CHAPTER IV - SUMMARY OF FORECAST VERIFICATION

1. ANNUAL FORECAST VERIFICATION

a. Western North Pacific Ocean

The positions given for warning times and those at the 24-, 48-, and 72-hour forecast times were verified against the post-analysis "best-track" positions at the same valid times. The resultant vector and right angle (track) errors (illustrated in Figure 4-1) were then calculated for each tropical cyclone and are presented in Table 4-1. Figure 4-2 provides the frequency distributions of vector errors for 24-, 48- and 72-hour forecasts of all 1982 tropical cyclones in the western North Pacific. A summation of the mean errors, as calculated for all tropical cyclones in each year, is shown in Table 4-2 for comparative purposes. The data used in this table are not to be confused with that presented in earlier years where the sample was restricted to tropical cyclones that reached typhoon intensity and then had the forecast errors calculated only for that portion of the life-cycle when the intensity was greater than 34 knots (last published as Table 5-1, 1977 Annual Typhoon Report). A comparison of the results using the truncated data set and those obtained for all tropical cyclones can be seen directly in Table 4-3. The annual mean vector errors are graphed in Figure 4-3.

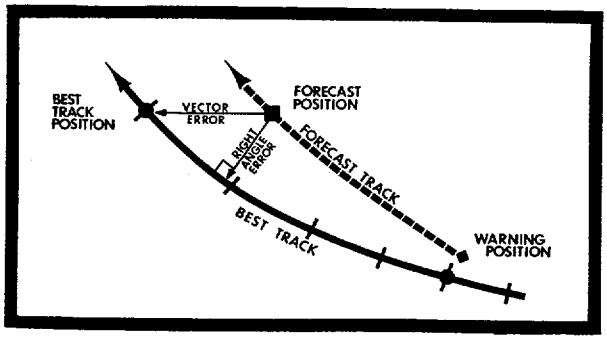

FIGURE 4-1. Illustration of the method to determine vector error and right angle error.

TABLE 4-1.

FORECAST ERROR SUMMARY FOR THE WESTERN NORTH PACIFIC SIGNIFICANT TROPICAL CYCLONES OF 1982. (ERRORS IN NM)

		WARNING			24-HOUR			48-HOUR			72-HOUR		
		POSIT ERROR	RT ANGLE ERROR	NR OF WRNGS	POSIT ERROR	RT ANGLE ERROR	NR OF WRNGS	POSIT ERROR	RT ANGLE ERROR	NR OF WRNGS	POSIT ERROR	RT ANGLE ERROR	NR OF WRNGS
1.	TY MAMIE	25	14	35	93	48	32	188	86	24	276	115	23
2.	TY NELSON	24	13	53	95	57	49	180	114	44	170	72	37
3.	TY ODESSA	29	16	25	228	113	21	520	226	17	742	385	13
4.	TY PAT	28	24	23	149	134	19	299	237	15	583	394	11
5.	TY RUBY	27	12	23	144	64	19	275	143	15	425	326	11
6.	TS TESS	15	9	14	107	73	10	217	142	3	144	41	1
7.	TS SKIP	16	15	7	95	32	3						
8.	TS VAL	29	22	5	363	33	1						
9.	TS WINONA	22	13	21	100	42	16	175	93	13	224	121	9
10.	TY ANDY	24	14	32	99	50	28	168	106	23	231	144	19
11.	STY BESS	18	13	43	121	64	39	267	122	35	396	198	31
12.	TY CECIL	14	9	39	102	41	33	172	75	30	219	141	23
13.	TY DOT	22	17	27	108	68	24	218	172	20	262	208	16
14.	TY ELLIS	14	8	36	76	42	32	171	81	26	263	153	22
15.	TY FAYE	18	8	50	142	89	41	384	273	33	639	445	27
16.	TY GORDON	15	11	38	100	63	34	214	101	30	364	210	26
17.	TS HOPE	19	9	10	186	79	6	426	118	2			
18.	TY IRVING	13	9	44	73	42	40	110	72	35	172	126	32
19.	TY JUDY	19	15	29	125	73	25	298	126	19	401	262	13
20.	TY KEN	15	9	37	75	49	33	201	134	29	344	263	25
21.	TS LOLA	21	14	12	88	68	8	232	152	4			
22.	TD 22	35	21	5	155	83	1						
23.	STY MAC	14	13	32	90	63	28	162	104	24	294	149	20
24.	TY NANCY	12	10	29	86	74	26	213	175	21	430	333	17
25.	TD 25	35	33	5	113	119	1						
26.	TY OWEN	24	18	40	146	103	32	362	236	24	550	285	18
27.	TY PAMELA	20	14	60	139	79	56	263	149	45	280	140	34
28.	TY ROGER	17	17	12	129	116	8	383	329	4			
ALL FORECASTS:		19	13	786	113	67	665	237	139	535	341	206	428

TABLE 4-2. ANNUAL MEAN FORECAST ERRORS (NM) FOR THE WESTERN PACIFIC

	24-HOUR		48-HOUR		72-HOUR	
YEAR	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE
1971	111	64	212	118	317	117
1972	117	72	245	146	381	210
1973	108	74	197	134	253	162
1974	120	78	226	157	348	245
1975	138	84	288	181	450	290
1976	117	71	230	132	338	202
1977	148	83	283	157	407	228
1978	127	75	271	179	410	297
1979	124	77	226	151	316	223
1980	126	79	243	164	389	287
1981*	123	75	220	119	334	168
1982*	113	67	237	139	341	206

* The technique for calculating right angle error was revised in 1981; therefore, a direct correlation in right angle statistics cannot be made for the errors computed before 1981 and the errors computed since 1981.

TABLE 4-3. ANNUAL MEAN FORECAST ERRORS (NM) FOR WESTERN NORTH PACIFIC

	24-HOUR		48-HOUR		72-HOUR	
YEAR	ALL	TYPHOON*	ALL	TYPHOON*	ALL	TYPHOON*
1950-58		170				
1959		117**		267**		
1960		177**		354**		
1961		136		274		
1962		144		287		476
1963		127		246		374
1964		133		284		429
1965		151		303		418
1966		136		280		432
1967		125		276		414
1968		105		229		337
1969		111		237		349
1970	104	98	190	181	279	272
1971	111	99	212	203	317	308
1972	117	116	245	245	381	382
1973	108	102	197	193	253	245
1974	120	114	226	218	348	351
1975	138	129	288	279	450	442
1976	117	117	230	232	338	336
1977	148	140	283	266	407	390
1978	127	120	271	241	410	459
1979	124	113	226	219	316	319
1980	126	116	243	221	389	362
1981	123	117	220	215	334	342
1982	113	114	237	229	341	337

* For Typhoons only while winds were over 35 kt (18 m/sec).

** Forecast positions north of 35°N were not verified.

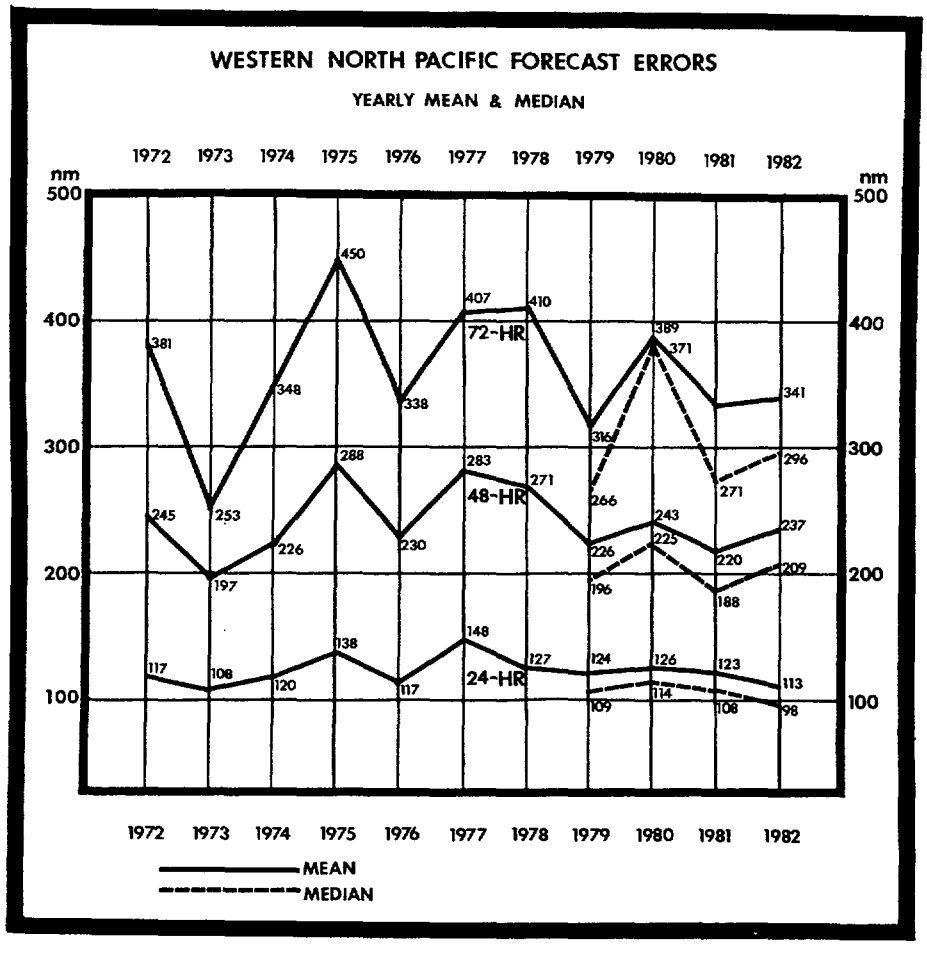

FIGURE 4-3. *Annual mean and median vector errors (nm) for all tropical cyclones in the western North Pacific.*

b. North Indian Ocean

The positions given for warning times and those at the 24-, 48- and 72-hour valid times were verified for tropical cyclones in the North Indian Ocean by the same methods used for the western North Pacific. It should be noted that due to the low number of North Indian Ocean tropical cyclones, these error statistics should not be taken as representative of any trend. Table 4-4 is the forecast error summary for the North Indian Ocean and Table 4-5 contains the annual average of forecast errors back through 1971. Vector errors are plotted in Figure 4-4. (Seventy-two hour forecast errors were evaluated for the first time in 1979).

TABLE 4-4.

FORECAST ERROR SUMMARY FOR THE NORTH INDIAN OCEAN
SIGNIFICANT TROPICAL CYCLONES OF 1982. (ERRORS IN NM)

		WARNING			24-HOUR			48-HOUR			72-HOUR		
		POSIT ERROR	RT ANGLE ERROR	NR OF WRNGS	POSIT ERROR	RT ANGLE ERROR	NR OF WRNGS	POSIT ERROR	RT ANGLE ERROR	NR OF WRNGS	POSIT ERROR	RT ANGLE ERROR	NR OF WRNGS
1.	TC 20-82	23	14	14	118	43	10	283	87	6	340	116	2
2.	TC 22-82	22	16	8	106	36	5	238	85	1			
3.	TC 23-82	34	18	9	88	49	6	151	86	2			
4.	TC 24-82	22	15	7	68	22	3						
5.	TC 25-82	55	34	17	205	113	13	487	264	9	931	519	5
ALL FORECASTS:		35	21	55		66	37	368	175	18	762	404	7

TABLE 4-5.

ANNUAL MEAN FORECAST ERRORS FOR THE NORTH INDIAN OCEAN

	24-HOUR		48-HOUR		72-HOUR	
YEAR	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE
1971*	232	-	410	-	-	-
1972*	224	101	292	112	-	-
1973*	182	99	299	160	-	-
1974*	137	81	238	146	-	-
1975	145	99	228	144	-	-
1976	138	108	204	159	-	-
1977	122	94	292	214	-	-
1978	133	86	202	128	-	-
1979	151	99	270	202	437	371
1980	115	73	93	87	167	126
1981**	109	65	176	103	197	73
1982**	138	66	368	175	762	404

* The western Bay of Bengal and the Arabian Sea were not included in the JTWC area of responsibility until the 1975 tropical cyclone season.

** The technique for calculating right angle error was revised in 1981; therefore, a direct correlation in right angle statistics cannot be made for the errors computed before 1981 and the errors computed since 1981.

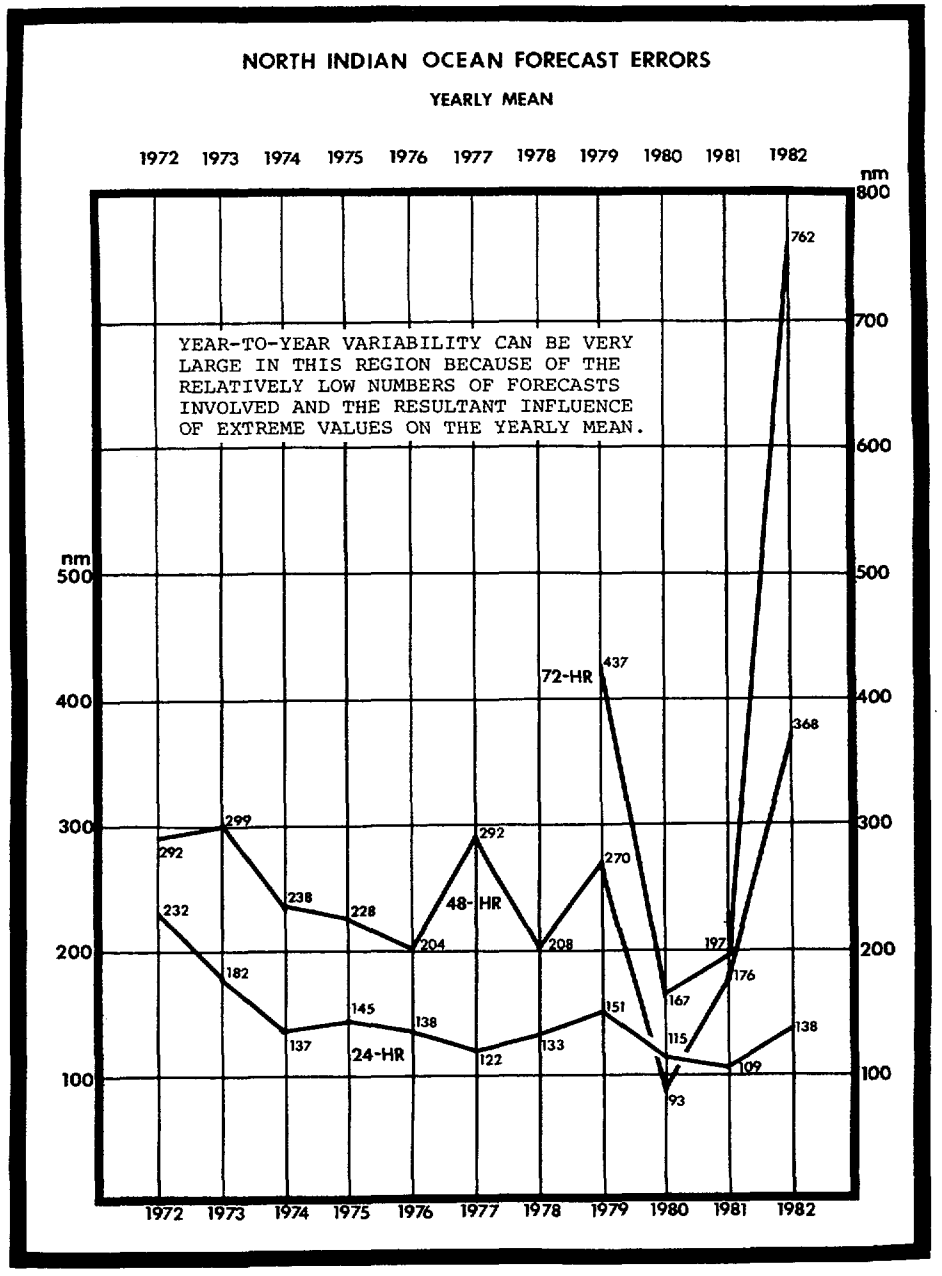

FIGURE 4-4. Annual mean vector errors (nm) for all tropical cyclones in the North Indian Ocean.

2. COMPARISION OF OBJECTIVE TECHNIQUES

a. General

Objective techniques used by JTWC are divided into five main categories:

(1) climatological and analog techniques;

(2) extrapolation;

(3) steering techniques;

(4) dynamic models;

(5) empirical and analytical techniques

In September 1981, JTWC began to initialize its array of objective forecast techniques (described below) on the six-hour-old preliminary best track position (an interpolative process) rather than the forecast (partially extrapolated) warning position, e.g. the 0600Z warning is now supported by objective techniques developed from the 0000Z preliminary best track position. This operational change has yielded several advantages:

*techniques can now be requested much earlier in the warning development time line, i.e. as soon as the track can be approximated by one or more fix positions on, or after the valid time of the previous warning;

*receipt of these techniques is virtually assured prior to development of the next warning

*improved (mean) forecast accuracy.

This latter aspect arises because JTWC now has a more reliable approximation of the short-term tropical cyclone movement. Further, since most of the objective techniques are biased for persistence, this new procedure optimizes their performance and provides more consistent guidance on short-term movement, indirectly yielding a more accurate initial position estimate as well as lowering 24-hour forecast errors.

b. Description of Objective Techniques

(1) CLIM -- A climatological aid providing 24-, 48- and 72-hour tropical cyclone forecast positions (and intensity changes in the western North Pacific) based upon the position of the tropical cyclone. The output is based upon data records from 1945 to 1981 for the western North Pacific Ocean and 1900 to 1981 for the North Indian Ocean.

(2) TYAN78 -- An updated analog program which combines the earlier versions TYFN 75 and INJAH 74. The program scans history tapes for tropical cyclones similar (within a specified acceptance envelope) to the current tropical cyclone. For the western North Pacific Ocean, three forecasts of position and intensity are provided for 24-, 48- and 72-hours: RECR - a weighted mean of all accepted tropical cyclones which were categorized as "recurving" during their best track period; STRA - a weighted mean of all accepted tropical cyclones which were categorized as moving "straight" (westward) during their best track period; and TOTL - a weighted mean of all accepted tropical cyclones, including those used in the RECR and STRA forecasts. For the North Indian Ocean, a single (total) forecast track is provided for 12-hour intervals to 72 hours.

(3) BPAC -- A program which generates 12- to 72-hour forecast positions based on blending the past motion of the tropical cyclone with the CLIM forecast positions. The blending routine gives less weight to persistence at each succeeding forecast interval.

(4) XTRP -- Forecast positions for 24- and 48-hours are derived from the extension of a straight line which connects the most-recent and 12-hour-old preliminary best track positions.

(5) HPAC -- 24- and 48-hour forecast positions are derived by merely connecting the mid-points of straight lines which connect these positions on the XTRP and CLIM tracks, respectively.

(6) CYCLOPS -- An updated version of the HATTRACK/MOHATT steering program which can provide geostrophic steering forecasts at the 1000-, 850-, 700-, 500-, 400-, and 200-mb levels. The program can be run in a modified (includes a 12-hour persistence bias) or unmodified mode applied to either analysis or prognostic fields. The program advects a point vortex on a preselected analysis and/or smoothed prognostic field at designated levels in six-hour time steps through 72 hours. In 1982, only the modified version, in the prognostic mode for the 500-mb level was verified; however, JTWC routinely uses many of the other levels and modes as operational forecast aids.

(7) OTCM -- (One-way Tropical Cyclone Model) A coarse-mesh, three-layer in the vertical, primitive equation model with a 205 km grid spacing over a 6400 x 4700 km domain. The model's fields are computed around a bogused, digitized cyclone vortex using FNOC Global Bands prognostic fields for the specified valid time. The past motion of the tropical cyclone is compared to initial steering fields and a bias correction is computed and applied to the model. FNOC hemispheric prognostic fields are used at 12-hour intervals to update the model's boundaries. The resultant forecast positions are derived by locating the 850 mb vortex at six-hour intervals to 72 hours. In 1982, the OTCM was requested for each warning; and when computer resources were available, the OTCM forecast was normally available to the TDO within one hour of the request.

(8) NTCM -- (Nested Tropical Cyclone Model) A primitive equation model with similar properties as the OTCM. The NTCM differs by containing a finer scale "nested" grid, initializing on Global Bands analysis fields, not containing a (persistence) bias correction, and being a channel model which runs independent of FNOC prognostic fields (not requiring updating of its boundaries). The "nested" grid covers a 1200 x 1200 km area with a 41 km grid spacing which moves within the coarse-mesh domain to keep an 850 mb vortex at its center. In 1982, the NTCM was incorporated into the FNOC job-stream and 72-hour forecast tracks were produced automatically from analysis fields, utilizing the 0000Z and 1200Z warning positions. These forecasts were normally received within 12 hours of their valid times and provided guidance for 1200Z and 0000Z warnings, respectively.

(9) TAPT -- A technique which utilizes upper-tropospheric wind fields to estimate the latitude of initial acceleration associated with the tropical cyclone's interaction with the mid-latitude westerly steering currents. Further, the technique provides speed of movement guidelines for duration and upper-limits, and insight on the probable path of the tropical cyclone, given a prevailing upper-wind pattern during the acceleration process.

(10) THETA E -- An empirically derived relationship between a tropical cyclone's minimum sea level pressure (MSLP) and (700 mb) equivalent potential temperature (θ_e) was developed by Sikora (1976) and Dunnavan (1981). By monitoring MSLP and θ_e trends, the forecaster can evaluate the potential for sudden, rapid deepening of a tropical cyclone.

(11) WIND RADIUS -- Following an analytic model of the radial profiles of sea level pressures and winds in mature tropical cyclones (Holland, 1980), a set of radii for 30-, 50-, and 100-knot winds based on the tropical cyclone's maximum intensity and radius of maximum winds have been produced to aid the forecaster in determining forecast wind radii.

(12) DVORAK -- An estimation of a tropical cyclone's current and 24-hour forecast intensity is made from interpretation of visual satellite imagery (Dvorak, 1973) and provided to the forecaster. These intensity estimates are used in conjunction with other intensity-related data and trends to forecast tropical cyclone intensity.

c. Testing and Results

A comparison of selected techniques is included in Table 4-7 for all western North Pacific tropical cyclones and in Table 4-9 for all North Indian Ocean tropical cyclones. In these tables, "X-AXIS" refers to techniques listed vertically. The example in Table 4-7 compares CY50 to OTCM, i.e. in the 435 cases available for a (homogeneous) comparison, the average vector error at 24 hours was 111 nm for CY50 and 119 nm for OTCM. The difference of 8 nm is shown in the lower right. (Differences are not always exact, due to computational round-off which occurs for each of the cases available for comparison).

A comparison of mean and median forecast errors (for a non-homogeneous data set) is provided for selected techniques in Table 4-6 for all western North Pacific tropical cyclones and in Table 4-8 for all North Indian Ocean tropical cyclones.

TABLE 4-6.

COMPARISON OF FORECAST ERRORS (NM) BY TECHNIQUE
IN 1982 FOR THE WESTERN NORTH PACIFIC

	24-HOUR RESULTS*				48-HOUR RESULTS*				72-HOUR RESULTS*			
TECHNIQUE	MEAN	MEDIAN	STD DEV	(CASES)	MEAN	MEDIAN	STD DEV	(CASES)	MEAN	MEDIAN	STD DEV	(CASES)
JTWC	113	98	73	(665)	237	209	158	(535)	341	296	225	(428)
RECR	116	97	77	(588)	237	203	144	(504)	387	344	243	(423)
STRA	121	101	85	(589)	258	205	185	(513)	434	312	271	(434)
TOTL	112	96	72	(612)	230	197	145	(523)	440	321	246	(440)
CY50	112	100	69	(579)	277	236	184	(496)	408	407	315	(408)
NTCM	143	128	85	(181)	238	208	140	(153)	353	347	180	(124)
OTCM	122	108	73	(479)	232	206	134	(405)	330	289	220	(330)
BPAC	123	104	79	(613)	248	207	169	(527)	442	309	285	(442)
CLIM	150	126	100	(648)	272	226	182	(554)	467	323	295	(467)
XTRP	117	101	89	(635)	264	229	168	(542)				
HPAC	112	98	76	(633)	217	183	143	(540)				

* THIS DATA SET REPRESENTS ALL FORECAST ERRORS FOR EACH TECHNIQUE LISTED AGAINST THE CORRESPONDING BEST TRACK POSITIONS AT 24, 48, AND 72 HOURS.

TABLE 4-7. 1982 ERROR STATISTICS FOR SELECTED OBJECTIVE TECHNIQUES IN THE WESTERN NORTH PACIFIC OCEAN

24-HOUR FORECAST ERRORS (NM)

24-	JTWC		RECR		STRA		TOTL		CY50		NTCM		OTCM		BPAC		CLIM		XTRP		HPAC	
JTWC	665	113																				
	113	0																				
RECR	583	113	588	116																		
	115	2	116	0																		
STRA	584	110	561	114	589	121																
	121	11	120	7	121	0																
TOTL	607	112	583	116	583	121	612	112														
	112	0	110	-5	110	-10	112	0														
CY50	575	112	534	114	532	119	554	111	579	112												
	112	0	110	-2	107	-11	110	0	112	0												
NTCM	179	102	163	111	159	120	167	108	159	113	181	143										
	143	40	141	30	137	17	141	33	142	29	143	0										
OTCM	477	113	441	119	436	122	455	113	435	111	138	137	479	122								
	122	9	123	4	118	-2	122	9	119	8	120	-15	122	0								
BPAC	610	111	556	114	559	119	580	110	548	110	170	140	458	120	613	123						
	122	11	121	8	120	1	121	12	119	9	119	-20	121	1	123	0						
CLIM	643	112	585	116	587	121	609	112	574	111	176	142	476	122	611	122	648	150				
	150	38	148	32	146	25	150	38	149	38	148	7	150	28	147	24	150	0				
XTRP	630	112	575	116	575	121	599	112	566	111	171	142	469	121	600	121	633	150	635	117		
	117	5	114	-1	110	-10	113	1	115	5	113	-29	119	-1	116	-4	117	-32	117	0		
HPAC	628	111	573	116	575	121	597	112	564	110	171	142	468	121	600	121	633	150	633	117	633	112
	111	0	109	-5	107	-14	110	-1	110	0	108	-33	113	-8	109	-11	112	-37	112	-4	112	0

NUMBER OF CASES	X-AXIS TECHNIQUE ERROR
Y-AXIS TECHNIQUE ERROR	ERROR DIFFERENCE Y - X

48-HOUR FORECAST ERRORS (NM)

48-	JTWC		RECR		STRA		TOTL		CY50		NTCM		OTCM		BPAC		CLIM		XTRP		HPAC	
JTWC	535	237																				
	237	0																				
RECR	476	233	504	237																		
	233	0	237	0																		
STRA	486	231	489	234	513	258																
	258	26	256	22	258	0																
TOTL	493	234	498	238	508	257	523	230														
	228	-5	227	-10	228	-28	230	0														
CY50	466	235	458	239	468	261	475	231	496	277												
	267	32	277	39	272	12	277	46	277	0												
NTCM	145	221	139	231	139	258	141	224	139	291	153	238										
	238	16	237	6	237	-20	243	19	244	-47	238	0										
OTCM	384	237	373	248	380	264	384	233	371	270	122	238	405	232								
	229	-7	232	-14	231	-32	233	0	228	-41	236	-1	232	0								
BPAC	498	232	479	233	493	258	499	226	473	275	146	239	386	229	527	248						
	240	8	249	17	247	-9	249	23	251	-23	245	6	250	21	248	0						
CLIM	521	234	501	237	512	258	520	230	492	275	151	238	402	233	526	248	554	272				
	267	32	271	34	270	12	275	45	273	-1	273	36	277	45	266	18	272	0				
XTRP	509	234	491	237	501	258	510	230	485	275	147	237	397	232	517	248	540	270	542	264		
	262	28	260	23	255	-2	258	28	262	-12	262	24	266	34	264	16	263	-6	264	0		
HPAC	507	233	489	237	501	258	508	230	483	273	147	237	396	232	517	248	540	270	540	263	540	217
	212	-20	214	-21	213	-45	216	-13	218	-53	220	-16	223	-8	215	-32	217	-52	217	-45	217	0

JTWC - OFFICIAL JTWC FORECAST
RECR - RECURVER (TYAN 78)
STRA - STRAIGHT (TYAN 78)
TOTL - TOTAL (TYAN 78)
CY50 - CYCLOPS MODIFIFD 500 MB PROG
NTCM - NESTED TROPICAL CYCLONE MODEL
OTCM - ONE-WAY TROPICAL CYCLONE MODEL
BPAC - BLENDED PERSISTENCE AND CLIM
CLIM - CLIMATOLOGY
XTRP - 12-HOUR EXTRAPOLATION
HPAC - MEAN OF XTRP AND CLIM

72-HOUR FORECAST ERRORS (NM)

72-	JTWC		RECR		STRA		TOTL		CY50		NTCM		OTCM		BPAC		NTCM	
JTWC	428	341																
	341	0																
RECR	378	328	423	387														
	365	37	387	0														
STRA	393	333	413	383	434	390												
	386	53	385	2	390	0												
TOTL	396	336	418	387	430	388	440	373										
	360	25	364	-22	368	-19	373	0										
CY50	366	345	375	384	387	393	390	377	408	463								
	433	88	465	82	463	70	466	89	463	0								
NTCM	113	326	116	387	116	418	116	378	111	487	124	353						
	356	30	355	-30	356	-61	360	-17	358	-128	353	0						
OTCM	299	326	303	390	310	391	312	364	293	440	98	338	330	346				
	332	7	342	-47	341	-49	348	-16	340	-99	356	19	346	0				
BPAC	402	336	399	379	414	390	417	369	388	465	119	359	313	341	442	388		
	364	28	384	4	384	-4	389	20	389	-75	375	17	375	34	388	0		
CLIM	420	340	420	387	432	389	437	373	405	464	123	355	327	346	442	388	467	409
	390	50	399	12	406	17	415	42	405	-58	399	45	410	64	402	14	409	0

TABLE 4-8.

COMPARISON OF FORECAST ERRORS (NM) BY TECHNIQUE
IN 1982 FOR THE NORTH INDIAN OCEAN

	24-HOUR RESULTS*				48-HOUR RESULTS*				72-HOUR RESULTS*			
TECHNIQUE	MEAN	MEDIAN	STD DEV	(CASES)	MEAN	MEDIAN	STD DEV	(CASES)	MEAN	MEDIAN	STD DEV	(CASES)
JTWC	138	115	93	(37)	368	277	189	(18)	762	887	277	(7)
TOTL	132	120	82	(20)	375	307	181	(7)	883	870	13	(2)
NTCM	319	338	69	(7)	556	578	161	(5)	918	923	80	(3)
CY85	159	142	82	(27)	289	248	136	(13)	426	405	212	(5)
CY50	192	166	129	(27)	433	628	283	(13)	940	1119	420	(5)
OTCM	235	235	66	(13)	522	522	77	(7)	765	798	224	(4)
BPAC	134	133	73	(29)	340	336	127	(12)	853	666	283	(4)
CLIM	218	242	78	(29)	483	523	123	(13)	818	838	51	(4)
XTRP	128	104	75	(28)	326	297	150	(14)				
HPAC	159	167	65	(27)	385	403	112	(13)				

* THIS DATA SET REPRESENTS ALL FORECAST ERRORS FOR EACH TECHNIQUE LISTED AGAINST THE CORRESPONDING BEST TRACK POSITIONS AT 24, 48, AND 72 HOURS.

TABLE 4-9. 1982 ERROR STATISTICS FOR SELECTED OBJECTIVE TECHNIQUES IN THE NORTH INDIAN OCEAN

24-HOUR FORECAST ERRORS (NM)

24-	JTWC		TOTL		NTCM		CY85		CY50		OTCM		BPAC		CLIM		XTRP		HPAC	
JTWC	37	138																		
	138	0																		
TOTL	20	133	20	132																
	132	0	132	0																
NTCM	7	201	4	166	7	319														
	319	118	268	102	319	0														
CY85	27	153	20	132	6	301	27	159												
	159	7	164	31	170	-130	159	0												
CY50	27	153	20	132	6	301	27	159	27	192										
	192	40	179	47	219	-81	192	33	192	0										
OTCM	13	172	9	128	3	329	13	140	13	208	13	235								
	235	63	223	95	280	-47	235	95	235	27	235	0								
BPAC	29	137	19	121	5	293	26	165	26	186	13	235	29	134						
	134	-2	129	8	170	-123	134	-30	134	-51	153	-81	134	0						
CLIM	29	137	19	121	5	293	26	165	26	186	13	235	29	134	29	218				
	218	81	198	77	210	-82	217	53	217	31	235	0	218	84	218	0				
XTRP	28	149	19	134	5	310	25	150	25	194	12	237	27	136	27	219	28	128		
	128	-20	126	-7	195	-114	130	-19	130	-63	135	-101	120	-15	120	-98	128	0		
HPAC	27	141	18	122	4	304	24	155	24	187	12	237	27	136	27	219	27	120	27	159
	159	18	155	33	185	-117	165	10	165	-21	183	-53	159	23	159	-59	159	39	159	0

NUMBER OF CASES | X-AXIS TECHNIQUE ERROR
Y-AXIS TECHNIQUE ERROR | ERROR DIFFERENCE Y - X

48-HOUR FORECAST ERRORS (NM)

48-	JTWC		TOTL		NTCM		CY85		CY50		OTCM		BPAC		CLIM		XTRP		HPAC	
JTWC	18	368																		
	368	0																		
TOTL	7	371	7	375																
	375	4	375	0																
NTCM	5	444	2	404	5	556														
	556	112	423	18	556	0														
CY85	13	397	7	375	4	564	13	289												
	289	-107	290	-84	261	-302	289	0												
CY50	13	397	7	375	4	564	13	289	13	433										
	433	36	465	90	568	4	433	144	433	0										
OTCM	7	473	3	449	2	705	7	238	7	528	7	522								
	522	49	557	108	566	-138	522	284	522	-5	522	0								
BPAC	12	356	6	331	2	494	11	300	11	386	6	504	12	340						
	340	-15	354	23	260	-233	326	26	326	-59	417	-86	340	0						
CLIM	13	370	6	331	3	559	12	298	12	406	7	522	12	340	13	483				
	483	113	432	101	436	-122	480	181	480	73	549	27	475	135	483	0				
XTRP	14	392	7	375	4	564	13	289	13	433	7	522	12	340	13	483	14	326		
	326	-64	355	-19	419	-144	324	36	324	-107	386	-136	295	-43	307	-175	326	0		
HPAC	13	370	6	331	3	559	12	298	12	406	7	522	12	340	13	483	13	307	13	385
	385	15	370	38	381	-177	381	82	381	-25	452	-70	375	36	385	-97	385	78	385	0

JTWC - OFFICIAL JTWC FORECAST
TOTL - ANALOG (TYAN 78)
NTCM - NESTED TROPICAL CYCLONE MODEL
CY85 - CYCLOPS MODIFIED 850 MB PROG
CY50 - CYCLOPS MODIFIED 500 MB PROG
OTCM - ONE-WAY TROPICAL CYCLONE MODEL
BPAC - BLENDED PERSISTENCE AND CLIM
CLIM - CLIMATOLOGY
XTRP - 12-HOUR EXTRAPOLATION
HPAC - MEAN OF XTRP AND CLIM

72-HOUR FORECAST ERRORS (NM)

72-	JTWC		TOTL		NTCM		CY85		CY50		OTCM		BPAC		CLIM	
JTWC	7	762														
	762	0														
TOTL	2	983	2	883												
	883	-99	883	0												
NTCM	3	943	1	870	3	918										
	918	-23	923	53	918	0										
CY85	5	801	2	883	3	918	5	426								
	426	-374	333	-549	366	-552	426	0								
CY50	5	801	2	883	3	918	5	426	5	940						
	940	139	1218	335	1105	187	940	515	940	0						
OTCM	4	746	1	896	2	916	4	467	4	884	4	765				
	765	20	899	3	885	-30	765	298	765	-118	765	0				
BPAC	4	746	1	896	2	916	4	467	4	884	4	765	4	853		
	853	107	935	39	906	-9	853	386	853	-30	853	88	853	0		
CLIM	4	746	1	896	2	916	4	467	4	884	4	765	4	853	4	818
	818	72	838	-57	793	-122	818	351	818	-65	818	53	818	-34	818	0