NOAA Technical Memorandum NWS SR-210

A RIP CURRENT ASSESSMENT OF THE FLORIDA PANHANDLE COASTAL WATERS

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1. Introduction

Two major studies involving the development of rip currents along the coastal waters of Florida have been presented during the 1990's. These studies were conducted by WFO Miami (Lushine 1991), and by WFO Melbourne (Lascody 1998). The conception of these studies arose from the fact that drownings attributed to rip currents along Florida beaches had, in previous years, exceeded deaths due to the combination of hurricanes, tornadoes, lightning, and floods. The studies found a correlation between rip current development and weather patterns. Empirical forecasting techniques were developed that would aid in the prediction of days in which rip currents were more likely to occur. Even though deaths due to rip currents have been documented along most of the Florida coastline, these two studies focused on factors that are pertinent to the east coast of Florida. This approach will focus on factors relevant to the Gulf of Mexico, in particular the eastern Florida panhandle, while incorporating parameters known to enhance rip current potential.

Since documented deaths related to rip currents along the Florida Panhandle are not as numerous as those along the east coast of Florida, a statistical study was not feasible. Therefore, subjective correlations were developed between weather/oceanic factors and the days in which deaths occurred. Meteorological and oceanographic similarities among the days involved were analyzed, and a set of forecasting guidelines was established in order to predict days that have a greater probability of rip current development, much like the procedures used at WFOs Miami and Melbourne. This information can then be relayed to various emergency management and/or beach patrol agencies via issuances of the early morning Hazardous Weather Outlook.

2. Rip Current Dynamics

A rip current is defined as a narrow channel of water that flows seaward through a break in a sand bar. Rip currents develop when waves break between the shore line and the underwater sand bar. The action of continuously breaking waves in this region results in water piling up between the shore line and the sand bar. This water moves laterally and is referred to as a longshore current. Weaknesses then develop in the sand bar and the water eventually spills seaward through the breaks in the sand bar (this is referred to as a rip current). When this occurs, the rip current will move seaward and perpendicular to the shore. Often this current can be strong enough (4+ knots) to pull swimmers out to sea, and even strong swimmers cannot swim against the current. Rip Currents can be discerned visually by observing some common characteristics often associated with their occurrence. These characteristics include brown or discolored water, unusual choppiness, and debris or foam moving seaward, Fig. 1.

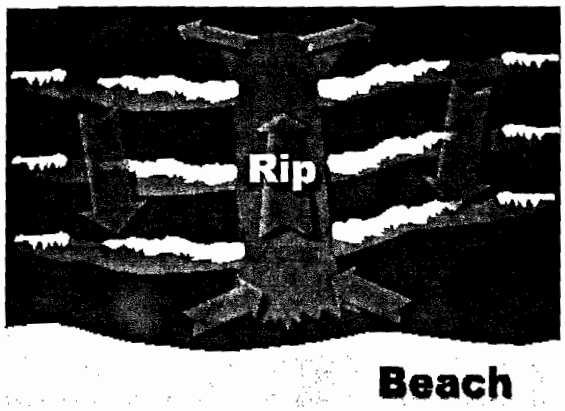


Fig. 1 Schematic of a Rip Current

In fact, the Panama City Beach Patrol (Bay County) publishes brochures to inform the beach-going public of the hazards of rip currents, and includes these visual clues as part of their education/awareness campaign (Smith 2000, Personal Communication). A system of flags is also employed to warn beach-goers of the threat of rip current development. The lifeguard on duty usually makes a judgement call as to the color of flag to be used on a given day, based on a combination of visual clues, and the existence of a strong onshore wind. The flag system is comprised of three colors. A blue flag indicates calm seas and unrestricted swimming, but does not assure the swimmer of safe (rip current free) water. A yellow flag indicates that rip currents could be present, and cautions the swimmer. A red flag indicates that dangerous rip currents could develop, and also restricts the public from entering the water.

In addition to posting flags, the beach patrol also educates the public on methods of breaking free from the control of a rip current. One way is to swim parallel to the shore until free from the current, then swim back to shore. Rip currents are usually 10 to 30 yards wide, so by swimming parallel to the shore a swimmer will be out of the current within a short time. Most deaths occur because people panic and try to swim directly towards shore, but become exhausted while fighting the current. The second method of breaking free is to allow the current to take you seaward. Within a fairly short distance from the surf zone the rip current usually weakens significantly, and the swimmer is able to swim back to shore.

3. Study Methodology

To begin the search, records of drownings were obtained for 1980-95 from the Florida Department of Health, State Office of Vital Statistics, Public Health Statistics Section (Sammett and Luaces, 1999). However, this list consisted of over 500 drownings, and included drownings in swimming pools, lakes, rivers, etc. The search was then narrowed by including only those deaths that occurred in the Gulf of Mexico. This resulted in a list of 175 deaths. Among this list were cases in which alcohol, jet skies, boats, or ill health (e. g. heart attack) were contributing factors. From this reduced list, cases were found that corresponded with one or more of the following: a newspaper article(s) matched with the case indicated an eyewitness who saw the person caught in a rip current, or a yellow or red flag was flying on that day. After 1995, 5 additional cases were found in the STORM DATA publications (NCDC 1996), bringing the total cases to 25.

As mentioned earlier, previous studies were conducted (Lushine 1991, and Lascody 1998) along the southeast and east coasts of Florida, and several factors were determined to contribute to the enhancement of rip current development and/or their strength. These factors included an onshore wind perpendicular to the shore, the strength of the wind, occurrence of low tide, and swells. Lushine's study concluded that although all of these factors affect the development of rip currents, the wind direction and speed was the most crucial. However, Lascody concluded that in addition to the above factors, long period swells were critical for the east central coast of Florida, even when swell height was rather low (around 2 feet).

4. Analysis

Like previous studies, this paper will focus on the three factors which have already been shown to contribute to rip current development: **winds, tides, and swells.** It should be noted that within WFO Tallahassee's County Warning Area (CWA) there are 8 coastal counties. As Fig. 2 shows, they are from West to East, Walton, Bay, Gulf, Franklin, Wakulla, Jefferson, Taylor, and Dixie Counties. Documented rip current drownings have occurred in Walton, Bay, Gulf, and Franklin Counties, since all of these counties have beaches that attract tourists and local residents alike. However, no documented rip current drownings have occurred in Wakulla, Jefferson, Taylor, or Dixie Counties, where the coastline is marshy, and there are few sandy beaches.

Fig. 2. WFO Tallahassee County Warning Area

a. Wind Analysis

For this analysis, Sea Level Pressure and Surface Wind data were obtained from NOAA's Climate Diagnostics Center (NOAA-CIRES CDC, 2000) for the dates that appeared to correspond to a rip current drowning. NCEP/NCAR, 4 times per day (0000, 0600, 1200, 1800 UTC) reanalysis data were used, with 1800 UTC being the time chosen for purposes of this study.

Lushine's and Lascody's studies approached the wind direction aspect of rip current development by determining the angle of the wind direction with respect to the shoreline. A perpendicular direction to the coast received higher weighting than a direction in which the wind was blowing parallel to the coast, with no enhancement to the rip current potential if the wind had an offshore component.

A similar approach was used for this study. Three wind regimes appeared to result in rip current development. In all of the graphics in Figs. 3 through 5, the pressure is plotted in millibars, the surface wind barbs are in meters per second (a full barb = 10 ms^{-1}, a half barb = 5 ms^{-1}), and the location of the drowning is noted by an asterisk. The first regime is a southwest to west flow, which can be seen in Figs. 3a-n. The second is a southeast to south flow, which is displayed in Figs. 4a-i. And the last is a northwest flow in Figs. 5a-b. Of the twenty-five cases, 14 rip current drownings occurred with a southwest or west surface wind, 9 cases with a southeast or south wind, and only two cases with a northwest surface wind.

Of the 14 cases under southwest to west flow, no rip current drownings were reported in Franklin County. This could be attributed to the fact that the Franklin County coast line faces southeast, and in a southwest to west flow the wind would be blowing either parallel to the coast or offshore, which has been shown to inhibit rip current development. The majority of the cases occurred in Bay County (10), Walton County (3), and Gulf County (1). Bay County faces southwest, which in this wind regime, would indicate a flow perpendicular to the shore and blowing onshore, which is the most preferred for rip current enhancement. However, it could also be argued that the majority of deaths in this regime occurred in Bay County due to the fact that some of the most popular beaches are located there, thus a greater number of people are present at those beaches on any given day.

In addition, the southwest to west regime consisted of 8 cases with wind speeds of 5 ms^{-1} (11.2 mph), 4 cases with speeds of 2 ms^{-1} (4.5 mph), and only 2 cases with speeds of 10 ms^{-1} (22.4 mph). This could imply that a light to moderate wind speed has more of an impact than does a moderate to strong flow, but there are not enough cases to reach that conclusion. Indeed, other studies have shown a stronger flow helps to pile the water between the shore and sandbar which is a key ingredient in the evolution of a rip current. Another factor could be that fewer people swim when the winds are strong (i.e., rough surf).

In the second wind regime (southeast to south), 9 cases occurred, but none of them involved Gulf County. The shoreline of Gulf county faces west, therefore a southeast or south wind would be blowing either offshore or parallel to the coast, a situation which has been shown from previous studies to inhibit rip currents (Lushine 1991, Lascody 1998). Once again the bulk of cases (6 of 9) occurred in Bay County. The same reasoning used for the first regime regarding the occurrence of

deaths in Bay County could also be used for this wind regime as well. One death occurred in Franklin County (Fig. 4e), where the shore line would be most perpendicular to a southeast to south flow. Franklin County generally attracts less beach-goers than does Bay County, which could help to explain why only 1 death occurred in the most favorable county in this regime with respect to shoreline orientation. The wind speeds in the southeast to south wind regime were all 5 ms^{-1} (11.2 mph), again implying that a light to moderate flow may be all that is required to generate rip currents.

The northwest regime had 2 cases, both of which occurred in Bay County, one with a wind speed of 2 ms^{-1} (4.5 mph), and the other with a wind speed of 5 ms^{-1} (11.2 mph). Since only 2 deaths occurred with this regime, no conclusive evidence with respect to the development of rip currents can be inferred.

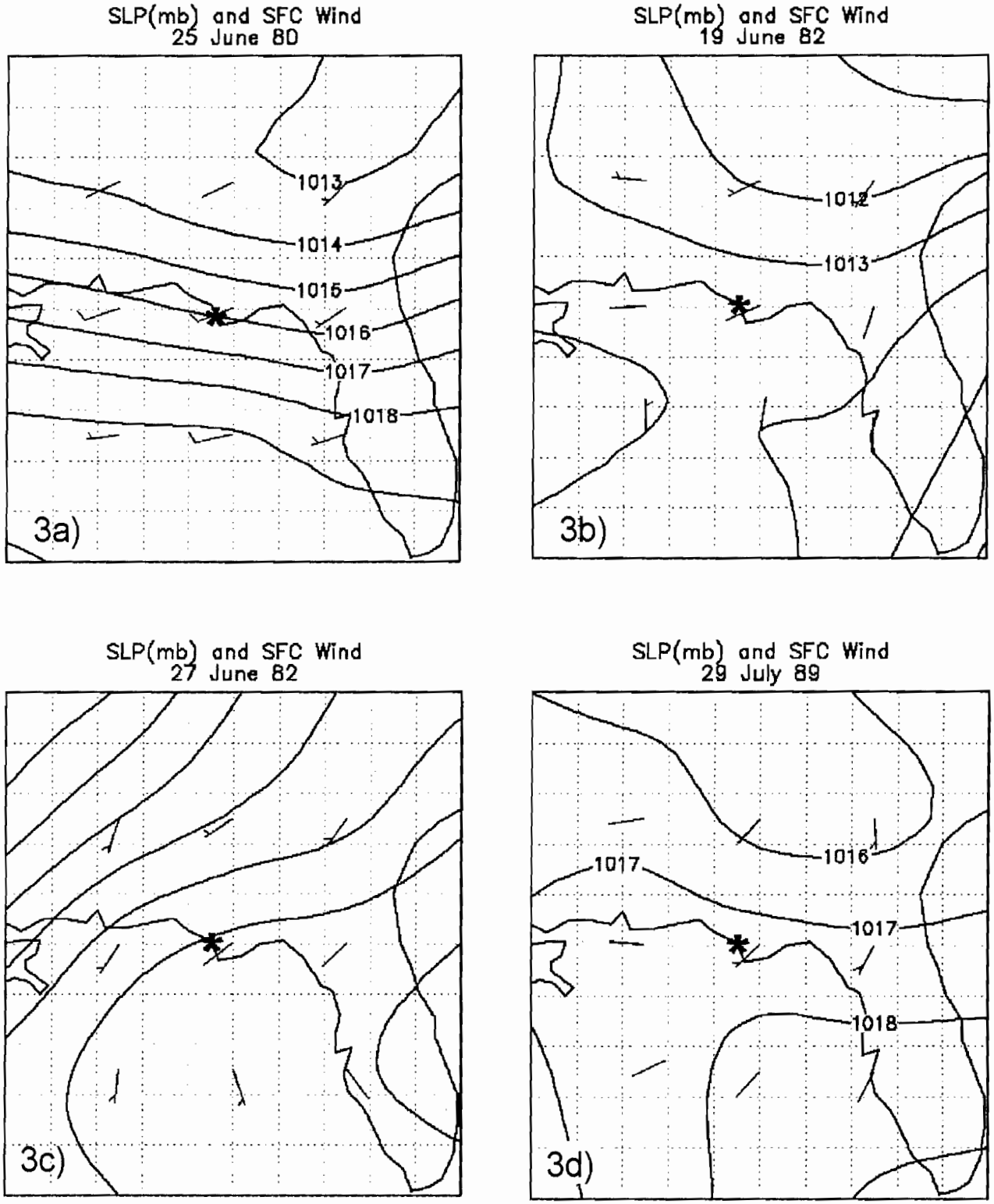


Figure 3. Southwest to west flow. Asterisk denotes location of drowning. Surface pressure (mb) and wind barbs (m/s) are plotted.

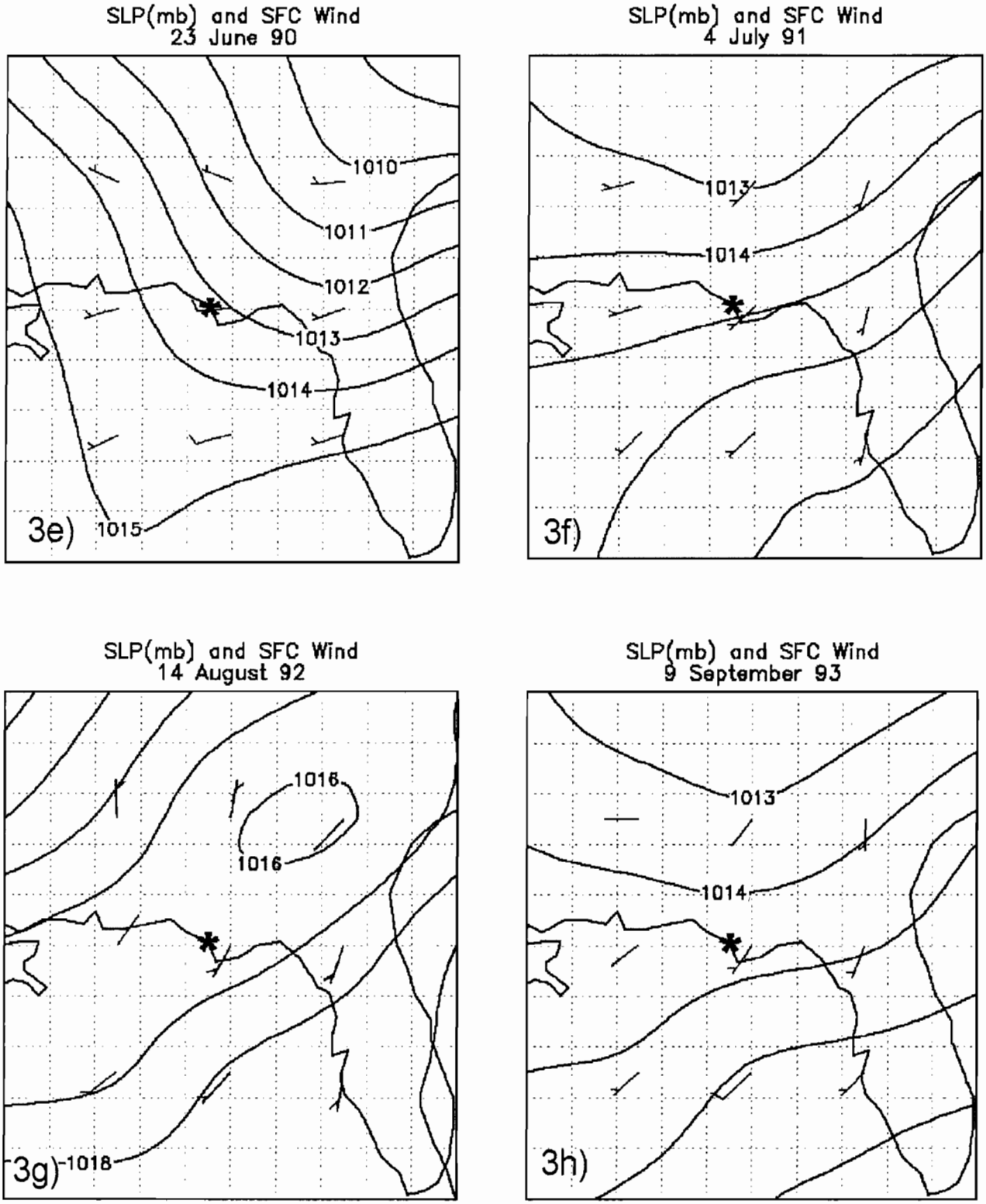


Figure 3 continued. Southwest to west flow. Asterisk denotes location of drowning. Surface pressure (mb) and wind barbs (m/s) are plotted.

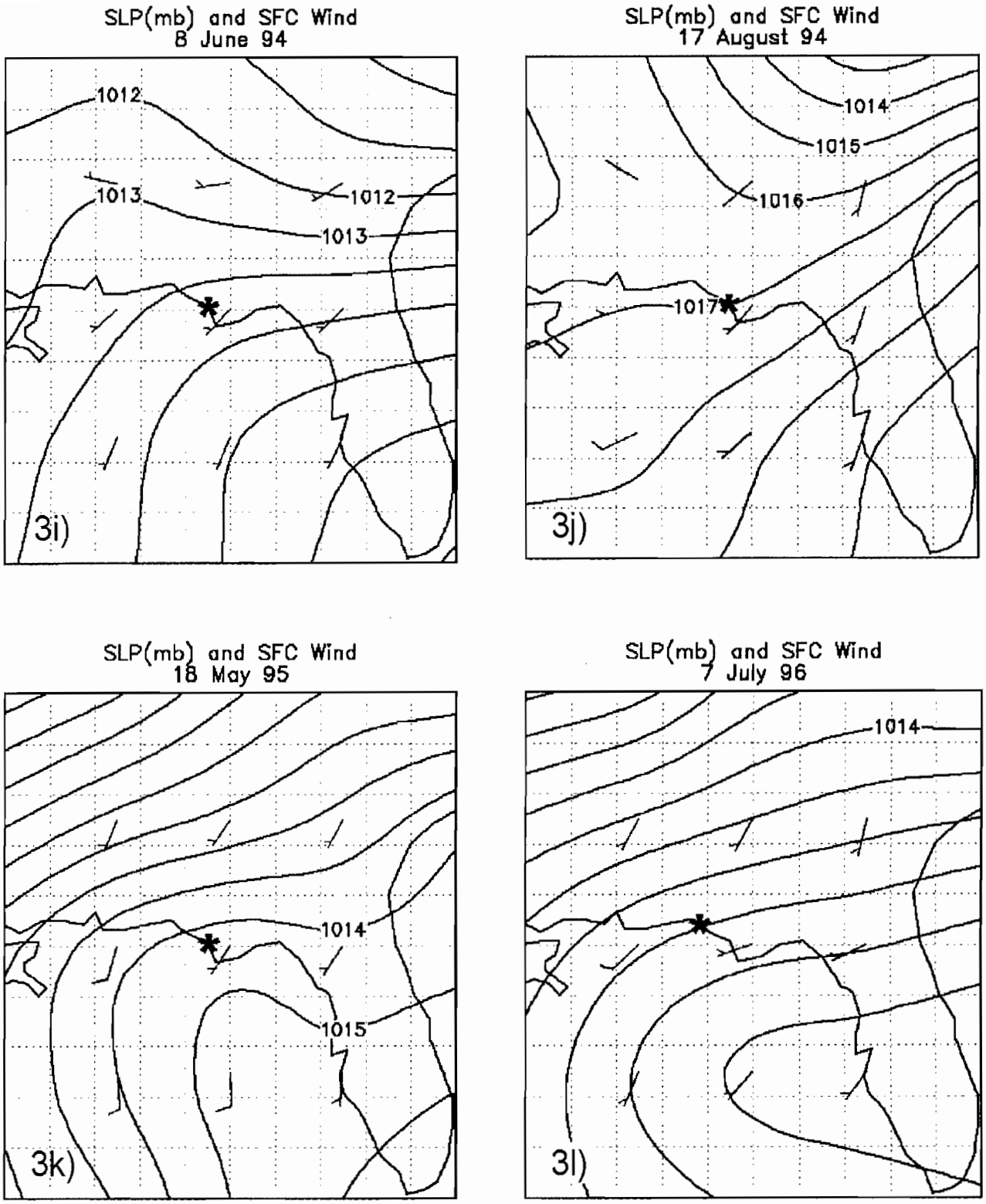


Figure 3 continued. Southwest to west flow. Asterisk denotes location of drowning. Surface pressure (mb) and wind barbs (m/s) are plotted.

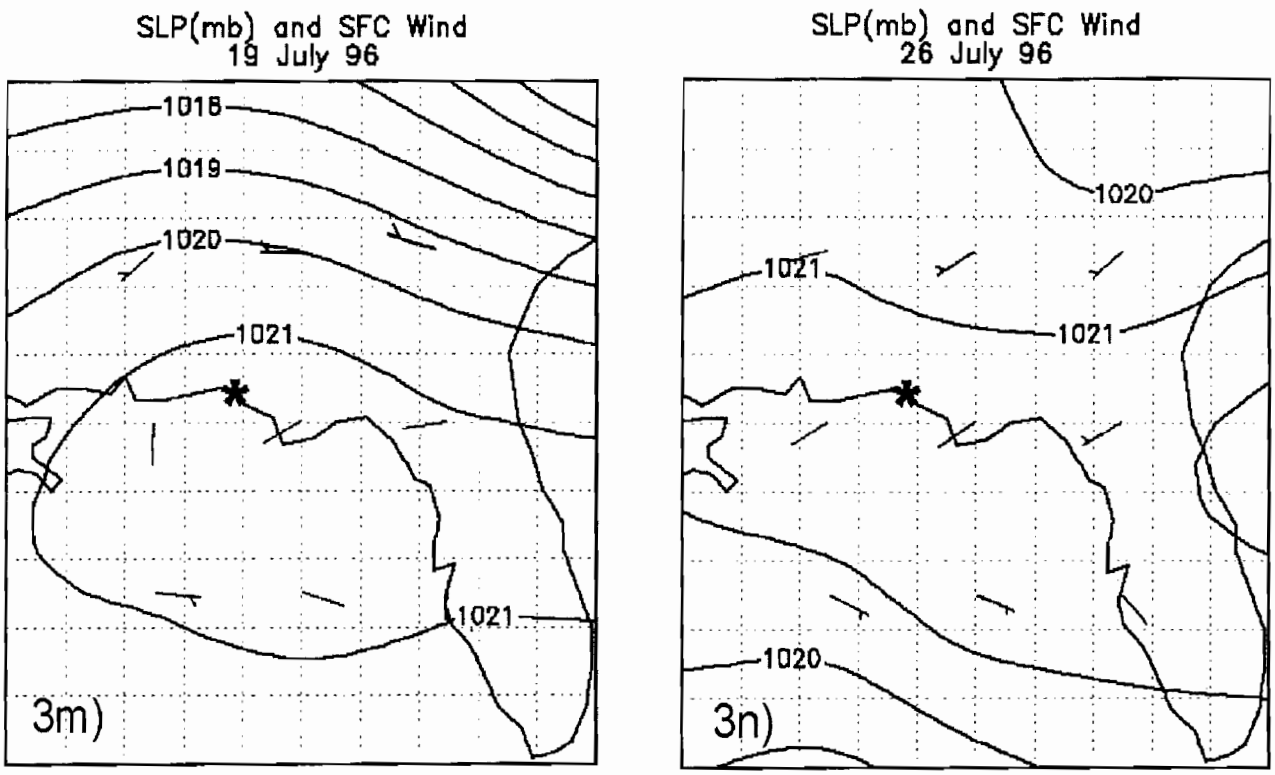


Figure 3 continued. Southwest to west flow. Asterisk denotes location of drowning. Surface pressure (mb) and wind barbs (m/s) are plotted.

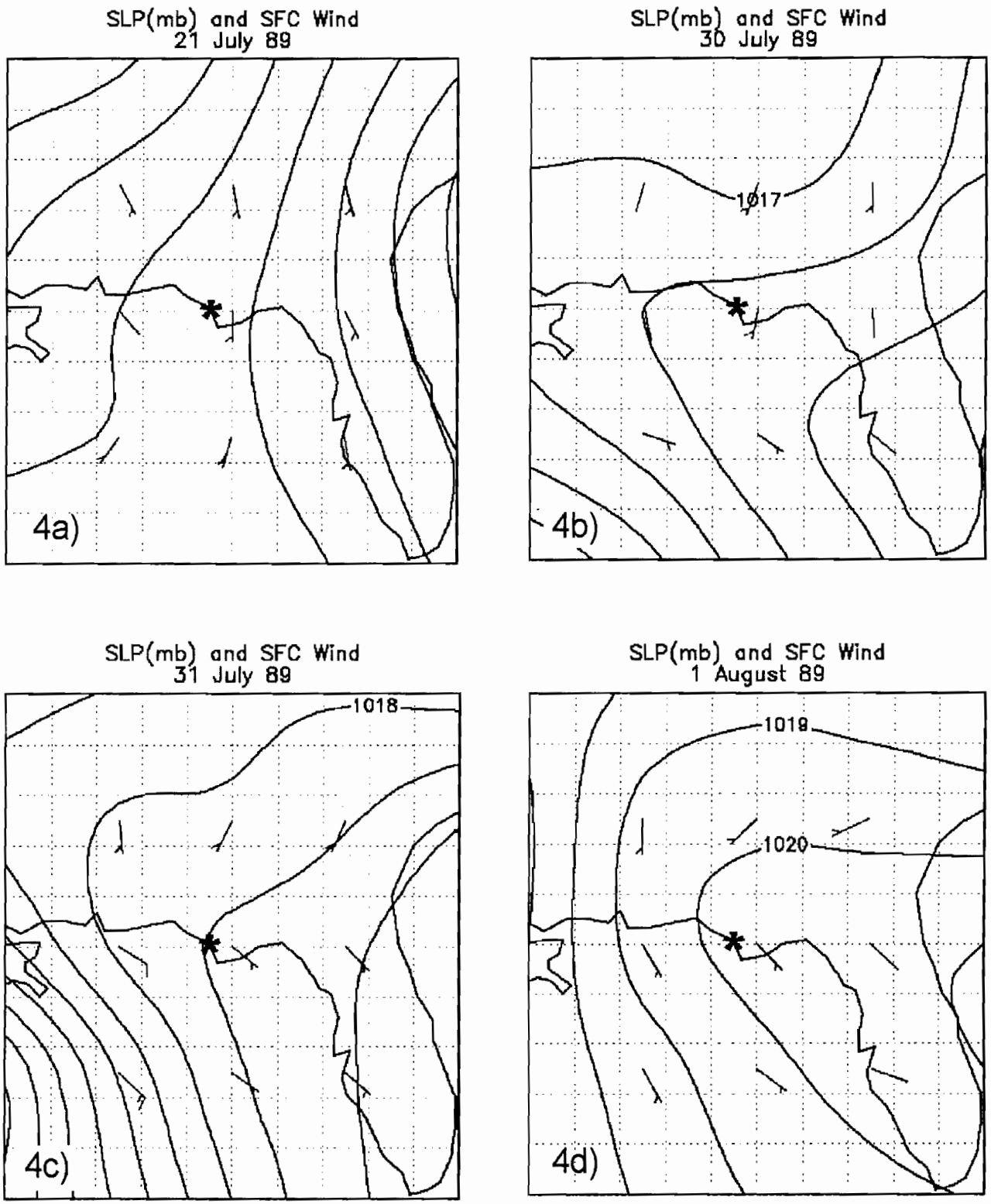


Figure 4. Southeast to south flow. Asterisk denotes location of drowning. Surface pressure (mb) and wind barbs (m/s) are plotted.

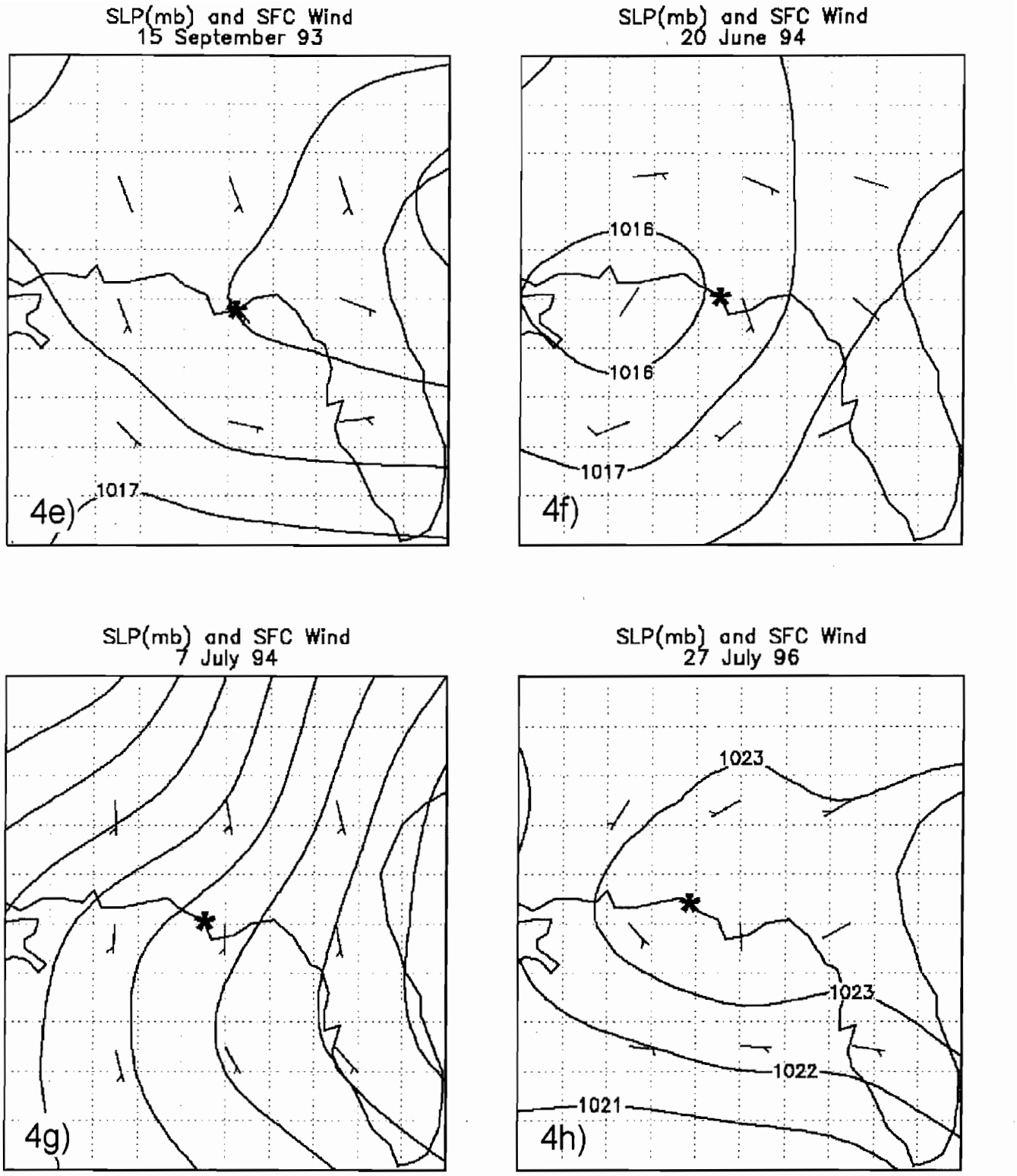


Figure 4 continued. Southeast to south flow. Asterisk denotes location of drowning. Surface pressure (mb) and wind barbs (m/s) are plotted.

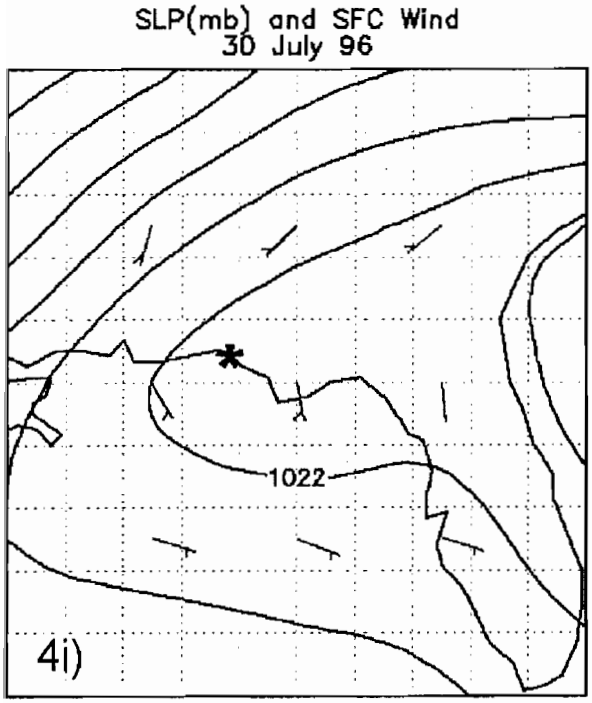
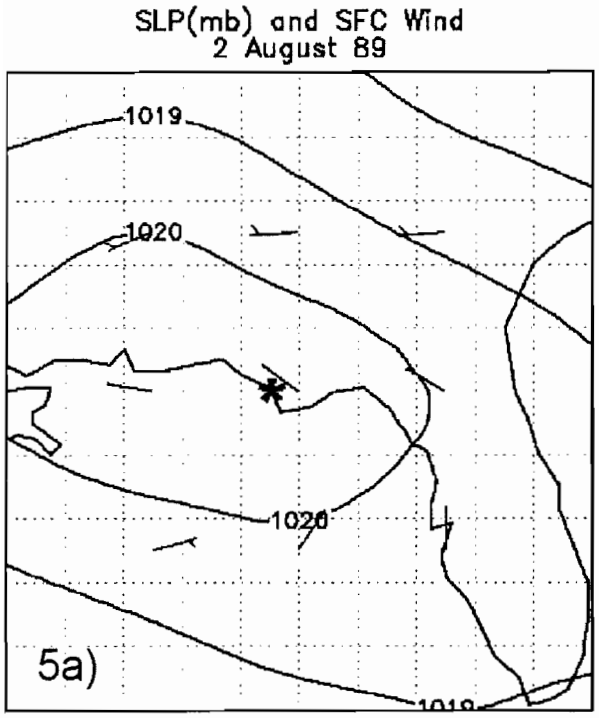


Figure 4 continued. Southeast to south flow. Asterisk denotes location of drowning. Surface pressure (mb) and wind barbs (m/s) are plotted.



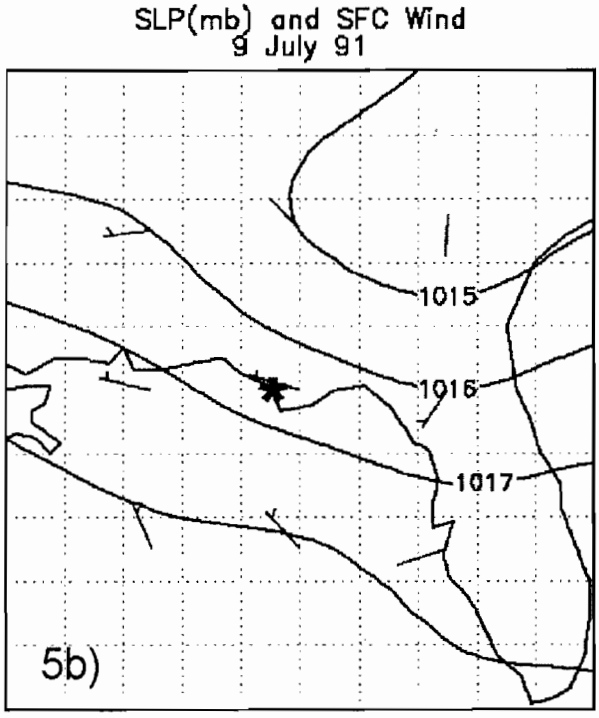


Figure 5. Northwest flow. Asterisk denotes location of drowning. Surface pressure (mb) and wind barbs (m/s) are plotted.

b. Tidal Analysis

The coastal waters of WFO Tallahassee's CWA possess two types of tidal cycles. Over the Florida panhandle coastal waters, generally west of Apalachicola, the tides are classified as **diurnal,** meaning that there is only one high tide and one low tide in each tidal day (24.84 hours). Figure 6 shows a typical example of a tidal day for a panhandle location. Over the Big Bend coastal waters (Apalachee Bay), the tidal cycle is classified as **semidiurnal,** meaning that in a tidal day there will be two high tides and two low tides, with the highs and lows being of approximately equal height. An example of a semidiurnal tidal cycle can be seen in Fig. 7.

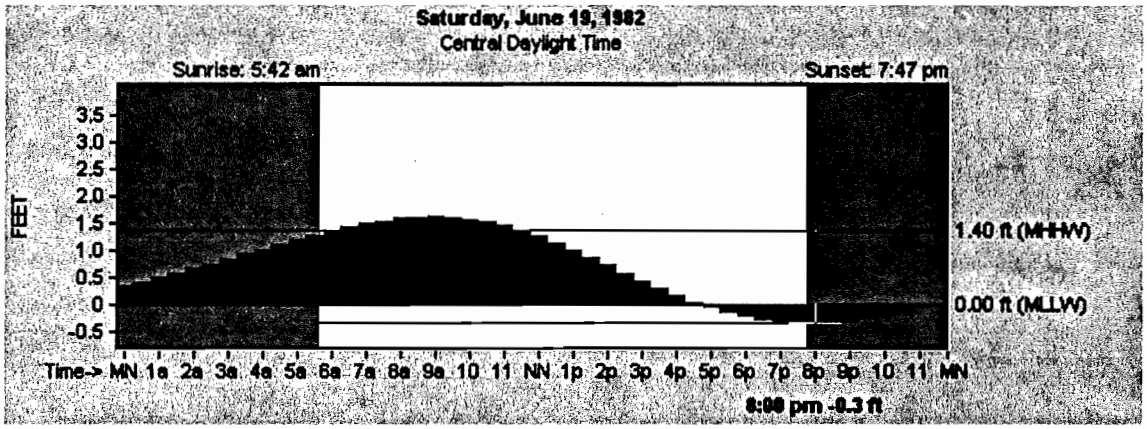


Fig. 6 Typical one high tide and one low tide in a diurnal cycle.

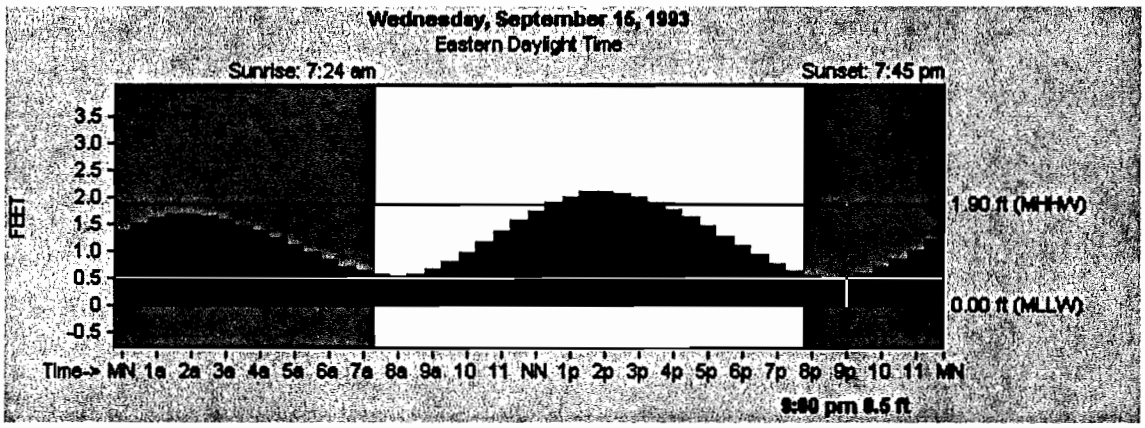


Fig. 7 Typical two high and two low tides in a semidiurnal cycle.

Lushine (1991) noted in his study that tidal effects played an important role in the enhancement of rip currents. Specifically, it was noted that two hours prior to the occurrence of low tide, and four hours after low tide there were four times as many drownings as at other times in the tidal cycle. During ebb tide, the seaward flow tends to accentuate rip currents that develop.

Of the 25 cases in this study, 18 cases indicated a time of death on the death certificates. These times were used to make a correlation between the occurrence of low tide with respect to the time of the drowning. In Fig. 8, the abscissa is labeled from -10 to +12 with zero being the time of the occurrence of low tide. It should be noted that the abscissa scale varies. Negative numbers are in increments of a half hour, while positive numbers are in increments of two hours. The negative numbers refer to the number of hours prior to low tide that the drowning occurred, while positive numbers refer to the number of hours after low tide in which the drowning occurred. The ordinate represents the number of rip current related deaths. It is also significant that nearly all of the rip current deaths occurred in an area with a diurnal tidal cycle.

As seen in Fig. 8, 17 of the 18 cases (94%) occurred prior to the occurrence of low tide. The times ranged from nearly two hours, to well over 9 hours before the occurrence of low tide. It is also interesting to note that 12 of the 18 deaths (67%) occurred between 1.5 to near 6.5 hours before low tide, and 8 of the 18 deaths (44%) occurred between 4 to 6.5 hours prior to low tide. This seems to confirm the importance of the tidal effects which were discovered in Lushine's study. Even though the number of cases in this study is rather low, it still points to a strong case in which the ebb tide plays an important role in the enhancement of rip currents.

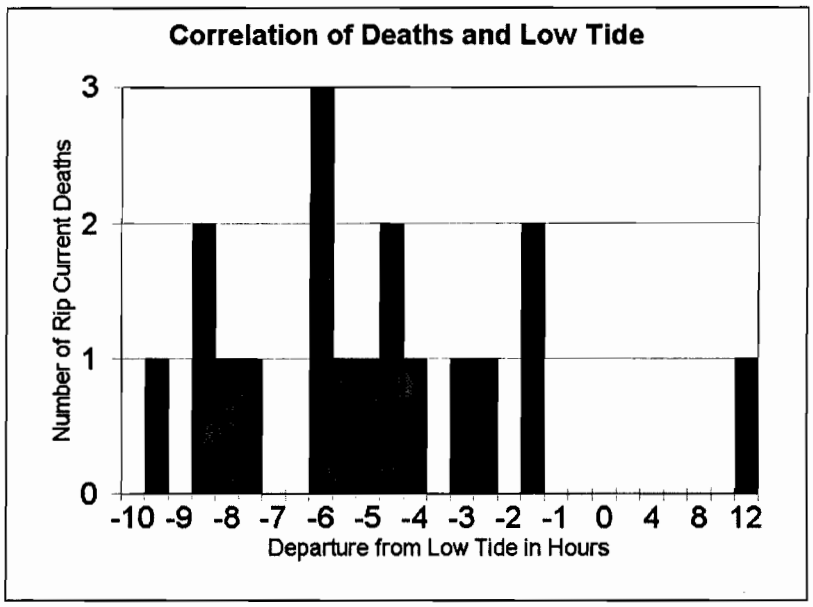


Fig. 8.Correlation between the time of low tide and the number of drownings. (Note that the abscissa scale varies; negative numbers are in increments of a half hour, positive numbers are in increments of two hours. Nearly all of the deaths occurred in a diurnal tidal cycle.)

c. Swell Analysis

Another component that has been shown to enhance rip current development is swells. The east coast Florida studies (Lushine 1991 and Lascody 1998) found that the higher the swell the greater the likelihood of rip currents (Lushine 1991), while Lascody's study (1998) seemed to indicate that longer swell periods (i.e., greater than 12 seconds) had as much influence on the occurrence of rip currents as did swell height, even when the heights were relatively low (i.e., around 2 feet).

In the Gulf of Mexico swell plays a lesser role than in the Atlantic waters. Swells in the Atlantic are generally much higher than in the Gulf, due to the fact that the Gulf is an 'enclosed' body of water that is protected from the influence of distant storms. Below is a list of the swell data that was obtained from buoys in the Gulf of Mexico for the 25 days being analyzed in this study (Hervey 2000, Personal Communication).

West to Southwest Regime

Date	Swell Height (ft)	Swell Period (s)
42003 (Eastern Gulf of Mexico Buoy) 25° 56' 10" N; 85° 54' 51" W		
6/25/80	1.97	7.1
6/19/82	2.30	9.1
6/27/82	1.31	8.3
7/29/89	1.97	8.3
6/23/90	1.31	7.1
7/04/91	1.97	5.9
8/14/92	1.31	5.3
9/09/93	0.33	7.1
42036 (West Tampa Buoy) / 42039 (Pensacola South Buoy) 28° 30' 22" N; 84° 30' 37" W / 28° 47' 05" N; 86° 02' 16" W		
6/08/94	2.95	8.3
8/17/94	1.97	6.7
5/18/95	0.00	--
7/07/96	3.28/4.26	8.3/5.3
7/19/96	2.62/2.62	5.6/8.3
7/26/96	1.97/2.30	5.3/7.1

Average Swell Height - 2.03 feet
Average Swell Period - 6.6 seconds
Maximum Swell Height - 4.26 feet
Maximum Swell Period - 9.1 seconds

South to Southeast Regime

Date	Swell Height (ft)	Swell Period (s)
	42003 (Eastern Gulf of Mexico Buoy)	
	25° 56' 10" N; 85° 54' 51" W	
7/21/89	1.64	4.5
7/30/89	2.95	7.1
7/31/89	3.28	7.7
8/01/89	4.26	8.3
9/15/93	0.00	—
	42036 (West Tampa Buoy) / 42039 (Pensacola South Buoy)	
	28° 30' 22" N; 84° 30' 37" W / 28° 47' 05" N; 86° 02' 16" W	
6/20/94	1.97	5.6
7/07/94	0.98	6.3
7/27/96	1.31/2.62	5.6/7.7
7/30/96	2.30/2.62	5.0/7.7

Average Swell Height - 2.18 feet
Average Swell Period - 6.0 seconds
Maximum Swell Height - 4.26 feet
Maximum Swell Period - 8.3 seconds

The northwest regime only had swell data for two dates, therefore an analysis of swell for this regime was not used.

It should be noted that during most of the warm season, the swells in the Gulf of Mexico are relatively low, except in the presence of a tropical system. Generally swells are a foot or less in the months when beach going activities are at their highest. As indicated in the data, the average swell heights for both the southwest to west, and the south to southeast wind regimes were slightly higher than 2 feet; higher than normally expected. In addition, the maximum swell height for both the southwest to west regime, and the south to southeast regime was over 4 feet.

Based on the above evidence, it would seem likely that a higher incidence of rip currents could be expected when swells are at the average height for both of the regimes, (i.e., around 2 feet). One would expect the threat to increase considerably, as swell heights approach or exceed the maximum height for both regimes, (which was over 4 feet), thus causing a significant volume of water to pile up between the sand bar and the shore.

5. Application

Based on the analysis of the data above, and incorporating techniques used by both WFOs Miami and Melbourne, a checklist was developed that would allow the midnight - 8am forecaster to assess the potential for rip currents for that day (Fig. 9). The checklist allows the forecaster to determine the degree to which each of the factors plays a role. A final value is determined by adding the values that have been assigned for each of the factors of winds, tides, and swells. The final value is then given a threat assessment for the day. The categories of risk are nil, slight, moderate, and high. On a day in which the forecaster has determined that a moderate risk will exist, he/she mentions the danger in the early morning issuance of the Hazardous Weather Outlook (MIASPSTLH/Fig. 10), issued daily at 6 am Eastern Time. In addition, this information is made available to the Panama City Beach Patrol, St George Island State Park Rangers, and other agencies that protect or patrol local beaches.

6. Summary and Conclusions

As with any empirical study, ongoing research should be conducted in order to better understand the factors involved in generating rip currents. WFO Tallahassee plans to maintain a channel of communication with the Panama City Beach Patrol and the St. George Island State Park Rangers, in order to refine and improve the thresholds in the rip current forecasting checklist (Fig 9). This will hopefully allow the WFO Tallahassee staff to help save lives through a better understanding of rip currents, a more effective assessment of the potential for rip current development, and a procedure for alerting the appropriate agencies of an enhanced potential for rip currents (Fig. 10).

Acknowledgments

The authors wish to thank Stanley Hobbs for his work in identifying data sources, and collecting data for this project. Thanks also go to Anita Dye and Paul Duval for their valuable assistance in proof reading the final document.

Date _____

FLORIDA PANHANDLE DAILY RIP CURRENT THREAT ASSESSMENT

1. Wind Factor: Surface Winds (Synoptic Scale Flow Only - Disregard the Sea Breeze)

Knots	SW-W	SE-S	NW-N	NE-E
5	0.5	0.5	0.0	0.0
5-10	1.0	0.5	0.0	0.0
10	1.5	1.0	0.0	0.0
10-15	2.0	1.5	0.0	0.0
15	3.0	2.0	0.0	0.0
15-20	4.0	3.0	0.0	0.0
20	5.0	4.0	0.0	0.0
20-25+	5.0	5.0	0.0	0.0

If the wind direction is in the SE-S regime, fill in **BOTH** the Panhandle and Franklin County Wind, Tide and Swell Factors. If the wind direction is in the SW-W regime fill in **ONLY** the Panhandle factors.

PANHANDLE WIND FACTOR _____ **FRANKLIN CO. WIND FACTOR** _____

***** IF THE WIND FACTOR IS 0.0, SKIP STEPS 2 & 3 *****

2. Tide Factor:

If low tide will occur during a preferred time (i.e., between Noon and 10 pm; or more specifically if beach-going hours will occur during ebb tide), the tide factor will be 1.0, otherwise 0.0.

Use Tides and Currents Software located on both Carmen and Floyd (Specific instructions located in Sea-Breeze/Rip Current Binder).

PANHANDLE TIDE FACTOR _____ **FRANKLIN CO. TIDE FACTOR** _____

3. Swell Factor: Use Latest Swell Data from Buoy 42039

If swell height is greater than or equal to 4 feet, the swell factor is **2.0**

If swell height is greater than or equal to 2 feet, but less than 4 feet the swell factor is **1.0**

If the swell height is greater than 0.5 feet, but less than 2 feet, the swell factor is **0.5**

If the swell height is 0.5 feet or less, the swell factor is **0.0**

PANHANDLE SWELL FACTOR _____ **FRANKLIN CO. SWELL FACTOR** _____

Use the same swell factor for both the panhandle, and Franklin Co. coasts.

4. Total Assessment Factor

PANHANDLE WIND FACTOR + PANHANDLE TIDE FACTOR + PANHANDLE SWELL FACTOR= _____

FRANKLIN CO. WIND FACTOR + FRANKLIN CO. TIDE FACTOR + FRANKLIN CO. SWELL FACTOR=_____

If Total = 0.0 to 0.5; risk for rip currents is **NIL**.

If Total = 1.0 to 3.0; risk for rip currents is **SLIGHT**.

If Total = 3.5 to 5.5; risk for rip currents is **MODERATE**.

If Total = 6.0 to 8.0; risk for rip currents is **HIGH**.

Fig. 9

HAZARDOUS WEATHER OUTLOOK
NATIONAL WEATHER SERVICE TALLAHASSEE FL
600 AM EDT FRI JUNE 23, 2000

...POSSIBLE RIP CURRENTS ALONG THE BEACHES OF WALTON...BAY AND GULF COUNTIES TODAY...

THE FOLLOWING ALERT IS ISSUED IN COOPERATION BETWEEN THE NATIONAL WEATHER SERVICE AND THE PANAMA CITY BEACH PATROL.

SOUTHWEST TO WEST WINDS OF 15 TO 20 KNOTS ARE EXPECTED ACROSS PORTIONS OF THE FLORIDA PANHANDLE TODAY. WINDS OF THIS SPEED AND DIRECTION ARE CONDUCIVE FOR GENERATING RIP CURRENTS.

A RIP CURRENT...SOMETIMES MISTAKENLY CALLED AN UNDERTOW...IS A STRONG BUT NARROW CURRENT OF WATER FLOWING FROM THE BEACH THROUGH THE SURF ZONE. IT CAN RAPIDLY CARRY A SWIMMER INTO DEEPER WATER AND EXHAUST AN INDIVIDUAL TRYING TO SWIM AGAINST IT.

IF YOU ARE CAUGHT IN A RIP CURRENT...WADE SIDEWAYS PARALLEL TO THE BEACH UNTIL YOU ARE OUT OF ITS PULL. ANOTHER MEANS OF ESCAPE FOR THOSE WHO ARE GOOD SWIMMERS IS TO RIDE THE CURRENT OUT BEYOND THE SURF ZONE WHERE THE RIP CURRENT DISSIPATES...THEN SWIM TO SHORE OUTSIDE THE EFFECTS OF THE NARROW CURRENT.

HEED THE ADVICE OF THE BEACH PATROL...WATCH YOUR CHILDREN...AND BE ESPECIALLY CAUTIOUS NEAR PIERS...JETTIES...AND UNGUARDED BEACHES.

ADDITIONAL STATEMENTS CONCERNING THE THREAT OF RIP CURRENTS WILL BE ISSUED AS NECESSARY.

Fig. 10

References

Hervey, R., Computer Sciences Corporation, National Data Buoy Center, Stennis Space Center, MS, Personal Communication, Winter/Spring 2000.

Lascody, R. L., 1998: East Central Florida Rip Current Program, National Weather Digest, **22**, 25-30.

Lushine, J. B., 1991: A Study of Rip Current Drownings and Related Weather Factors, National Weather Digest, **16**, 13-19.

National Climatic Data Center. 1996: Storm Data, **38**, Number 7, July 1996.

NOAA-CIRES Climate Diagnostics Center, Boulder, CO: Available [on-line]: *http://www.cdc.noaa.gov/*

Sammett, G.J., and F.L. Luaces, Florida Department of Health, State Office of Vital Statistics, Public Health Section; Public Health Statistics 1980-1996.

Smith, M., Panama City Beach Patrol. Personal Communication, Fall 1999/Winter 2000.