EAST CENTRAL FLORIDA RIP CURRENT PROGRAM

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ABSTRACT

A rip current is a complex meteorological/oceanographic phenomenon that poses significant danger to beach goers worldwide. Rip currents are narrow channels of water flowing out past the surf zone that can pull even strong swimmers into deep water beyond the offshore sand bar. In Florida, rip current-related drownings averaged 21 per year during the period 1989-97. East central Florida averaged 4-5 rip current-related drownings per year during this period.

An examination of east central Florida rip current data showed that large numbers of rescues occurred most often when long period ocean swells were impacting the beaches. This was in contrast to a study by Lushine (1991) which found that rip currents along the southeast Florida coast were mainly due to moderate onshore winds.

The empirical forecasting technique developed by Lushine (LURCS) was adapted for use in east central Florida (ECFL LURCS). Available rip current data was used to calculate the Probability of Detection (POD), which is the percentage of events that are detected, and the False Alarm Ration (FAR), which is the percentage of unverified warnings/forecasts. For events with a greater than normal number of rip current rescues, the POD was found to be slightly better than the 1994 national average POD for severe weather (Crowther and Halmstad 1995). A high FAR showed the need to further improve ECFL LURCS and become aggressive in verification.

In May 1997, forecasters at the National Weather Service Office in Melbourne began issuing statements detailing the daily rip current threat based on a set of thresholds that were determined by this study. These statements are disseminated to the media and broadcast on NOAA Weather Radio. Points of contact at lifeguard stations are being utilized to provide feedback about the number of rip currents that occur after a statement is issued. This data will be used to refine the empirical forecasting scheme.

1. Introduction

Bascom (1980) describes the physical oceanography involved in rip current formation in the following manner: 1) Waves continually break over an underwater sand bar which results in a pileup of water between the bar and the beach, 2) water then begins flowing laterally along the beach (longshore current), 3) a low spot on the bar allows the water to move seaward as a rip current and 4) large amounts of water trapped behind the bar and/or a convergence of the laterally flowing currents produce the strongest rip currents.

Attempting to swim directly back to shore against the rip current, which can be as strong as 4 kt (Open University 1989), will result in exhaustion and in some cases, drowning. For the period 1989-97, an average of 21 rip current-related drownings occur *each year* along the nearly 1,200 miles of Florida coastline. Rip current deaths, like lightning deaths, receive less publicity due to the fact that they usually kill only one person at a time. However, rip currents, on average, result in more deaths in Florida than hurricanes, tropical storms, tornados, severe thunderstorms and lightning *combined.* Many victims are out-of-state visitors who are unfamiliar with the dangers at the beach.

Though rip currents are an oceanographic phenomena, meteorological factors (pressure patterns and winds) influence their development. Since the primary goal of the National Weather Service is protection of life, Lushine (1991) developed a forecast methodology to warn beach goers when rip currents would pose a significant threat along the southeast Florida coast.

Lifeguard logs, newspaper clippings and medical examiner's reports were utilized to compile statistics on rip current-related rescues and drownings along the east central Florida coastal counties of Volusia, Brevard, Indian River, St. Lucie and Martin. This data showed that an average of 4-5 rip current-related drownings occurred each year during the period 1989-97 (Fig 1). Therefore, the National Weather Service Office in Melbourne developed a similar empirical forecasting scheme to warn beach goers when rip currents would be more dangerous than normal. Several years of data were analyzed and correlated with wind and sea conditions to establish patterns under which large numbers of rip current rescues occurred.

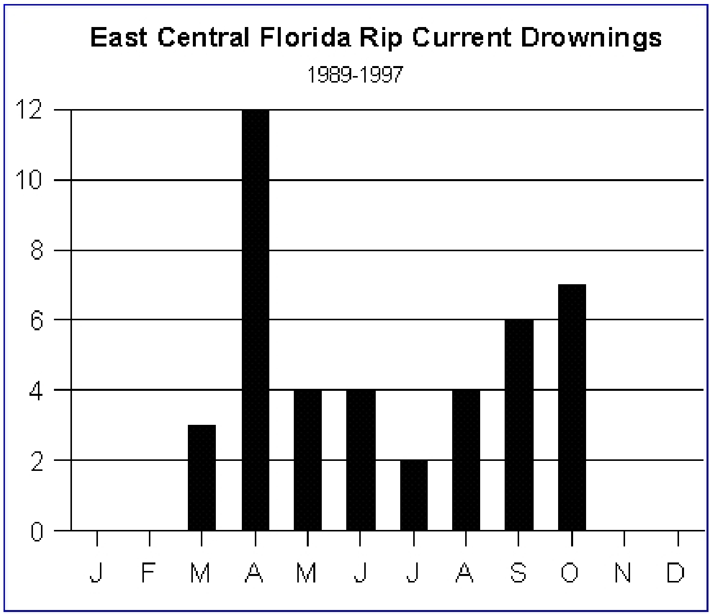

Figure 1. Total number of rip current drownings along the east central Florida beaches during the period 1989-97 (average 4-5 per year). Data was compiled from newspaper clippings and medical examiner reports.

The number of rip current rescues varies for each coastal county across east central Florida (Fig 2).

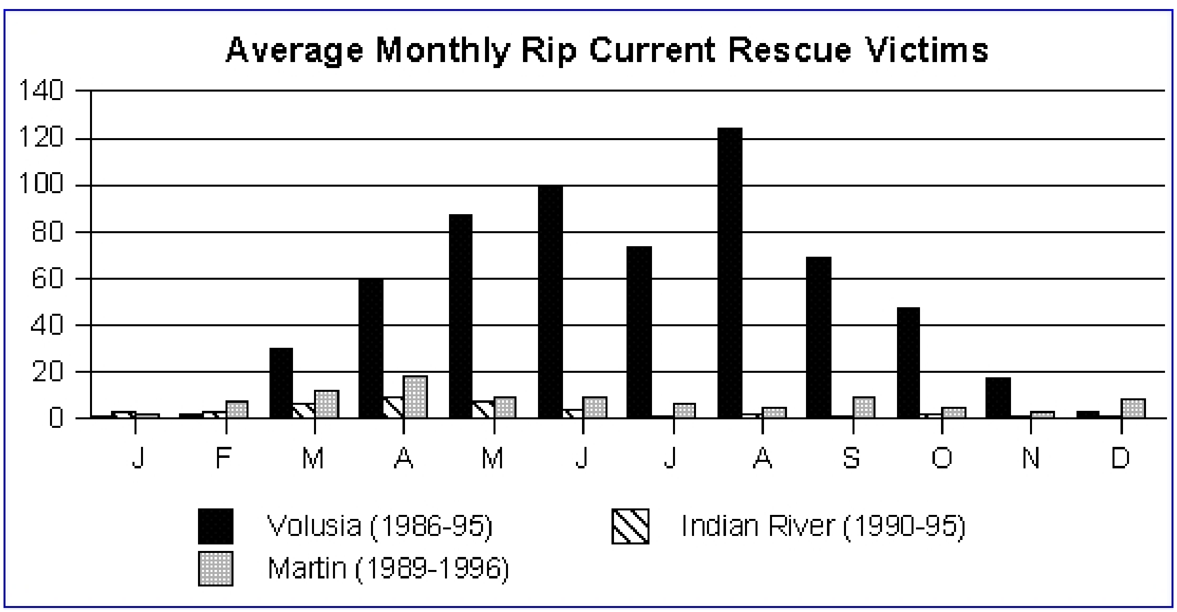

Figure 2. Average number of rip current rescue victims for each month for three east central Florida counties (during their periods of record shown). Volusia county (includes Daytona Beach) has by far the greatest number of rip current rescues except in the months of December through February when ocean temperatures are in the 50s and 60s. Martin county (east of Lake Okeechobee) has more rip current rescues during December through February due to the warmer Gulf Stream waters just offshore.

Volusia County averages more rescues each year than all other counties in Florida combined. This is due to many factors which generate numerous, strong rip currents and the very high volume of people entering the surf around Daytona Beach, which is sometimes touted as "the world's most famous beach." One contributing factor is that Volusia County shorelines have finer sediments than a lot of beaches in Florida. This allows sand to move more freely and form bars which are important for rip current generation. Additionally, the coast is frequently affected by ocean swells that produce mass transport of water onto the beach, which is necessary for strong rip current formation. The Volusia County beach safety program is among the five largest in the country. Lifeguards are well trained with respect to the dangers of rip currents, which occur nearly everyday.

The remaining coastal counties of east central Florida have significantly less rip current rescues than Volusia County. However, there are an increasing number of people visiting the beaches of these counties, many of whom do not understand the danger of rip currents and attempt to swim where there are no lifeguards. Many local communities have plans for substantial beach replenishment where erosion has depleted beaches significantly during the past several decades. This could lead to an increase in the formation of sand bars that help generate dangerous rip currents.

2. Development of Empirical Forecast Model

Lushine's empirical model to forecast rip currents along the southeast Florida coast, LURCS, (LUshine Rip Current Scale) placed the greatest weight on moderate to strong onshore winds. However, an analysis of east central Florida rip current rescues showed that about 75 percent occurred on days when *long period swells* were the primary formation mechanism (Fig 3).

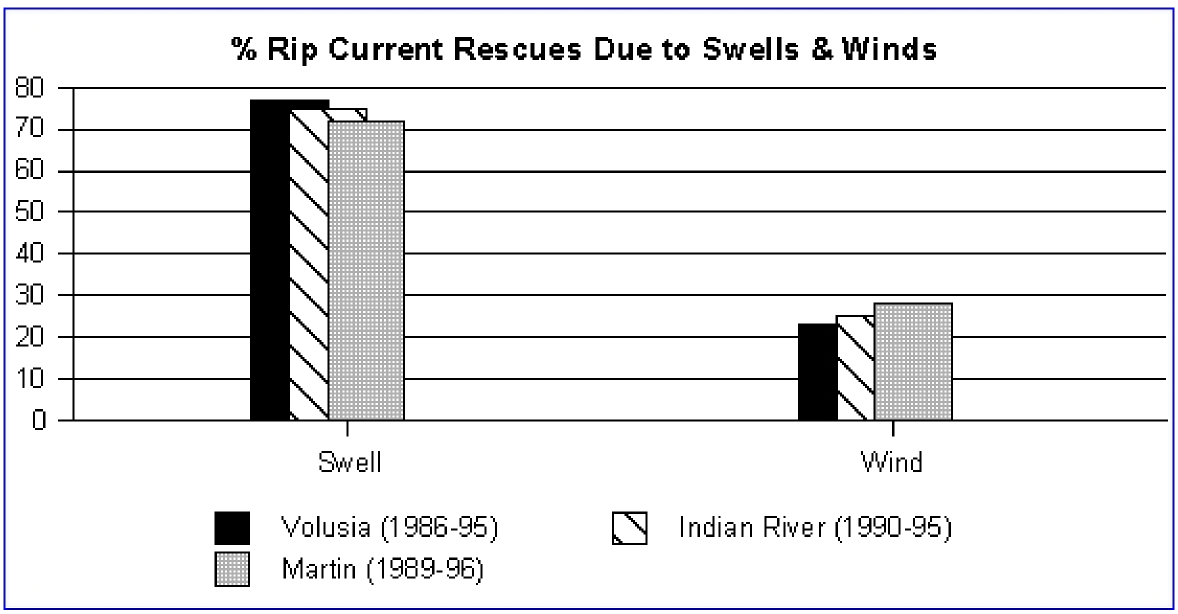

Figure 3. Percentage of rip current rescues due to swells and winds for three east central Florida counties (during their periods of record shown).

The southeast Florida coastline is protected from most long period swells. This is due to: 1) the north northeast to south southwest orientation of the shoreline, which prevents north swells from reaching the coast and 2) the shallow waters around the Bahama Islands which block most of the effects of northeast, east and southeast swells. However, a few rip current drownings have occurred along the southeast coast when winds were *offshore* but swells generated by distant hurricanes were impacting the beaches. For example, Hurricane Bertha moved to within 300 miles of southeast Florida during July 1996. Swells generated by the hurricane contributed to two rip current-related drownings on 13 July at Miami Beach (National Climatic Data Center 1996).

Analysis results for east central Florida showed that swells with long periods (> 12 sec.) were almost always accompanied by greater numbers of rip current rescues, even when the swell heights were only two feet.

Therefore, the LURCS model was modified to account for the greater impact of swells. An East Central Florida (ECFL) LURCS checklist (see Appendix) was formulated that Melbourne forecasters use to calculate the daily rip current threat. Similar to LURCS, this checklist incorporates a Wind and Swell Factor. The Wind Factor places the greatest emphasis on onshore winds (40-110º) for rip current formation. More oblique angles to the coastline are also included with the qualification that a longshore movement of water is the greatest danger (drownings have occurred with this weaker current as people are pushed off the sand bar into deep water). The LURCS model includes a swell *height* factor only. In order to give greater weight to the Swell Factor, a swell *period* factor is included in ECFL LURCS. Lastly, a Miscellaneous Factor accounts for: 1) the residual wind/swell effects that may not be shown by the sparse data network, and 2) the higher astronomical tides associated with a full moon.

Thresholds have been established for the level of the daily rip current threat. Regularly issued Hazardous Weather Outlooks (Fig. 4) emphasize that the threat is either *greater* or *much greater* than normal. Statements called for by the LURCS model mention a *chance* of rip currents or a *likelihood* of rip currents. This latter phraseology was deemed inappropriate for east central Florida since rip currents occur nearly every day along some beaches.

EAST CENTRAL FLORIDA HAZARDOUS WEATHER OUTLOOK
NATIONAL WEATHER SERVICE MELBOURNE FL
700 AM EDT FRI MAY 30 1997

...RIP CURRENT THREAT REMAINS MUCH GREATER THAN NORMAL TODAY...

HIGH PRESSURE ALONG THE EASTERN SEABOARD WILL PRODUCE ONE MORE DAY OF MODERATELY STRONG EASTERLY WINDS. SEAS OFFSHORE REMAIN IN THE 6 TO 7 FOOT RANGE THIS MORNING. WITH A CONTINUATION OF ONSHORE WINDS OF 10 TO 15 MPH...THE THREAT OF RIP CURRENTS WILL AGAIN BE GREATER THAN NORMAL. TRY TO SWIM AT BEACHES GUARDED BY THE BEACH PATROL. IF NO GUARDS ARE PRESENT...CONSIDER STAYING OUT OF WATER GREATER THAN KNEE DEEP. IF YOU ARE CAUGHT IN A RIP CURRENT...SIGNAL SOMEONE ON SHORE FOR HELP AND SWIM PARALLEL TO THE BEACH TO GET OUT OF THE RIP CURRENT...THEN SWIM TOWARD SHORE.

Figure 4. Example of a statement issued to alert the public and emergenct management officials of the rip current threat during an event that occurred 29-31 May 1997.

More than 50 percent of the rip current rescues occurred on weekends and major holidays. Therefore, the threshold for statement issuance on weekends/holidays was set slightly lower to account for the greater number of people that visit the beaches on those days.

Frequently, large numbers of rescues occur with the following sequence of events: 1) moderate/strong onshore winds generate choppy surf and strong rip currents, but most people stay out of the water due to the relentless beach pounding caused by the short period wind waves, 2) as winds subside and the seas become less choppy, people venture back into the surf in large numbers, however long period swells result in above normal amounts of water piling up on the beach and formation of dangerous rip currents. If these events are not anticipated by the beach patrols, a significant staffing shortage could occur and lead to increased danger to bathers. Therefore, the east central Florida rip current program has placed an emphasis on diagnosing when these types of events will occur.

A rip current event that followed this scenario occurred in late May 1997. High pressure built to the mid Atlantic coast on the 29th behind a frontal system. This produced 20 kt northeast winds over the coastal waters and very rough surf conditions but few rip current rescues. The gradient relaxed to 15 kt on 30 May (Fig. 5A) which allowed more people to enter the surf. There were 10 rescues in Volusia county and one drowning at Daytona Beach Shores. The pressure gradient became slack on Saturday, 31 May (Fig. 5B). The data buoy 20 nm offshore Cape Canaveral showed incoming swells of 4 ft with a period of 9-11 sec. In excess of 100 rescues occurred in Volusia county and two were reported in Martin county.

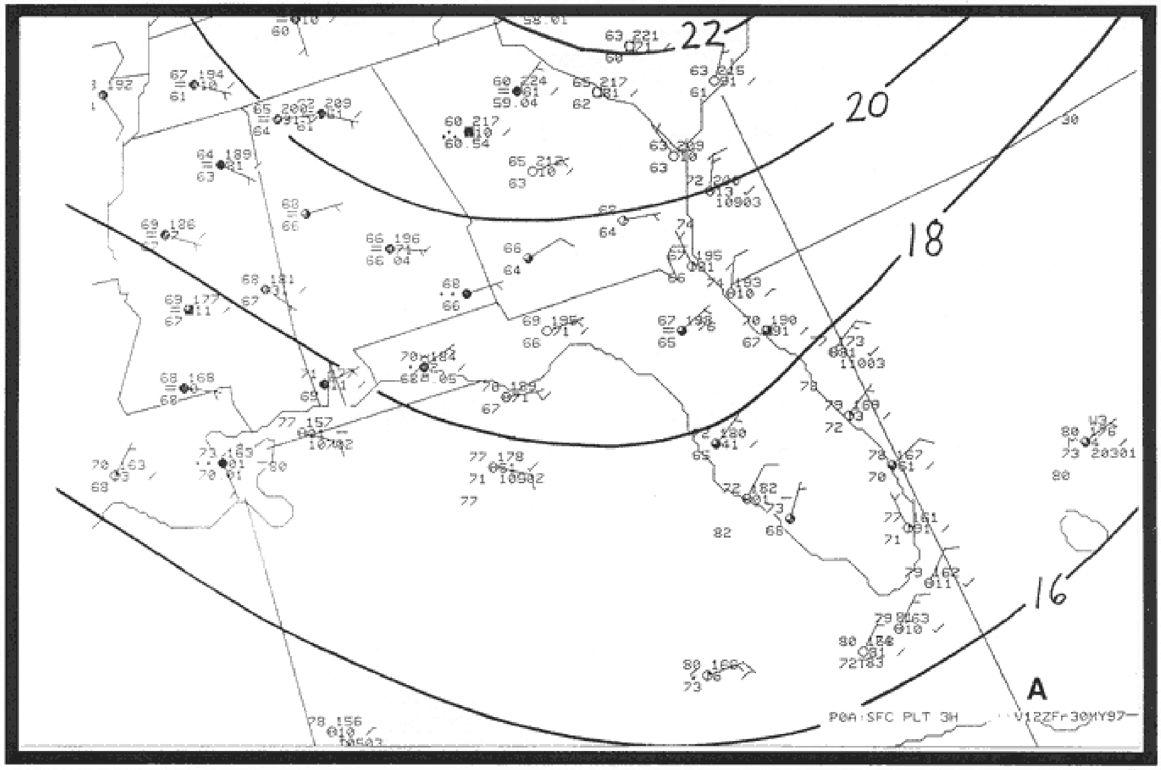

Figure 5A. Surface chart valid 1200 UTC 30 May 97. High pressure center is well north of Florida; east central Florida receiving a 15 knot northeast gradient wind.

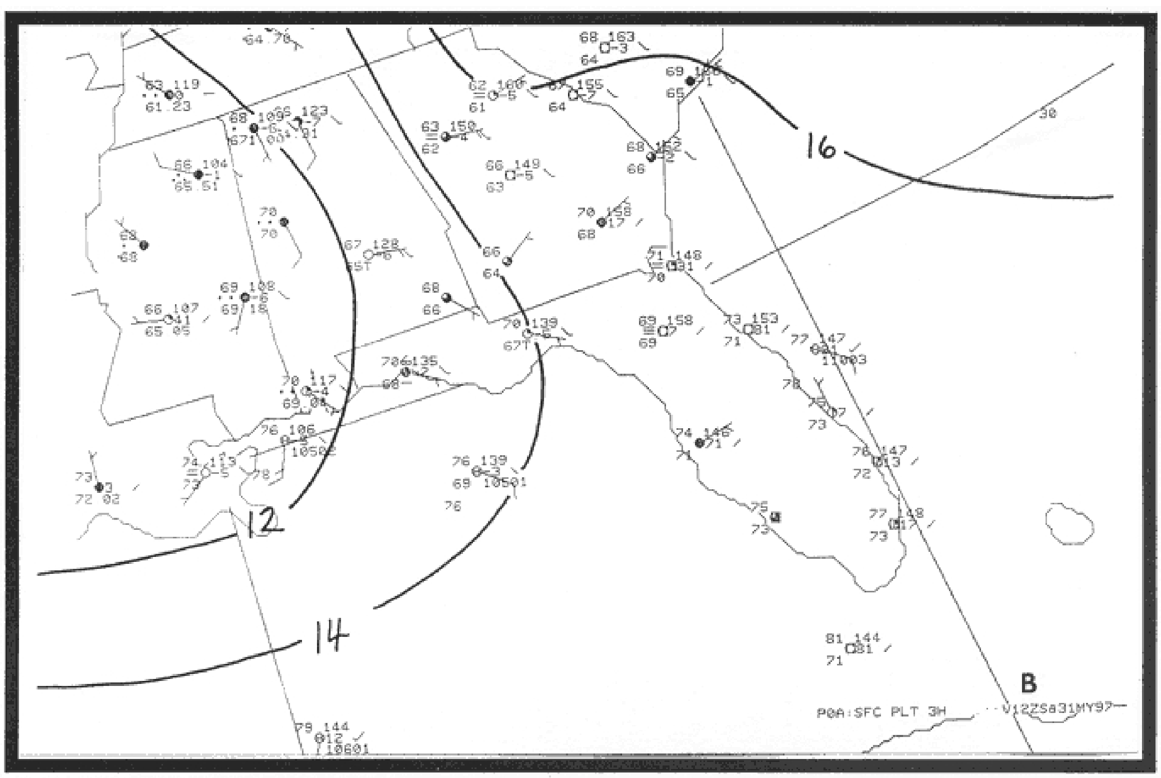

Figure 5B. Surface chart valid 1200 UTC 31 May 97. Weak pressure gradient exists across Florida.

3. Analysis and Verification of Forecast Model

Figure 2 shows that the number of Volusia county rip current rescue victims[1] increases significantly during the summer. However, the most *drownings* in east central Florida occur in April (Fig. 1) , which may indicate that the *strongest* rip currents occur at this time and not during the summer, when the most *rescues* occur. The frequency of breezy onshore winds across east central Florida increases during March and April, which indicates that rip currents should be numerous. The April drowning maximum also coincides with the beginning of a period of significant warming of Daytona Beach water temperatures, from an average 65 ºF in March, to 73 ºF by the end of April and 78 ºF by May (National Ocean Data Center 1987). Therefore, cool water temperatures likely keep most people out of the water during March, while lighter winds during May reduce the number and/or strength of rip currents. These factors lead to fewer rip current drowning victims during March and May, compared to the maximum which occurs in April. The summer peak in rescues (Fig. 2) is due to the greater volume of people entering the surf. Possible explanations for the lower number of summer *drownings* are: 1) the rip currents are not as strong and/or 2) a greater number of people in the water allows for quicker recognition of those caught in rip currents.

The secondary peak in rip current drownings that occurs in September and October is likely due to the combination of three factors: 1) long period swells generated by tropical cyclones that reach the coast, 2) compared to summer, the frequency of stronger wind events increases, and 3) ocean waters remain warm which produces favorable swimming conditions.

Using the checklist in the Appendix and rip current *rescue* data available for the 1989-1996 period, a POD of 0.76 was attained. This is slightly better than the 1994 national average POD for severe weather (0.72) determined by Crowther and Halmstad (1995). The POD for rip current *drownings* during this same period was 0.91.

In order to determine whether an inordinate number of false alarms would occur using the checklist, daily ECFL LURCS values were calculated for 1995 and the first nine months of 1996, then compared to days where rescues were documented. A FAR of 0.59 was calculated, which is much higher than the 0.44 value that was found by Lushine (1991). This relatively high FAR is misleading in that *rescues* were used to verify whether there were rip currents. Just because there were no rescues reported on a particular day does not necessarily mean that there were *no* rip currents. The data also showed that when the surf was very rough (i.e., the ECFL LURCS value was >4), there often were *no* rip current rescues reported. There are likely very dangerous rip currents on these days, but most people stay out of the water due to the rough conditions. Additionally, the east central Florida air and water temperatures during the winter months are much cooler than along the southeast coast. There have been no reported rip current drownings across east central Florida during the November-February period (Fig. 1). A lower FAR (0.51) was attained when these months were deleted from the verification data.

As a further check of the proposed forecasting scheme, a detailed twelve month data sample was obtained from St. Lucie County. Lifeguards recorded all days where rip currents were *observed*. Analysis of this data confirmed the assertion that the high FAR obtained for the 1995-96 data sample was due to lack of observational data. The FAR during this twelve month period was reduced to an astonishingly low 0.10. However, the POD was also reduced (0.66). This is likely because the data included days that had only minor, less threatening rip currents. Any forecasting scheme will likely have a difficult time detecting these weaker events.

4. Summary and Goals

Collected data revealed that an average of 4-5 rip current-related drownings occur each year in east central Florida. Analysis of wind/wave reports showed that specific synoptic weather patterns were usually identifiable on days with rip current-related drownings or large numbers of rescues. The resultant conclusion was that rip currents, though an oceanographic phenomena, were driven by meteorological factors. Since the main goal of the National Weather Service is to protect life, an East Central Florida Rip Current Program was conceived. An empirical forecasting scheme developed for southeast Florida (LURCS) was adapted for use in computing the daily east central Florida rip current threat (ECFL LURCS checklist). The primary modifications to LURCS include a quantification of the wind direction along with the addition of the effects of swell *period* and high astronomical tides. The checklist also emphasizes days where the longshore current is likely to be strong. Future plans are to establish a threshold for the issuance of a Heavy Surf Advisory.

Using the ECFL LURCS checklist and available data, a POD for rip current rescues was found to be better than the 1994 national average POD for severe weather. The high FAR value that was calculated for 1995-96 shows the need to further improve the forecasting scheme and become aggressive in verification. Points of contact have been established at lifeguard stations to provide feedback about the number of rip currents that occur after a statement is issued. This is the data that will be used to refine the empirical forecasting scheme.

Increased public awareness is also a goal of the East Central Florida Rip Current Program. The media will be called upon to bring greater awareness of rip current danger to those who use the beaches. Tourists are especially vulnerable since they are not all knowledgeable about ocean dangers and do not seem to pay attention to the news reports while on vacation. Therefore, national exposure from the news media will likely be utilized to increase awareness across the country.

All county offices having access to the normal suite of National Weather Service products will receive statements indicating the threat of rip currents. The statements will also be broadcast on NOAA Weather Radio so individual lifeguard stations as well as the general public will be alerted.

Acknowledgments

The author is especially grateful to Jackie Cartwright and Terry Ingoldsby who participated in the collection of data for this study. Appreciation is also shown to those who made the rip current data available in Brevard, Indian River, Martin, St. Lucie and Volusia counties. Additionally, a very special thanks to Jim Lushine, who inspired this work and Dave Sharp who offered valuable advice during preparation of this paper.

Author

Randy Lascody received a BS degree in meteorology from Northern Illinois University in 1981. His career in the National Weather Service began in 1986 at the Miami, Florida office. He transferred to Melbourne in 1990 and is now a Senior Forecaster. Experience in the office's SWIFT Boat Project in 1994 developed his understanding of coastal marine forecasting problems. He became the marine focal point for the Melbourne NWS office in 1995.

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[1]**Rip current *rescue* data included in this paper is for the following time periods:**
Volusia 1986-1996
Brevard 1996 (5 months)
Indian River 1990-95 (excluding 1991)
St Lucie 10/95 - 9/96
Martin 1989-1996

APPENDIX

East central Florida LURCS checklist and computed value (shaded) for 5/31/97.

1. WIND FACTORS	**MOST FAVORABLE FOR RIP CURRENTS**	**MOST FAVORABLE FOR LONGSHORE CURRENTS**
SPEED / DIRECTION	(40-110�)	(120-160�, 340-30�)
5 kt	0.5	0.0
5-10	1.0	**0.5**
10	1.5	1.0
10-15	2.0	1.5
15	3.0	2.0
15-20	4.0	3.0
20	5.0	4.0
20-25+	5.0	4.0
	WIND FACTOR	**0.5**

2. SWELL FACTORS		
a)	SWELL HEIGHT	SWELL HEIGHT FACTOR
	1 ft	0.5
	2	1.0
	3-4	**2.0**
	5-7	3.0
	8-10	4.0
b)	SWELL PERIOD	SWELL PERIOD FACTOR
	7-8 sec	0.5
	9-10	1.0
	11-12	**2.0**
	>12	3.0

c) **SWELL HEIGHT FACTOR + SWELL PERIOD FACTOR = SWELL FACTOR**	**4.0**

3. MISCELLANEOUS FACTORS	
If astronomical tides are higher than normal (i.e., near full moon), add 0.5	
If previous day **Wind Factor** or **Swell Factor** greater than or equal to 2.0/1.5, respectively, add 0.5	
MISCELLANEOUS FACTOR	**0.5**

4. TODAY'S RIP CURRENT THREAT is a summation of the 3 factors.	
LONGSHORE / RIP CURRENT THREAT	**5.0**

5. If RIP CURRENT THREAT is 3.0 - 4.0****** (2.5 - 3.5 ****** on weekends/major Holidays):
issue statement for greater than normal threat of rip currents.

If RIP CURRENT THREAT is 4.5 - >5.0 ** (4.0 - >5.0 ** on weekends/major Holidays):
issue statement for <u>much</u> greater than normal threat of rip currents and/or heavy surf.
**** (and it looks reasonable, e.g., an arctic outbreak, rainy day, hurricane, etc. is not occurring)**