CHAPTER IV - SUMMARY OF FORECAST VERIFICATION

1. ANNUAL FORECAST VERIFICATION

a. Western North Pacific Area

Forecast positions at warning times and 24-, 48- and 72-hour valid times were verified against corresponding best tracks and vector errors and right angle errors were calculated (Table 4-1). Annual, mean errors are listed in Table 4-2 for comparison. Frequency distributions of the vector errors of the 24-, 48- and 72-hour forecasts on all 1978 cyclones are shown in Figure 4-1 and annual, mean vector errors are graphed in Figure 4-2. Previous reports have shown a graph of the annual, mean vector errors for typhoons when best track intensity at verifying time was 35 kt or greater. This, subset, error graph is shown in Figure 4-3. Mean vector errors shown in Figure 4-3 are lower than those depicted in Figure 4-2; nonetheless, similar trends are evident from year to year.

TABLE 4-1. FORECAST ERROR SUMMARY FOR THE 1978 WESTERN NORTH PACIFIC SIGNIFICANT TROPICAL CYCLONES.

	WARNING			24 HOUR			48 HOUR			72 HOUR		
CYCLONE	POSIT ERROR	RT ANGLE ERROR	# WRNGS	FCST ERROR	RT ANGLE ERROR	# WRNGS	FCST ERROR	RT ANGLE ERROR	# WRNGS	FCST ERROR	RT ANGLE ERROR	# WRNGS
1. TS NADINE	23	15	20	185	109	16	568	381	12	980	708	8
2. TY OLIVE	14	10	36	100	62	32	224	129	28	328	215	20
3. TS POLLY	16	10	16	93	50	12	139	93	8	208	97	?
4. TS ROSE	37	21	7	235	142	3						
5. TS SHIRLEY	24	15	3									
6. TY TRIX	21	17	38	174	122	35	425	298	30	657	531	24
7. TY VIRGINIA	20	12	43	112	63	39	231	127	35	399	283	31
8. TY WENDY	21	12	40	112	75	36	235	188	30	328	188	30
9. TS AGNES	10	7	22	97	59	19	243	191	12	410	309	3
10. TS BONNIE	31	20	8	121	36	4						
11. TY CARMEN	19	10	36	124	56	30	250	129	19	429	266	12
12. TS DELLA	29	20	10	116	73	6	217	131	2			
13. TD-14	25	23	6	169	127	2						
14. TY ELAINE	22	15	20	132	77	16	278	157	12	263	174	8
15. TY FAYE	15	12	44	158	113	40	360	285	36	514	396	29
16. TS GLORIA	21	13	11	138	79	7	496	331	3			
17. TS HESTER	34	17	9	198	28	5	300	52	1			
18. TY IRMA	14	12	15	92	44	12	134	31	8	154	67	4
19. TY JUDY	19	12	18	127	51	14	242	131	10	346	185	6
20. TS KIT	32	16	21	165	84	18	231	134	10	295	210	7
21. TY LOLA	13	9	34	54	40	30	112	79	26	134	88	17
22. TY MAMIE	25	14	18	182	68	14	386	143	10	722	327	6
23. TS NINA	19	16	35	120	94	31	240	212	27	382	340	22
24. TY ORA	19	14	21	124	99	17	314	239	11	460	391	5
25. TD-26	40	10	7	218	22	4						
26. TD-27	38	30	6	175	168	3						
27. TY PHYLLIS	22	13	28	132	86	24	263	198	20	436	377	15
28. ST RITA	15	10	51	107	60	47	214	114	43	301	157	39
29. TS TESS	29	21	20	108	53	16	194	127	12	367	237	8
30. TD-32	50	33	12	133	108	9	401	349	5	973	871	1
31. TY VIOLA	19	10	29	96	51	25	269	172	21	434	338	17
32. TS WINNIE	34	16	12	238	81	8	614	274	4			
ALL FORECASTS	21	13	696	127	75	574	271	179	435	410	297	304

JTWC

TABLE 4-2. ANNUAL MEAN FORECAST ERRORS FOR THE WESTERN NORTH PACIFIC.

	24-HR		48-HR		72-HR	
YEAR	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE
1970	104	-	190	-	279	-
1971	111	64	212	118	317	177
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

JTWC

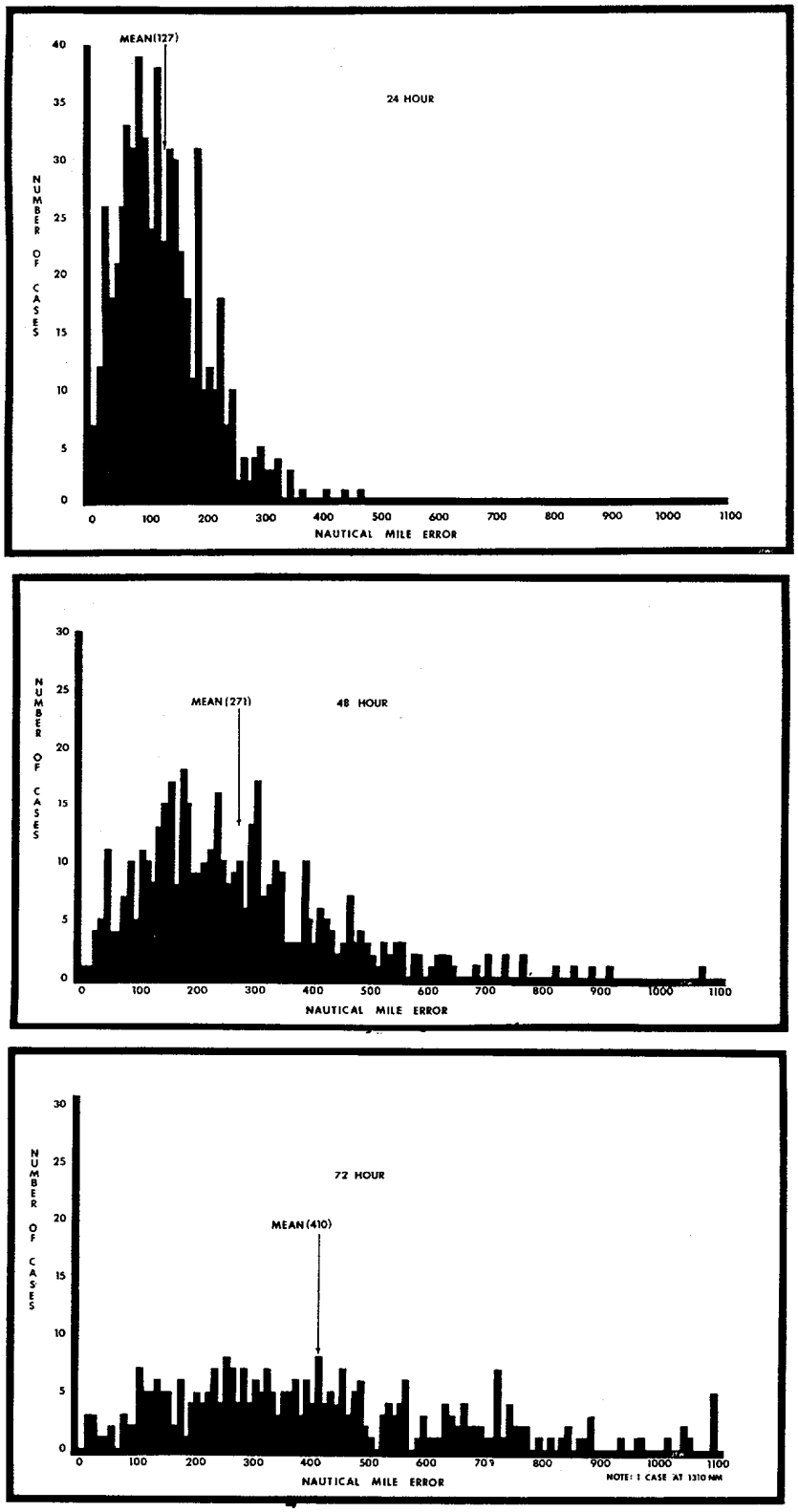

FIGURE 4-1. *Frequency distribution of 1978 24-, 48-, and 72-hour forecast vector errors for all significant tropical cyclones in the western North Pacific.*

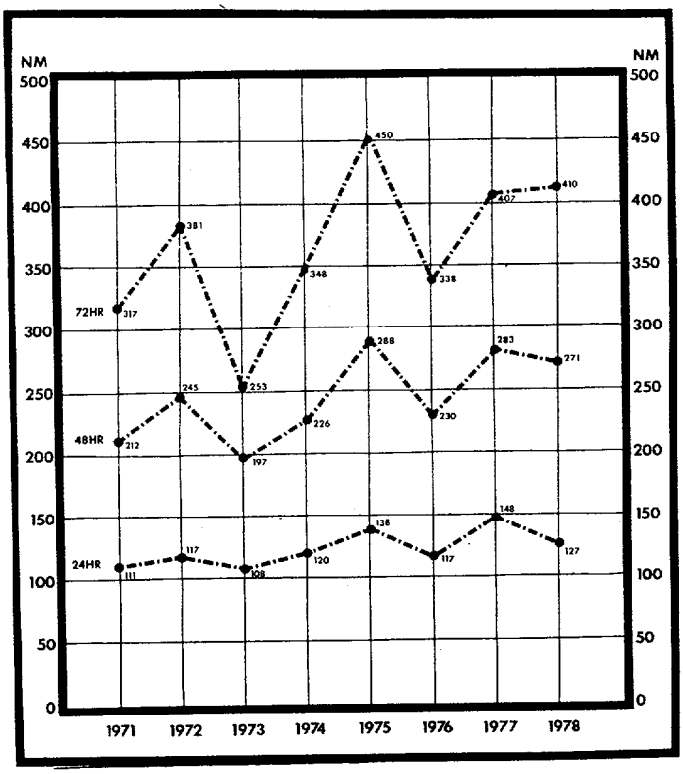

FIGURE 4-2. Annual mean vector errors (nm) for all cyclones in the western North Pacific.

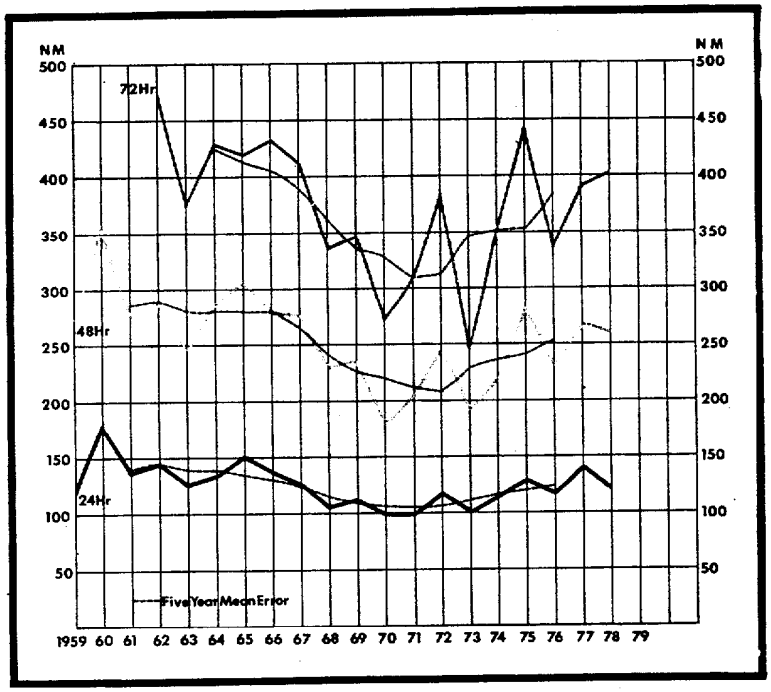

FIGURE 4-3. Annual mean vector errors (nm) for western North Pacific typhoons only when best track intensities were greater than 34 knots at time of verification.

Intensity verification statistics for all significant, tropical cyclones in the western North Pacific area are depicted in Figures 4-4 and 4-5. The average absolute magnitude of the intensity error as well as the intensity bias (algebraic average) are graphically depicted. An analysis of the errors indicates that JTWC intensity forecasts often lag the true intensity; in an intensifying situation, JTWC underforecasts, and in a weakening situation, JTWC overforecasts thereby causing large average magnitude error but small average bias. Objective intensity forecasting aids verification is also depicted in Figures 4-4 and 4-5. (An explanation of the objective forecasting aids can be found in this chapter, Section 2 - Comparison Of Objective Techniques.) It is interesting to note that the objective intensity forecasting aids consistently overforecast by approximately 10 knots.

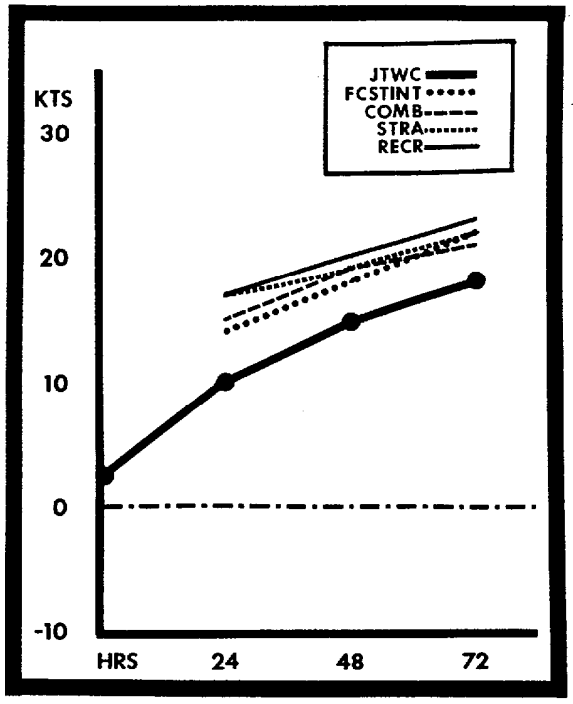

FIGURE 4-4. Comparison of average intensity errors (magnitude) for all cyclones in the western North Pacific.

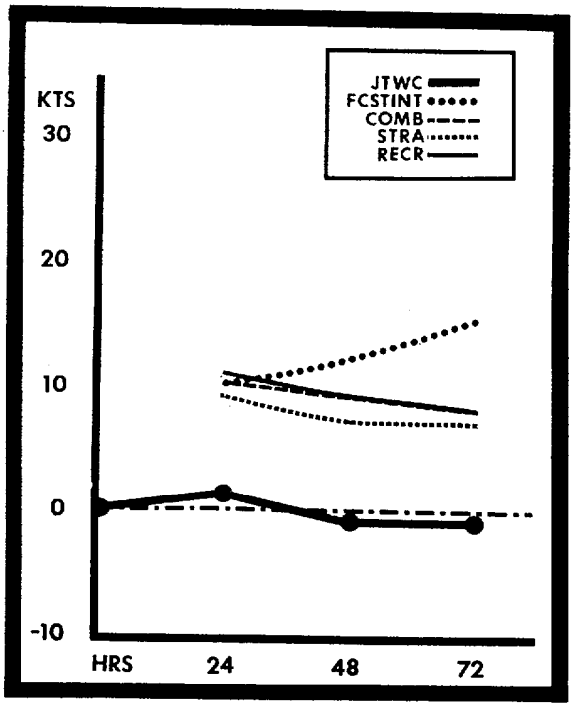

FIGURE 4-5. Comparison of average intensity errors (biases) for all cyclones in the western North Pacific.

b. North Indian Ocean Area

Forecast postions at warning times and 24- and 48-hour valid times were verified by the same methods used for the western North Pacific area verification. Table 4-3 is the forecast error summary for the four significant tropical cyclones in the North Indian Ocean area. Table 4-4 contains the annual average of forecast errors back through 1971. Vector errors are plotted in Figure 4-6.

Forecast intensities were not verified.

TABLE 4-3. FORECAST ERROR SUMMARY FOR THE 1978 NORTH INDIAN OCEAN SIGNIFICANT TROPICAL CYCLONES.

	WARNING			24 HOUR			48 HOUR		
CYCLONE	POSIT ERROR	RT ANGLE ERROR	# WRNGS	FCST ERROR	RT ANGLE ERROR	# WRNGS	FCST ERROR	RT ANGLE ERROR	# WRNGS
18-78	55	51	4	88	41	3	78	45	1
19-78	35	25	7	203	183	3			
20-78	54	25	12	165	101	9	205	102	5
21-78	31	18	16	104	62	13	213	147	11
ALL FORECASTS	41	25	39	133	86	28	202	128	17

JTWC

TABLE 4-4. ANNUAL MEAN FORECAST ERRORS FOR THE NORTH INDIAN OCEAN (THE ARABIAN SEA WAS NOT INCLUDED PRIOR TO 1975).

	24-HR		48-HR	
YEAR	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

JTWC

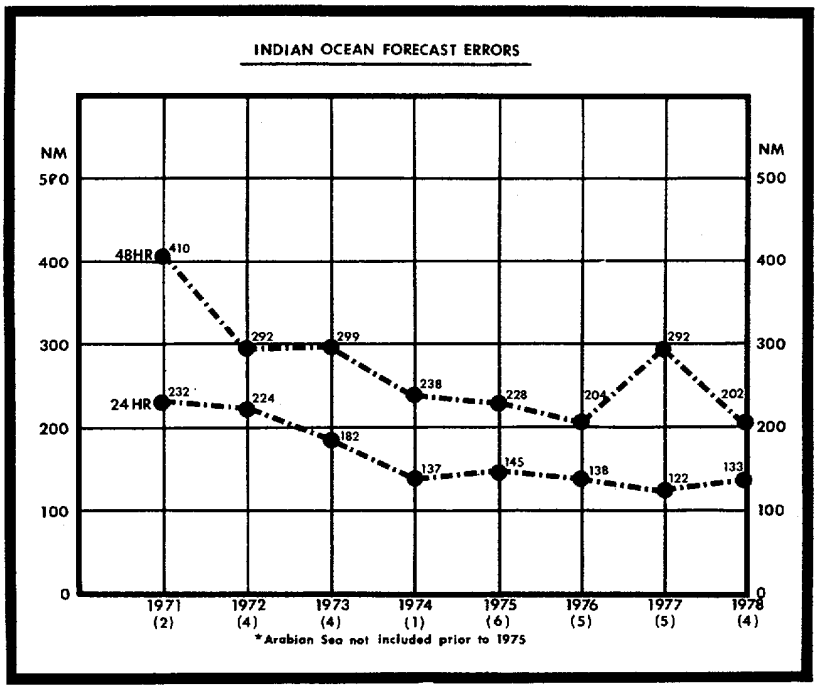

FIGURE 4-6. Annual mean vector errors (nm) for all cyclones in the North Indian Ocean.

2. COMPARISON OF OBJECTIVE TECHNIQUES

a. General

Objective techniques employed by JTWC are divided into four main categories: (1) climatological and analog techniques; (2) extrapolation; (3) steering techniques; and, (4) a dynamical model. The analog technique provides three movement forecasts, one for straight moving cyclones, one for recurving cyclones and one combining the tracks of straight, recurving and cyclones that do not meet the criteria of straight or recurving analogs. All techniques were executed using the operational data available at the warning time.

b. Description of Objective Techniques

(1) TYFN75 - Analog program which scans history tapes for cyclones similar (within a specified acceptance envelope) to the current cyclone. Three 24-, 48-, and 72-hour position and intensity forecasts are provided.

(2) MOHATT 700/500 - Steering program which advects a point vortex on a preselected analysis and smoothed prognostic fields at designated levels in 6-hour time steps through 72 hours. Utilizing the previous 12-hour history position, MOHATT computes the 12-hour forecast error and applies a bias correction to the forecast position.

(3) TCM - Tropical Cyclone Forecast Model is a coarse mesh (220 km) PE Model, with the digitized storm warning position bogused at the 850 mb level of the FNWC Global Band Analysis utilizing wind and temperature fields. Boundary conditions permit no mass transfer across north or south walls, and east/west boundaries are cyclical.

(4) FCSTINT - Intensity forecast program which utilizes statistical regression equations to provide 24-, 48-, and 72-hour forecast intensities.

(5) 12-HR EXTRAPOLATION - A track through current warning position and 12-hour old preliminary best track position is linearly extrapolated to 24 and 48 hours.

(6) HPAC - Mean 24 and 48 hour forecast positions are derived by averaging the 24 and 48 hour positions from the 12-HR EXTRAPOLATION track and a track based on climatology.

(7) INJAH74 - Analog program for North Indian Ocean. Similar to TYFN75, except tracks are not segregated.

(8) TYAN - An updated analog program which combines TYFN75, INJAH74, and other analog programs for the remaining northern/southern Pacific Ocean areas and the South Indian Ocean.

(9) CYCLOPS - An updated version of MOHATT program which has the capability to select steering forecasts at the 1000, 850, 700, 500, 400, 300 and 200 mb levels.

c. Testing and Results

A comparison of selected techniques is included in Table 4-5 for all western Pacific cyclones and Table 4-6 for Indian Ocean cyclones. In Tables 4-5 and 4-6 "X-AXIS" refers to techniques listed horizontally across the top, while "Y-AXIS" refers to techniques listed vertically. The example in Table 4-5 compares COMB to MH70. In the 407 cases available for comparison the average 24-hour vector error for COMB was 139 nm, while that for MH70 was 140 nm. The difference of 1 nm is shown in the lower right. (Differences are not always exact due to computational round off.)

TABLE 4-5.

24-HOUR

	JTWC	STRA	RECR	COMB	MH70	MH50	TCMW	TCMD	XTRP	HPAC
JTWC	574 127 127 0									
STRA	462 120 147 27	465 147 147 0								
RECR	509 126 140 14	442 148 138 -10	511 141 141 0							
COMB	516 125 136 11	445 147 134 -12	496 140 137 -2	519 137 137 0						
MH70	440 126 140 14	373 150 134 -15	402 143 141 -1	407 139 140 1	442 140 140 0					
MH50	374 125 145 20	318 148 140 -7	341 143 147 3	347 139 145 7	375 135 145 10	375 145 145 0				
TCMW	128 122 175 53	111 150 156 6	120 135 172 37	116 137 175 38	99 138 180 42	97 147 182 35	128 175 175 0			
TCMD	117 121 237 116	102 149 213 64	110 135 235 100	111 141 236 96	92 136 251 115	89 142 253 111	82 172 251 79	117 237 237 0		
XTRP	564 127 137 11	458 147 128 -17	506 140 137 -2	513 137 137 0	435 140 137 -2	371 146 134 -11	126 173 129 -43	117 237 130 -106	567 137 137 0	
HPAC	538 127 137 9	444 147 128 -18	486 141 136 -4	492 137 136 -1	423 139 135 -3	360 143 133 -9	123 170 127 -42	115 231 129 -100	541 138 137 0	541 137 137 0

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

48-HOUR

	JTWC	STRA	RECR	COMB	MH70	MH50	TCMW	TCMD	XTRP	HPAC
JTWC	435 271 271 0									
STRA	368 262 301 39	388 304 304 0								
RECR	389 264 262 -1	368 310 267 -42	405 268 268 0							
COMB	390 263 251 -11	369 303 252 -50	394 265 256 -8	410 254 254 0						
MH70	325 270 289 18	307 316 284 -31	314 281 293 12	316 264 291 27	343 293 293 0					
MH50	278 269 288 19	264 313 290 -23	267 283 293 10	271 265 289 24	294 290 288 -1	294 288 288 0				
TCMW	89 262 284 22	85 295 275 -19	86 256 287 31	81 243 284 41	71 269 302 32	69 270 304 35	92 284 284 0			
TCMD	84 266 362 96	80 308 354 47	83 260 364 104	82 251 362 111	69 260 385 125	67 263 385 122	56 298 370 72	87 363 363 0		
XTRP	425 270 291 21	374 302 289 -12	393 264 293 29	397 253 291 39	329 291 301 10	285 288 297 8	88 281 286 5	85 362 303 -59	438 294 294 0	
HPAC	394 276 262 -13	354 305 247 -57	367 266 258 -6	368 257 256 0	314 290 260 -29	271 287 257 -29	86 283 245 -37	82 364 257 -106	406 298 263 -34	407 263 263 0

JTWC - OFFICIAL JTWC FORECAST
STRA - STRAIGHT (TYFN 75)
RECR - RECURVE (TYFN 75)
COMB - COMBINED (TYFN 75)
MH70 - MONATT 700-MB PROG
MH50 - MONATT 500-MN PROG
TCMW - TROPICAL CYCLONE MODEL (SAME WARNING)
TCMD - TROPICAL CYCLONE MODEL (SAME DATA)
XTRP - 12-HOUR EXTRAPOLATION
HPAC - MEAN OF XTRP AND CLIMATOLOGY

72-HOUR

	JTWC	STRA	RECR	COMB	MH70	MH50	TCMW	TCMD
JTWC	304 410 410 0							
STRA	258 391 412 21	306 422 422 0						
RECR	275 403 341 -61	288 429 350 -79	320 359 359 0					
COMB	276 400 325 -74	292 421 325 -95	313 358 336 -21	324 334 334 0				
MH70	211 412 446 34	229 431 442 11	458 373 233 85	235 342 454 112	255 449 449 0			
MH50	183 407 438 32	200 433 430 -1	203 378 433 55	204 341 427 86	220 434 429 -4	221 430 430 0		
TCMW	60 414 452 38	62 402 447 45	63 356 466 110	60 339 452 113	51 414 495 81	49 430 490 59	68 458 458 0	
TCMD	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0

24-HOUR

	JTWC	INJA	MH7Ø	MH5Ø	XTRP	HPAC
JTWC	28 133 133 0					
INJA	20 136 117 -18	23 132 132 0				
MH7Ø	9 128 222 95	8 122 245 123	10 219 219 0			
MH5Ø	7 131 251 120	6 117 282 165	7 236 251 15	7 251 251 0		
XTRP	25 119 137 18	22 128 159 31	9 203 133 -69	6 231 109 -123	28 151 151 0	
HPAC	22 117 114 -1	18 119 124 5	6 246 134 -111	3 331 105 -225	24 144 123 -20	24 123 123 0

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

48-HOUR

	JTWC	INJA	MH7Ø	MH5Ø	XTRP	HPAC
JTWC	17 202 202 0					
INJA	11 194 202 8	14 231 231 0				
MH7Ø	3 99 149 49	3 270 263 -6	4 224 224 0			
MH5Ø	3 168 246 78	3 310 270 -39	3 279 186 -93	4 243 243 0		
XTRP	16 200 244 44	13 214 298 85	3 149 304 155	3 246 330 84	19 286 286 0	
HPAC	15 205 191 -13	12 211 225 13	2 82 88 6	2 287 201 -85	18 276 221 -54	18 221 221 0

JTWC - OFFICIAL JTWC FORECAST
INJA - ANALOG
MH7Ø - MOHATT 700-MB PROG
MH5Ø - MOHATT 500-MB PROG
XTRP - 12-HOUR EXTRAPOLATION
HPAC - MEAN OF XTRP AND CLIMATOLOGY

TABLE 4-6.