimum Track Ship Routing (OTSR) should be consulted as to the best evasion route.

If the tropical cyclone is approaching Muroran from the south or southeast on the Pacific Ocean side of Japan, a recommended evasion course would take the ship through the

Tsugaru Strait into the Sea of Japan. Such an action would place the ship in northerly flow on the weaker left semicircle of the storm's circulation while moving away from the storm center. An evasion course to the east of Japan is not recommended since it would place the ship in a vulnerable position north of the storm.

If the tropical cyclone is forecast to approach Muroran across the Sea of Japan, a recommended evasion course would take the ship east and south along the coast of Honshu. If such an option were chosen, it must be initiated early because of the liklihood of encountering southerly head winds and seas that will only become stronger as the storm approaches.

Port Visit Information

November 1992: NRL Meteorologists CDR R. G. Handlers, USN, and Mr. L. Phegley, and SAIC Meteorologist Mr. R. D. Gilmore met with Port Captain Mr. T. Setooka and LCDR T. Yamamoto of the Maritime Safety Agency to obtain much of the information contained in this port evaluation.

11.0 HACHINOHE

SUMMARY

The conclusion reached in this study is that the port of Hachinohe is not a typhoon haven for U. S. Navy ships, primarily because of the lack of shelter from potentially damaging winds.

Although a sortie should be the first option considered in a typhoon threat situation, cognizant authorities may choose to allow fuel barges moored to the fuel piers adjacent to the mouth of the Niida River to remain at the port. The low profile of the barge hull and their more protected location near the mouth of the Niida River would subject them to less severe effects from the wind. Also, the slow speed capability of the tug/barge combinations would severely reduce reasonable evasion options if a sortie was not initiated early in the decision process.

11.1 LOCATION AND TOPOGRAPHY

The port of Hachinohe, Japan is located at 40°33′N 141°32′E on the northeastern coast of Honshu, the largest of the four main Japanese islands (Figure V-144).

Hachinohe is situated on a relatively small bay on the mostly north-south oriented coastline, approximately 11 nmi south-southeast of Misawa. Hachinohe is a busy port, with much of the traffic related to the local chemical plants and petroleum refinery. The port is also an important fishing harbor and is home to a multitude of fishing boats.

Approaches to the port should be made from seaward rather than along the coast. There are numerous submerged scallop nets in several locations within 3 nmi of the coastline of northern

HACHINOHE

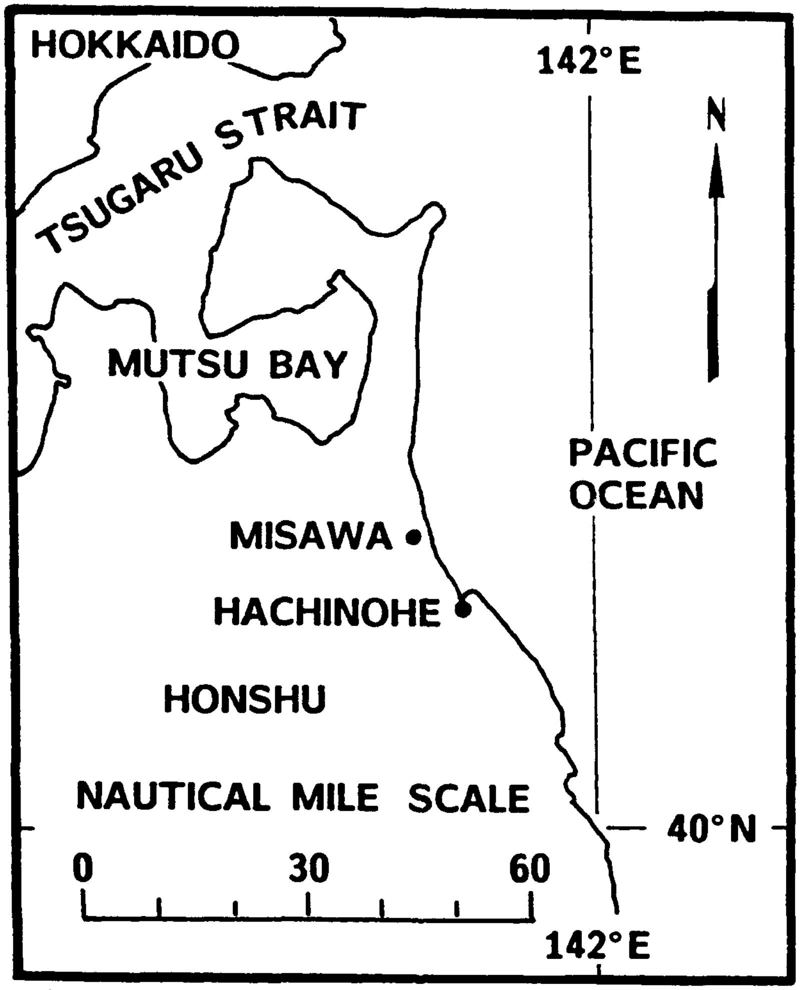

Figure V-144. Location of Hachinohe on the northeast coast of Honshu.

Japan, and they may pose a fouling hazard. Harbor personnel advise calling the harbor on VHF Channel 16 to check on net location if a coastal route is necessary.

The terrain in the land areas immediately adjacent to the port is low-lying, but elevations increase somewhat just short distances from the port (Figure V-145). One peak reaches the height of 2,428 ft (740 m) just 8.5 nmi south-southeast of the port, while another reaches 2,018 ft (615 m) about 13 nmi to the southwest. A small peninsula east of the port has hills exceeding 164 ft (50 m) in several locations. Other elevations routinely exceed 328 ft (100 m) within 3 nmi of the port. Farther west, the northern part of the mountain range commonly called the Japanese Alps parallels the coastline and influences the weather at Hachinohe.

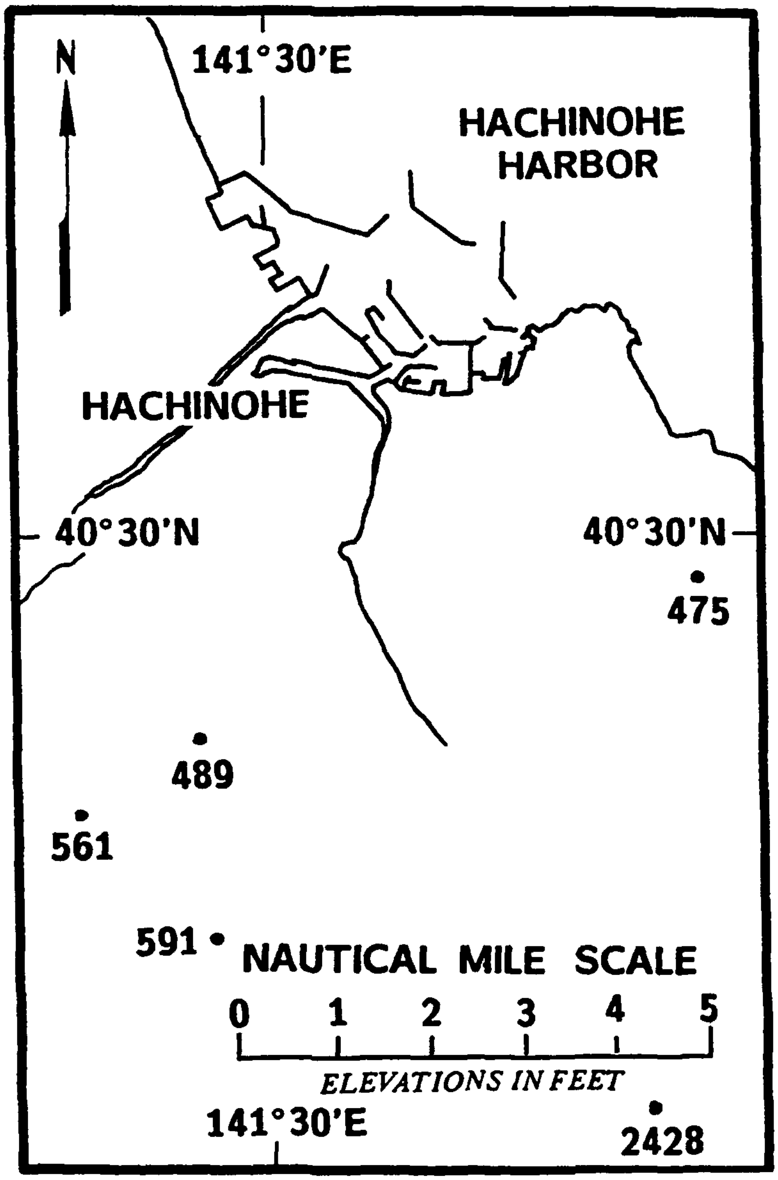

Figure V-145. Relation of Hachinohe to various elevations near the harbor.

HACHINOHE

The astronomical tidal range at Hachinohe is relatively small. During a port visit in 1987, USS Blue Ridge (LCC-19) reported a range of only 3.2 ft (0.97 m). Currents within the harbor are generally less than 1 kt.

11.2 HACHINOHE HARBOR

Because of the port's essentially unprotected exposure to the Pacific Ocean, a complex series of breakwaters has been constructed to mitigate the effects of wave motion on the inner harbors (Figure V-146). The port of Hachinohe is entered through a 492 yd (450 m) wide channel which passes between two of the outer breakwaters.

Ship berths at Hachinohe are assigned designators based on their location in the harbor. Berths on wharf number 1 are assigned letters A through F. A specific berth would be referred to as berth 1A, 1B, etc. Wharf 2 has berths H through M. Wharf 3 has berths designated N and O, which are assigned to berths on the northwest side of the wharf. Wharf 4 has a single face for ship berthing, so the designators assigned to wharf 4 are E and W, which stand for east and west, respectively.

The berth used by the USS Blue Ridge (LCC-19) on a visit in 1987, and according to local port personnel the one likely to be assigned to U. S. Navy ships during future visits, is designated 1-E. As shown in Figure V-146, to reach berth 1-E, an incoming vessel must make two turns to starboard after passing between the two outer breakwaters. Upon making the second turn, the channel width decreases to 383 yd (350 m). The designated channel depth is 43 ft (13 m) to the pier, but DMA chart 97041 shows several areas where the depth is less--as shallow as 41.3 ft (12.6 m).

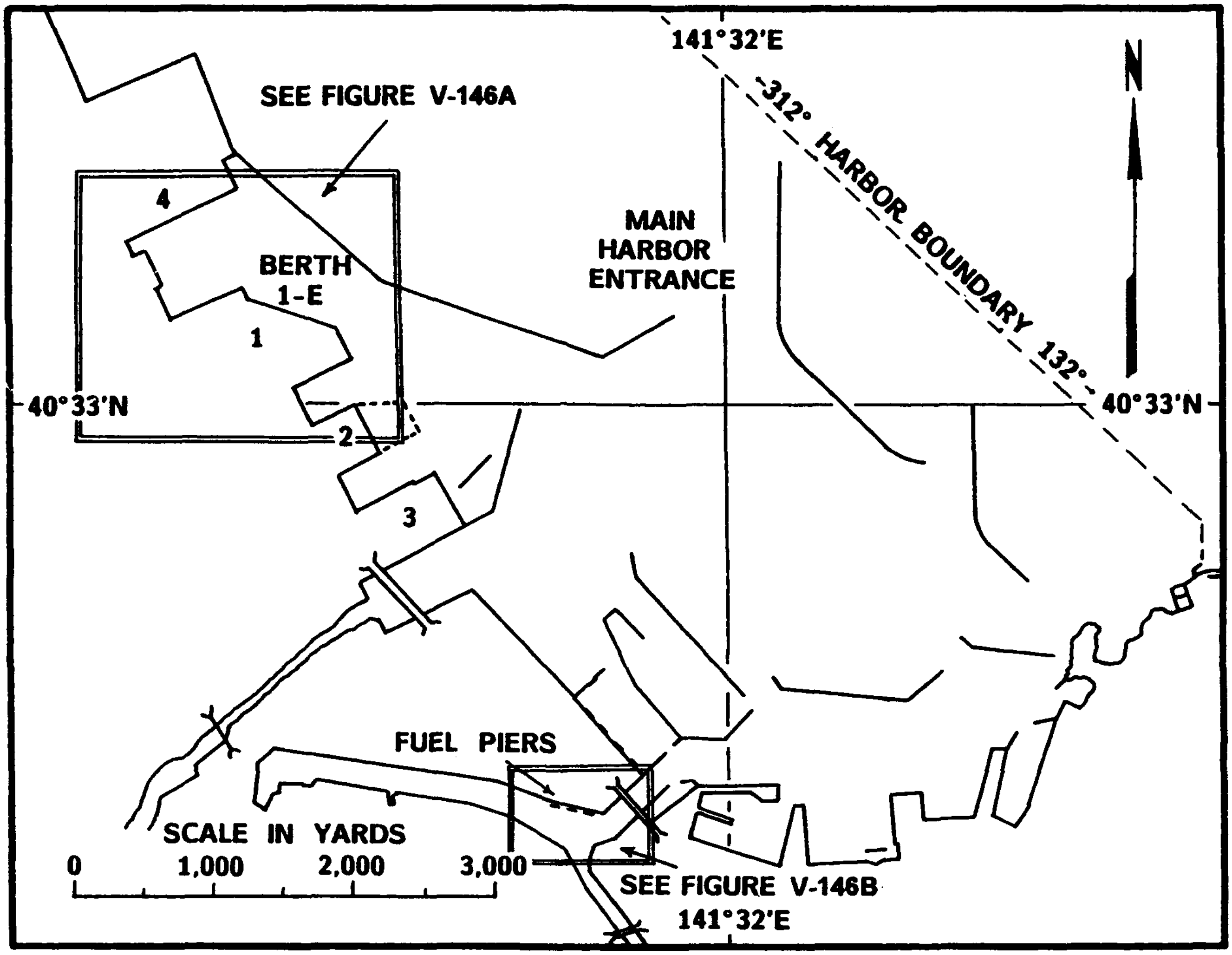

Figure V-146. Hachinohe harbor configuration.

Berth 1-E is 755 ft (230 m) long, with an alongside depth of 43 ft (13 m). Although they state it is not likely, local personnel say that other berths could possibly be assigned to U. S. Navy ships. The same harbor personnel relate that each of

HACHINOHE

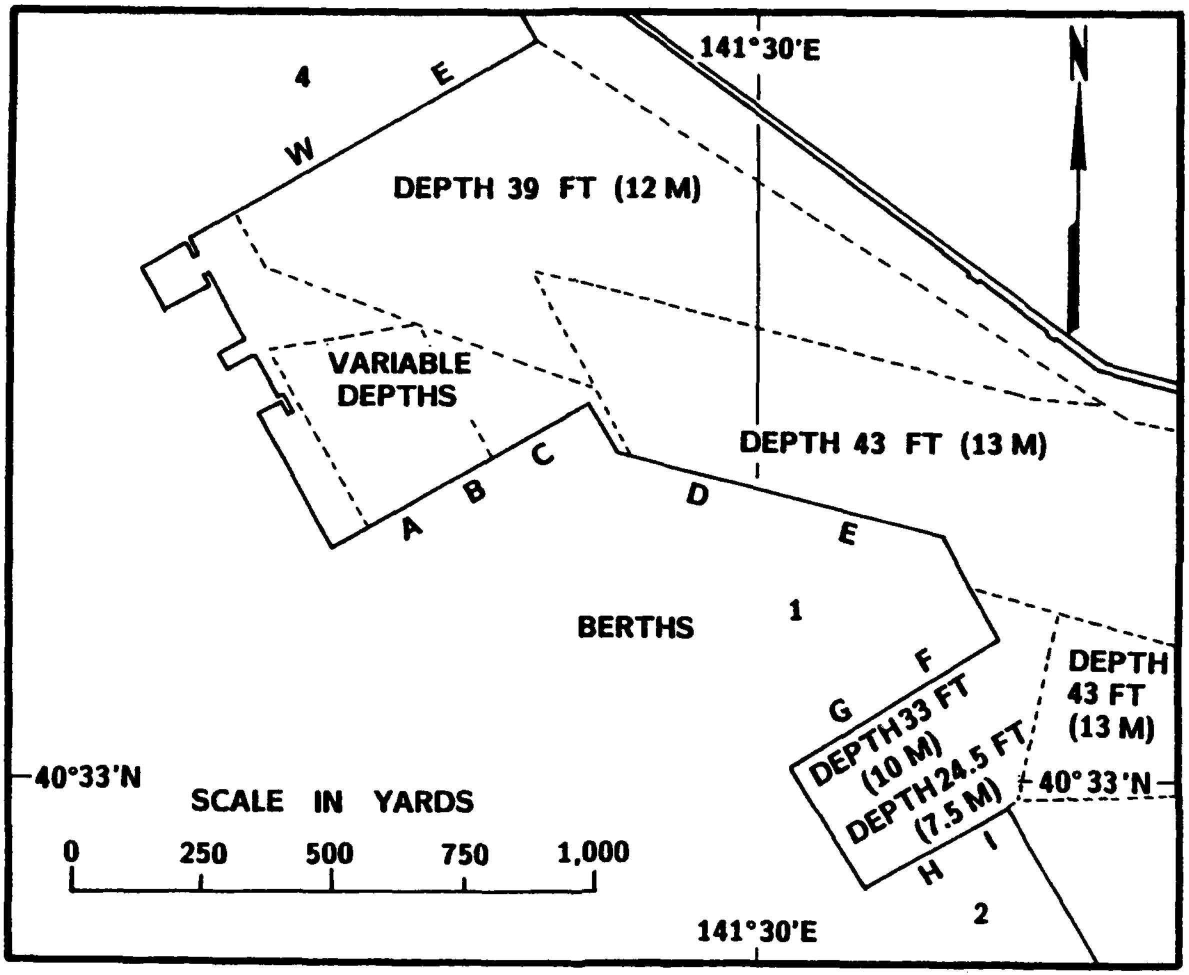

Figure V-146A. Berth 1-E and adjacent berths.

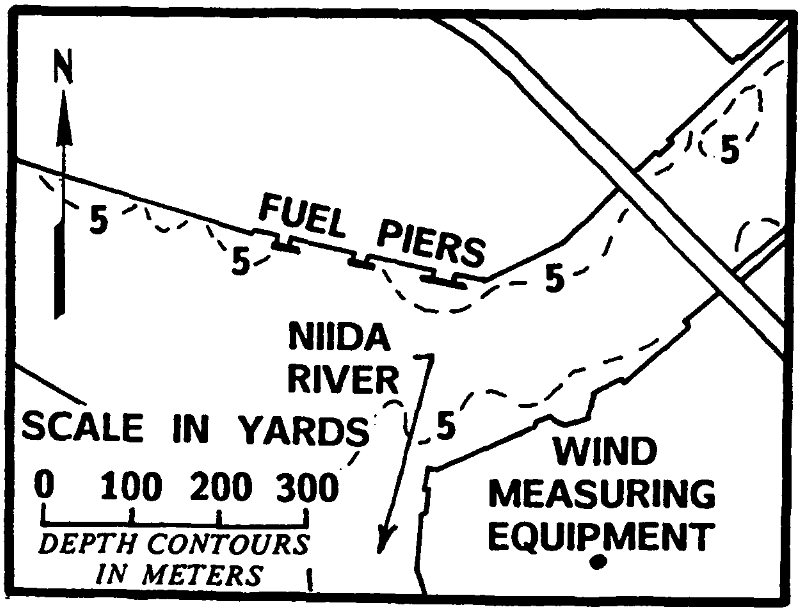

Figure V-146B. Fuel piers.

the pier faces have built-in rubber fenders suitable for use by large ships. Table V-34 lists the statistics for each of the berths identified on Figure V-146A, and others.

Table V-34. Berth statistics for Hachinohe, Japan.

WHARF-BERTH	LENGTH	PIERSIDE DEPTH
1-D	755 ft (230 m)	42.7 ft (13.0 m)
1-E	755 ft (230 m)	42.7 ft (13.0 m)
1-G & F together	1,214 ft (370 m)	32.8 ft (10.0 m)
2-H & I together	853 ft (260 m)	24.6 ft (7.5 m)
2-M & L together	853 ft (260 m)	24.6 ft (7.5 m)
3-N & O together	853 ft (260 m)	24.6 ft (7.5 m)
4-west part	623 ft (190 m)	32.8 ft (10.0 m)
4-east part	663 ft (202 m)	39.4 ft (12.0 m)

In November 1992, construction was progress at several locations in the harbor, and the configuration shown in Figure V-146 will change. When completed, one of the projects will add a total of 2,461 ft (750 m) of berthing space at the end of wharf 2, to be divided among three pier faces (dashed lines on Figure V-146). Two will be 886 ft (270 m) long and one will be 689 ft (210 m).

A second pier facility that is routinely used by the U. S. Navy is located on the channel that leads from the southeastern part of the harbor to the mouth of the Niida River. See Figure 146B. The facility is used by fuel barges bringing aviation fuel for subsequent transfer, via pipeline, to the Naval Air Facility at Misawa. Fuel pier statistics, such as length and alongside water depth, are not specified, but measurements on a harbor chart indicate the three adjacent piers at the facility to be approximately 100 ft (30 m) to 165 ft (50 m) long. Water depths near the piers on DMA chart 97041 vary from 8.5 ft (2.6 m), at one location near the easternmost pier, to 17.7 ft (5.4 m).

The western entrance to the channel that leads from the main harbor to the basin, on which the fuel pier is located, is the one most likely to be used and is approximately 394 ft (120 m) wide as measured from DMA chart 97041. The eastern entrance to the same channel has a width of approximately 656 ft (200 m) as measured on the same DMA chart. The chart shows depths between 20 and 23 ft (6 and 7 m) in the channel between the entrance and the fuel pier. Depths in the eastern entrance are between 39 and 43 ft (12 and 13 m) but decrease to 20 to 23 ft (6 to 7 m) well before the fuel piers are reached.

A small anchorage in water of unspecified depth and bottom type exists outside the outer breakwaters, but from the information gathered during the November 1992 port visit, it should be used in fair weather only. Anchor dragging is a severe problem in windy situations.

11.3 HARBOR FACILITIES

Local harbor personnel state that five tug boats are available at the port. According to FICPAC (1987), harbor facilities also include one derrick with a lifting capacity of 33 tons, an operating radius of 49 ft (15 m) and a hoist of 33 ft (10 m), and two mobile cranes, each with a lifting capacity of 15 tons, operating radius of 69 ft (21 m), and a hoist of 56 ft (17 m). Two "portal jibs" are available at the port. One has a lifting capacity of 19 tons, an operating radius of 72 ft (22 m), and a hoist of 62 ft (19 m), and the other has a lifting capacity of 8 tons, an operating radius of 52 ft (16 m) with a hoist of 46 ft (14 m). Other equipment available at the port includes forklifts, trucks (including a dump truck), 6 truck cranes with 35-50 ton capacities, several 3 to 9 ton shovel loaders, and 2 pneumatic unloaders with 400 tons/hour capacities.

11.4 TROPICAL CYCLONES AFFECTING HACHINOHE

11.4.1 Tropical Cyclone Climatology at Hachinohe

Tropical cyclones which affect Japan generally form in the area bounded by 5°N to 30°N and 120°E to 165°E. The latitudinal boundaries shift poleward during the summer months and then equatorward in winter in response to the seasonal changes of the synoptic environment. Although affected by tropical cyclone activity, Hachinohe is well north of the latitudes where tropical cyclones most frequently occur and are the strongest. Also, because of Hachinohe's high latitude, many of the storms become extratropical by the time they enter the 180 nmi threat radius. Consequently, although the port is exposed and vulnerable to strong winds whatever the cause, the effects of tropical cyclone activity at Hachinohe are routinely less frequent and mostly less intense than that observed at more southerly locations in Japan.

For the purpose of this study, any tropical storm or typhoon approaching within 180 nmi of Hachinohe is considered to represent a threat to the port. Table V-35 contains a descriptive history of all tropical storms and typhoons passing within 180 nmi of Hachinohe during the 47-year period 1945-1991. All of the tropical cyclone statistics used in this report for storms passing within 180 nmi of Hachinohe are based on the SAIC generated data set used to compile Table V-35.

Because no observational records are available for Hachinohe, all observational data cited in this report are based on official weather observations recorded at Misawa, which is located approximately 11 nmi north-northwest of Hachinohe.

Table V-35. Descriptive history of the 55 tropical storms and typhoons passing within 180 nmi of Hachinohe during the 47-year period 1945-1991.

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAXIMUM WIND AT STORM CENTER	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
1	IDA	1945	SEP	18	18	55	163 (SE)	056/36.2
2	IONE	1948	SEP	16	14	50	147 (SE)	045/27.5
3	KITTY	1949	SEP	1	9	45	105 (WNW)	012/29.2
4	JANE	1950	SEP	3	8	45	58 (WNW)	038/30.9
5	KEZIA	1950	SEP	14	9	52	90 (NNW)	078/52.6
6	RUTH	1951	OCT	15	11	43	155 (SSE)	061/33.6
7	KAREN	1952	AUG	19	8	40	157 (N)	085/22.0
8	TESS	1953	SEP	25	15	53	44 (SE)	024/34.3
9	KATHY	1954	SEP	8	9	38	164 (NW)	032/41.5
10	MARIE	1954	SEP	26	12	67	79 (W)	359/37.1
11	LOUISE	1955	SEP	30	15	73	114 (NW)	051/34.1
12	NORA	1955	OCT	11	18	64	163 (ESE)	039/49.1
13	OPAL	1955	OCT	20	19	38	102 (SE)	039/53.6
14	BABS	1956,	AUG	18	9	33	93 (WNW)	024/10.6
15	BESS	1957	SEP	7	9	39	23 (NNW)	059/36.9
16	ALICE	1958	JUL	23	9	53	25 (NE)	007/41.6
17	HELEN	1958	SEP	18	14	60*	147 (SE)	037/32.7
18	IDA	1958	SEP	27	15	33	85 (E)	015/21.6
19	SARAH	1959	SEP	18	14	70	128 (NNW)	063/25.6
20	VERA	1959	SEP	26	15	78	15 (S)	056/33.2
21	VIRGINIA	1960	AUG	12	10	63*	20 (WSW)	071/46.6
22	WENDY	1960	AUG	13	11	45	101 (SSW)	070/29.1
23	NANCY	1961	SEP	16	18	65	71 (WNW)	016/58.4
24	VIOLET	1961	OCT	10	23	48	160 (SE)	051/24.8
25	NORA	1962	AUG	3	8	35	24 (NE)	089/39.5
26	THELMA	1962	AUG	27	14	30	49 (N)	079/24.0
27	SHIRLEY	1963	JUN	20	4	46	145 (NNW)	073/21.7
28	KATHY	1964	AUG	25	15	40	35 (SSE)	074/30.3
29	WILDA	1964	SEP	25	24	44	21 (ESE)	049/57.1
30	SHIRLEY	1965	SEP	10	24	63*	129 (WNW)	028/35.1
31	TRIX	1965	SEP	18	25	63*	12 (NNE)	029/42.7
32	KIT	1966	JUN	28	4	43	129 (ESE)	032/31.2
33	IDA	1966	SEP	25	23	50	53 (SE)	049/45.5
34	DINAH	1967	OCT	28	30	50	68 (SE)	043/24.2
35	WILDA	1970	AUG	15	8	47	136 (WNW)	030/38.5
36	ALICE	1972	AUG	7	13	45	168 (SE)	046/16.4
37	HELEN	1972	SEP	17	20	52	86 (WNW)	016/22.3
38	RITA	1975	AUG	23	8	30	16 (SE)	045/28.8
39	VIRGINIA	1978	AUG	1	7	42	176 (SE)	038/17.2
40	OWEN	1979	OCT	1	19	35	48 (SSE)	036/47.0
41	TIP	1979	OCT	19	23	53	85 (SE)	043/73.8
42	THAD	1981	AUG	23	15	53	41 (W)	005/43.2
43	JUDY	1982	SEP	12	19	40	113 (WSW)	034/36.3
44	IRMA	1985	JUL	1	6	58	158 (SE)	051/39.7
45	RUBY	1985	AUG	31	14	45	95 (SSE)	042/19.9
46	MAC	1989	AUG	6	15	30	126 (WSW)	338/14.1
47	NANCY	1989	AUG	16	17	55	168 (E)	007/13.1
48	ROGER	1989	AUG	27	20	40	53 (WNW)	025/27.2
49	WINONA	1990	AUG	10	12	45	80 (SE)	039/26.3
50	ZOLA	1990	AUG	23	14	45	71 (NNW)	071/34.7
51	FLO	1990	SEP	20	20	53	61 (SSE)	062/35.2
52	PAGE	1990	DEC	1	29	45	71 (SSW)	010/24.2
53	HARRY	1991	AUG	31	16	40	134 (SE)	056/33.5
54	KINNA	1991	SEP	14	19	43	146 (S)	081/33.7
55	MIREILLE	1991	SEP	27	21	63*	49 (N)	048/58.5

NOTES:
Datetimes are in UTC, winds are in knots, distances are in nautical miles. Parenthetical expression in column 8 gives bearing of storm from site at closest point of approach to site (CPA). Maximum winds are at time of CPA and did not necessarily occur at site. Asterisk (if any) after maximum wind indicates that storm was classified as a typhoon (at least 64 kts) somewhere within 180 nautical mile radius of site but not at CPA. Site location is 40.5°N, 141.5°E.

The primary tropical cyclone season for Hachinohe is from August through October, although historically they have occurred in all months in the genesis area described in a preceding paragraph. As shown in Table V-36, no tropical cyclones passed within 180 nmi of Hachinohe prior to June or during November in any year since 1945. Two have occurred in each of the months of June and July, and 1 occurred in December. Of the 55 storms occurring during the 47-year period, only 6 were of typhoon intensity (≥64 kt) at CPA. The table also shows the motion history of the storms. The average heading and speed of tropical storms and typhoons passing within 180 nmi of Hachinohe during the 47-year period was 042° at 34 kt at CPA. The average storm speed during October is a high 44 kt.

The storm speeds given in Table V-36 are relatively high when compared to "normal" movement speeds for tropical cyclones, and are due to the northerly location of Hachinohe. By the time the storms reach the 180 nmi threat radius, they are usually being influenced by upper-level westerly flow and accelerating to the northeast.

During the 47-year period 1945 through 1991, there were 55 tropical storms and typhoons that met the 180 nmi threat criterion for Hachinohe, an average of just over 1 per year. Figure V-147 shows the monthly distribution of the 55 storms by 7-day periods. As the figure shows, the period of peak activity is from early August through September. Of the 5 storms that were still classified as typhoons while at CPA, 4 occurred during September, and 1 in October.

Table V-36. Frequency of motion of the 55 tropical storms and typhoons passing within 180 nmi of Hachinohe during the 47-year period 1945-1991.

Total number of storms passing within 180 n mi	0	0	0	0	0	2	2	19	24	7	0	1	55
Number of storms having at least typhoon intensity at CPA	0	0	0	0	0	0	0	0	5	1	0	0	6
Number of storms less than typhoon intensity at CPA	0	0	0	0	0	2	2	19	19	6	0	1	49
Average heading (degs) towards which storms were moving at CPA	---	---	---	---	---	*	*	046	041	045	---	*	042
Average storm speed (knots) at CPA	---	---	---	---	---	*	*	27	37	44	---	*	34
Month when storm was at CPA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR

* indicates insufficient storms for average direction and speed computations.

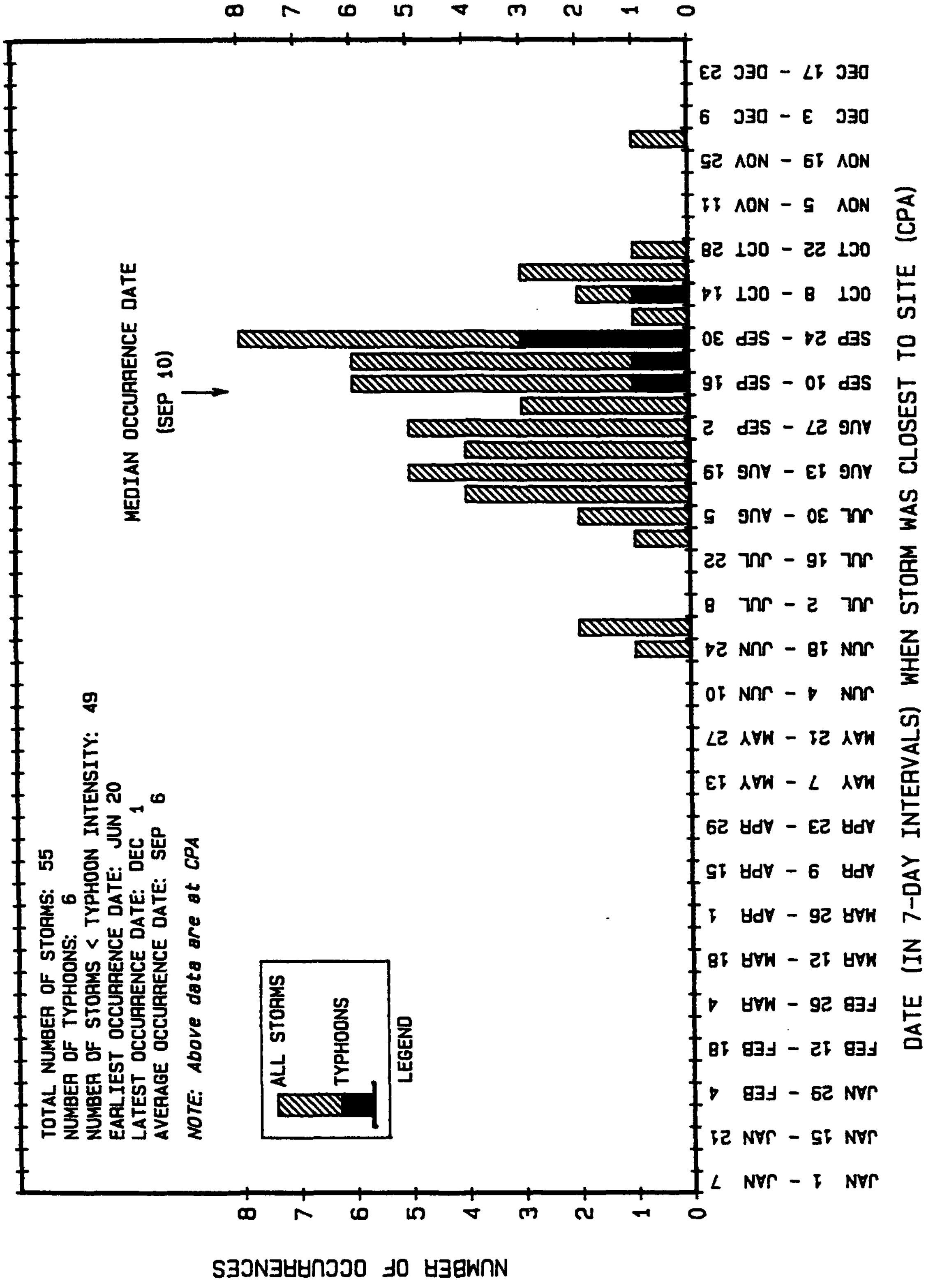

Figure V-147. Monthly distribution of the 55 tropical storms and typhoons passing within 180 nmi of Hachinohe during the 47-year period 1945-1991.

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Figure V-148 shows the annual distribution of tropical storms and typhoons passing within 180 nmi of Hachinohe during the 47-year period 1945 through 1991. During the 20-year period 1948 through 1967 there were no years without at least one tropical cyclone passing within 180 nmi. For several years in the 1970's and 1980's no tropical storms or typhoons passed within the 180 nmi threat radius.

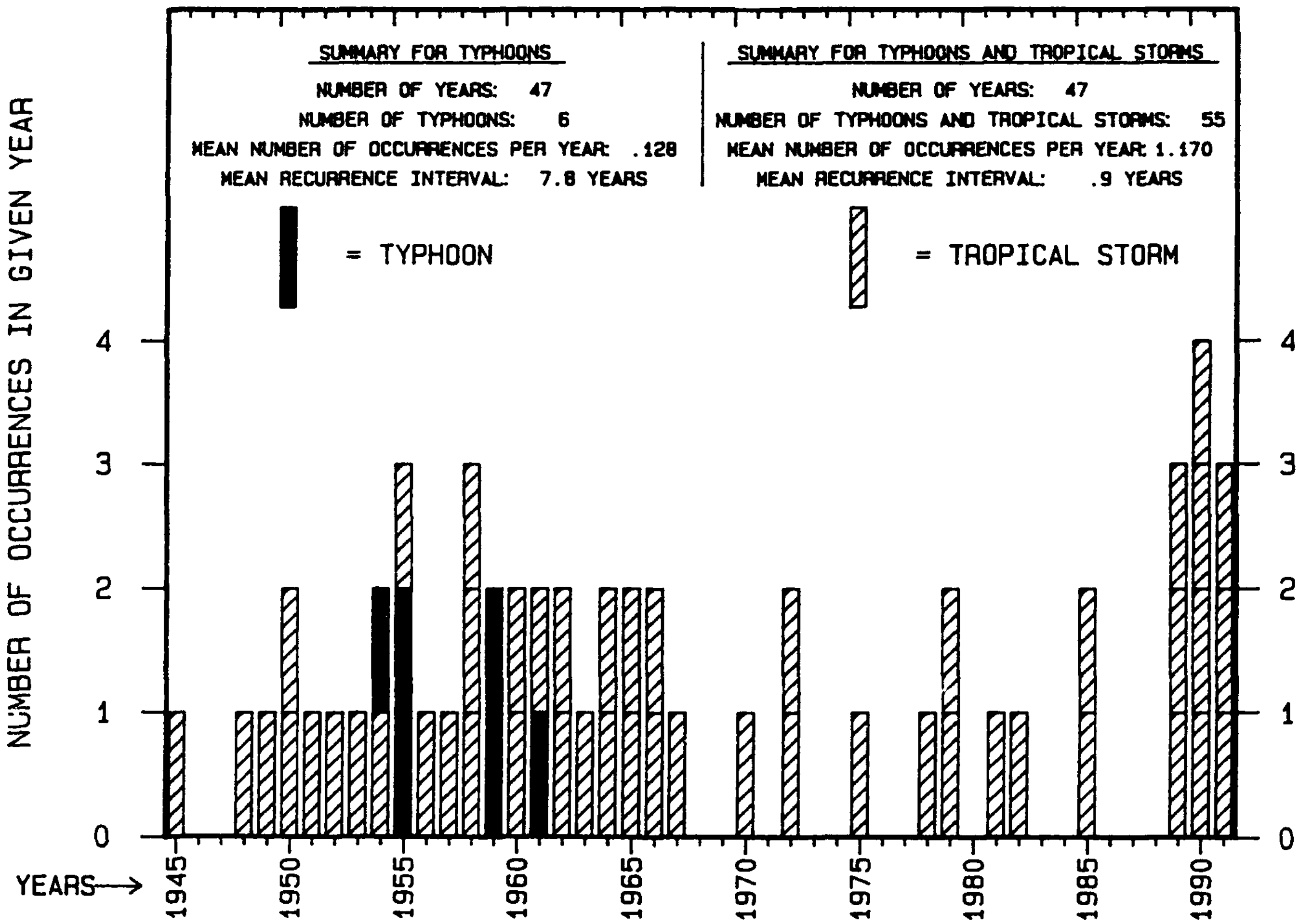

Figure V-148. Chronology of the 55 tropical storms and typhoons passing within 180 nmi of Hachinohe during the 47-year period 1945-1991. Storm intensity is determined at time of closest point of approach (CPA) to Hachinohe.

Figure V-149 presents a graphical depiction of the number of tropical cyclones versus CPA. The storm classification is based on the maximum wind near the storm center while that center was within 180 nmi of Hachinohe, not necessarily at CPA. The sloping lines represent mathematical fits to the data points for the various intensity classifications. The average radii of maximum wind for 34, 100, and 140 kt tropical cyclones at Hachinohe are 35.4, 33.8, and 30.9 nmi, respectively.

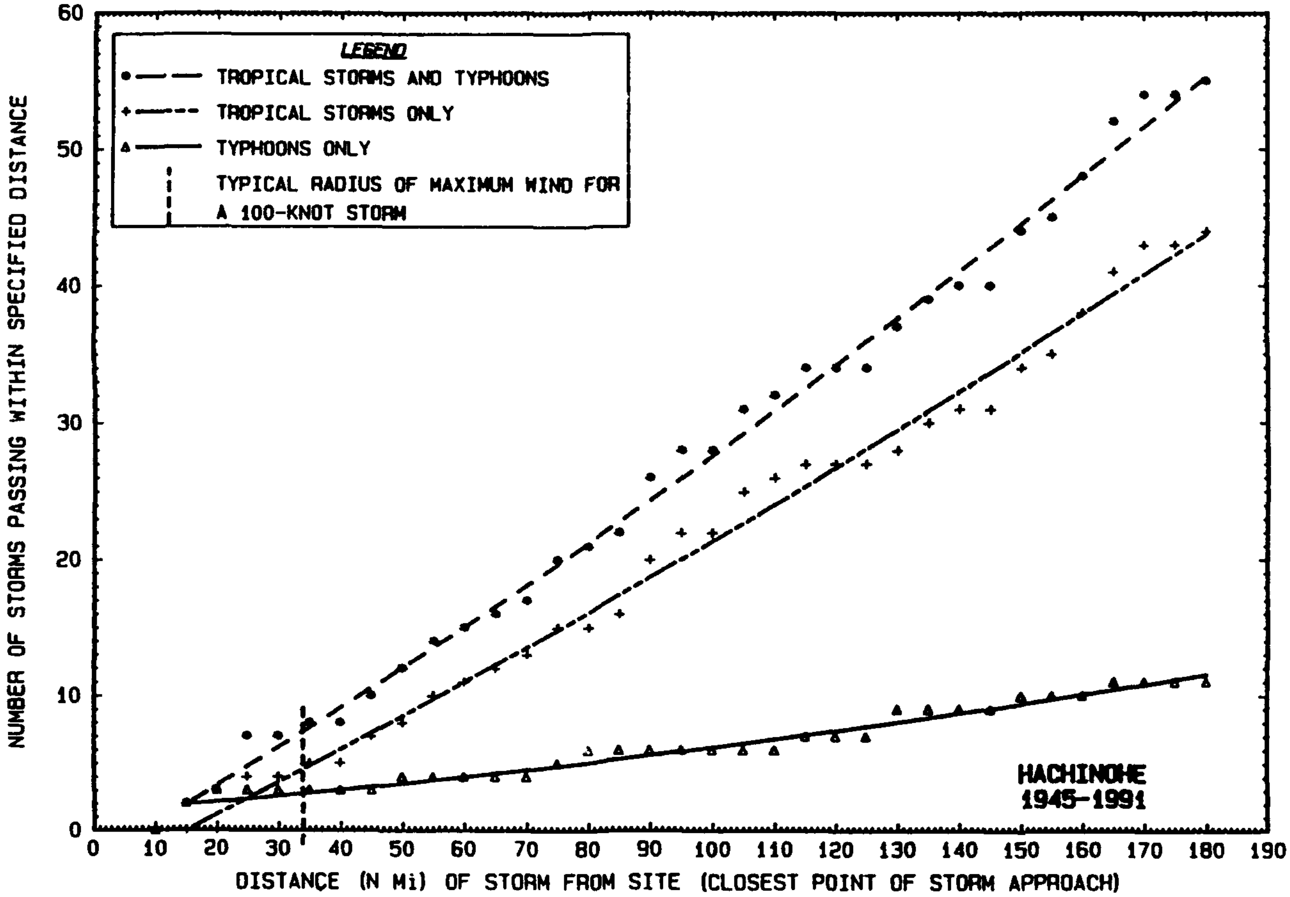

Figure V-149. Number of tropical cyclones passing at various distances from Hachinohe during the 47-year period of record. Tropical storm or typhoon classification is based on maximum wind near storm center while that center was within 180 nmi of Hachinohe, and not necessarily at CPA. Sloping lines represent mathematical fit to data points. Average radii of maximum wind for 34, 100, and 140 kt storms at Hachinohe are 35.4, 33.8, and 30.9 nmi respectively.

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Figure V-150 depicts, on an 8-point compass, the octants from which the 55 tropical cyclones in the data set approached Hachinohe. The majority of the storms, 35 of 55 (63.6%), approached Hachinohe from the southwest octant, with the remainder, 20 of 55 (36.4%), equally split between the west and south octants. It should be noted that the approach direction is determined at CPA, and may not represent the initial approach direction of the tropical storm or typhoon toward Hachinohe.

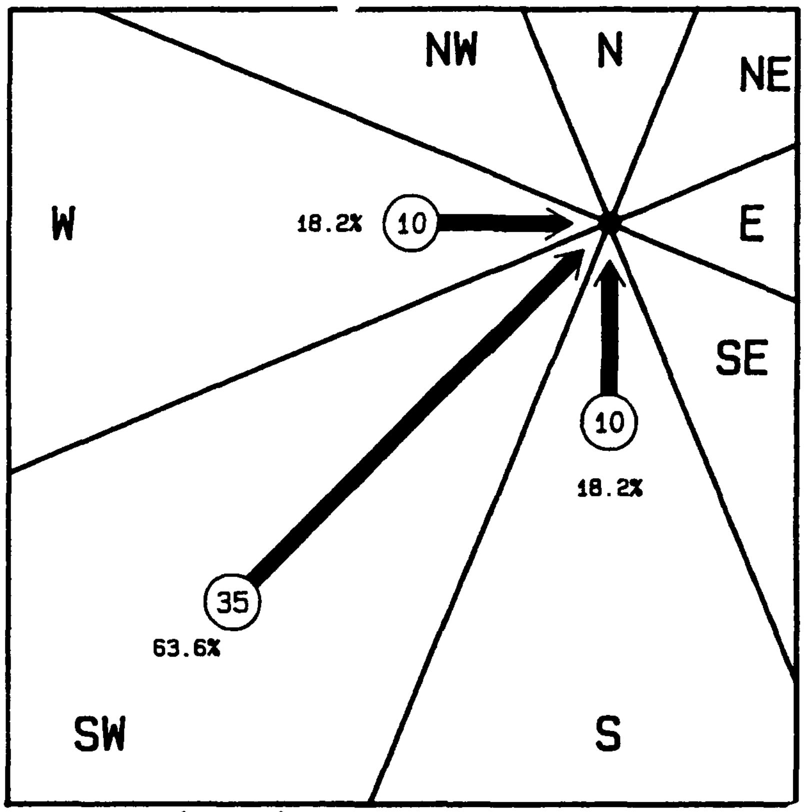

Figure V-150. Directions of approach for the 55 tropical cyclones passing within 180 nmi of Hachinohe during the 47-year period of record. Length of directional arrow is proportional to the number of storms given in the circles of each octant. Approach directions are determined at CPA.

Figures V-151 and V-152 provide information on the probability of remote tropical storms and/or typhoons passing within 180 nmi of Hachinohe and average time to CPA. The solid lines represent a 'percent threat' for any tropical cyclone location within the area depicted. The heavy dashed lines represent the approximate time in days for a system to reach Hachinohe. For example, in Figure V-151, during the months of July and August, a tropical cyclone located at 25°N 135°E has approximately a 10% probability of passing within 180 nmi of Hachinohe and would reach Hachinohe in about 3 to 4 days.

There is a minor difference in threat axis orientation southwest of Hachinohe on the preceding two figures, but the most significant difference in the figures is the threat axis orientation south of Japan. The axis extends south of central Honshu to about 30°N before turning southeastward to the more tropical latitudes during July and August, while the threat axis for the other months continues a southwestward orientation south of Japan before finally turning southeastward south of 25°N.

11.4.2 Wind and Topographical Effects

The harbor is exposed and vulnerable to wind. Winds from the western semicircle prevail during the autumn and winter seasons, with the strongest normally being post-frontal winds associated with extra-tropical low pressure systems. Some of the effects of westerly winds are diminished by the hills near the port and, to a limited degree, by the northern extension of the Japanese Alps. Winds from the eastern semicircle are another matter, however, and reach the port with their full open-ocean strength.

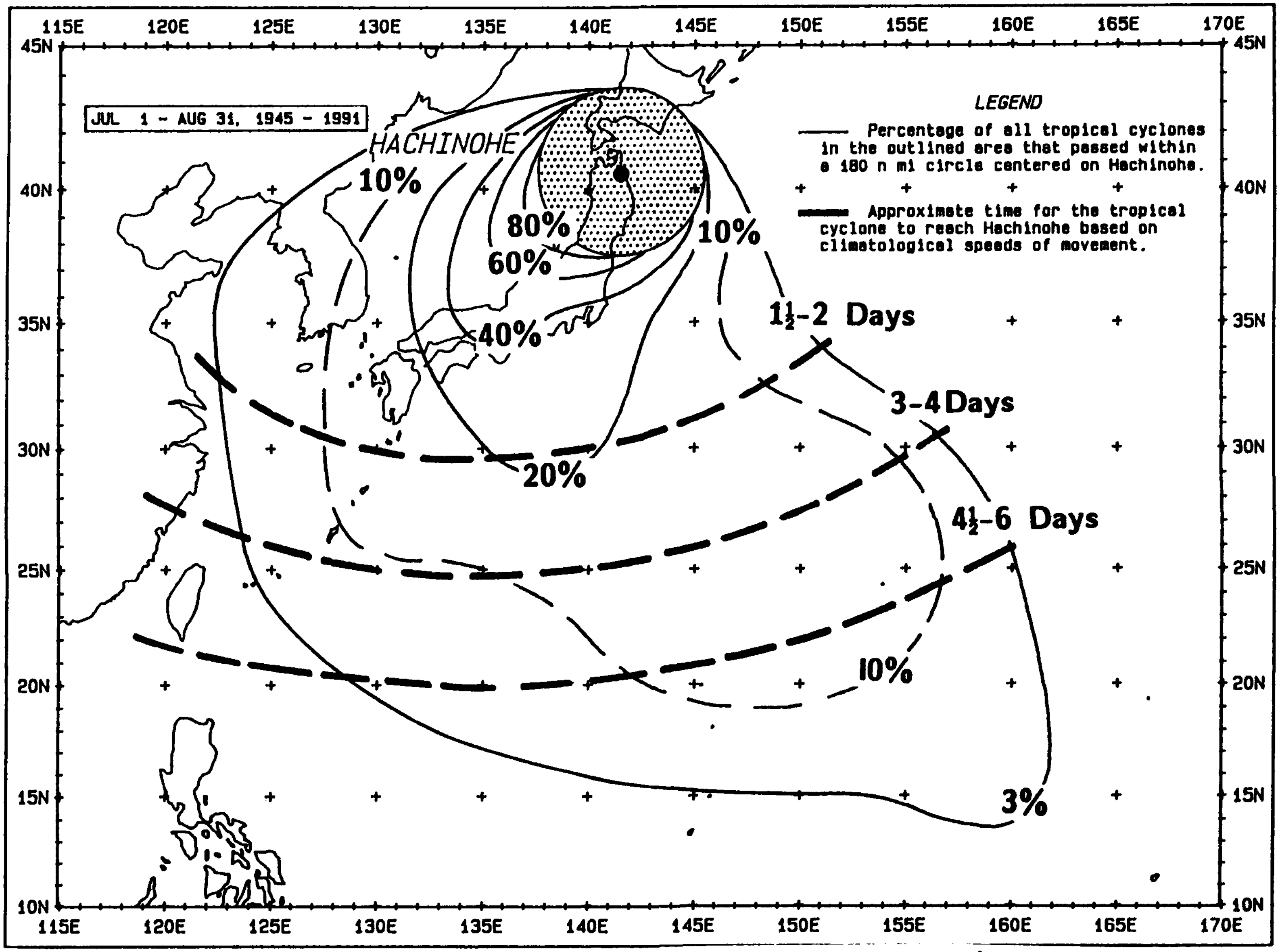

Figure V-151. Probability that a tropical storm or hurricane will pass within 180 nmi of Hachinohe (circle), and approximate time to closest point of approach, during July and August (based on data from 1945-1991).

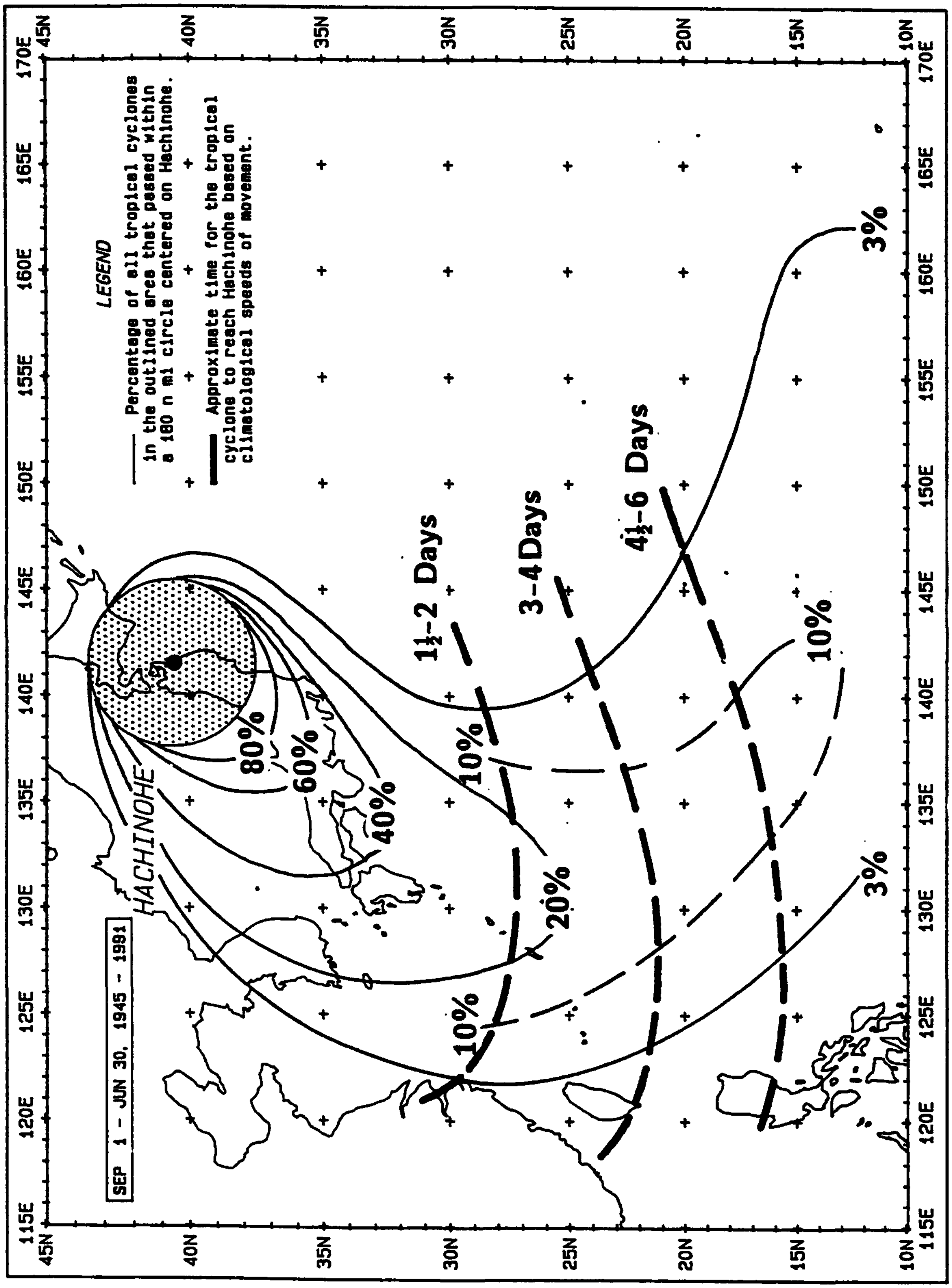

Figure V-152. Probability that a tropical storm or hurricane will pass within 180 nmi of Hachinohe (circle), and approximate time to closest point of approach, during the period September through June (based on data from 1945-1991).

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Prevailing winds at the port vary by season (Table V-37). Wind measurements for the port are taken near the mouth of the Niida River at the weather station (Fig. V-146B). Elevation of the wind equipment is about 66 ft (20 m) above sea level, and considered to be representative of winds in the port area.

Table V-37. Prevailing wind directions at the port of Hachinohe.

SEASON	PREVAILING WIND DIRECTION
Spring	Split between east-southeasterly & west-southwesterly
Summer	Southeasterly
Autumn	Southwesterly
Winter	Westerly

Typhoons affect the local area but are relatively infrequent occurrences; the port is affected primarily by strong extra-tropical weather systems. Port personnel state that winds to 70 kt (35 m/s) were observed when Typhoon Kinna passed in September 1991. The strong winds were forecast, and large ships left the port to evade at sea rather than remain in port.

Local harbor personnel state that the most hazardous winds for the port area are caused by a migratory extra-tropical double low pressure system, with centers over the Sea of Japan and over the Pacific Ocean east of Japan. The double-low configuration apparently causes the easternmost of the two lows to move northward close along the coast of Honshu, and then intensify as the low in the Sea of Japan merges with the easternmost low. The scenario brings strong winds and high seas from the northeast quadrant to Hachinohe--the worst situation for the port.

11.4.3 Local Weather Conditions

The data contained in Table V-38 has been selected from observations recorded at Misawa (11 nmi north-northwest of Hachinohe), the closest official recording station to the port.

Table V-38. Center data and related weather associated with selected tropical cyclone passages within 180 nmi of Hachinohe 1945-1991. Weather data is taken from observations taken at Misawa, Japan, 11 nmi north-northwest of Hachinohe.

TYPHOON DATA				RELATED LOCAL WEATHER		
DATE (NAME)	MVMT DIR/SOA (KT)	DIR/CPA FM STAT (NMI)	CNTR WIND (KT)	MAX WIND & GUSTS (KT)	24-HR PRECIP (IN)	COMMENTS
49/09/16 IONE	045/28	139/147	50	W 30G40	2.40	
52/08/19 KAREN	085/22	351/157	40	SSW 30	TRACE	
54/09/26 MARIE	359/37	272/79	67	SSW 39G61	1.65	
55/10/20 OPAL	039/54	137/102	38	E 16	2.55	
58/09/18 HELEN	037/33	127/147	60	W 18G26	4.37	
58/09/27 IDA	015/22	101/85	33	NE 34G45	3.71	
59/09/18 SARAH	063/26	334/128	70	SW 25G38	TRACE	BLOWING DUST VSBY 1/2 NMI
59/09/26 VERA	056/33	169/15	78	NE 46G76	2.29	
61/09/16 NANCY	016/58	295/71	65	WSW 38G54	1.41	
63/06/20 SHIRLEY	073/22	343/145	46	WSW 25G36	0.43	
67/10/28 DINAH	043/24	139/68	50	ENE 38G51	UNK	
79/10/01 OWEN	036/47	159/48	35	NNW 33G42	4.50	
79/10/19 TIP	043/74	126/85	53	WNW 31G42	2.10	
90/09/20 FLO	062/35	162/61	53	NE 24	3.92	
91/09/27 MIRIELLE	048/58	349/49	63	WNW 22	0.06	

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A total of 55 tropical storms or typhoons passed within 180 nmi of Hachinohe during the period 1945 through 1991. Of that total, 21 (38%) caused winds of ≥22 kt at Misawa, the nearest observation station to the port (11 nmi north-northwest), and only 3 (5%) caused winds of gale force (≥34 kt). The direction of passage made little difference in the observed winds, as 10 (48%) of the 21 storms causing winds of ≥22 kt passed to the west and 11 (52%) passed to the east.

The basic difference between an east passage and a west passage is the direction of the resultant wind. If the tropical cyclone passes to the west of Hachinohe, the winds will generally have a strong southerly component. An example of this is Typhoon Nancy in 1961. Passing 71 nmi west-northwest of the port, Nancy caused sustained west-southwesterly winds of 38 kt at Misawa, with gusts to 54 kt.

If the tropical cyclone passes east of Hachinohe, the path will be over water and the winds at the port will be generally northerly. An example was Typhoon Owen in 1979, which brought sustained north-northwesterly winds of 33 kt with gusts to 42 kt to Misawa.

The track segments in Figure V-153 reflect the tropical cyclone positions when sustained winds of ≥22 kt were being experienced at Hachinohe (Misawa). Only 21 of the 55 storms that passed within 180 nmi during the period of 1945 through 1991 resulted in sustained winds of ≤22 kt at Hachinohe (Misawa). Figure V-154 shows the positions of the centers of the 3 tropical cyclones that caused sustained winds ≥34 kt at Hachinohe (Misawa).

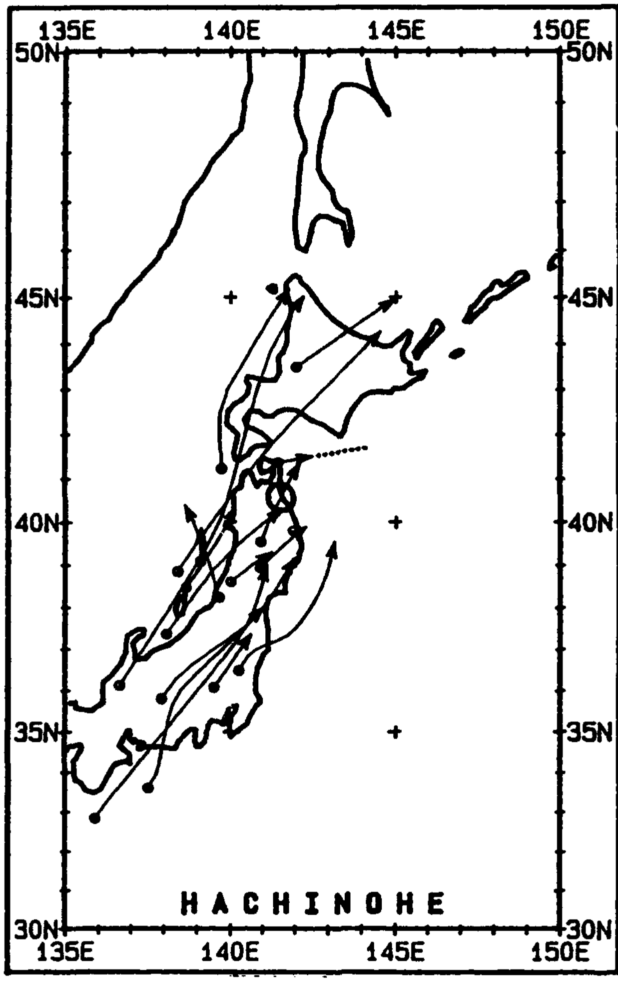

Figure V-153. Track segments of the 21 tropical storms or typhoons causing sustained winds of at least 22 kt at Hachinohe (Misawa) during the 43-year period 1948-1991.

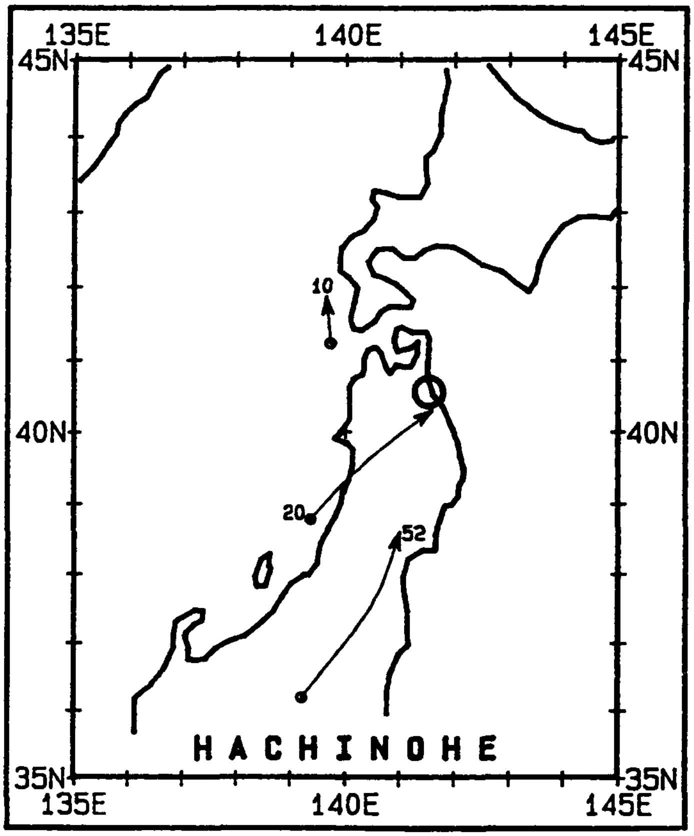

Figure V-154. Track segments of the 3 tropical storms or typhoons causing sustained winds of at least 34 kt at Hachinohe during the 43-year period 1948-1991. Index numbers correspond to those given in Table V-35.

11.4.4 Wave Action

As discussed in section 11.1 above, without the extensive grid of breakwaters the port of Hachinohe would be exposed and vulnerable to open ocean wave motion. Even with the breakwater system, some portions of the port still experience wave motion that passes through the harbor entrance between the breakwaters.

The port has observed 20 ft (6.09 m) waves outside of the breakwater system during strong winds from the eastern semicircle. Although the waves impact the breakwaters with great force, the breakwater system allows only a portion of the wave energy to pass into the inner harbor. When the highest waves are observed outside the breakwaters, the waves in the inner harbor are limited to 5 to 7 ft (1.5 to 2 m).

The berths that are most likely to be utilized by U.S. Navy vessels, berth 1-E and the fuel piers, are in well protected locations. Berth 1-E could experience waves of 5 to 7 ft from a strong easterly wind, but the waves would be parallel to the ship's longitudinal axis and should not pose a problem to the moored ship. Because of its location on the south side of a large filled-in land area, waves at the fuel piers would likely be limited to chop from wind waves.

11.5 OTHER HAZARDS AT THE PORT OF HACHINOHE

11.5.1 Fog

Fog can be a problem for ships entering and leaving the port at Hachinohe. The Hachinohe Branch of the Maritime Safety Association has issued a brochure that addresses collision and grounding problems in situations of poor visibility. The brochure calls for reaffirmation of ordinary seamanship practices for the prevention of marine casualties in fog, including the reinforcement of lookouts, appropriate use of radar, frequent confirmation of ship position, maintenance of safe speeds, earlier evasion in potentially hazardous situations and sounding proper fog signals.

11.5.2 Tsunami

Hachinohe has been subject to tsunamis resulting from earthquakes in various locations around the Pacific Ocean. While most of the effects have been relatively minor, some of the occurrences have been disastrous. In 1960, a severe earthquake in Chile (South America) caused a 17.4 ft (5.3 m) tsunami at Hachinohe, which is the largest water level rise since 1931. Lives were lost and ships were forced aground. Other, closer earthquakes have caused water level increases of 9.2 ft (2.8 m), 6.9 ft (2.1 m) and other lesser amounts. The infamous Good Friday earthquake in Alaska in late March 1964 caused a tsunami of 4.5 ft (1.4 m) at the port.

Advice from the Captain of the Port of Hachinohe is to sortie from the port if a large earthquake is felt, or a weaker earthquake with a slow motion and of long duration is felt. Remaining in port places the ships at risk of being lifted by the rising water and placed ashore.

11.6 THE DECISION TO EVADE OR REMAIN IN PORT

11.6.1 General

There is no U. S. Navy authority assigned to Hachinohe, so decisions to evade or remain in port will necessarily be made independently by the ship's captain in accordance with appropriate directives issued by higher authority.

11.6.2 Evasion Rationale

It is important that each commander recognize the inherent dangers that exist when exposed to the possibility of hazardous weather. Proper utilization of meteorological products, especially the NOCC/JTWC Guam Tropical Cyclone Warnings, and a basic understanding of weather will enable the commander to act in the best interest of his unit, and complete his mission when the unfavorable weather subsides. To assist in preparation for the threat posed by an approaching tropical cyclone, the following time/action sequence aid, to be used in conjunction with Figures V-155 and V-156, is provided.

I. An existing tropical cyclone moves into or development takes place in Area A with long range forecast movement toward Hachinohe.

   a. Review material condition of ship.

   b. Reconsider any maintenance that would render the ship incapable of riding out a storm or typhoon with the electrical load on ship's power, or would render the ship incapable of getting underway, if need be, within 48 hours. Begin planning a course of action to be taken in case of sortie.

   c. Plot NOCC/JTWC Guam warnings when received and construct the danger area (see Section I). Reconstruct the danger area for each new warning.

II. Tropical cyclone enters Area B with forecast movement toward Hachinohe (recall that tropical cyclones tend to accelerate rapidly after they have recurved):

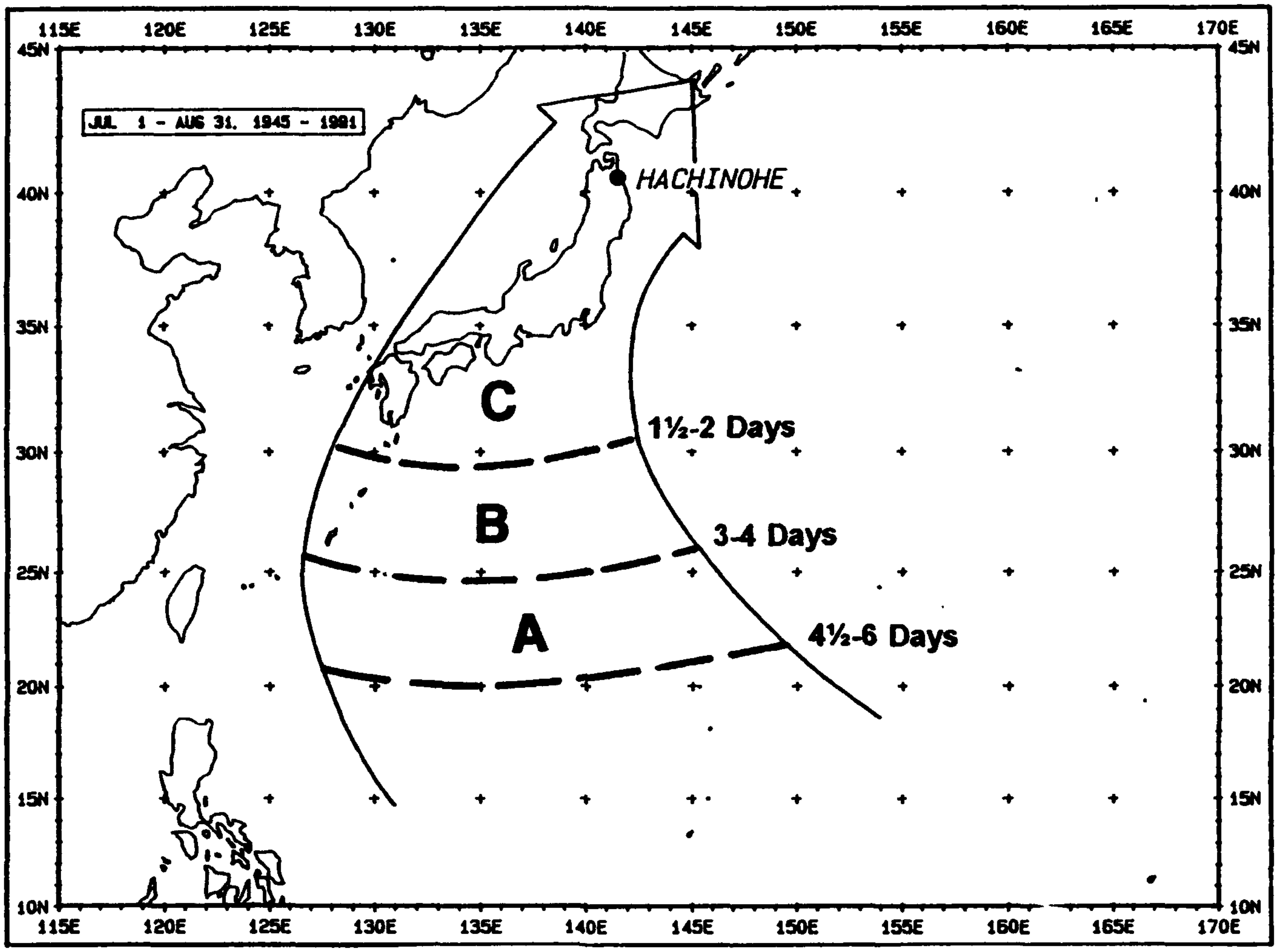

Figure V-155. Tropical cyclone threat axis for Hachinohe for July and August.

CHANGE 3

HACHINOHE

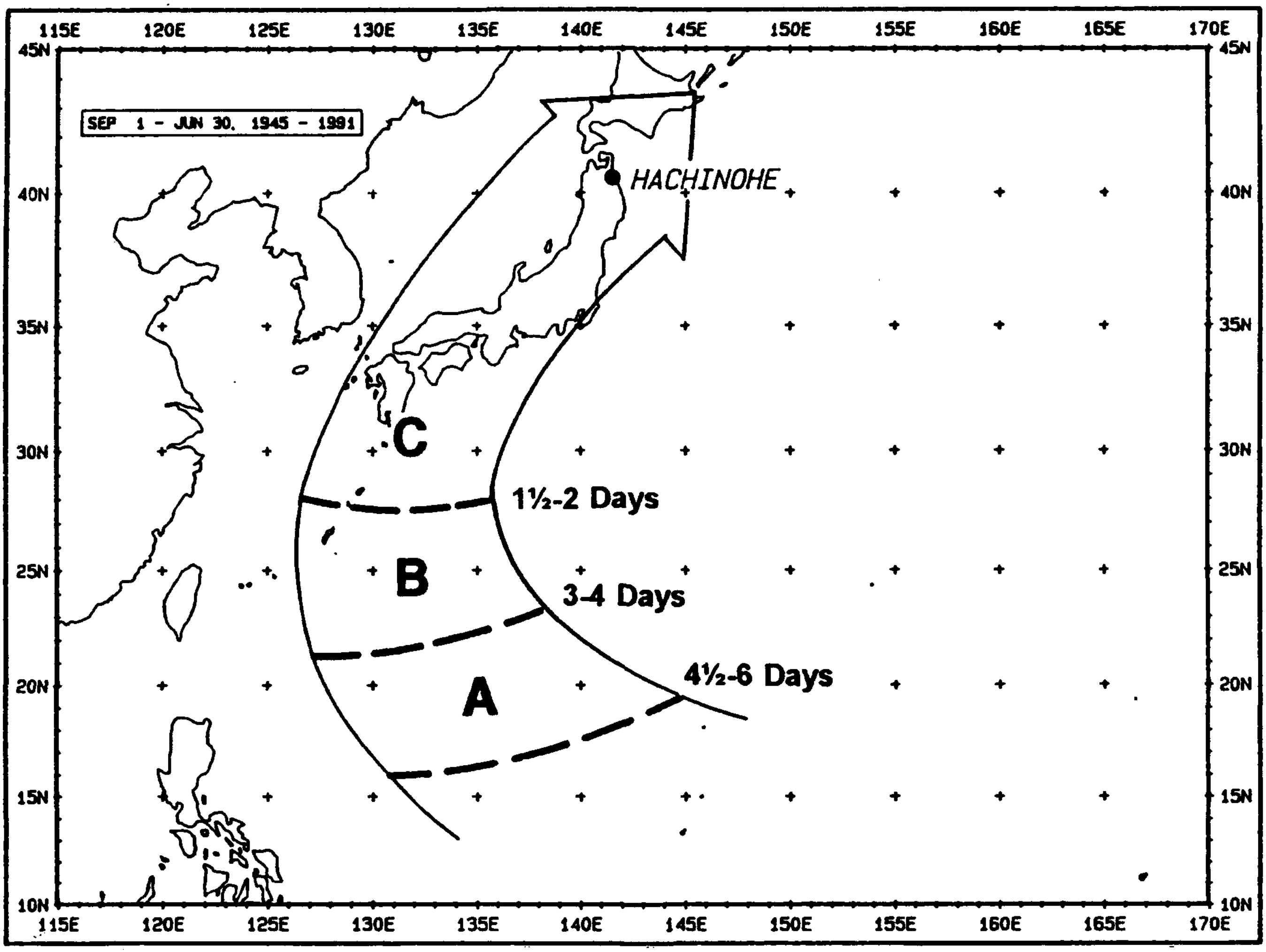

Figure V-156. Tropical cyclone threat axis for Hachinohe for the period September through June.

a. Execute sortie plans made in previous steps. Sortie should be completed before storm enters Area C.

b. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

III. Tropical cyclone has entered Area C and is moving toward Hachinohe:

a. If sortie was not accomplished by this time, evasion is no longer recommended. Anticipate the arrival of the tropical cyclone winds and take appropriate actions.

b. Plot NOCC/JTWC Guam warnings when received and construct the danger area. Reconstruct the danger area for each new warning.

11.6.3 Remaining in Port

Hachinohe is not a hurricane haven under most scenarios. The safest course of action would be for seaworthy ships to sortie from the port prior to the arrival of strong winds and evade at sea. An exception to this recommendation is for fuel barges moored to the more protected berths at the fuel piers adjacent to the mouth of the Niida River. Although they should sortie if possible, their low profile would expose them to less danger from wind, and their relatively slow SOA capability would severely reduce evasion options.

If a vessel could not get underway, it should take normal precautions for high winds. The winds that pose the greatest danger to the port are from the eastern semicircle. Since the most likely berth for a U. S. Navy ship is 1-E, the longitudinal axis of the ship would be on a bearing of approximately 105°/285° true. North to northeast winds will be broad on the beam of the moored vessel, and tend to force the ship against her berth. Winds from soutnwest to south would also be broad on the ship's beam, but tend to force the ship off her berth. Easterly winds would be the most favorable as far as direct impact on the vessel and strain on its moorings because they would be more-or-less parallel with the longitudinal axis of the hull. Extra attention should be given to the brow and mooring lines during the passage of the storm. Ships should put out extra line and wire as deemed necessary and should be ready to tend mooring lines.

11.6.4 Evasion at Sea

Except for slow moving tug/fuel barge combinations, evasion at sea is considered to be the wisest and safest course of action under most scenarios. An early sortie from the harbor will provide the captain with several evasion options that would not be available if sortie is delayed. It must be borne in mind, however, that tropical cyclones are historically unpredictable, and the 48-hour forecast position error often exceeds 200 nmi, and the storm could be closer to (or farther from) Hachinohe than the forecast indicates, or be to the right or left of the forecast track. While not a common occurrence, tropical cyclones do cross the mountainous terrain of Honshu, moving from the Sea of Japan to the Pacific Ocean, and from the Pacific Ocean to the Sea of Japan. Consequently, the prudent mariner will plan ahead, sortie early, and include back-up options in his planning in case the tropical cyclone does not follow the initial forecast track.

The cooler surface water and cool air found at higher latitudes cause tropical cyclones to lose their tropical characteristics, with a resultant weakening and ultimate dissipation of the storm as a tropical cyclone. Caution is necessary however; even though a circulation has lost its tropical identity it may still be accompanied by storm force (≥47 kt) winds.

Evasion routes at sea may be developed by the use of the NOCC/JTWC Guam tropical cyclone warnings (see paragraphs 6 and 7 of Chapter I), and Appendix A (the mean tropical cyclone tracks, track limits, and average speed of movements) for the month of interest in conjunction with Figures V-155 to V-156 (tropical cyclone threat axis and approach times to Hachinohe). In each specific case, Optimum Track Ship Routing (OTSR) should be consulted as to the best evasion route.

If the tropical cyclone is approaching Hachinohe from the south or southeast, a recommended evasion course would take the ship north from Hachinohe and west through the Tsugaru Strait into the Sea of Japan. Such an action would place the ship in northerly flow on the weaker left semicircle of the storm's circulation while moving away from the storm center. An evasion course that would keep the ship east of Japan is not recommended since it would place the ship in a vulnerable position north of the storm.

If the tropical cyclone is forecast to approach Hachinohe from the southwest across the Sea of Japan, a recommended evasion course would take the ship east and south along the coast of Honshu. If such an option were chosen, it must be initiated early because of the southerly head winds and seas that will only become stronger as the storm moves north.

Port Visit Information

November 1992: NRL Meteorologists CDR R. G. Handlers, USN, and Mr. L. Phegley, and SAIC Meteorologist Mr. R. D. Gilmore met with LCDR Carman, OIC NOCD Misawa, Mr. Matsuo, Maritime Safety Office and Mr. Inui, Guard and Rescue Division Headquarters to obtain much of the information included in this port evaluation. Mr. Yokosaka, NAF Misawa Interpreter, greatly aided in the collection of port information.

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Commander in Chief, U.S. Seventh Fleet
COMSEVENTHFLT OPORD 201-(YR) Annex H

Commander, U.S. Naval Forces Japan
COMNAVFORJAPANINST 3140.1 (series)

Commander, U.S. Fleet Activities, Yokosuka
COMFLEACTINST 3140.1 (TROPICAL CYCLONE PLAN)
COMFLEACTINST 5000.1 (SOPA ADMIN)

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APPENDIX A

BI-WEEKLY TROPICAL STORM AND TYPHOON TRACKS FOR THE WESTERN NORTH PACIFIC OCEAN[1]

While it must be realized that tropical storms and typhoons deviate from the mean tracks presented in this appendix, the use of these tracks should be of particular benefit in long range planning. The application of the average tracks to specific short range situations should be avoided. Warnings issued by JTWC Guam are the immediate source of information on predicted movement. Figure A-1 presents the frequency of western North Pacific tropical storms and typhoons on a monthly basis.

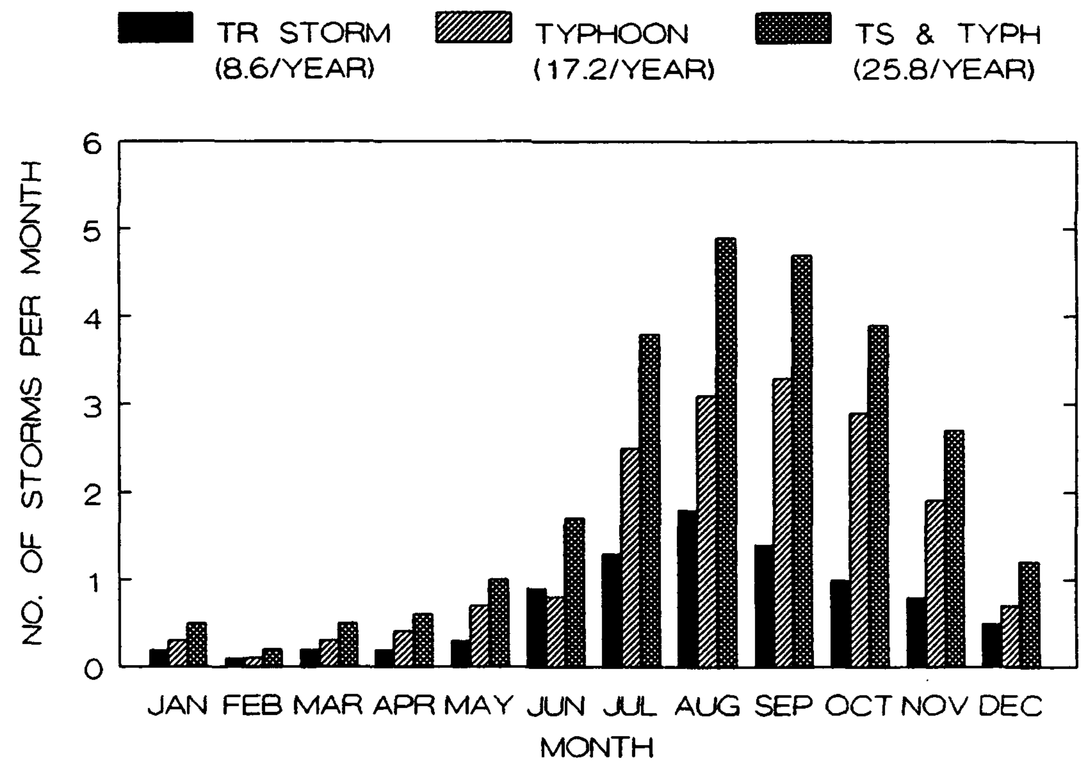

Figure A-1. Monthly WESTPAC tropical storm and typhoon frequency.

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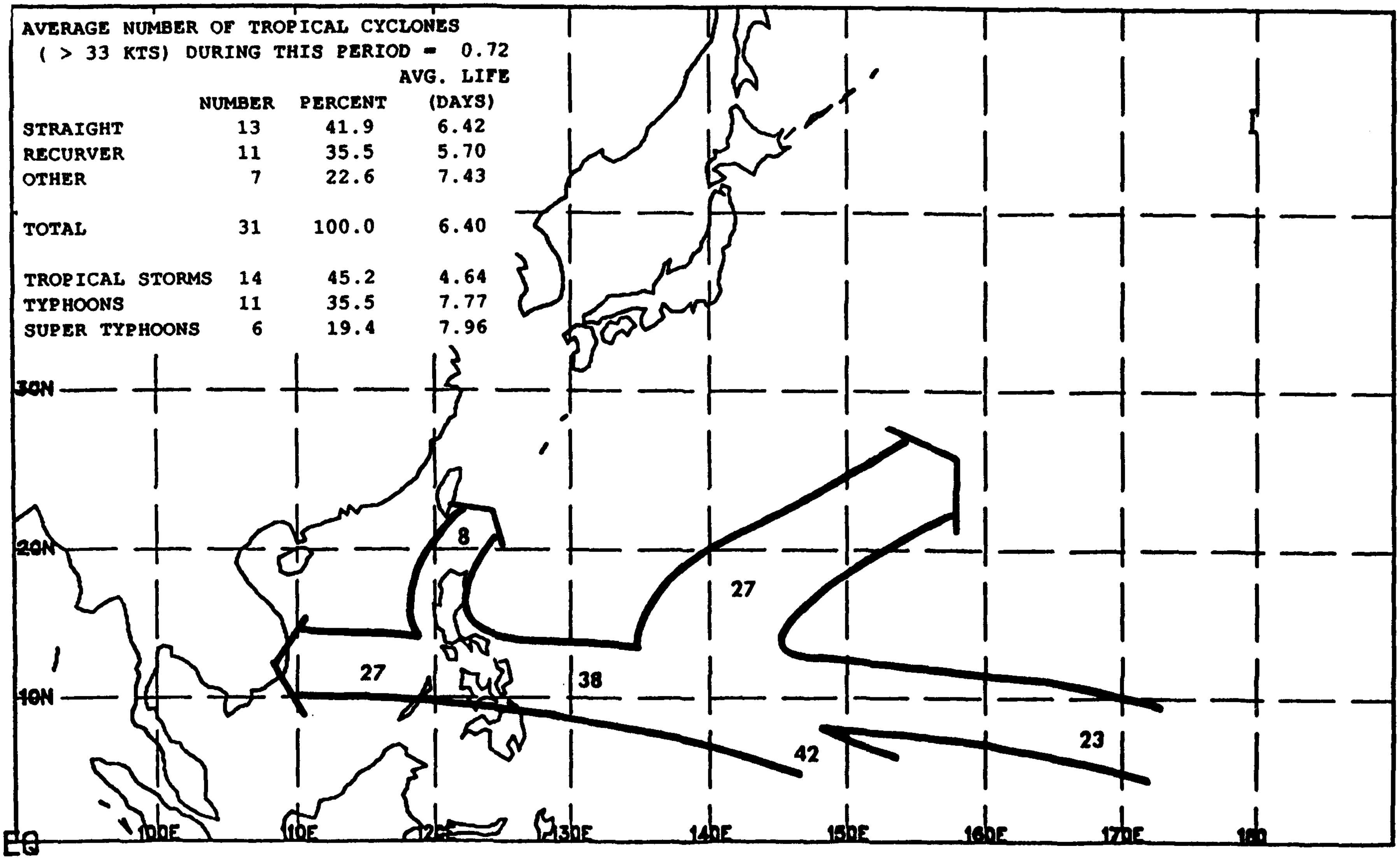
[1] Material in this appendix adapted from 'Climatology of North Pacific Tropical Cyclone Tracks', NAVENVPREDRESFAC Technical Report TR 88-10, Naval Research Laboratory, Monterey, CA 93943-5502.

MEAN PATHS FOR DEC 24 - JAN 8

AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 0.72

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	13	41.9	6.42
RECURVER	11	35.5	5.70
OTHER	7	22.6	7.43
TOTAL	31	100.0	6.40
TROPICAL STORMS	14	45.2	4.64
TYPHOONS	11	35.5	7.77
SUPER TYPHOONS	6	19.4	7.96

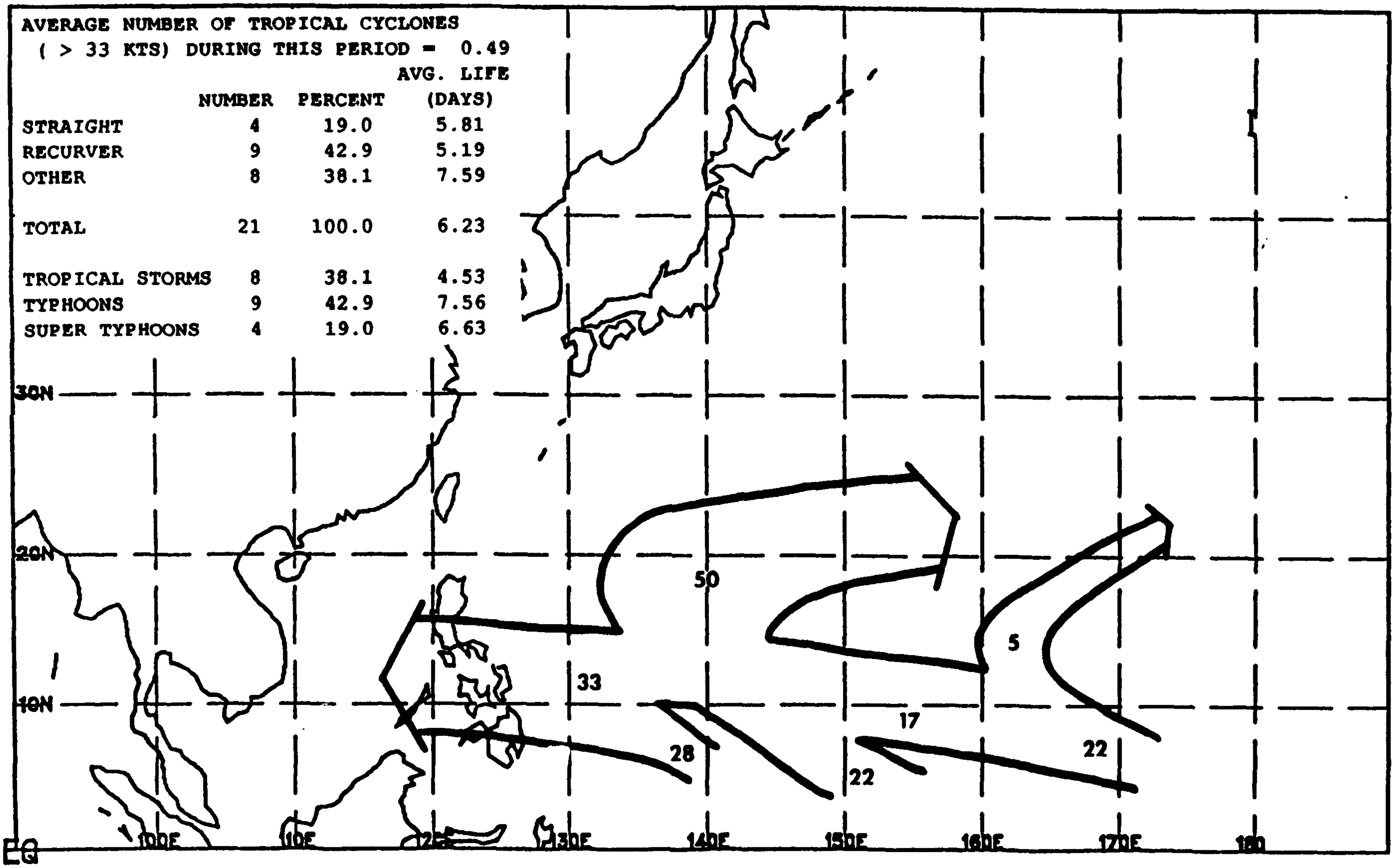


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored.

MEAN PATHS FOR JAN 9 - JAN 23

AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 0.49

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	4	19.0	5.81
RECURVER	9	42.9	5.19
OTHER	8	38.1	7.59
TOTAL	21	100.0	6.23
TROPICAL STORMS	8	38.1	4.53
TYPHOONS	9	42.9	7.56
SUPER TYPHOONS	4	19.0	6.63

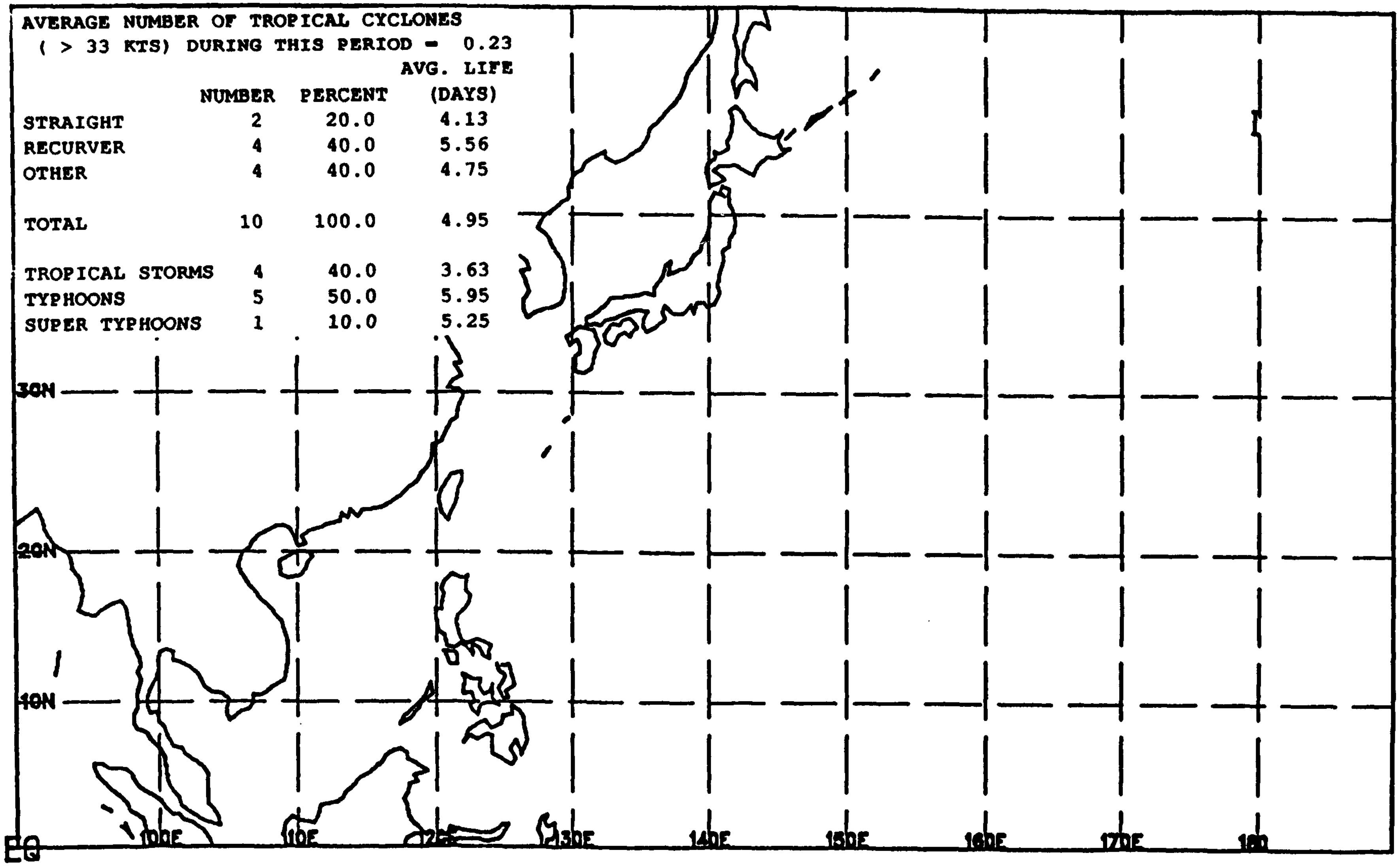


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored.

MEAN PATHS FOR JAN 24 - FEB 8

AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 0.23

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	2	20.0	4.13
RECURVER	4	40.0	5.56
OTHER	4	40.0	4.75
TOTAL	10	100.0	4.95
TROPICAL STORMS	4	40.0	3.63
TYPHOONS	5	50.0	5.95
SUPER TYPHOONS	1	10.0	5.25

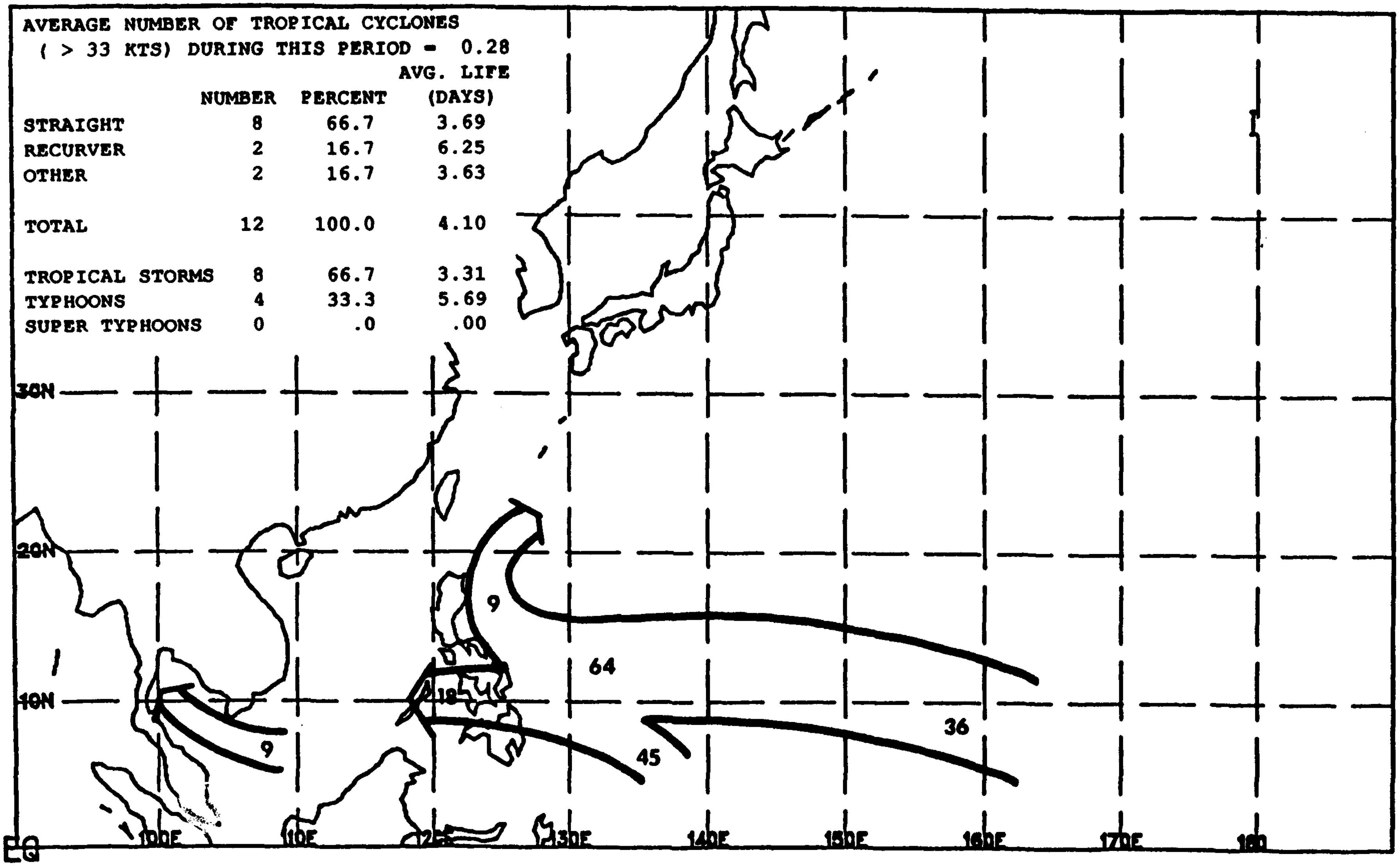


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored.

MEAN PATHS FOR FEB 9 - FEB 23

AVERAGE NUMBER OF TROPICAL CYCLONES
(> 33 KTS) DURING THIS PERIOD = 0.28

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	8	66.7	3.69
RECURVER	2	16.7	6.25
OTHER	2	16.7	3.63
TOTAL	12	100.0	4.10
TROPICAL STORMS	8	66.7	3.31
TYPHOONS	4	33.3	5.69
SUPER TYPHOONS	0	.0	.00



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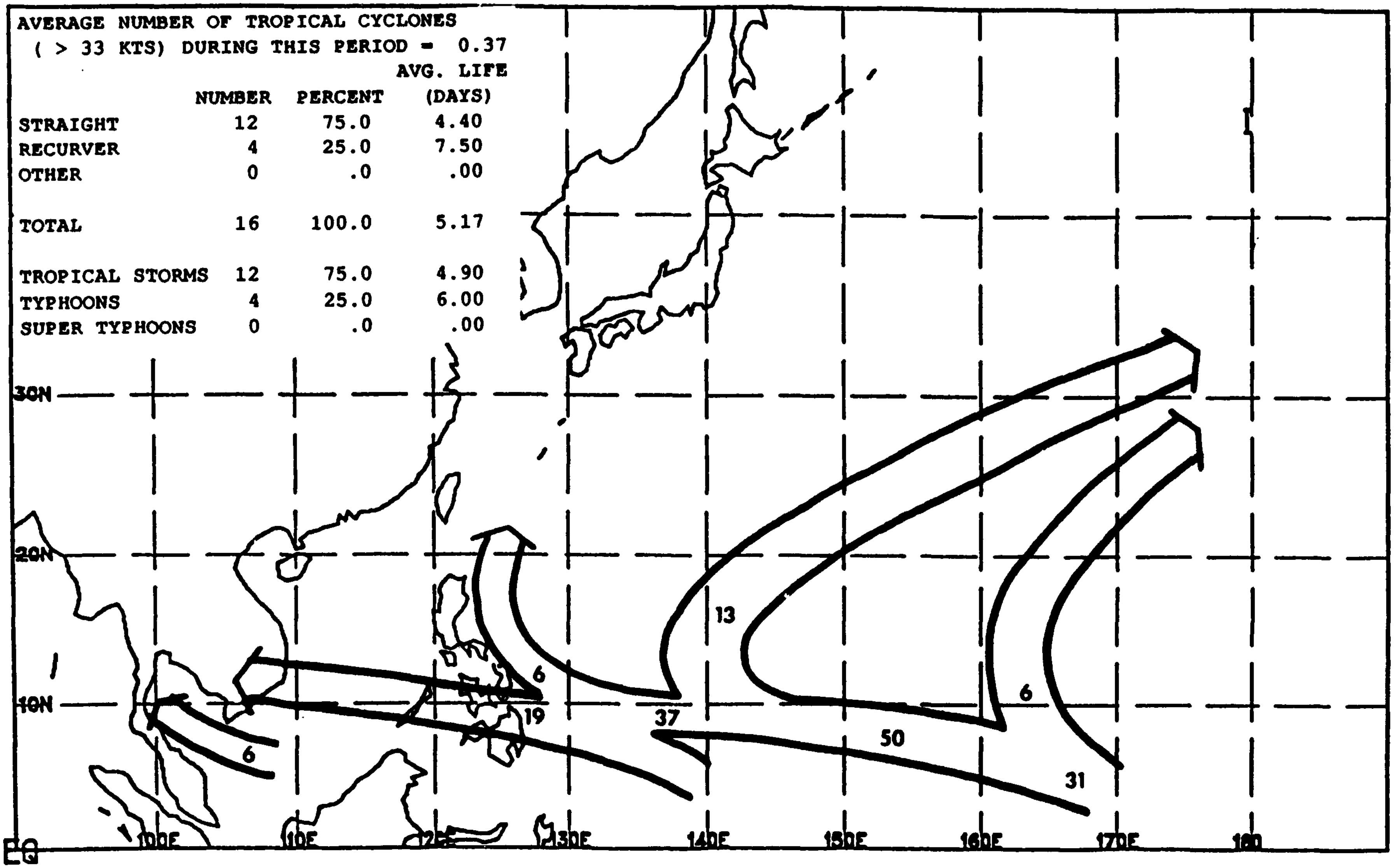
MEAN PATHS FOR FEB 24 - MAR 8

AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 0.37

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	12	75.0	4.40
RECURVER	4	25.0	7.50
OTHER	0	.0	.00
TOTAL	16	100.0	5.17
TROPICAL STORMS	12	75.0	4.90
TYPHOONS	4	25.0	6.00
SUPER TYPHOONS	0	.0	.00

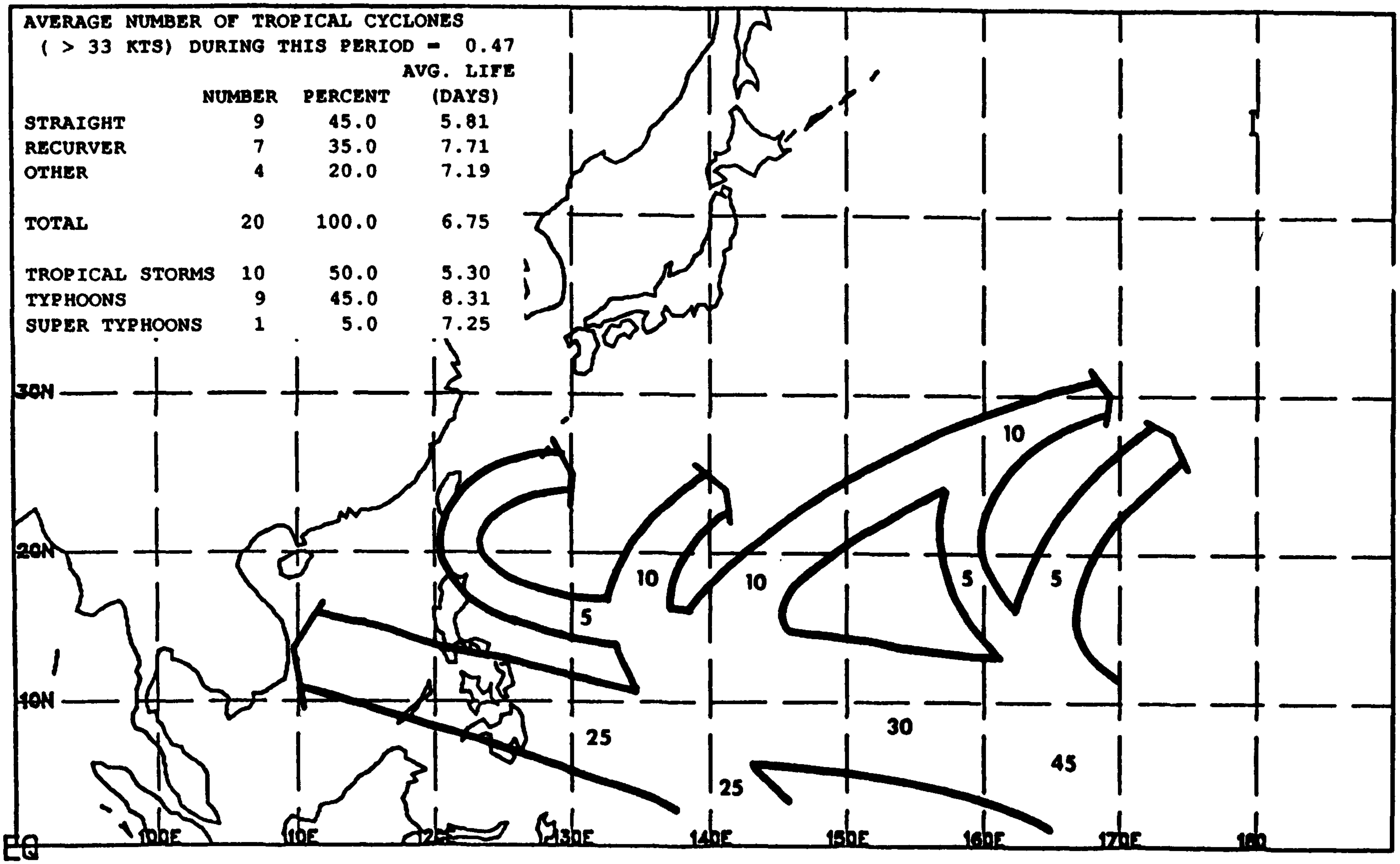


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored.

MEAN PATHS FOR MAR 9 - MAR 23

AVERAGE NUMBER OF TROPICAL CYCLONES
(> 33 KTS) DURING THIS PERIOD = 0.47

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	9	45.0	5.81
RECURVER	7	35.0	7.71
OTHER	4	20.0	7.19
TOTAL	20	100.0	6.75
TROPICAL STORMS	10	50.0	5.30
TYPHOONS	9	45.0	8.31
SUPER TYPHOONS	1	5.0	7.25

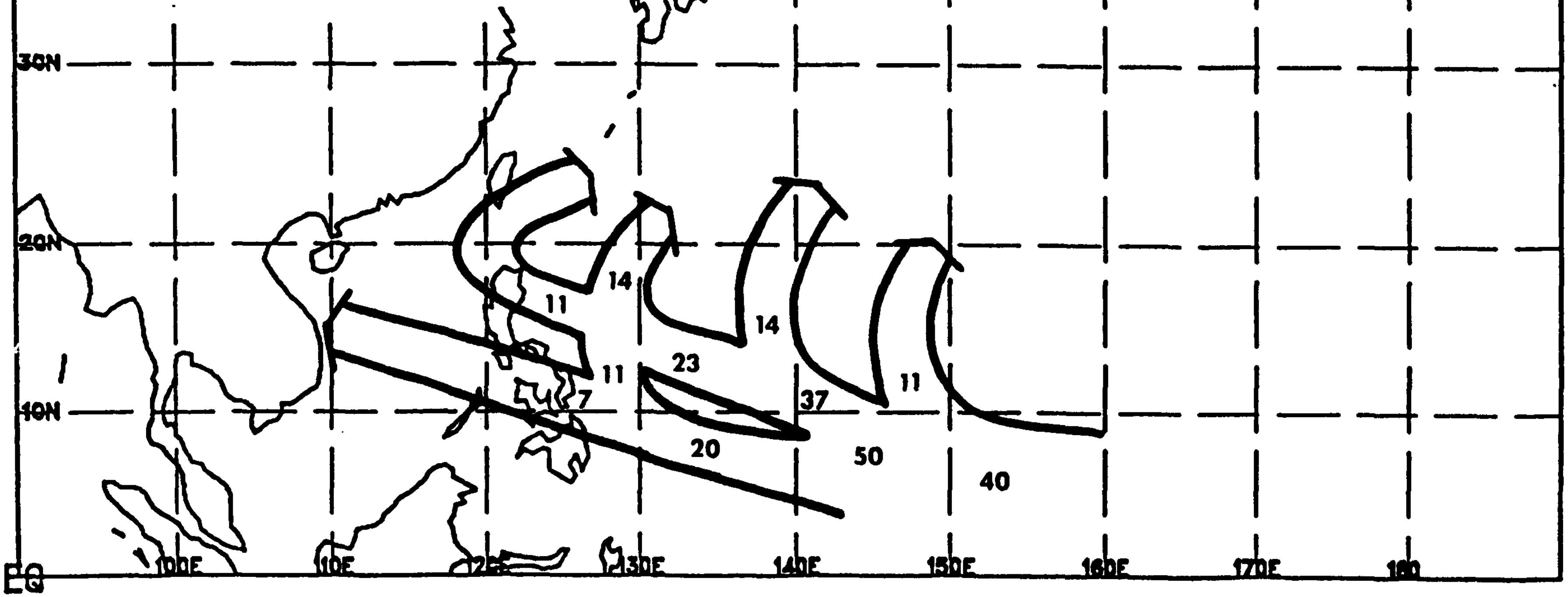


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored.

MEAN PATHS FOR MAR 24 - APR 8

AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 0.63

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	7	25.9	5.54
RECURVER	15	55.6	9.32
OTHER	5	18.5	7.80
TOTAL	27	100.0	8.06
TROPICAL STORMS	7	25.9	3.82
TYPHOONS	17	63.0	9.66
SUPER TYPHOONS	3	11.1	8.83

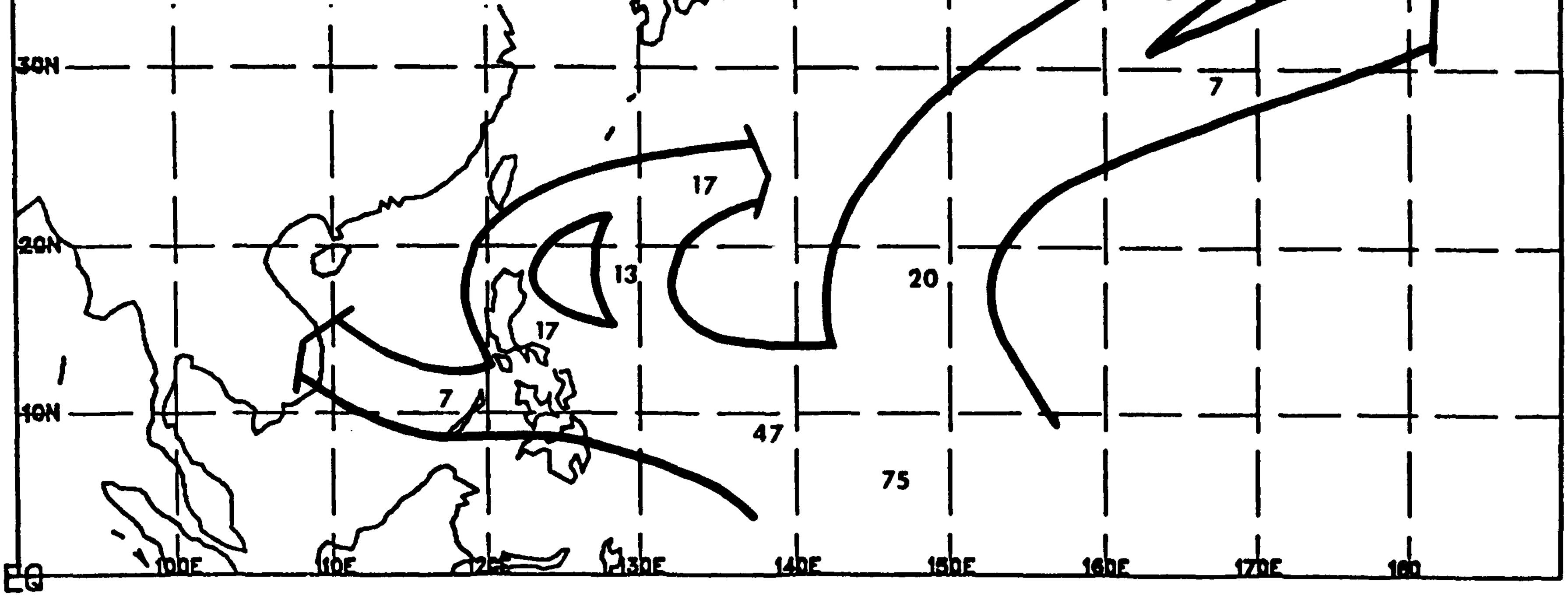


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored.

MEAN PATHS FOR APR 9 - APR 23

AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 0.70

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	8	26.7	6.28
RECURVER	16	53.3	9.23
OTHER	6	20.0	8.58
TOTAL	30	100.0	8.32
TROPICAL STORMS	8	26.7	6.56
TYPHOONS	18	60.0	8.68
SUPER TYPHOONS	4	13.3	10.19

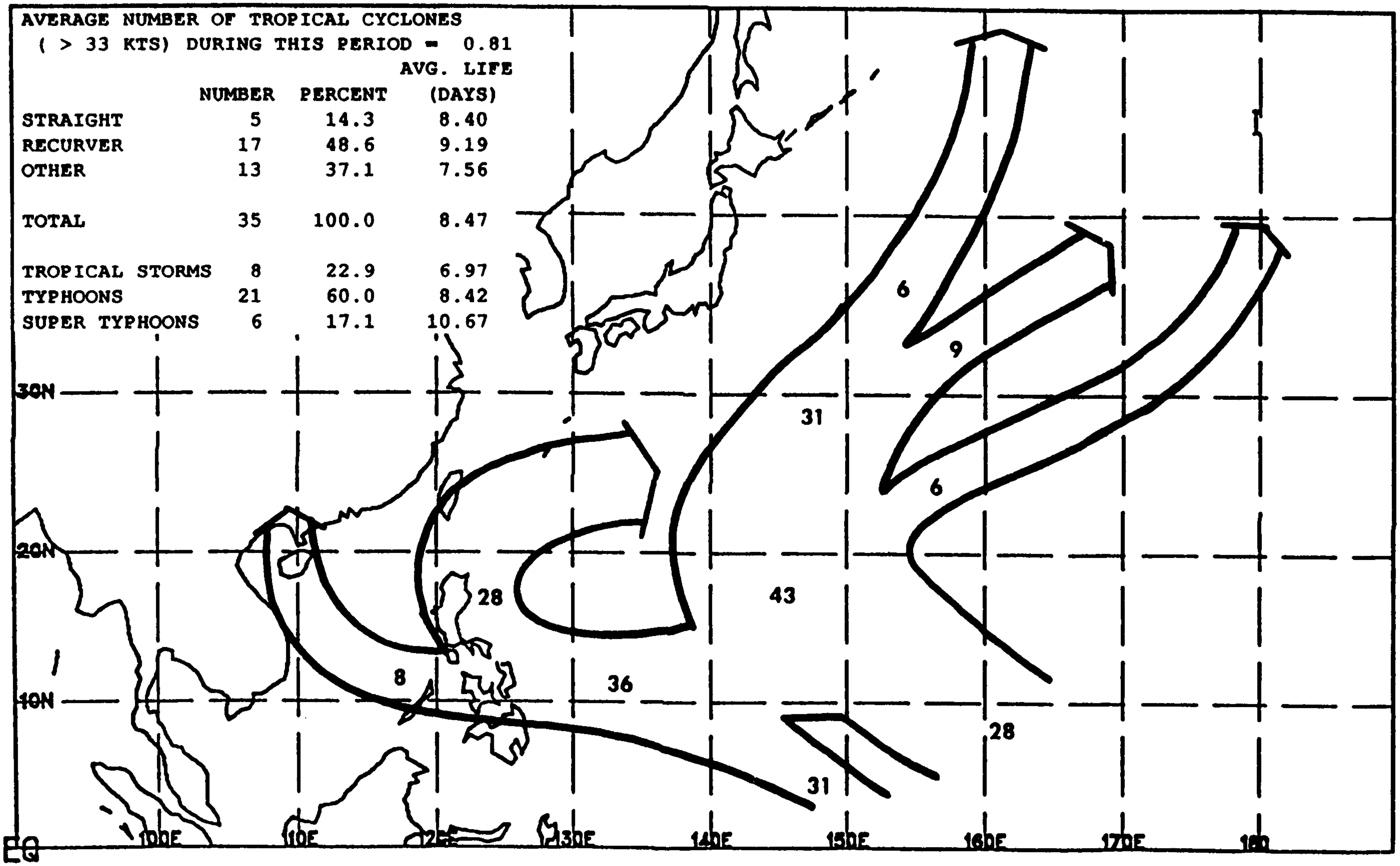


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored.

MEAN PATHS FOR APR 24 - MAY 8

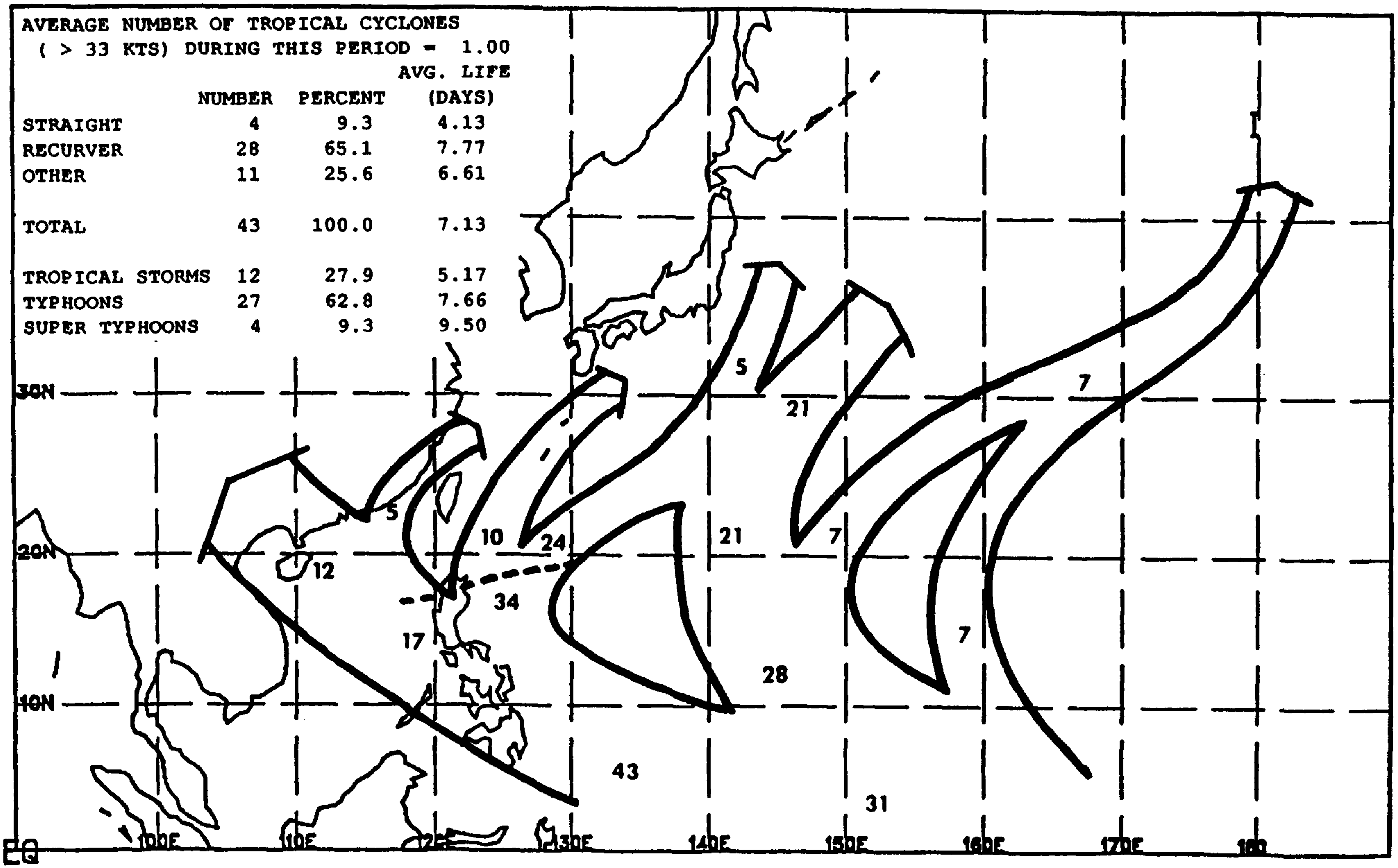
AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 0.81

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	5	14.3	8.40
RECURVER	17	48.6	9.19
OTHER	13	37.1	7.56
TOTAL	35	100.0	8.47
TROPICAL STORMS	8	22.9	6.97
TYPHOONS	21	60.0	8.42
SUPER TYPHOONS	6	17.1	10.67



Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored.

MEAN PATHS FOR MAY 9 - MAY 23

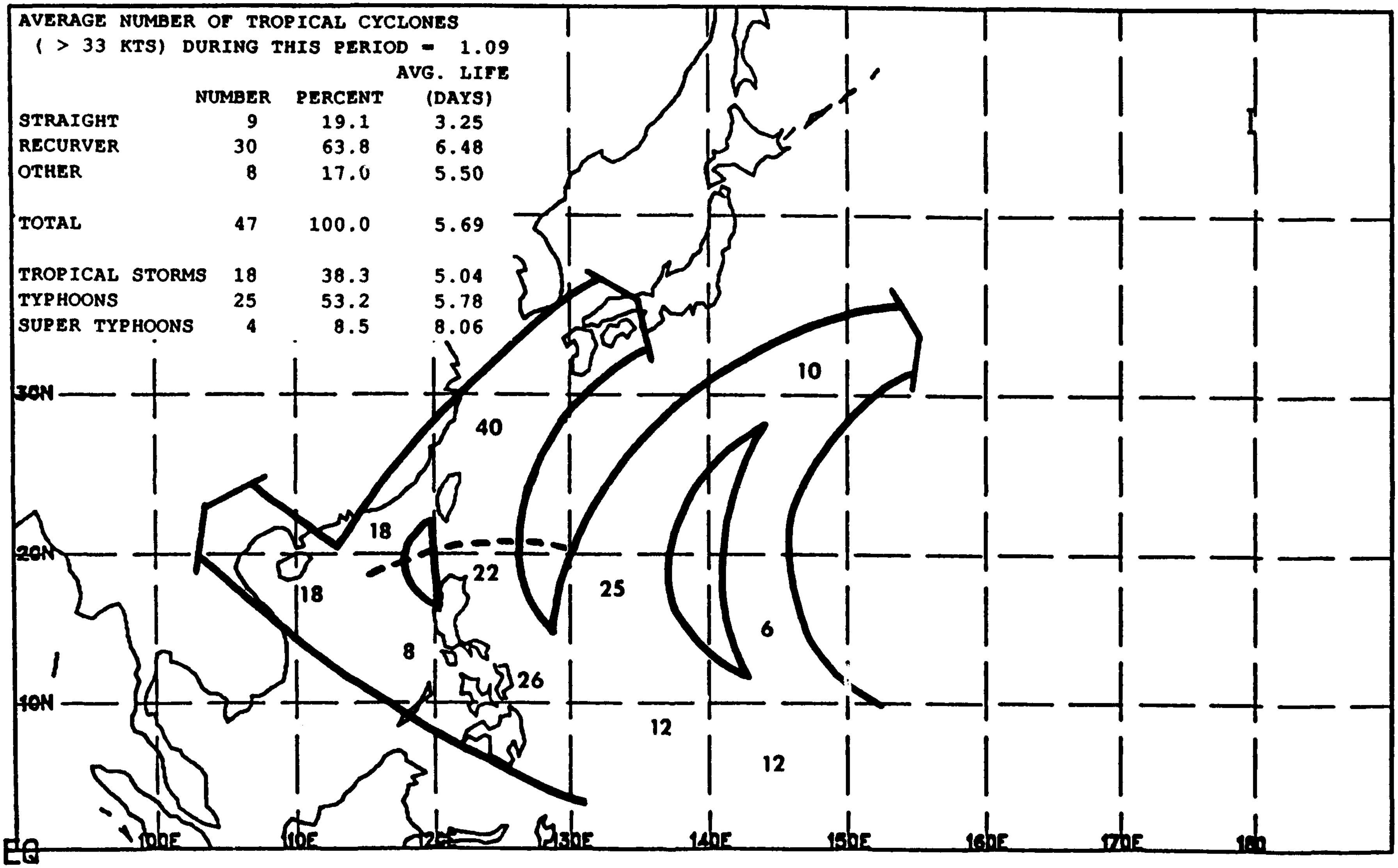


AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 1.00

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	4	9.3	4.13
RECURVER	28	65.1	7.77
OTHER	11	25.6	6.61
TOTAL	43	100.0	7.13
TROPICAL STORMS	12	27.9	5.17
TYPHOONS	27	62.8	7.66
SUPER TYPHOONS	4	9.3	9.50

Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR MAY 24 - JUN 8

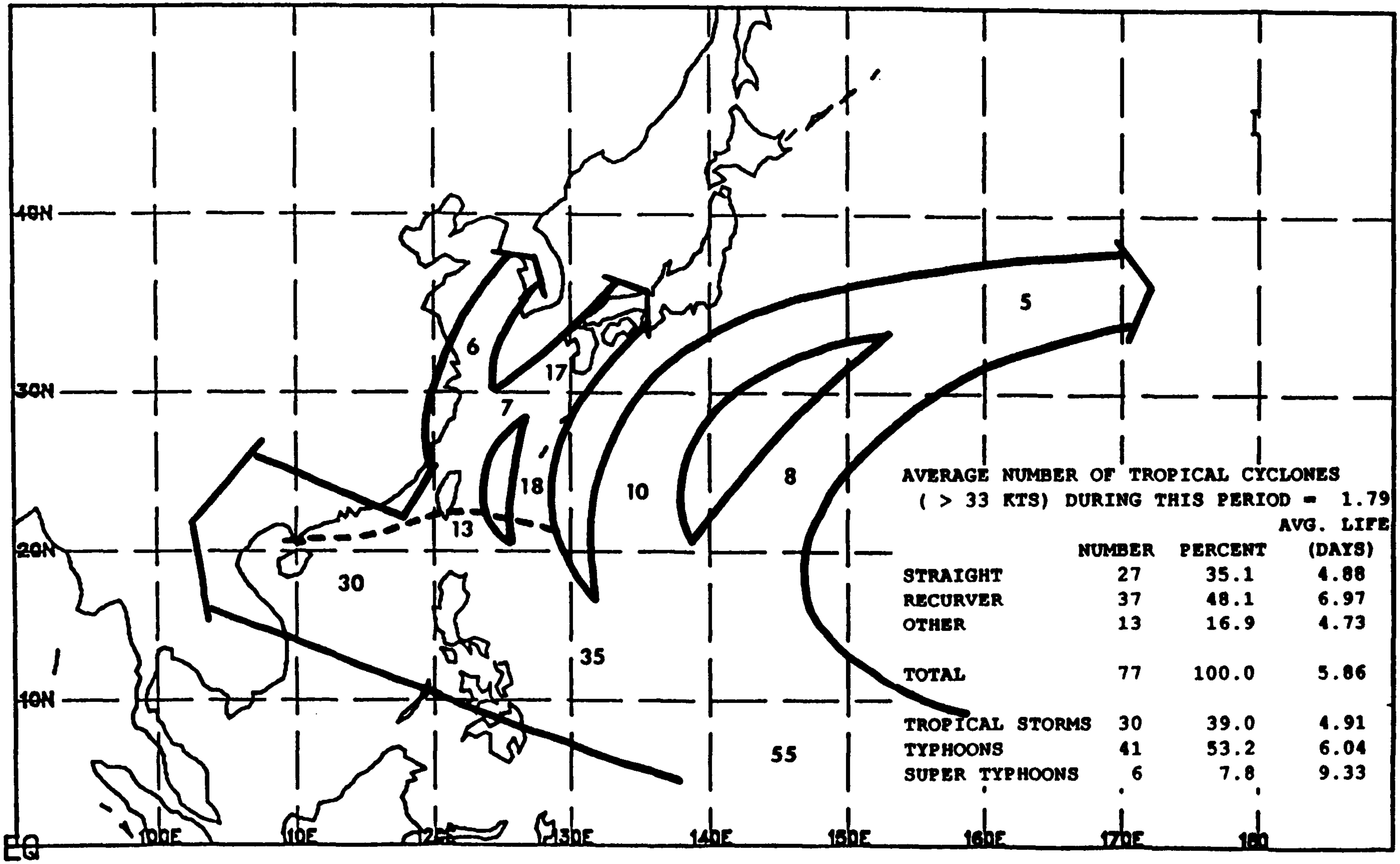


AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 1.09

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	9	19.1	3.25
RECURVER	30	63.8	6.48
OTHER	8	17.0	5.50
TOTAL	47	100.0	5.69
TROPICAL STORMS	18	38.3	5.04
TYPHOONS	25	53.2	5.78
SUPER TYPHOONS	4	8.5	8.06

Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR JUN 9 - JUN 23

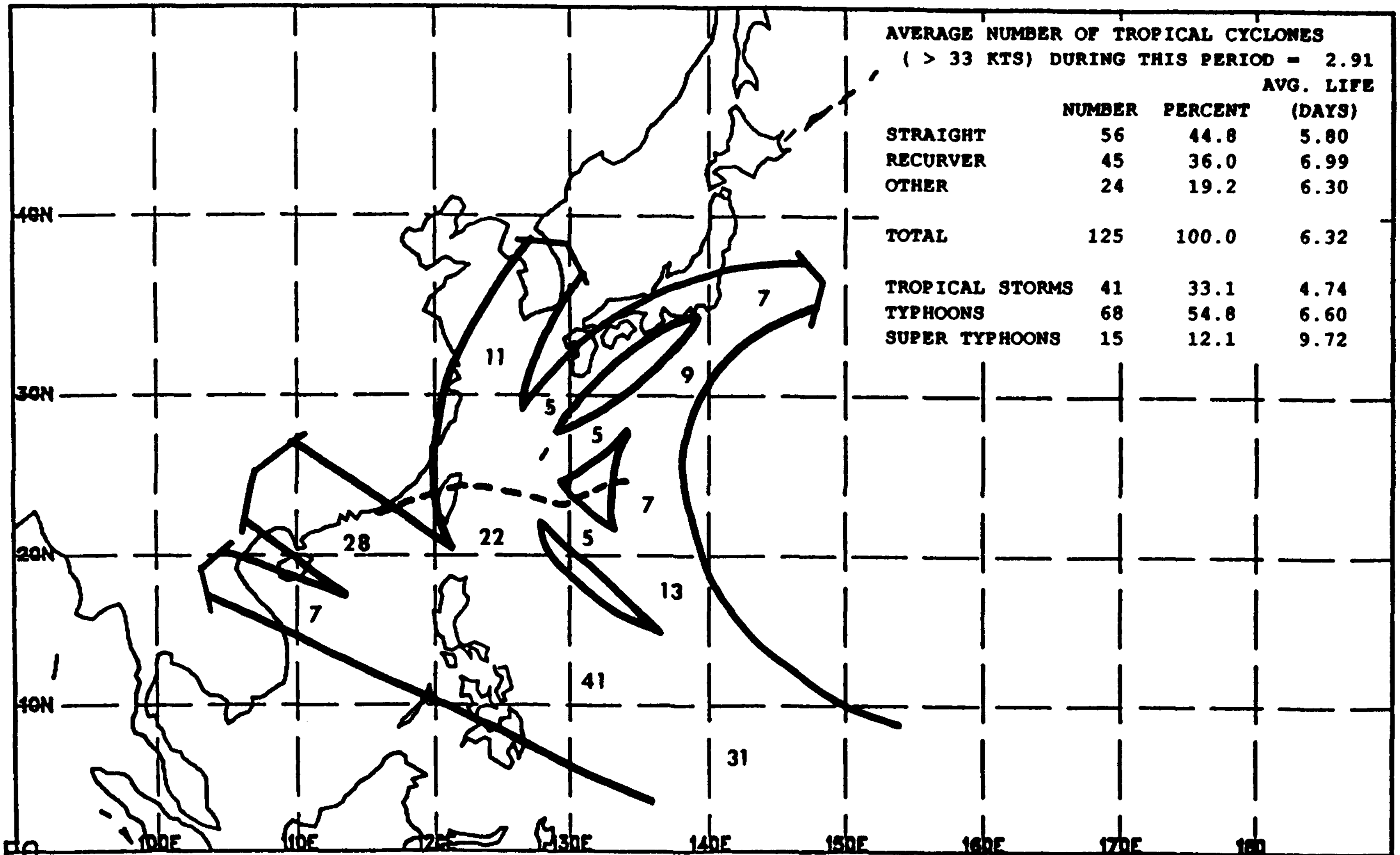


AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 1.79

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	27	35.1	4.88
RECURVER	37	48.1	6.97
OTHER	13	16.9	4.73
TOTAL	77	100.0	5.86
TROPICAL STORMS	30	39.0	4.91
TYPHOONS	41	53.2	6.04
SUPER TYPHOONS	6	7.8	9.33

Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR JUN 24 - JUL 8

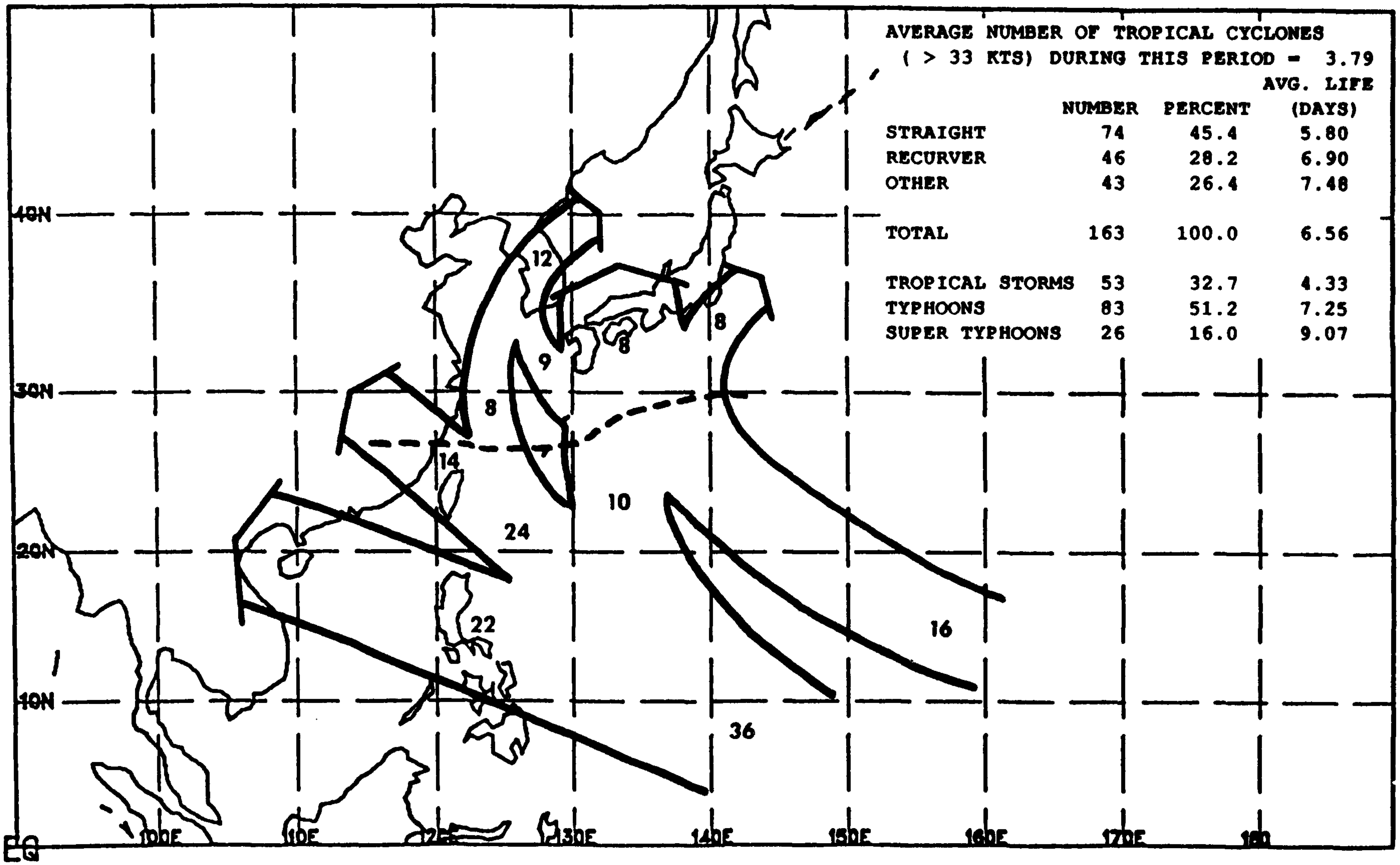


AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 2.91

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	56	44.8	5.80
RECURVER	45	36.0	6.99
OTHER	24	19.2	6.30
TOTAL	125	100.0	6.32
TROPICAL STORMS	41	33.1	4.74
TYPHOONS	68	54.8	6.60
SUPER TYPHOONS	15	12.1	9.72

Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR JUL 9 - JUL 23

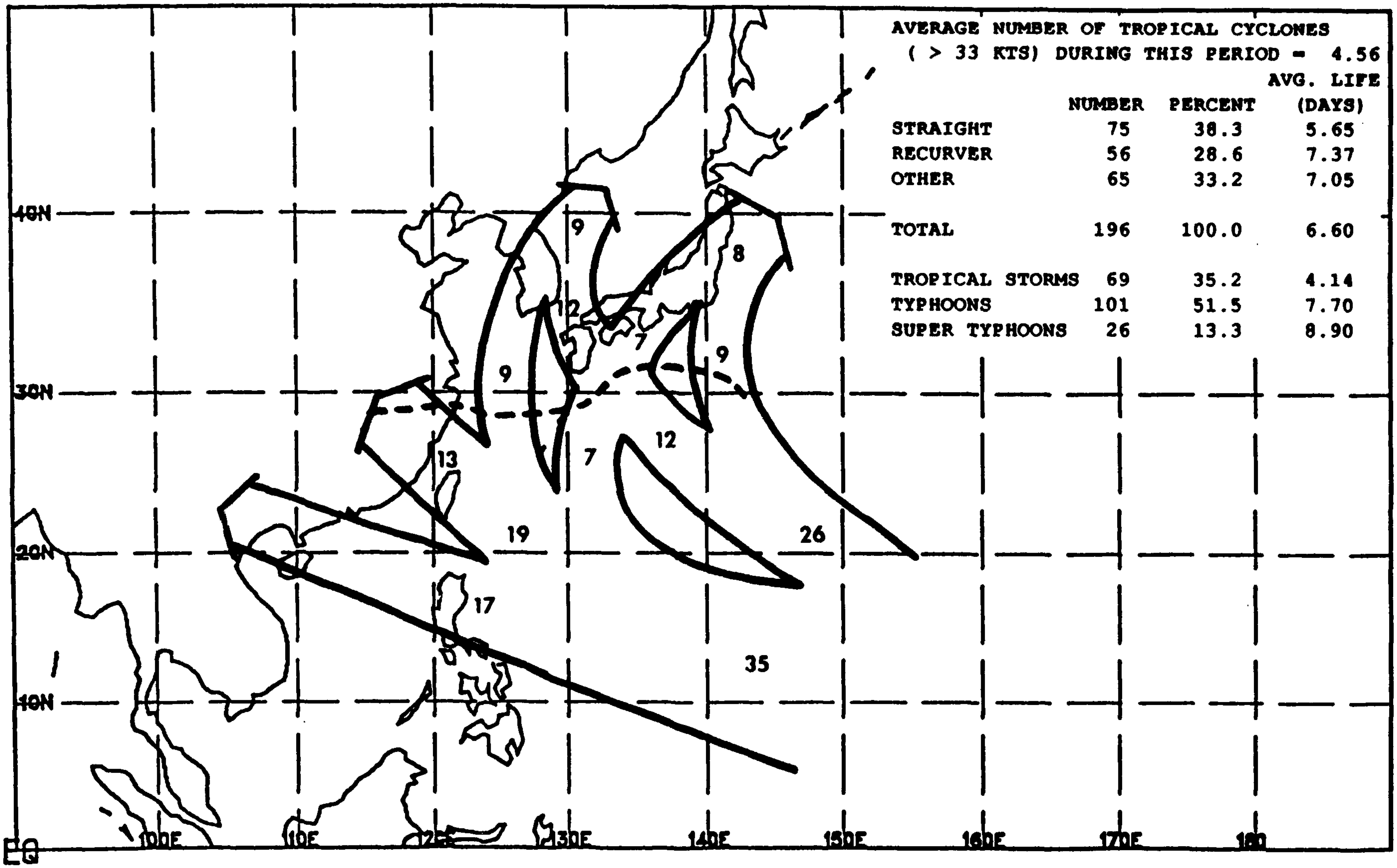


AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 3.79

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	74	45.4	5.80
RECURVER	46	28.2	6.90
OTHER	43	26.4	7.48
TOTAL	163	100.0	6.56
TROPICAL STORMS	53	32.7	4.33
TYPHOONS	83	51.2	7.25
SUPER TYPHOONS	26	16.0	9.07

Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

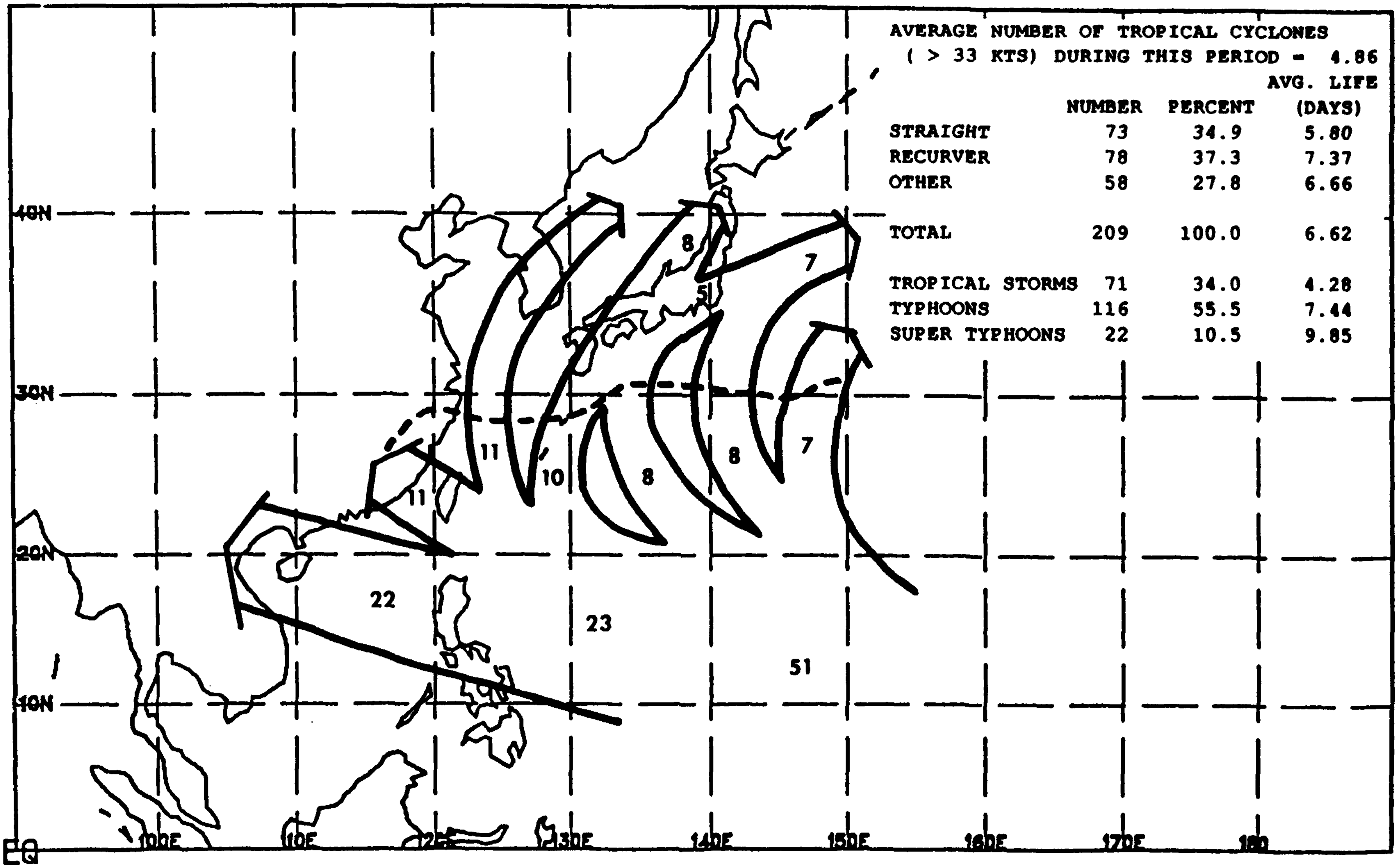
MEAN PATHS FOR JUL 24 - AUG 8



AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 4.56	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	75	38.3	5.65
RECURVER	56	28.6	7.37
OTHER	65	33.2	7.05
TOTAL	196	100.0	6.60
TROPICAL STORMS	69	35.2	4.14
TYPHOONS	101	51.5	7.70
SUPER TYPHOONS	26	13.3	8.90

Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR AUG 9 - AUG 23

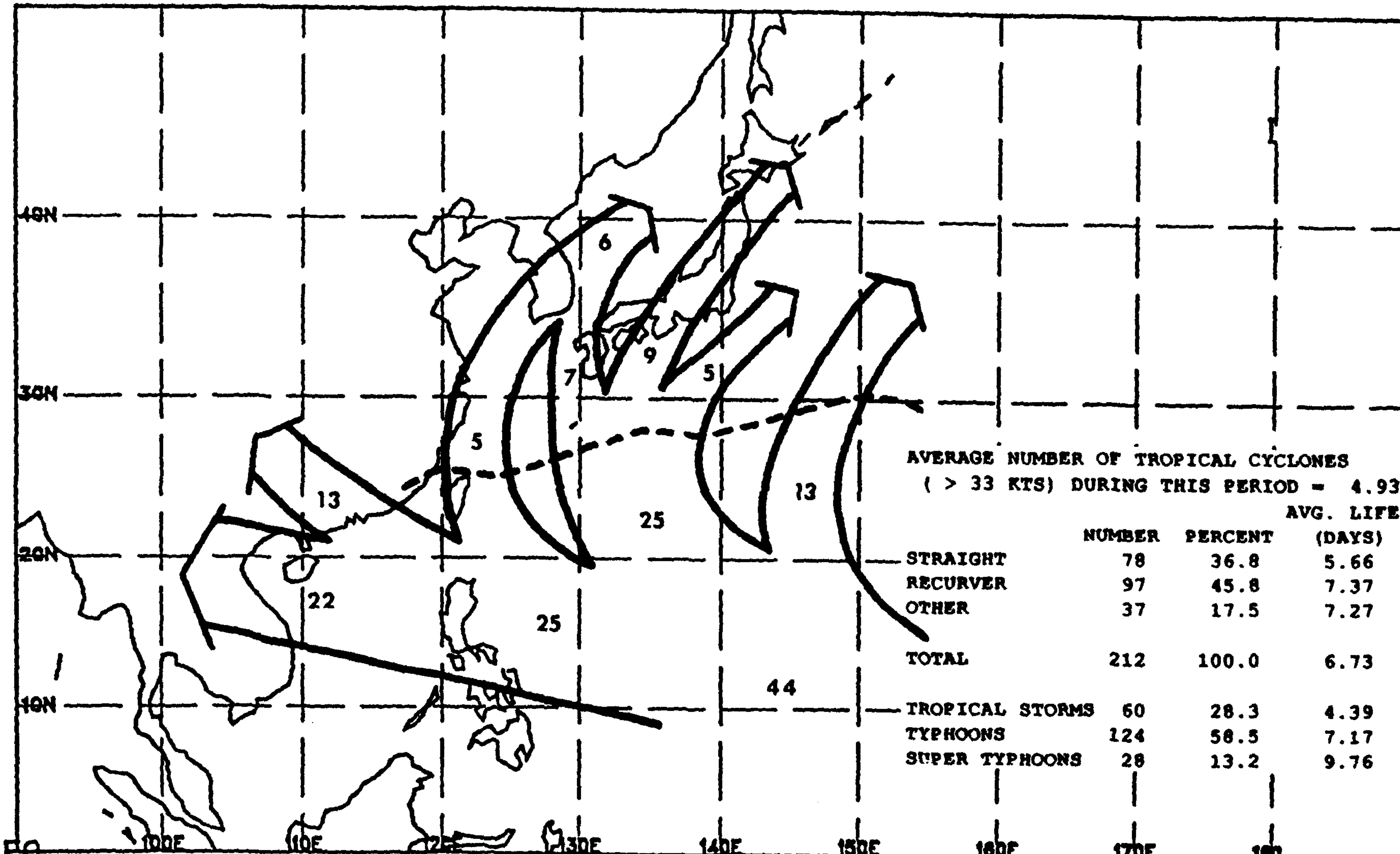


AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 4.86

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	73	34.9	5.80
RECURVER	78	37.3	7.37
OTHER	58	27.8	6.66
TOTAL	209	100.0	6.62
TROPICAL STORMS	71	34.0	4.28
TYPHOONS	116	55.5	7.44
SUPER TYPHOONS	22	10.5	9.85

Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR AUG 24 - SEP 8



AVERAGE NUMBER OF TROPICAL CYCLONES
(> 33 KTS) DURING THIS PERIOD = 4.93

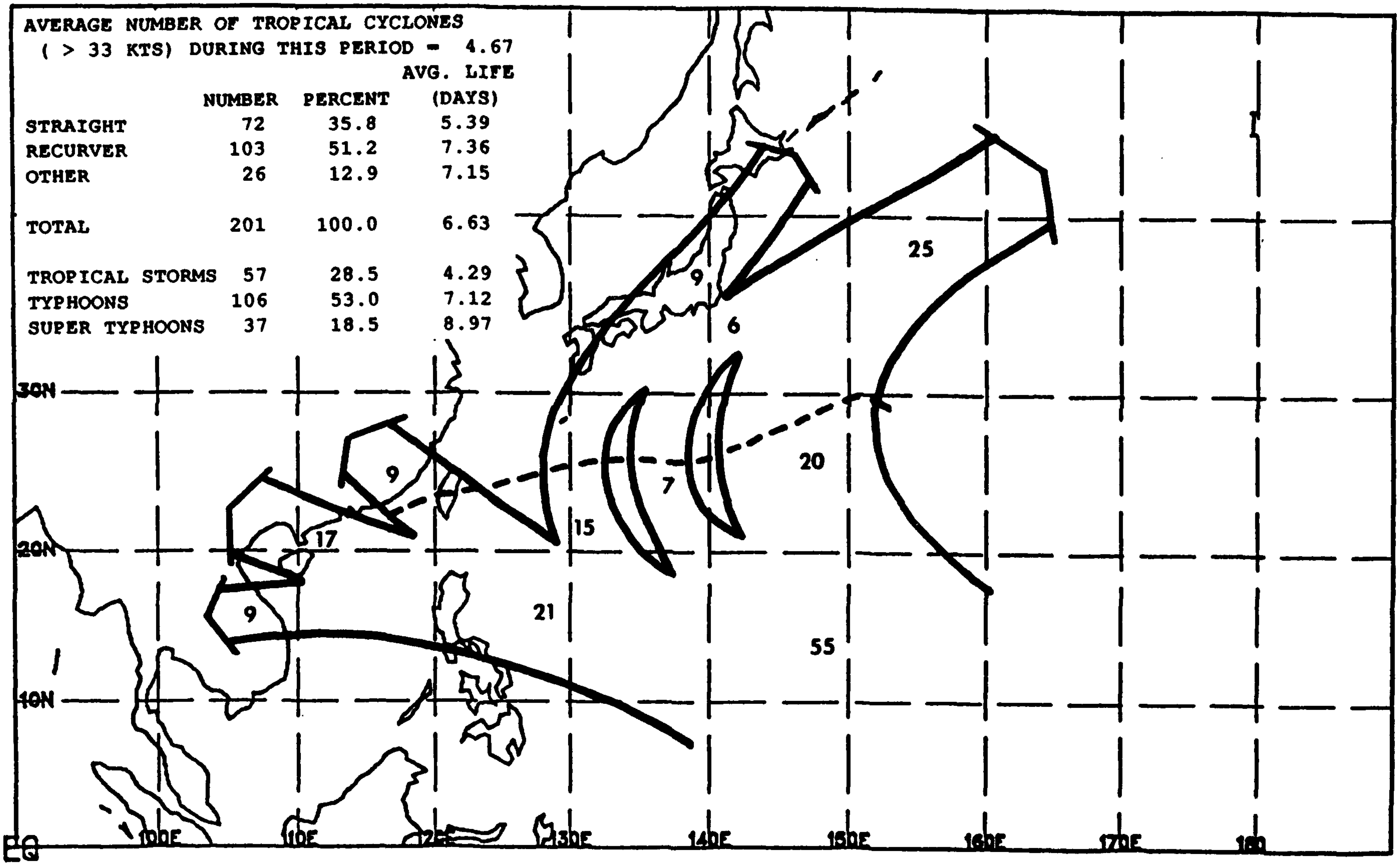
	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	78	36.8	5.66
RECURVER	97	45.8	7.37
OTHER	37	17.5	7.27
TOTAL	212	100.0	6.73
TROPICAL STORMS	60	28.3	4.39
TYPHOONS	124	58.5	7.17
SUPER TYPHOONS	28	13.2	9.76

Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These *numbers may not add up to 100%* since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR SEP 9 - SEP 23

AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 4.67

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	72	35.8	5.39
RECURVER	103	51.2	7.36
OTHER	26	12.9	7.15
TOTAL	201	100.0	6.63
TROPICAL STORMS	57	28.5	4.29
TYPHOONS	106	53.0	7.12
SUPER TYPHOONS	37	18.5	8.97

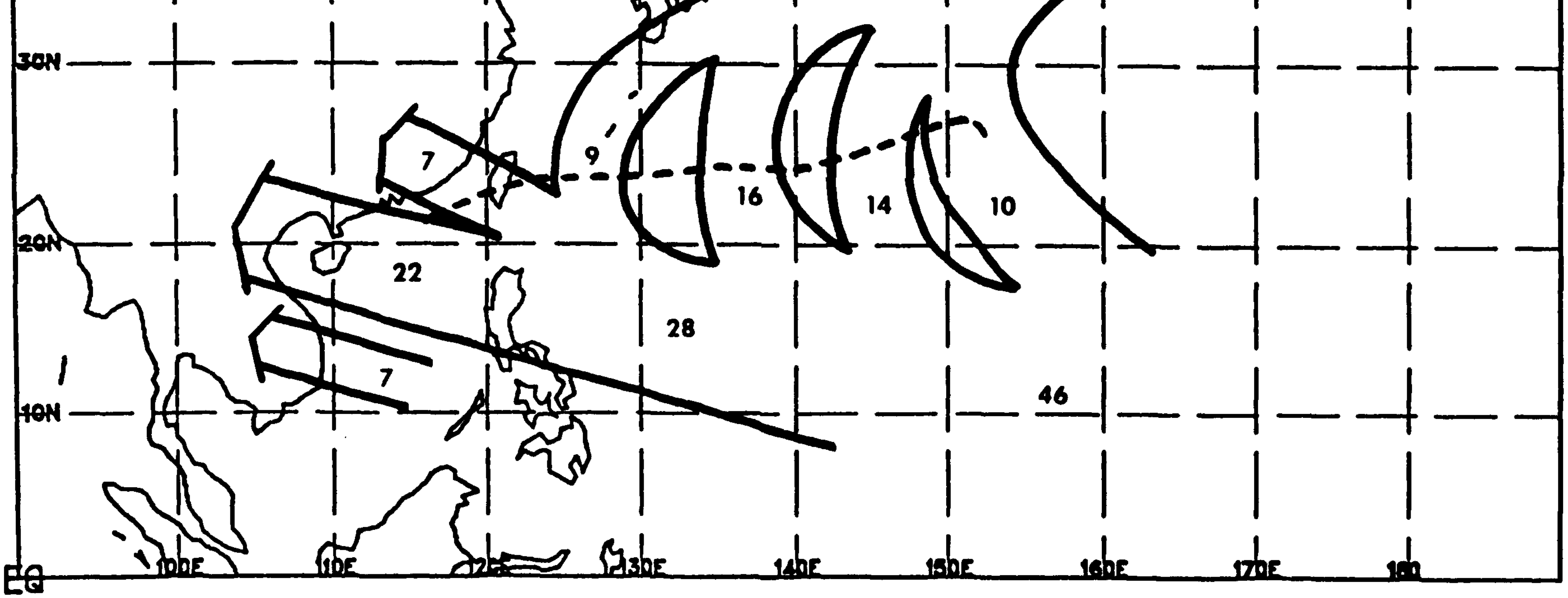


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR SEP 24 - OCT 8

AVERAGE NUMBER OF TROPICAL CYCLONES
(> 33 KTS) DURING THIS PERIOD = 4.53

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	67	34.4	6.01
RECURVER	101	51.8	7.31
OTHER	27	13.8	6.49
TOTAL	195	100.0	6.75
TROPICAL STORMS	55	28.4	4.11
TYPHOONS	99	51.0	7.23
SUPER TYPHOONS	40	20.6	9.30

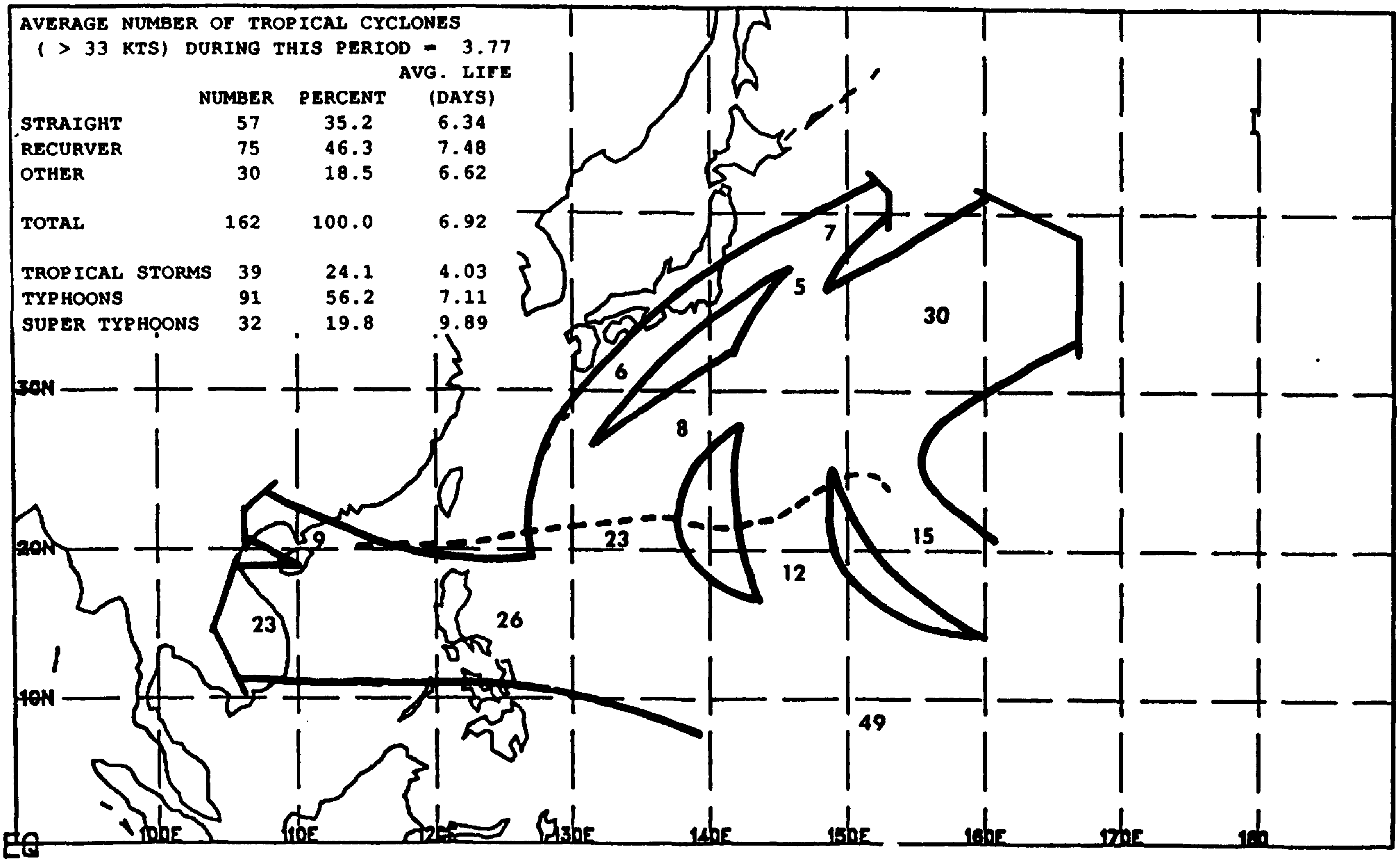


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR OCT 9 - OCT 23

AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 3.77

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	57	35.2	6.34
RECURVER	75	46.3	7.48
OTHER	30	18.5	6.62
TOTAL	162	100.0	6.92
TROPICAL STORMS	39	24.1	4.03
TYPHOONS	91	56.2	7.11
SUPER TYPHOONS	32	19.8	9.89

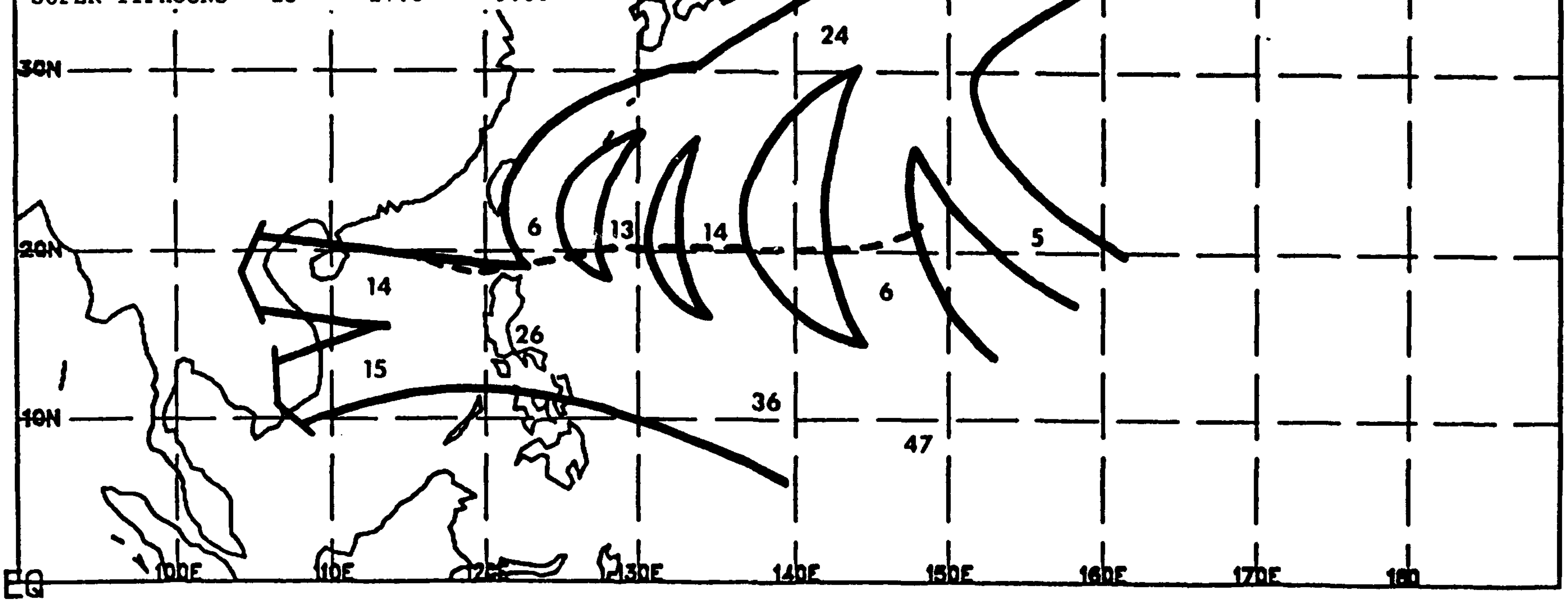


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR OCT 24 - NOV 8

AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 3.00

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	48	37.2	5.66
RECURVER	59	45.7	8.01
OTHER	22	17.1	6.47
TOTAL	129	100.0	6.87
TROPICAL STORMS	36	27.9	4.37
TYPHOONS	70	54.3	7.20
SUPER TYPHOONS	23	17.8	9.80

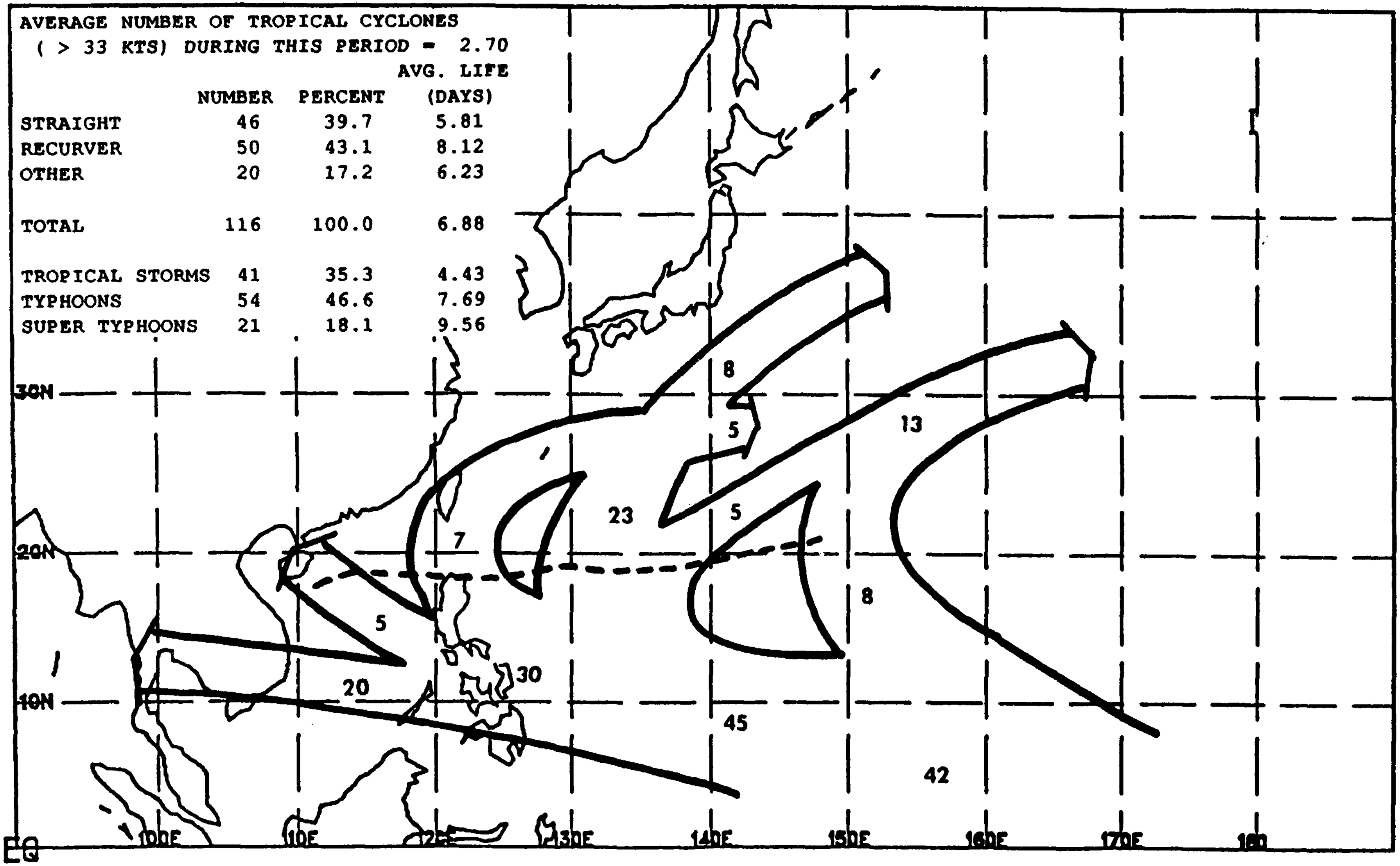


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 3_ kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR NOV 9 - NOV 23

AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 2.70

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	46	39.7	5.81
RECURVER	50	43.1	8.12
OTHER	20	17.2	6.23
TOTAL	116	100.0	6.88
TROPICAL STORMS	41	35.3	4.43
TYPHOONS	54	46.6	7.69
SUPER TYPHOONS	21	18.1	9.56

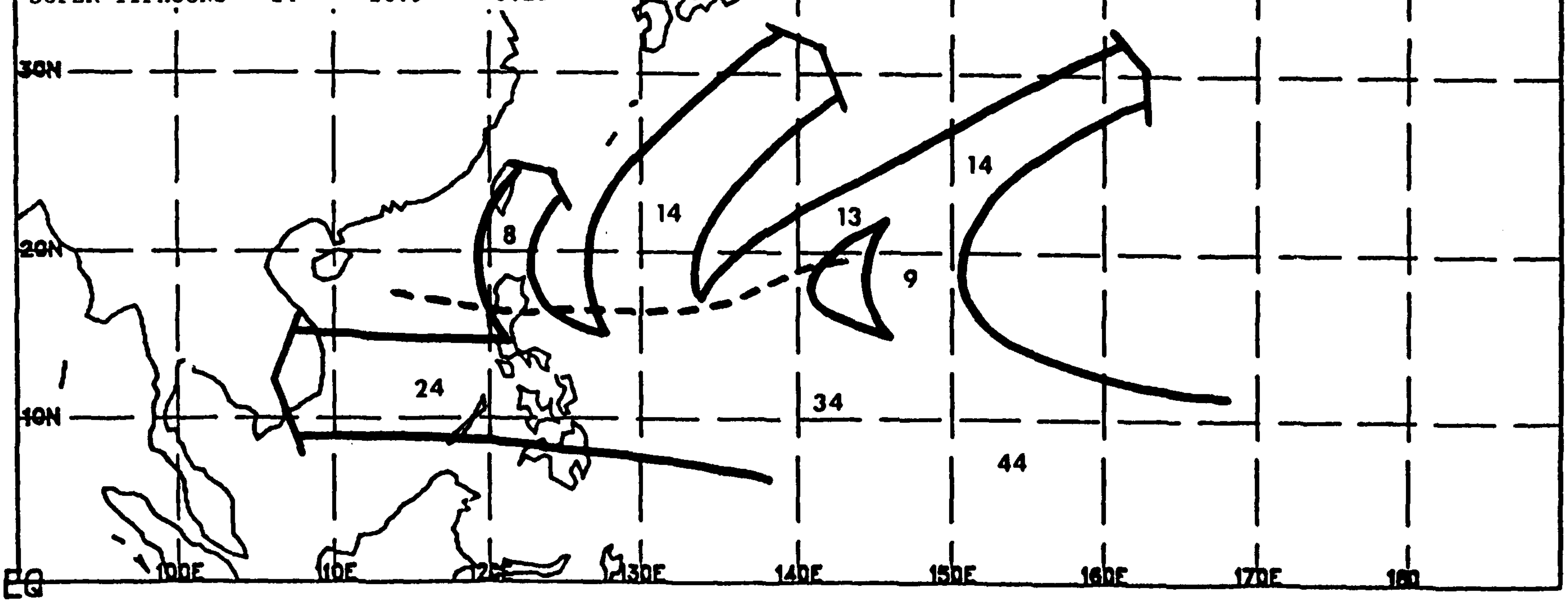


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR NOV 24 - DEC 8

AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 1.93

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	29	34.9	6.63
RECURVER	35	42.2	7.22
OTHER	19	22.9	5.61
TOTAL	83	100.0	6.64
TROPICAL STORMS	34	41.0	4.30
TYPHOONS	35	42.2	7.86
SUPER TYPHOONS	14	16.9	9.29

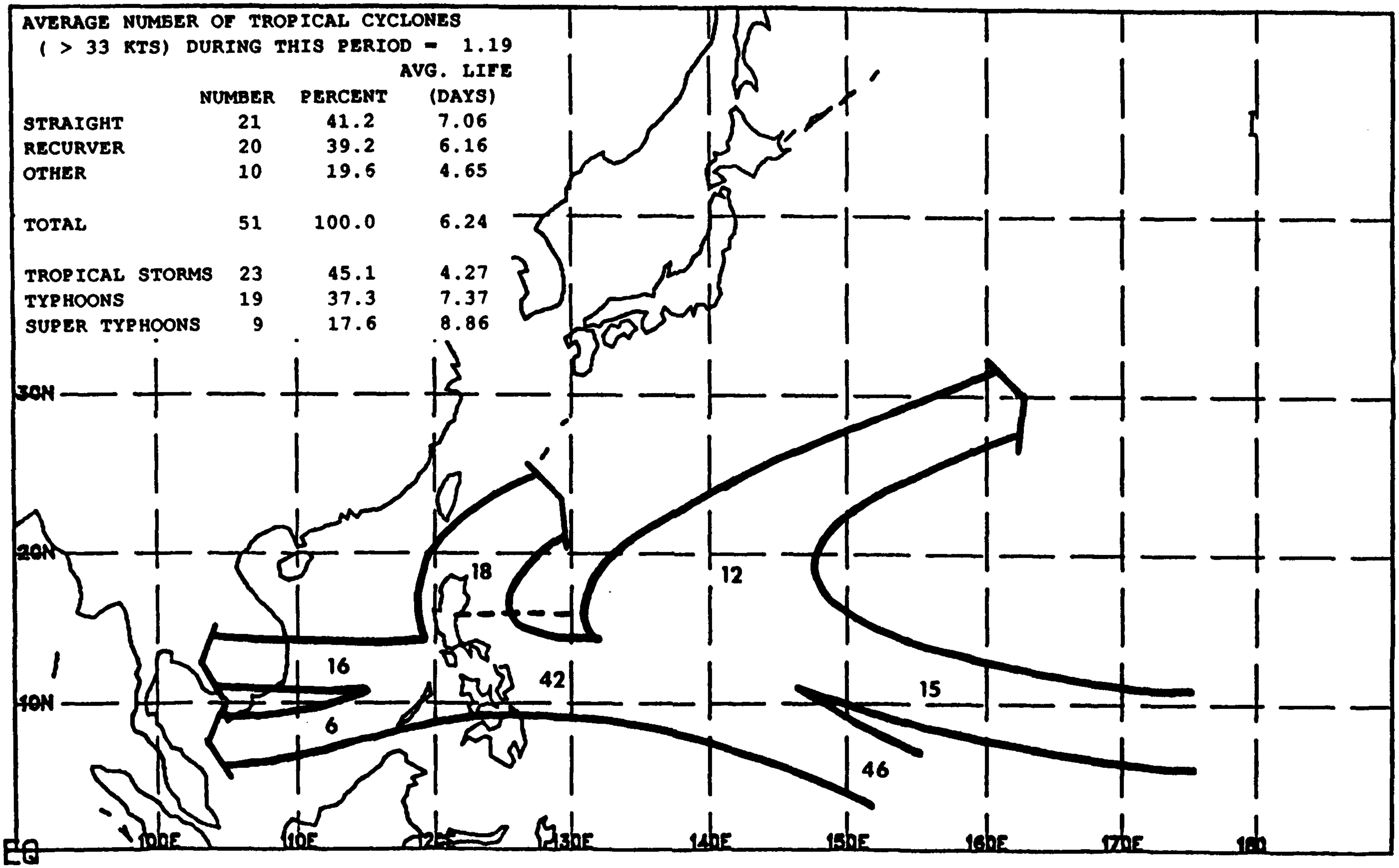


Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

MEAN PATHS FOR DEC 9 - DEC 23

AVERAGE NUMBER OF TROPICAL CYCLONES (> 33 KTS) DURING THIS PERIOD = 1.19

	NUMBER	PERCENT	AVG. LIFE (DAYS)
STRAIGHT	21	41.2	7.06
RECURVER	20	39.2	6.16
OTHER	10	19.6	4.65
TOTAL	51	100.0	6.24
TROPICAL STORMS	23	45.1	4.27
TYPHOONS	19	37.3	7.37
SUPER TYPHOONS	9	17.6	8.86



Mean tropical cyclone (> 33 kts) path. Numbers represent the percentage of tropical cyclones (> 33 kts) which followed the indicated path. These numbers may not add up to 100% since not all tropical cyclones (> 33 kts) follow a mean path and some develop/dissipate along a path. Tracks which contained less than 5% of the tropical cyclones (> 33 kts) are ignored. Dashed line represents mean recurvature position of tropical cyclones (> 33 kts) classified as recurvers.

APPENDIX B

MEAN MONTHLY AND COMBINED MONTHLY TROPICAL STORM AND CYCLONE TRACKS FOR THE NORTH INDIAN OCEAN (FROM NAVAIR 50–1C–61)

While it must be realized that tropical storms and cyclones deviate from the mean tracks presented in this appendix, the use of these tracks should be of particular benefit in long range planning. The application of the average tracks to specific short range situations should be avoided. Warnings issued by FWC/JTWC Guam are the immediate source of information on predicted movement.

Table I-B-1 presents the frequency of North Indian Ocean tropical storms and cyclones by month.

Table B-1. North Indian Ocean tropical storm and cyclone frequency (from NAVAIR 50-1C-61).

NORTH INDIAN OCEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TROPICAL STORMS	0.1			0.1	0.3	0.5	0.5	0.4	0.4	0.6	0.5	0.3	3.5
CYCLONES				0.1	0.5	0.2	0.1		0.1	0.4	0.6	0.2	2.2
TROPICAL STORMS AND CYCLONES	0.1		0.1	0.3	0.7	0.7	0.6	0.4	0.5	0.5	1.1	0.5	5.7

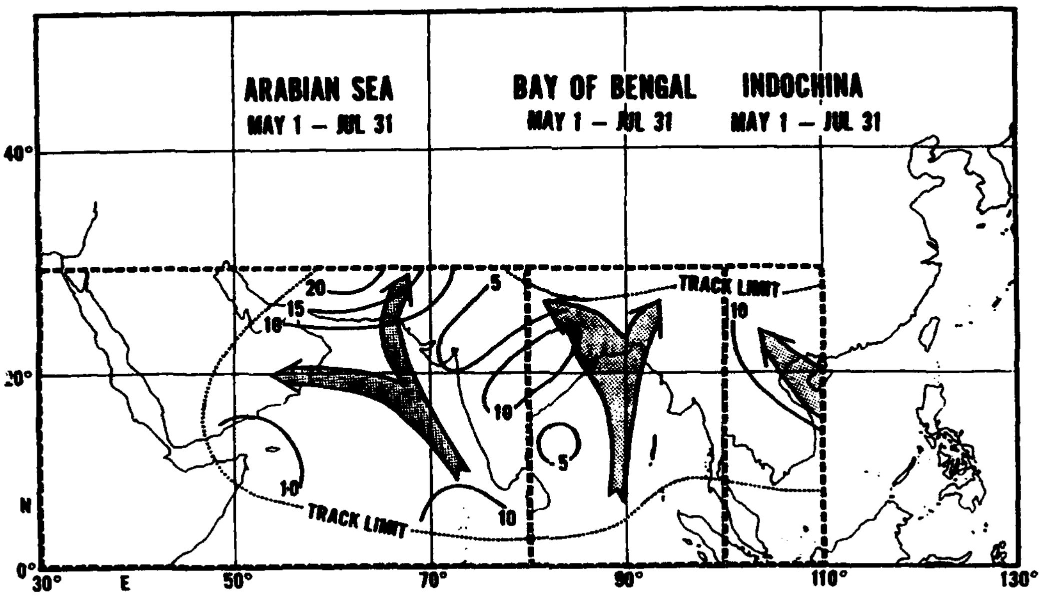


Figure B-1. Preferred North Indian Ocean tropical storm and cyclone tracks (May 1-Jul 31). Isolines show the average storm speed of movement in knots.

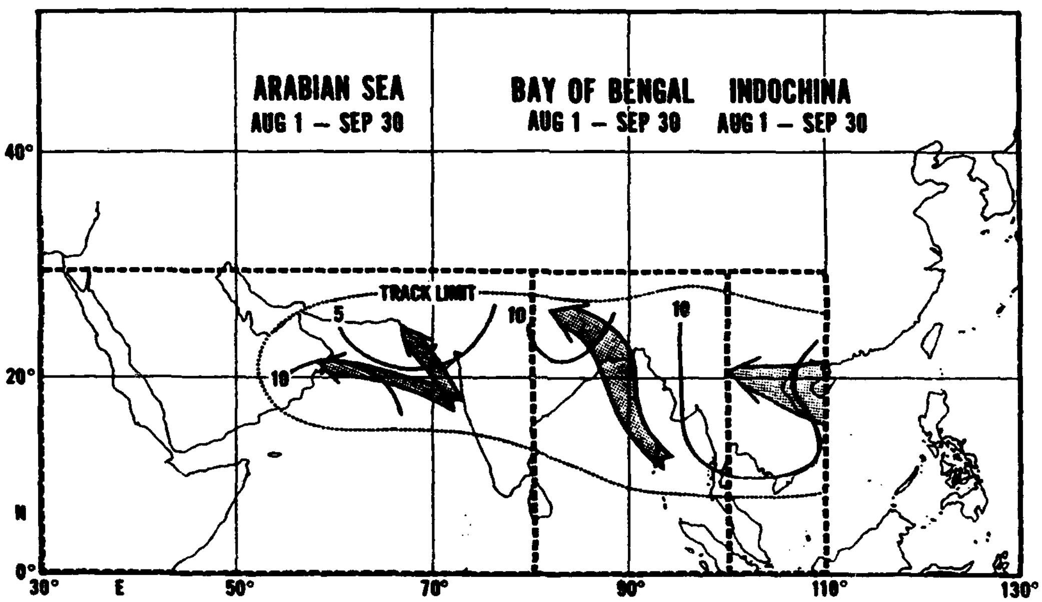


Figure B-2. Preferred North Indian Ocean tropical storm and cyclone tracks (Aug 1-Sep 30). Isolines show the average storm speed of movement in knots.

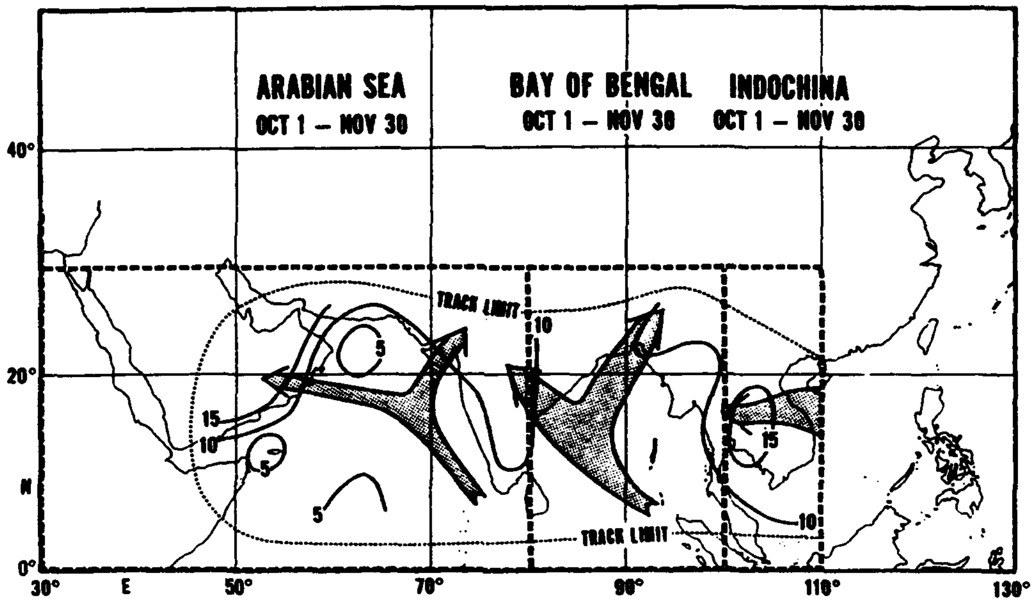


Figure B-3. Preferred North Indian Ocean tropical storm and cyclone tracks (Oct 1-Nov 30). Isolines show the average storm speed of movement in knots.

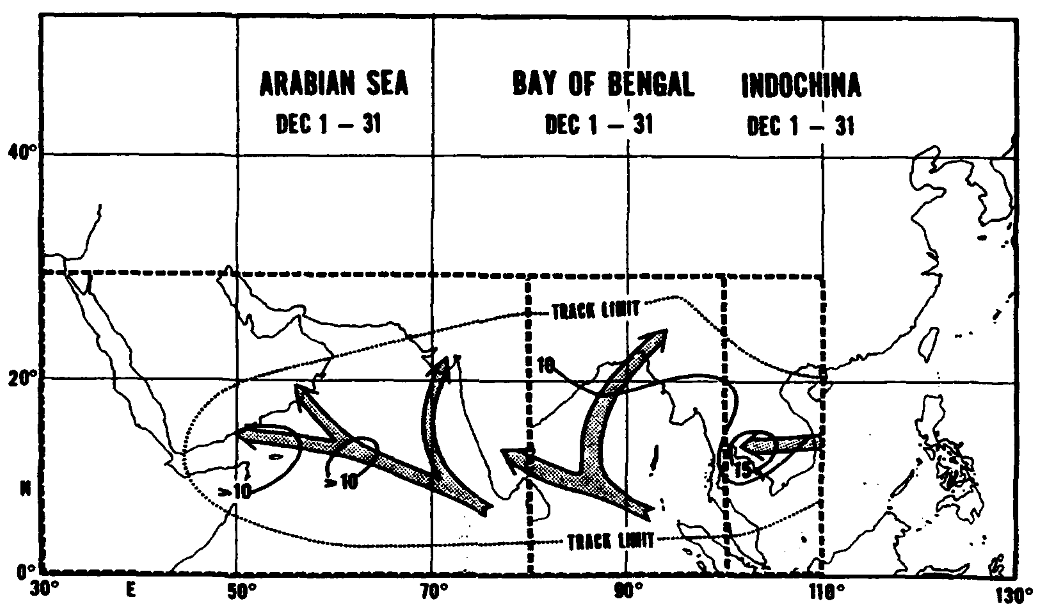


Figure B-4. Preferred North Indian Ocean tropical storm and cyclone tracks (Dec 1-31). Isolines show the average storm speed of movement in knots.

APPENDIX C

MEAN MONTHLY AND PART MONTHLY TROPICAL STORM AND HURRICANE TRACKS FOR THE SOUTHWEST INDIAN OCEAN (FROM NAVAIR 50–1C–61)

While it must be realized that tropical storms and hurricanes deviate from the mean tracks presented in this appendix, the use of these tracks should be of particular benefit in long range planning. The application of the average tracks to specific short range situations should be avoided. Warnings issued by FWC/JTWC Guam are the immediate source of information on predicted movement.

Table I-C-1 presents the frequency of Southwest Indian Ocean tropical storms and hurricanes by month.

Table C-1. Southwest Indian Ocean tropical storm and hurricane frequency (from NAVAIR 50-1C-61).

SOUTHWEST INDIAN OCEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TROPICAL STORMS	2.0	2.2	1.7	0.6	0.2					0.3	0.3	0.8	7.4
HURRICANES	1.3	1.1	0.8	0.4								0.5	3.8
TROPICAL STORMS AND HURRICANES	3.2	3.3	2.5	1.1	0.2					0.3	0.4	1.4	11.2

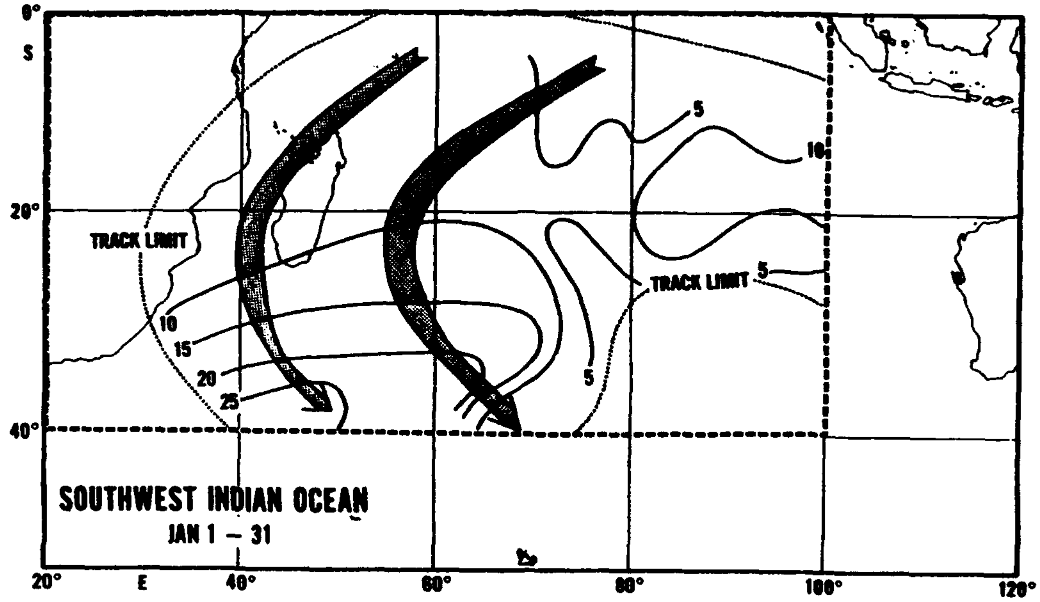


Figure C-1. Preferred Southwest Indian Ocean tropical storm and hurricane tracks (Jan 1-31). Isolines show the average storm speed of movement in knots.

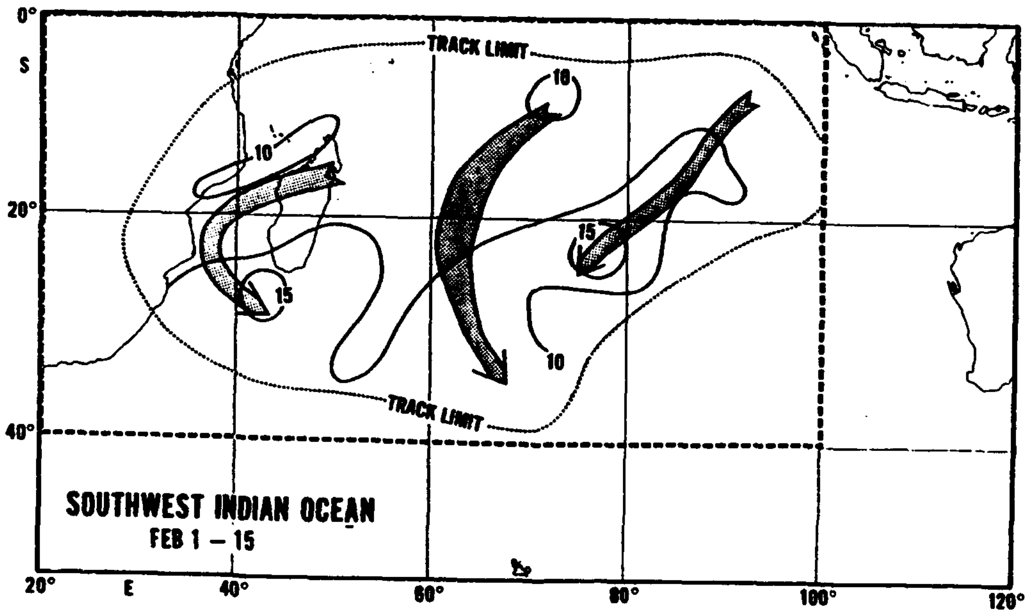


Figure C-2. Preferred Southwest Indian Ocean tropical storm and hurricane tracks (Feb 1-15). Isolines show the average storm speed of movement in knots.

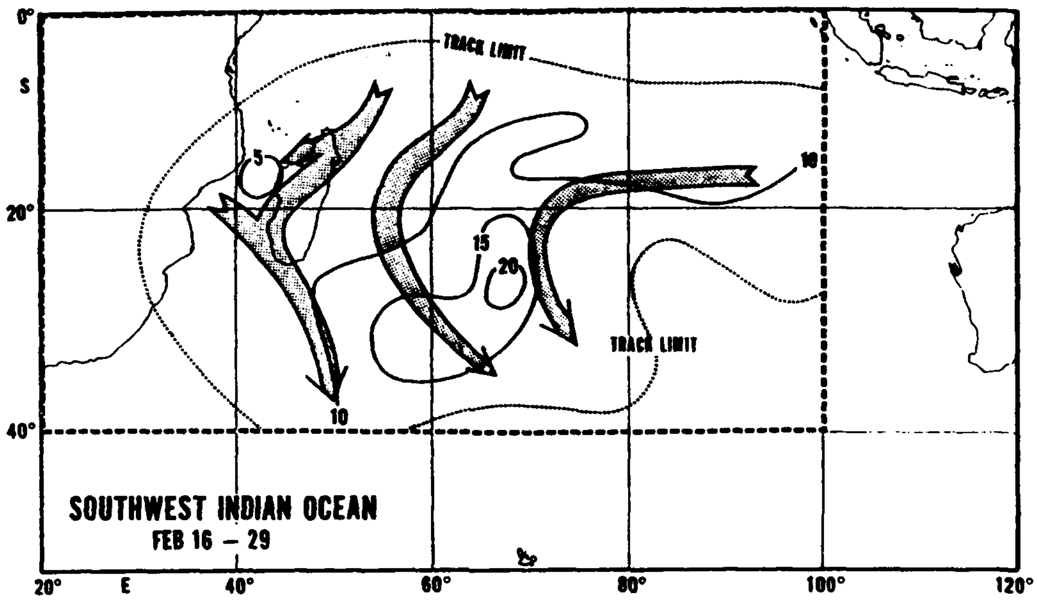


Figure C-3. Preferred Southwest Indian Ocean tropical storm and hurricane tracks (Feb 16-29). Isolines show the average storm speed of movement in knots.

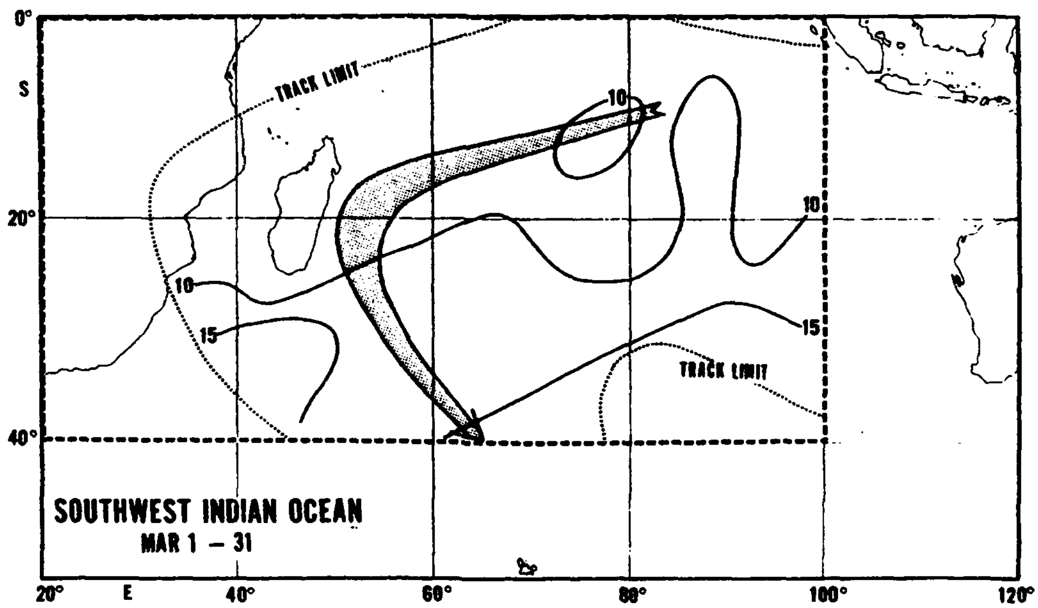


Figure C-4. Preferred Southwest Indian Ocean tropical storm and hurricane tracks (Mar 1-31). Isolines show the average storm speed of movement in knots.

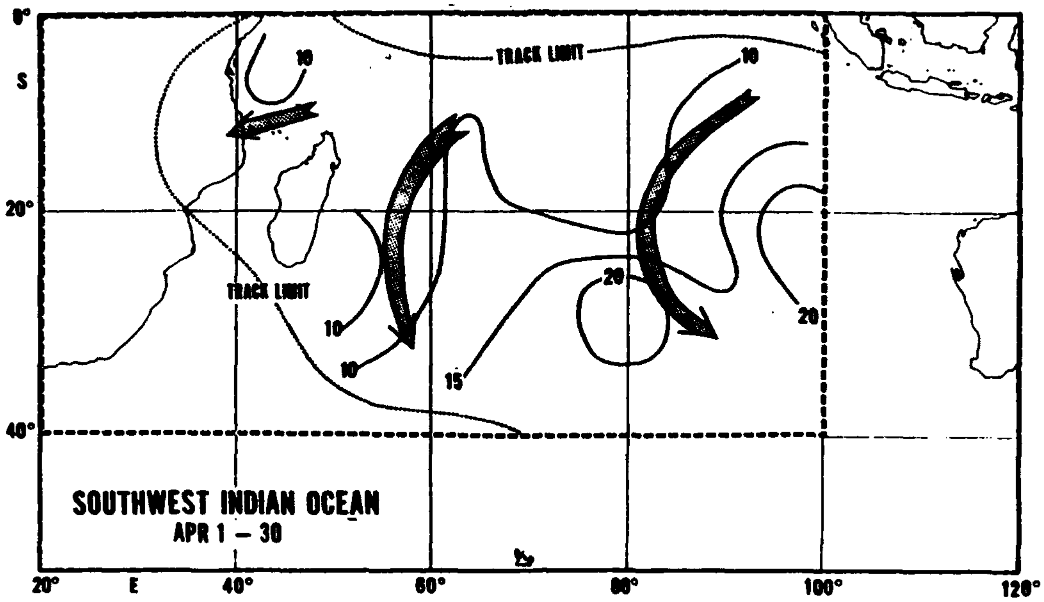


Figure C-5. Preferred Southwest Indian Ocean tropical storm and hurricane tracks (Apr 1-30). Isolines show the average storm speed of movement in knots.

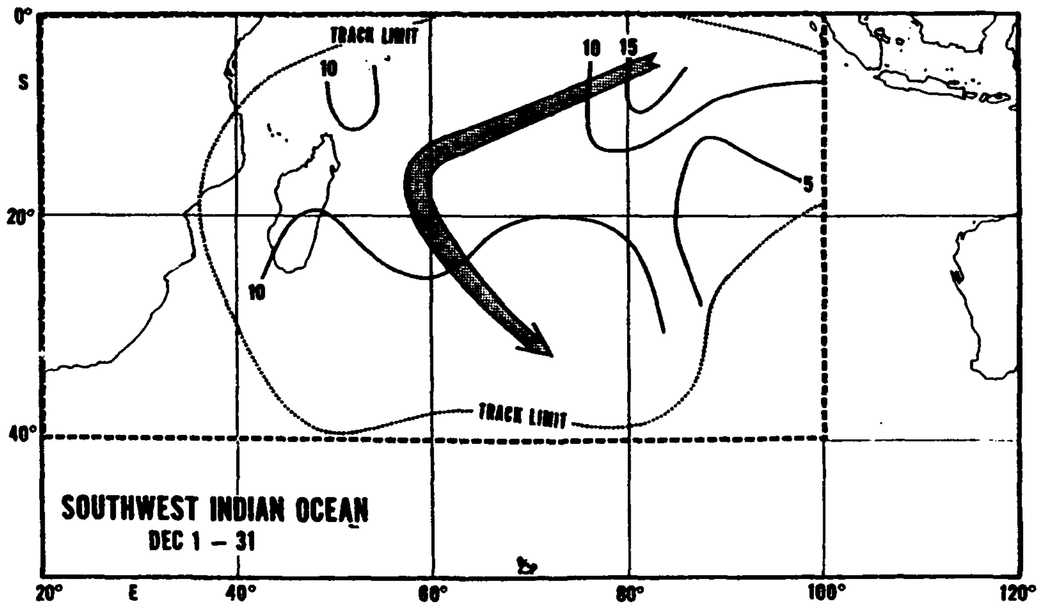


Figure C-6. Preferred Southwest Indian Ocean tropical storm and hurricane tracks (Dec 1-31). Isolines show the average storm speed of movement in knots.

APPENDIX D

MEAN MONTHLY AND PART MONTHLY TROPICAL STORM AND HURRICANE TRACKS FOR THE SOUTHWEST PACIFIC OCEAN AND AUSTRALIAN AREA (FROM NAVAIR 50–1C–61)

While it must be realized that tropical storms and hurricanes deviate from the mean tracks presented in this appendix, the use of these tracks should be of particular benefit in long range planning. The application of the average tracks to specific short range situations should be avoided. Warnings issued by FWC/JTWC Guam are the immediate source of information on predicted movement.

Table I-D-1 presents the frequency of Southwest Pacific and Australian area tropical storms and hurricanes by month.

Table D-1. Southwest Pacific and Australian area tropical storm and hurricane frequency (from NAVAIR 50-1C-61).

SOUTHWEST PACIFIC AND AUSTRALIAN AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TROPICAL STORMS	2.7	2.8	2.4	1.3	0.3	0.2				0.1	0.4	1.5	10.9
HURRICANES	0.7	1.1	1.3	0.3			0.1	0.1			0.3	0.5	3.8
TROPICAL STORMS AND HURRICANES	3.4	4.1	3.7	1.7	0.3	0.2	0.1	0.1		0.1	0.7	2.0	14.8

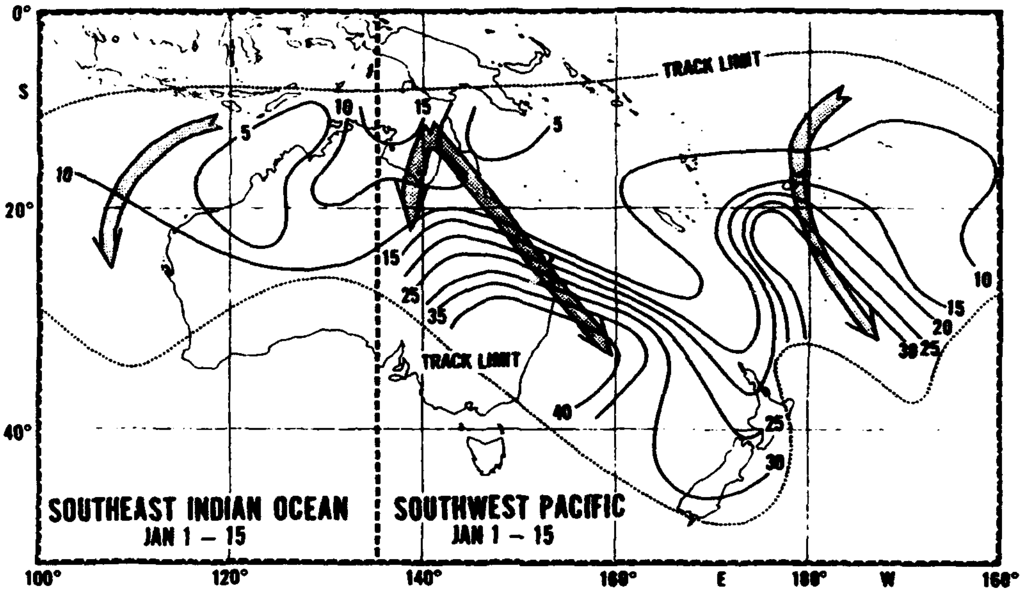


Figure D-1. Preferred Southwest Pacific and Australian area tropical storm and hurricane tracks (Jan 1-15). Isolines show the average storm speed of movement in knots.

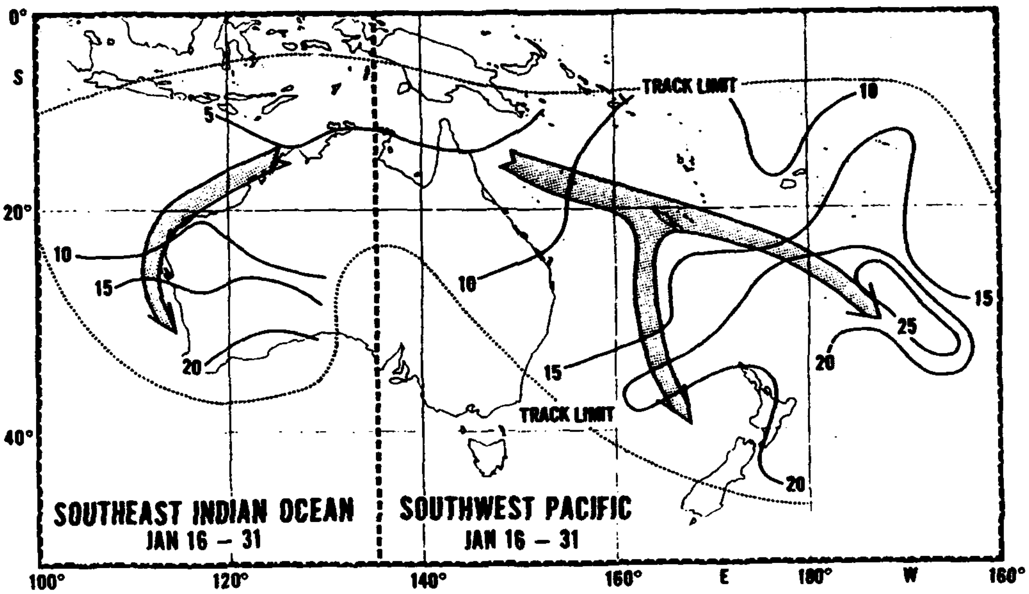


Figure D-2. Preferred Southwest Pacific and Australian area tropical storm and hurricane tracks (Jan 16-31). Isolines show the average storm speed of movement in knots.

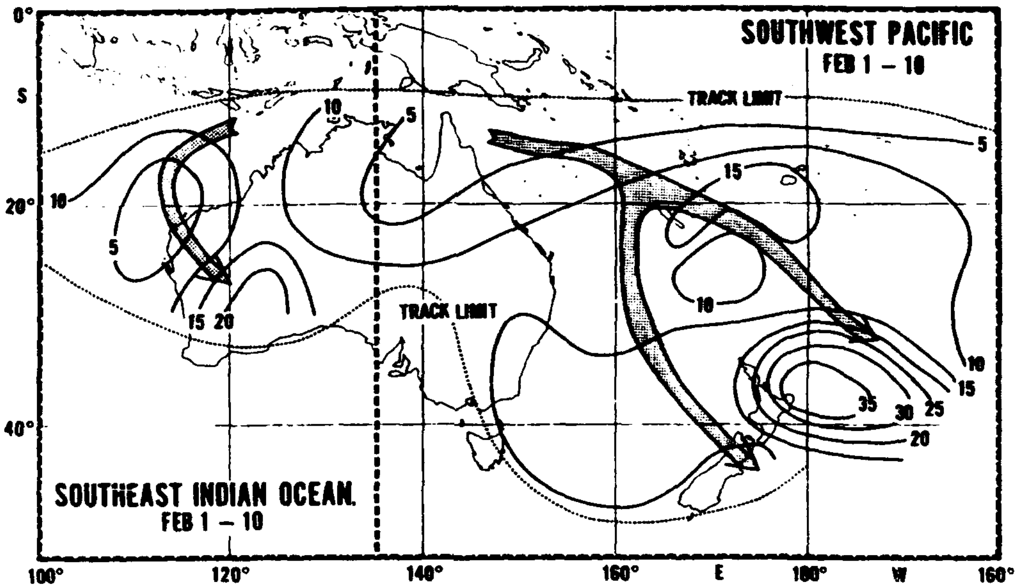


Figure D-3. Preferred Southwest Pacific and Australian area tropical storm and hurricane tracks (Feb 1-10). Isolines show the average storm speed of movement in knots.

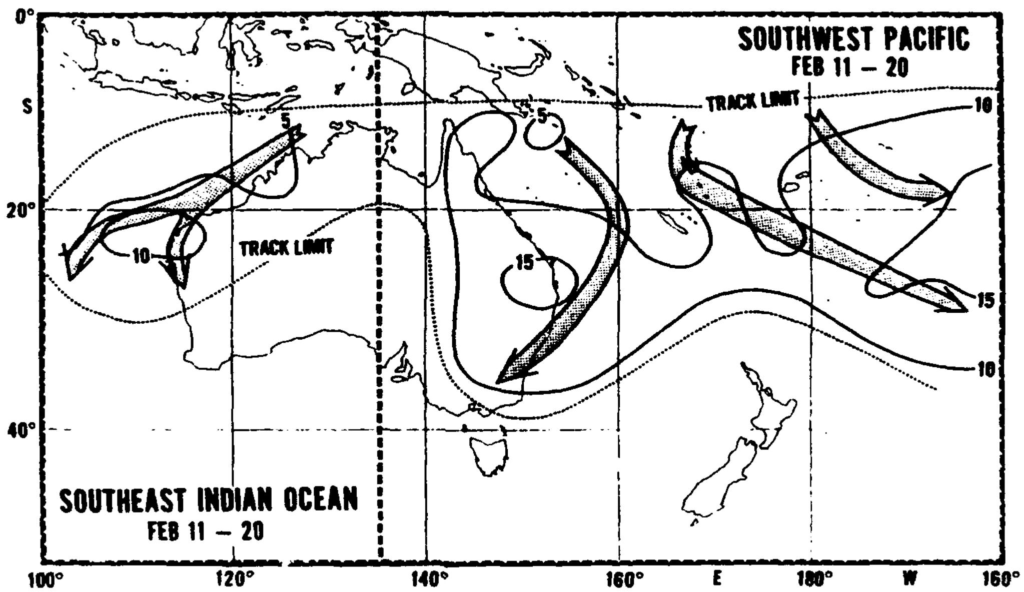


Figure D-4. Preferred Southwest Pacific and Australian area tropical storm and hurricane tracks (Feb 11-20). Isolines show the average storm speed of movement in knots.

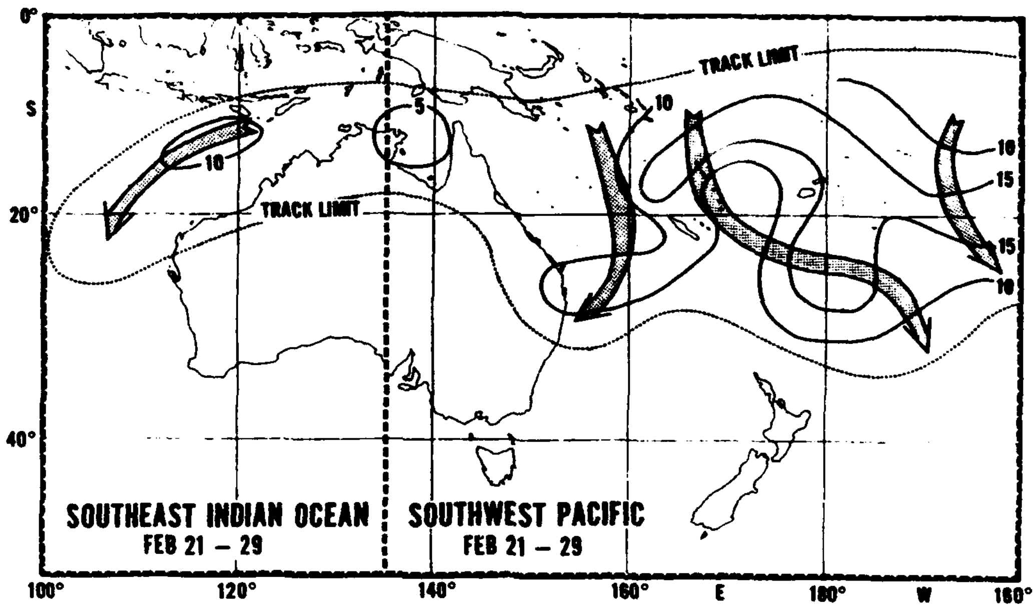


Figure D-5. Preferred Southwest Pacific and Australian area tropical storm and hurricane tracks (Feb 21-29). Isolines show the average storm speed of movement in knots.

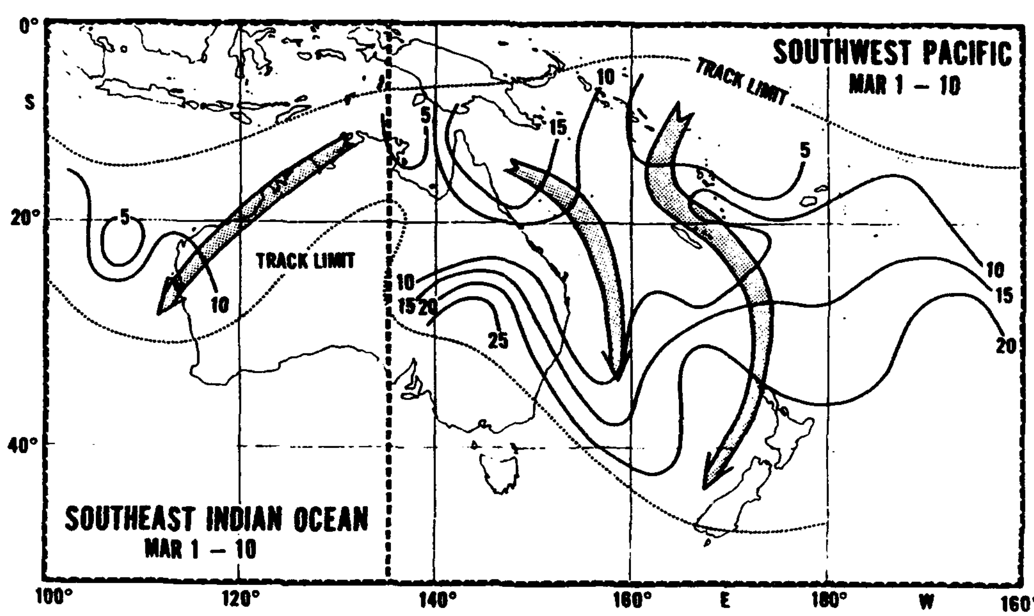


Figure D-6. Preferred Southwest Pacific and Australian area tropical storm and hurricane tracks (Mar 1-10). Isolines show the average storm speed of movement in knots.

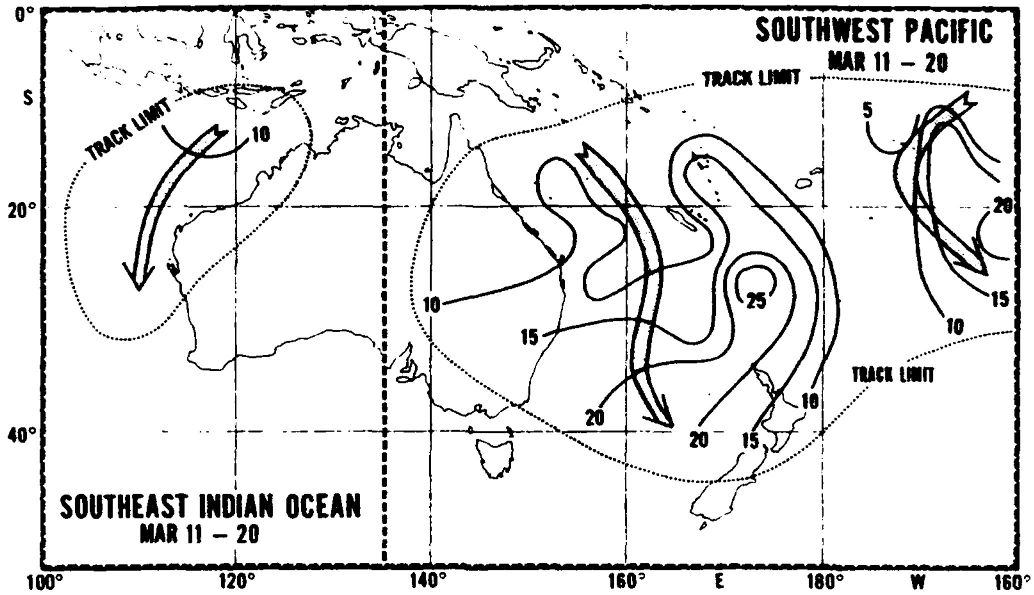


Figure D-7. Preferred Southwest Pacific and Australian area tropical storm and hurricane tracks (Mar 11-20). Isolines show the average storm speed of movement in knots.

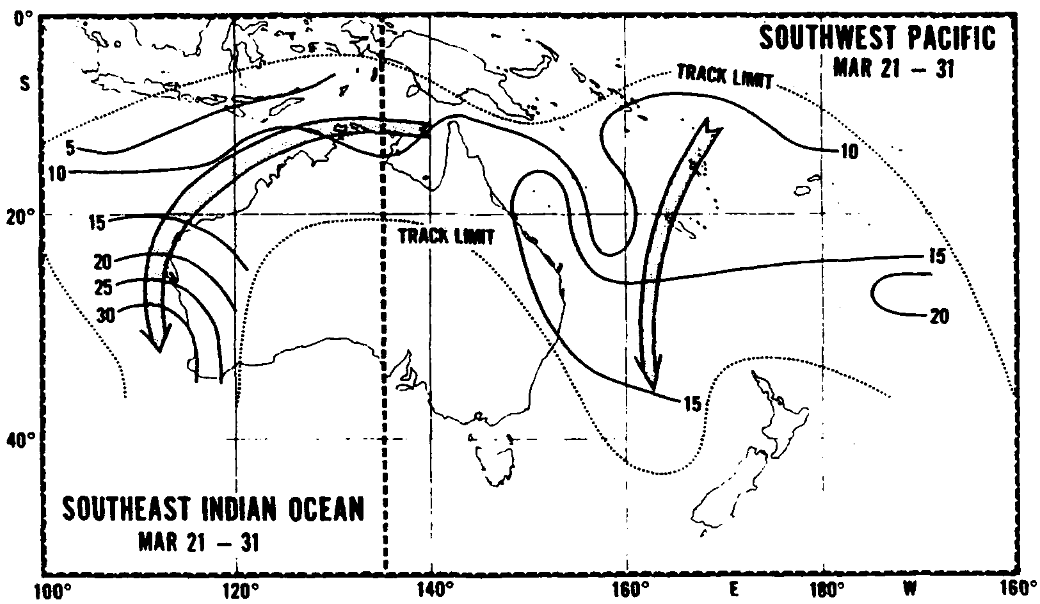


Figure D-8. Preferred Southwest Pacific and Australian area tropical storm and hurricane tracks (Mar 21-31). Isolines show the average storm speed of movement in knots.

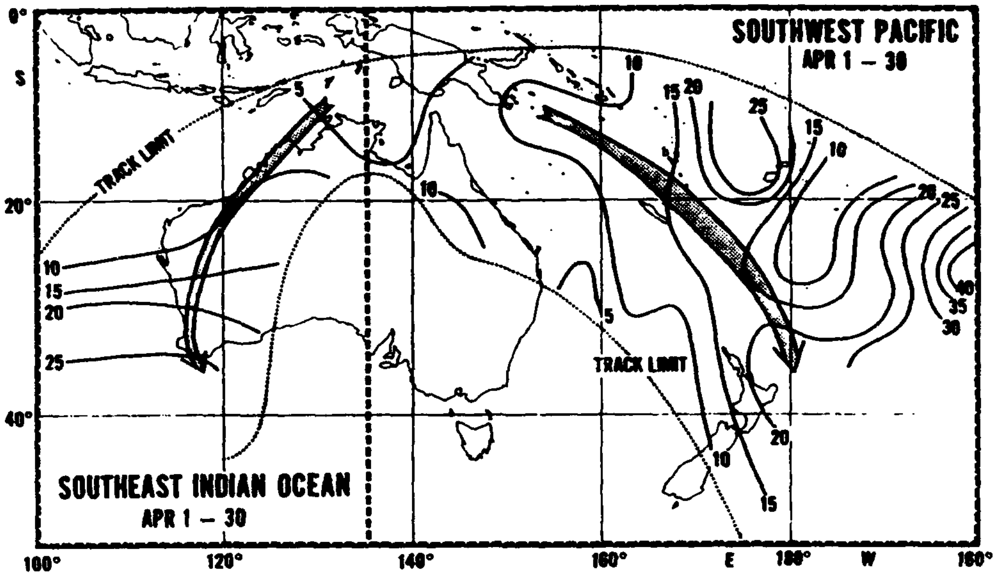


Figure D-9. Preferred Southwest Pacific and Australian area tropical storm and hurricane tracks (Apr 1-30). Isolines show the average storm speed of movement in knots.

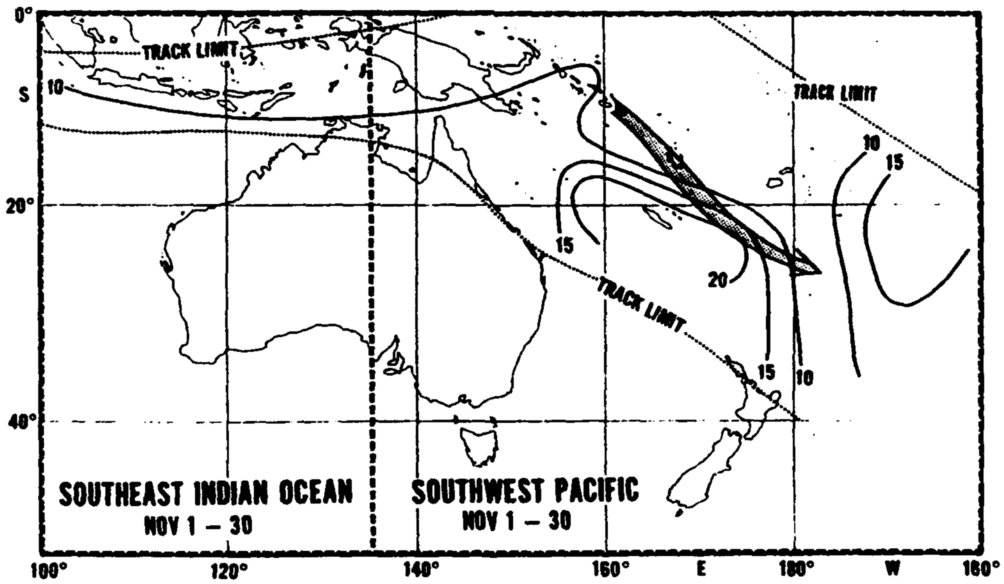


Figure D-10. Preferred Southwest Pacific and Australian area tropical storm and hurricane tracks (Nov 1-30). Isolines show the average storm speed of movement in knots.

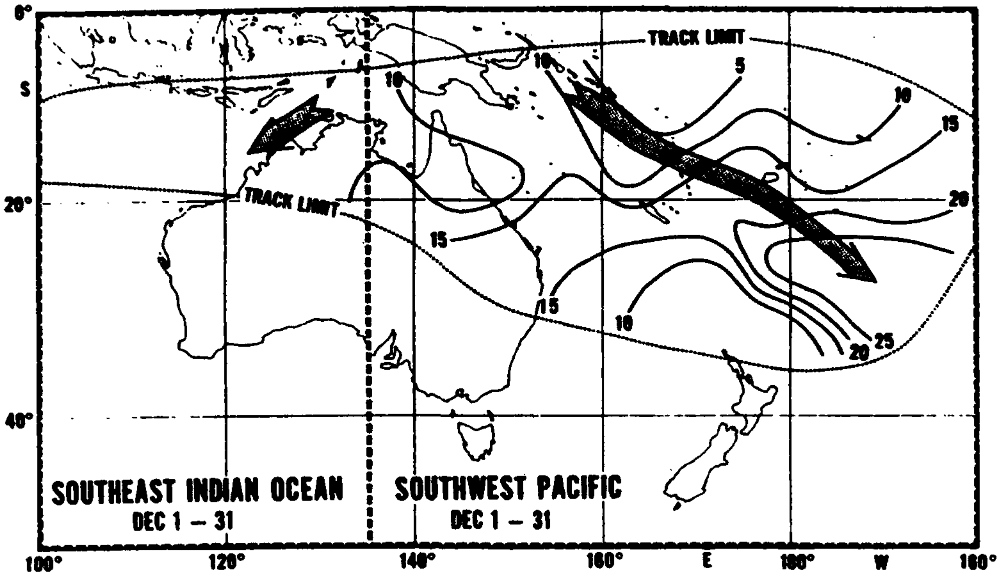


Figure D-11. Preferred Southwest Pacific and Australian area tropical storm and hurricane tracks (Dec 1-31). Isolines show the average storm speed of movement in knots.