Marine

A LOOK AT THE AUTOMATED GREAT LAKES WAVE FORECASTS FOR LAKE ERIE JULY-NOVEMBER 1983

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ABSTRACT

A study was done to investigate the differences between the observed wave heights at two buoys on Western Lake Erie and the automated Great Lakes wave forecasts for July through November 1983. The study showed that the forecasted wave heights were generally too high.

1. INTRODUCTION

During the summer and autumn of 1983 two buoys were located on the western third of Lake Erie. Buoy Number 5, a Nomad type buoy (Figure 1), was located in open water (water beyond 5 miles of the shore). An experimental E buoy (Figure 2) was located in the nearshore waters (water within 5 miles of the shore). A study was made to verify the observed significant wave heights at the buoys versus the automated Great Lakes wave height forecast guidance (2) for a specific forecast point near each buoy. Figure 3 shows all wave forecast points on Lake Erie and the locations of the buoys.

Automated Great Lakes wave height forecasts have been operationally produced by the National Meteorological Center (NMC) since January 1975. The wave height forecasts depend upon the automated Great Lakes wind forecasts. The wave height is the significant wave height which is the average height of the highest one third of the waves during the sampling period. The significant wave height calculations are based upon the Bretschneider Method (3, 4). This method uses wind speed, fetch length and duration time to determine significant wave height.

Wave height guidance is available from NMC twice daily several hours after 0000 GMT and 1200 GMT under the AFOS (Automation of Field Operations and Services) heading MRPGLW. The NMC program computes significant wave heights at 12-hour intervals out of 36 hours starting with the 00 hour. Forecasts are to the nearest foot and are valid for that spe- cific hour. A sample forecast is shown in Figure 4.

Each hour the buoys transmit, via satellite, significant wave height in addition to other data. The two Lake Erie buoys were operational during most of the 1983 boating season, but this study is confined to the period July-November 1983. Both buoys were taken out of service for the winter by the middle of December.

2. METHOD AND RESULTS

The wave forecast point closest to the location of the buoy was assumed to represent the respective buoy location. As shown in Figure 3, Forecast Point 8 is relatively close to Buoy 5 and Forecast Point 7 is close to Buoy 9. A comparison was done between the observed significant wave heights at Buoy 5 and the significant wave height forecasts for Point 8. The same comparison was done between Buoy 9 and Wave Forecast Point 7. If the buoy data were not available for the specific hour, data for the previous hour were used; if that data were missing, the data for the hour after the specific time were used. If none of the data were available, then that wave forecast was not used in the study.

The buoys measure wave heights to the nearest half meter, while the wave height forecasts are to the nearest foot. The buoy observations were converted to the nearest foot for verification purposes. As a result, the verification categories are calm (C), 1-2, 3-4, 5, 6-7, 8-9, 10 and 11-12 feet.

The data for this study are summarized in Tables 1 and 2. To the left of each table is a ratio of observations available to the total possible. Tables 3 and 4 present, in a quantitative way, the percentage of time the automated wave forecasts were correct versus being too high (overforecasting) or being too low (underforecasting).

A look at the data, especially Tables 3 and 4, shows the tendency for the automated wave forecasts to be too high. Pore (5) concluded after looking at a sample of wave forecasts versus wave observations that the wave forecasts were "generally a little too high". He also stated that those results were expected as the Bretschneider wave height forecast equation was developed from wind speeds at the 10 meter level, while the winds that presently go into the NMC wave forecast program are from the 20 meter level. With the stronger winds the automated wave forecasts are higher.

2a. WAVE HEIGHTS OF 5 FEET OR LESS

As can be seen in Tables 1 and 2 the wave height guidance does not usually forecast calm because automated wind guidance rarely forecasts calm winds.

Tables 3 and 4 show the Great Lakes wave forecasts have around a 45% chance of being correct for Point 8 (Buoy 5) for waves of 1 to 5 feet. The results are comparable for Point 7 (Buoy 9) with the automated wave forecast being right around 40% of the time for 1 to 2 foot and 5 foot waves. However, the guidance is correct only 20% of the time for 3 to 4 foot waves.

A close look at the observations for Buoy 9 and the forecast wave heights for Point 7 indicates most of the misses for waves of 3 to 4 feet occurred when there were strong southerly winds. Since the fetch is a little shorter from land to buoy 9 with a south wind than the distance from land to Point 7 that should account for the lower waves observed at Buoy 9.

The tables show guidance overforecast by 40 to 50% for point 8 and 50 to 70% for point 7. Underforecasting was slight for each forecast point, less than 15%.

2b. WAVE HEIGHTS OF 6 FEET OR GREATER:

The tables show for waves of 6 to 7 feet forecasts are correct about 20% of the time while overforecasts occur 65 to 75% of the time and underforecasts around 10%.

For waves of 8 feet or greater the amount of data are limited, less than 8 cases for each category, so the data may not be representative. However the trend of the guidance to overforecast continues.

A key reason why the wave guidance may really overforecast waves of 6 feet or higher is probably the shallowness of Western Lake Erie. Even though waves can build rapidly in shallow water, the height they attain is reduced.

2c. WAVES OF ALL HEIGHTS:

For all automated wave forecasts no period (00-h, 12-h, 24-h or 36-h) showed a definite trend at being better than other periods. The wave height forecasts were not significantly better at point 7 or 8. Also, when the automated wave forecast was either too high or too low its error was generally by 1 or 2 feet. This is not too bad for higher waves, but it is a more serious error for smaller waves.

2d. THE GLERL FACTOR:

The Great Lakes Environmental Reserach Laboratory (GLERL) conducted research in 1981 (6) which suggested observed waves from Buoy 5 were too high by a factor of 1.4. Table 5 compares the observations from Buoy 5 with the automated forecasts for October, while Table 6 provides the same information except the latter table reduces the wave heights from Buoy 5 by 1.4. Comparing Tables 5 and 6 shows that reducing the wave heights accentuates the differences between the observed and forecast waves. The result of such an adjustment gives further support to the supposition that the automated wave height forecasts are on the high side.

3. LIMITATIONS OF THE STUDY

There are several factors that could have influenced the study either in a positive or negative way:

1. The wave forecast points were not exactly at the buoy locations. This would mean for certain wind directions the fetch lengths would be different. So waves could be higher than observed or vice versa.

2. Lake Erie is relatively shallow, especially at the west end. Besides the wave heights being more variable, the shallower depth tends to reduce the wave heights achievable for a given fetch. This is not considered in the wave height forecast.

3. If the wind forecasts were in error the wave forecasts would be incorrect. The wave height forecast equations require input of winds from the 10 meter level. However, the winds that are used in the equations are from 20 meters. As a result the wave heights tend to be high.

4. The fetch is reduced with a southwest wind for Point 8 because of some islands. This would tend to reduce the observed wave heights, which would not be reflected in the wave forecast.

5. If the wave sensing equipment on the buoys were not calibrated properly or any other engineering problem existed there would be errors in the wave measurements. Also, the buoys have different hull designs which is a factor.

4. CONCLUSIONS

This study shows automated Great Lakes wave forecasts for the western end of Lake Erie have a tendency to be too high. Calm is seldom forecast by the wave height equations. For waves of 1 to 5 feet the automated wave height forecasts are correct around 40% of the time for forecast points 7 and 8. Overforecasting for the same locations occurred 40 to 60% of the time. For waves of 6 feet or higher the guidance is correct less than 20% of the time and overforecasting is observed over 50% of the time. For all wave heights underforecasting is slight.

Wave guidance overforecasts are largely due to the fact that the wind forecasts are for the 20 meter level while the wave forecast equations are designed for winds at the 10 meter level. Also, the shallowness of Lake Erie and the fact that the buoys were not exactly at the forecast points may also be contributing factors.

ACKNOWLEDGEMENTS

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Figure 1. Nomad Buoy

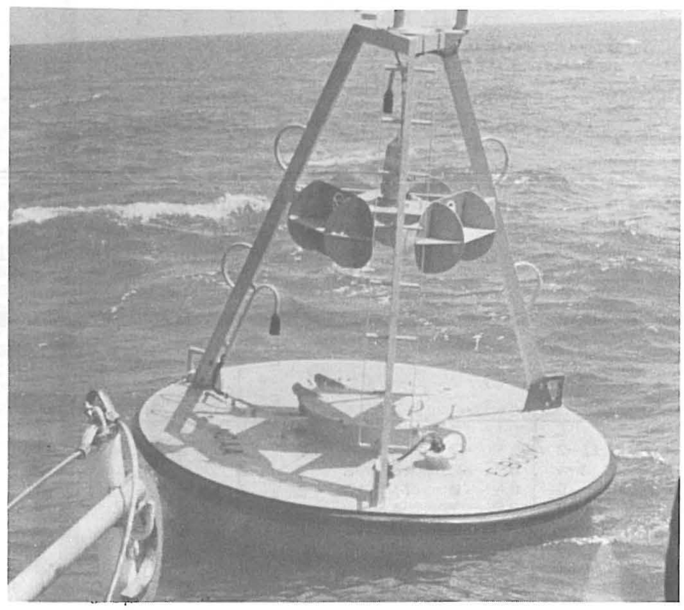

Figure 2. Experimental E Buoy

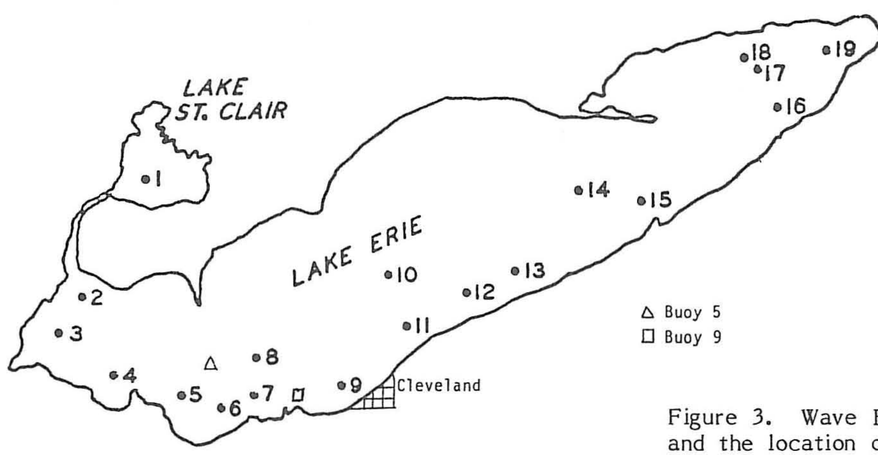

Figure 3. Wave Forecast points on Lake Erie and the location of the buoys.

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GREAT LAKES WAVE FORECAST HEIGHT IN FEET
    00 HR
POINT NO.   1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19
SUPERIOR   01 01 03 03 02 03 04 04 05 05 04
MICHIGAN   03 04 04 03 05 04 02 05 05 03 06 07 06 07 03 04
HURON      02 04 04 04 06 03 03 06 06 06
ERIE       03 03 03 05 03 05 05 05 06 05 06 06 05 04 04 04 03 02 02
ONTARIO    04 05 04 04 04 05 05 04 03 04
    12 HR
POINT NO.   1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19
SUPERIOR   02 03 03 03 02 04 02 02 03 03 03
MICHIGAN   02 03 03 02 03 03 02 04 03 02 04 04 02 05 02 02
HURON      03 03 03 02 04 02 02 04 03 02
ERIE       03 03 03 04 04 04 04 04 04 04 04 04 05 03 04 03 03 02 03
ONTARIO    03 03 03 04 04 05 05 04 04 04
    24 HR
POINT NO.   1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19
SUPERIOR   02 03 03 03 04 05 05 02 05 05 04
MICHIGAN   02 03 04 02 03 03 01 03 03 01 04 03 01 03 01 01
HURON      03 02 03 02 03 02 02 02 02 02
ERIE       02 02 02 03 03 02 03 03 03 03 03 03 04 04 04 03 03 02 02
ONTARIO    03 03 03 04 04 04 04 04 03 03
    36 HR
POINT NO.   1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19
SUPERIOR   02 03 03 02 05 03 02 02 05 02 03
MICHIGAN   04 04 02 04 03 03 03 03 03 02 03 01 01 01 02 01
HURON      03 02 04 02 03 03 02 02 03 01
ERIE       01 02 01 01 01 01 02 02 01 02 02 02 03 03 03 03 03 02 03
ONTARIO    02 02 03 02 03 01 03 03 03 04
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Figure 4. A sample output of the automated Great Lakes wave forecast. It is stored in AFOS under MRPGLW.

00-h

260/306 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	45	47	14	1	0	0	0	0	107
3-4	8	40	46	8	0	0	0	0	102
5	0	0	11	13	2	0	0	0	26
6-7	0	2	4	9	6	2	0	0	23
8-9	0	0	0	1	1	0	0	0	2
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	53	89	75	32	9	2	0	0	260

12-h

256/306 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	43	50	16	0	0	0	0	0	109
3-4	10	33	50	13	0	0	0	0	106
5	4	4	9	3	1	0	0	0	21
6-7	2	2	6	7	0	1	0	0	18
8-9	0	0	0	1	1	0	0	0	2
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	59	89	81	24	2	1	0	0	256

24-h

258/306 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	41	46	11	0	0	0	0	0	98
3-4	12	37	58	12	4	0	0	0	123
5	0	5	3	12	2	0	0	0	22
6-7	0	0	3	7	2	1	0	0	13
8-9	0	0	1	1	0	0	0	0	2
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	53	88	76	32	8	1	0	0	258

36-h

258/306 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	42	48	18	1	0	0	0	0	109
3-4	15	35	41	12	2	0	0	0	105
5	0	3	10	10	2	1	0	0	26
6-7	0	0	4	8	4	1	0	0	17
8-9	0	0	0	1	0	0	0	0	1
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	57	86	73	32	8	2	0	0	258

All Periods

1032/1224 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	171	191	59	2	0	0	0	0	423
3-4	45	145	195	45	6	0	0	0	436
5	4	12	33	38	7	1	0	0	95
6-7	2	4	17	31	12	5	0	0	71
8-9	0	0	1	4	2	0	0	0	7
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	222	352	305	120	27	6	0	0	1032

Table 1. Contingency tables of wave height observations(O) (ft) at Buoy 5 versus wave height forecasts (F) (ft)at Point 8 in Lake Erie for each period (00-h, 12-h, 24-h, 36-h) and all periods from July through November 1983. The ratio of observations available to the total possible is given to the left of each contingency table.

00-h

258/306 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	90	46	3	0	0	0	0	0	139
3-4	6	53	17	5	1	0	0	0	82
5	0	4	5	8	1	0	0	0	18
6-7	0	1	2	8	3	1	0	0	15
8-9	0	0	0	0	1	0	1	0	2
10	0	0	0	0	1	0	0	0	1
11-12	0	0	0	0	0	0	1	0	1
All	96	104	27	21	7	1	2	0	258

12-h

259/306 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	82	46	5	0	0	0	0	0	133
3-4	13	55	17	6	1	0	0	0	92
5	0	3	4	9	2	0	0	0	18
6-7	0	1	2	6	2	0	1	0	12
8-9	0	0	0	0	2	1	0	0	3
10	0	0	0	0	0	0	1	0	1
11-12	0	0	0	0	0	0	0	0	0
All	95	105	28	21	7	1	2	0	259

24-h

253/306 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	80	48	5	0	0	0	0	0	133
3-4	10	53	18	8	2	0	0	0	91
5	0	1	6	9	0	0	0	0	16
6-7	0	0	2	4	4	2	0	0	12
8-9	0	0	0	0	1	0	0	0	1
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	90	102	31	21	7	2	0	0	253

36-h

257/306 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	80	51	7	0	0	0	0	0	138
3-4	13	47	16	12	2	0	0	0	90
5	0	3	8	3	2	0	1	0	17
6-7	0	0	0	7	2	1	0	0	10
8-9	0	0	0	0	1	0	1	0	2
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	93	101	31	22	7	1	2	0	257

All Periods

1027/1224 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	332	191	20	0	0	0	0	0	543
3-4	42	208	68	31	6	0	0	0	355
5	0	11	23	29	5	0	1	0	69
6-7	0	2	6	25	11	4	1	0	49
8-9	0	0	0	0	5	1	2	0	8
10	0	0	0	0	1	0	1	0	2
11-12	0	0	0	0	0	0	1	0	1
All	374	412	117	85	28	5	6	0	1027

Table 2. Contingency tables of wave height observations (O) (ft) at Buoy 9 versus wave height forecasts (F) (ft) at Point 7 in Lake Erie for each period (00-h, 12-h, 24-h, 36-h) and all periods from July through November 1983. The ratio of observations available to the total possible is given to the left of each contingency table.

00-h

Category	Hits	Over Forecasts	Under Forecasts
C	0	0	0
1-2	44	42	14
3-4	45	47	8
5	50	42	8
6-7	26	65	9
8-9	0	100	0
10	0	0	0
11-12	0	0	0
All	43	47	10

12-h

Category	Hits	Over Forecasts	Under Forecasts
C	0	0	0
1-2	46	39	15
3-4	47	41	12
5	14	81	5
6-7	0	94	6
8-9	0	100	0
10	0	0	0
11-12	0	0	0
All	40	48	12

24-h

Category	Hits	Over Forecasts	Under Forecasts
C	0	0	0
1-2	47	42	11
3-4	47	40	13
5	55	36	9
6-7	15	77	8
8-9	0	100	0
10	0	0	0
11-12	0	0	0
All	46	43	11

36-h

Category	Hits	Over Forecasts	Under Forecasts
C	0	0	0
1-2	44	39	17
3-4	39	48	13
5	38	50	12
6-7	24	70	6
8-9	0	100	0
10	0	0	0
11-12	0	0	0
All	40	46	14

All Periods

Category	Hits	Over Forecasts	Under Forecasts
C	0	0	0
1-2	45	41	14
3-4	45	43	12
5	40	52	8
6-7	17	76	7
8-9	0	100	0
10	0	0	0
11-12	0	0	0
All	42	46	12

Table 3. Distribution of hits, overforecasts, and underforecasts by category in percent for wave heights observed at Buoy 5 and forecast for Point 8 for each period (00-h, 12-h, 24-h, 36-h) and all periods from July through November 1983.

00-h

Category	Hits	Over Forecasts	Under Forecasts
C	0	0	0
1-2	33	65	2
3-4	21	72	7
5	44	50	6
6-7	20	73	7
8-9	0	50	50
10	0	100	0
11-12	0	100	0
All	29	67	4

12-h

Category	Hits	Over Forecasts	Under Forecasts
C	0	0	0
1-2	34	62	4
3-4	18	74	8
5	50	39	11
6-7	17	75	8
8-9	33	67	0
10	100	0	0
11-12	0	0	0
All	29	65	6

24-h

Category	Hits	Over Forecasts	Under Forecasts
C	0	0	0
1-2	36	60	4
3-4	20	69	11
5	56	44	0
6-7	33	50	17
8-9	0	100	0
10	0	0	0
11-12	0	0	0
All	31	62	7

36-h

Category	Hits	Over Forecasts	Under Forecasts
C	0	0	0
1-2	37	58	5
3-4	18	67	15
5	18	64	18
6-7	20	70	10
8-9	0	50	50
10	0	0	0
11-12	0	0	0
All	28	62	10

All Periods

Category	Hits	Over Forecasts	Under Forecasts
C	0	0	0
1-2	35	61	4
3-4	19	71	10
5	42	49	9
6-7	23	67	10
8-9	13	62	25
10	50	50	0
11-12	0	100	0
All	29	64	7

Table 4. Distribution of hits, overforecasts, and underforecasts by category in percent for wave heights observed at Buoy 9 and forecast for Point 7 for each period (00-h, 12-h, 24-h, 36-h) and all periods from July through November 1983.

00-h

54/62 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	3	5	2	0	0	0	0	0	10
3-4	0	7	15	4	0	0	0	0	26
5	0	0	4	3	1	0	0	0	8
6-7	0	0	1	4	4	0	0	0	9
8-9	0	0	0	1	0	0	0	0	1
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	3	12	22	12	5	0	0	0	54

12-h

52/62 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	2	5	4	0	0	0	0	0	11
3-4	1	5	14	6	1	0	0	0	27
5	0	2	2	2	2	0	0	0	8
6-7	0	0	1	3	2	0	0	0	6
8-9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	3	12	21	11	5	0	0	0	52

24-h

54/62 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	3	6	1	0	0	0	0	0	10
3-4	2	14	13	3	0	0	0	0	32
5	0	2	1	2	1	0	0	0	6
6-7	0	0	0	3	2	0	0	0	5
8-9	0	0	1	0	0	0	0	0	1
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	5	22	16	8	3	0	0	0	54

36-h

53/62 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	1	5	3	1	0	0	0	0	10
3-4	2	5	14	4	1	0	0	0	26
5	0	2	4	3	2	0	0	0	11
6-7	0	0	1	3	2	0	0	0	6
8-9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	3	12	22	11	5	0	0	0	53

All Periods

213/248 F \ O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	9	21	10	1	0	0	0	0	41
3-4	5	31	56	17	2	0	0	0	111
5	0	6	11	10	6	0	0	0	33
6-7	0	0	3	13	10	0	0	0	26
8-9	0	0	1	1	0	0	0	0	2
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	14	58	81	42	18	0	0	0	213

Table 5. Contingency tables of wave height observations (O) (ft) at Buoy 5 versus wave height forecasts (F) (ft) at Point 8 in Lake Erie for each period (00-h, 12-h, 24-h, 36-h) and all periods for October 1983. The ratio of observations available to total possible is given to the left of each contingency table.

00-h

54/62 F\O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	3	7	0	0	0	0	0	0	10
3-4	0	22	4	0	0	0	0	0	26
5	0	4	3	1	0	0	0	0	8
6-7	0	1	4	4	0	0	0	0	9
8-9	0	0	1	0	0	0	0	0	1
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	3	34	12	5	0	0	0	0	54

12-h

52/62 F\O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	2	9	0	0	0	0	0	0	11
3-4	1	19	6	1	0	0	0	0	27
5	0	4	2	2	0	0	0	0	8
6-7	0	1	3	2	0	0	0	0	6
8-9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	3	33	11	5	0	0	0	0	52

24-h

54/62 F\O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	3	7	0	0	0	0	0	0	10
3-4	0	24	6	2	0	0	0	0	32
5	0	3	2	1	0	0	0	0	6
6-7	0	0	3	2	0	0	0	0	5
8-9	0	1	0	0	0	0	0	0	1
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	3	35	11	5	0	0	0	0	54

36-h

53/62 F\O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	1	8	1	0	0	0	0	0	10
3-4	2	19	4	1	0	0	0	0	26
5	0	6	3	2	0	0	0	0	11
6-7	0	1	3	2	0	0	0	0	6
8-9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	3	34	11	5	0	0	0	0	53

All Periods

213/248 F\O	C	1-2	3-4	5	6-7	8-9	10	11-12	All
C	0	0	0	0	0	0	0	0	0
1-2	9	31	1	0	0	0	0	0	41
3-4	3	84	20	4	0	0	0	0	111
5	0	17	10	6	0	0	0	0	33
6-7	0	3	13	10	0	0	0	0	26
8-9	0	1	1	0	0	0	0	0	2
10	0	0	0	0	0	0	0	0	0
11-12	0	0	0	0	0	0	0	0	0
All	12	136	45	20	0	0	0	0	213

Table 6. Contingency tables of wave height observations (O) (ft) at Buoy 5 versus wave height forecasts (F) (ft) at Point 8 in Lake Erie reduced by 1.4 for each period (00-h, 12-h, 24-h, 36-h) and all periods for October 1983. The ratio of observations available to the total possible is given to the left of each contingency table.

FOOTNOTES AND REFERENCES

1. Francis Michael Kieltyka earned his B.S. in Meteorology at the University of Michigan in 1976. He worked as an Air Pollution Meteorologist at ASARCO in Glover, Missouri in 1977-78. He started his National Weather Service career as a Meteorologist Intern in Great Falls, Montana in late 1978 and transferred to the Cleveland office of the National Weather Service in 1983 where he is currently employed as a general forecaster.

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