



U.S. Department  
of Transportation  
**National Highway  
Traffic Safety  
Administration**

---

**DOT HS 807 115**  
**NHTSA Technical Report**

**April 1987**

# **Holiday Effect on Traffic Fatalities**

1. Report No. DOT HS-807 115		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle  Holiday Effect on Traffic Fatalities				5. Report Date April 1987	
				6. Performing Organization Code NHTSA, NCSA, NRD 31	
7. Author(s) Robert Arnold and Ezio C. Cerrelli				8. Performing Organization Report No.	
9. Performing Organization Name and Address National Center for Statistics and Analysis Mathematical Analysis Division 400 7th St. S.W. Washington, DC 20590				10. Work Unit No. (TRAVIS)	
				11. Contract or Grant No.	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, DC 20590				13. Type of Report and Period Covered  Technical Report	
				14. Sponsoring Agency Code NHTSA, NCSA, NRD 31	
15. Supplementary Notes					
16. Abstract  The report identifies those holidays that show an increase in traffic fatalities and estimates the size of this increase for each national holiday.  A procedure is presented that can be used to forecast the expected fatality count for each upcoming holiday period.					
17. Key Words  Traffic fatalities, Holidays, Forecast, Trends			18. Distribution Statement  Document is available to the public through the National Technical Information Service, Springfield, VA. 22161		
19. Security Classif. (of this report)  Unclassified		20. Security Classif. (of this page)  Unclassified		21. No. of Pages  22	22. Price

## HOLIDAY EFFECT ON TRAFFIC FATALITIES

### Introduction

During holiday periods there is, in general, an increase in the number of people that are killed on the highways, perhaps due to increases in travel and changes in travel patterns.

This paper identifies those holidays that show an increase in traffic fatalities and estimates the size of this increase for each national holiday. No attempt is made to explain the reasons for these increases. A procedure is presented that can be used to forecast the expected fatality count for each upcoming holiday period.

### Procedure

The objective is to determine if and by how much the number of traffic fatalities increases during each specific holiday. It requires the adoption of a reference level from which change can be measured. To establish this reference level it is necessary to take into account some basic factors governing the size of the traffic fatality toll. The overall annual traffic fatality count varies considerably, due to changes in travel, safety programs, national economy, and many other factors. From 1975 to 1985, annual traffic fatalities ranged from a low of 42,589 in 1983 to a high of 51,093 in 1979, a difference of 20 percent. Figure 1 shows the annual trend in traffic fatalities during the 1975-1985 period. In addition, the number of traffic fatalities shows a large variation over the 12 months of the year, and an even stronger variation during the days of the week. January produces the fewest daily fatalities, an average of 97 each day over the 11-year period. This daily average rises steadily during the spring and summer months to a peak of 148 fatalities per day in August, then drops to 128 per day in December. Figure 2 presents these daily averages, over the 11 year period, for the 12 months of the year. Looking at the weekly pattern, Tuesdays have the lowest average count, 97 per day, as compared to Saturdays with an average count of 188 per day. Figure 3 show this weekly pattern. Finally, this weekly pattern is different for different months. Weekend traffic fatality counts have a stronger monthly variation than weekday counts. Figure 4 shows how these daily counts vary. In this figure all weekdays have been grouped together since they show a similar pattern.

The reference level adopted in this paper takes into account all the information presented in Figures 1 through 4 and consists of the average fatality count, over the 11 year period, for each day of the week in each month. The 84 average counts (7 x 12), thus obtained, represent the typical fatality counts from which the holiday effects are measured. Table A lists these base values, which are also plotted in Figure 5.

FIGURE 1

ANNUAL TRAFFIC FATALITIES  
(1975-1985)

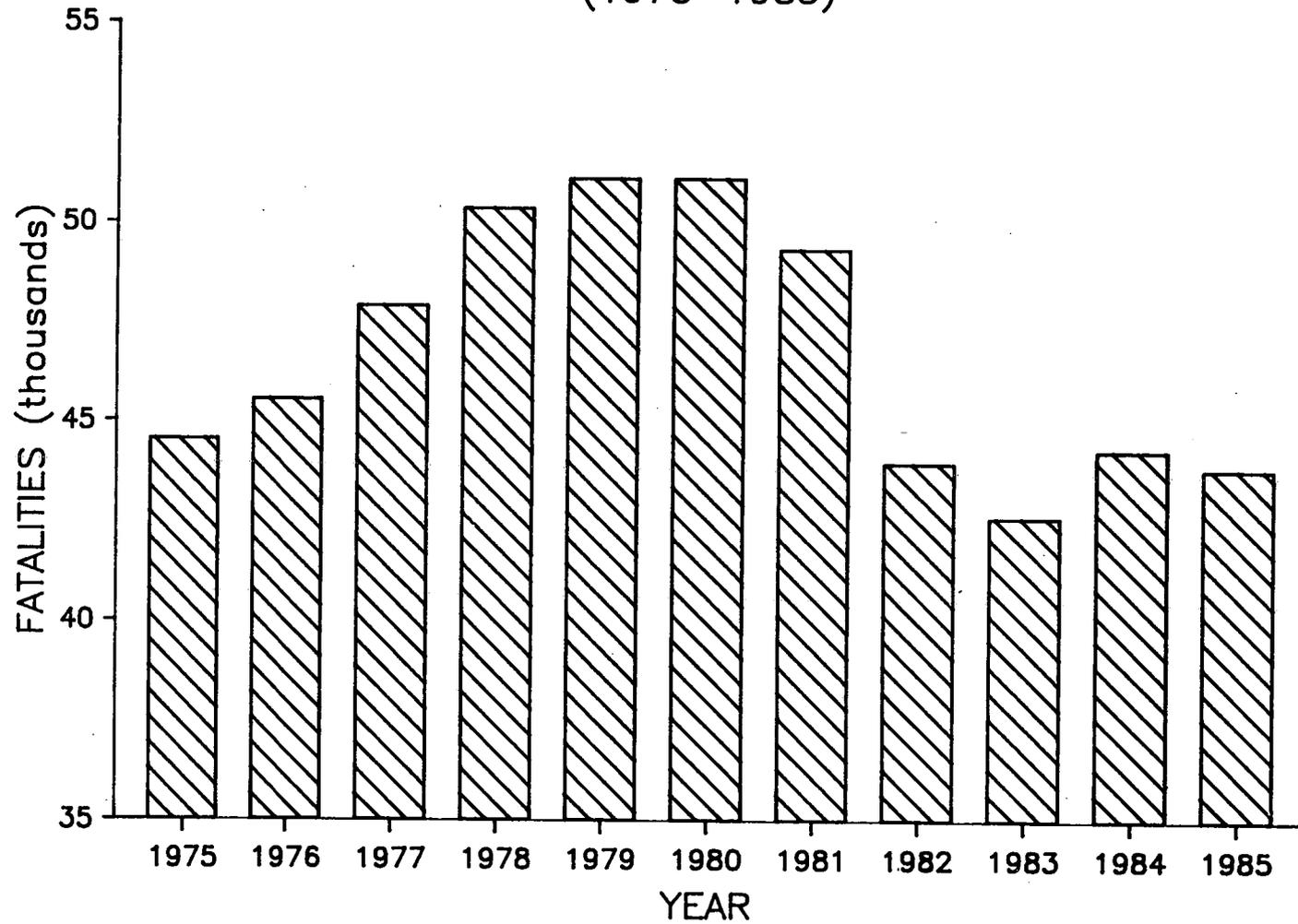


FIGURE 2

AVERAGE NUMBER OF FATALITIES/DAY  
(1975-1985)

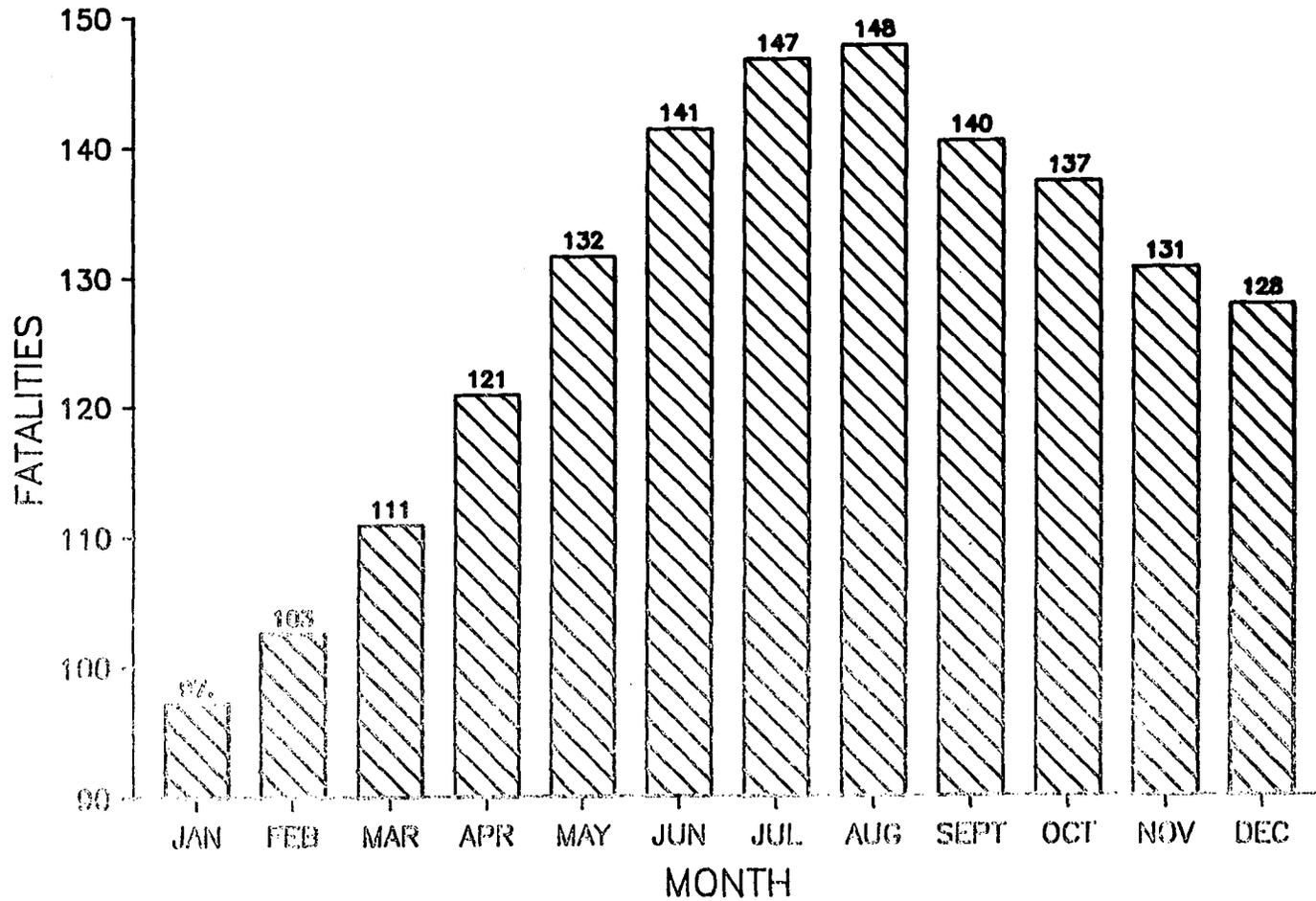


FIGURE 3

AVERAGE WEEKLY FATALITIES  
(1975-1985)

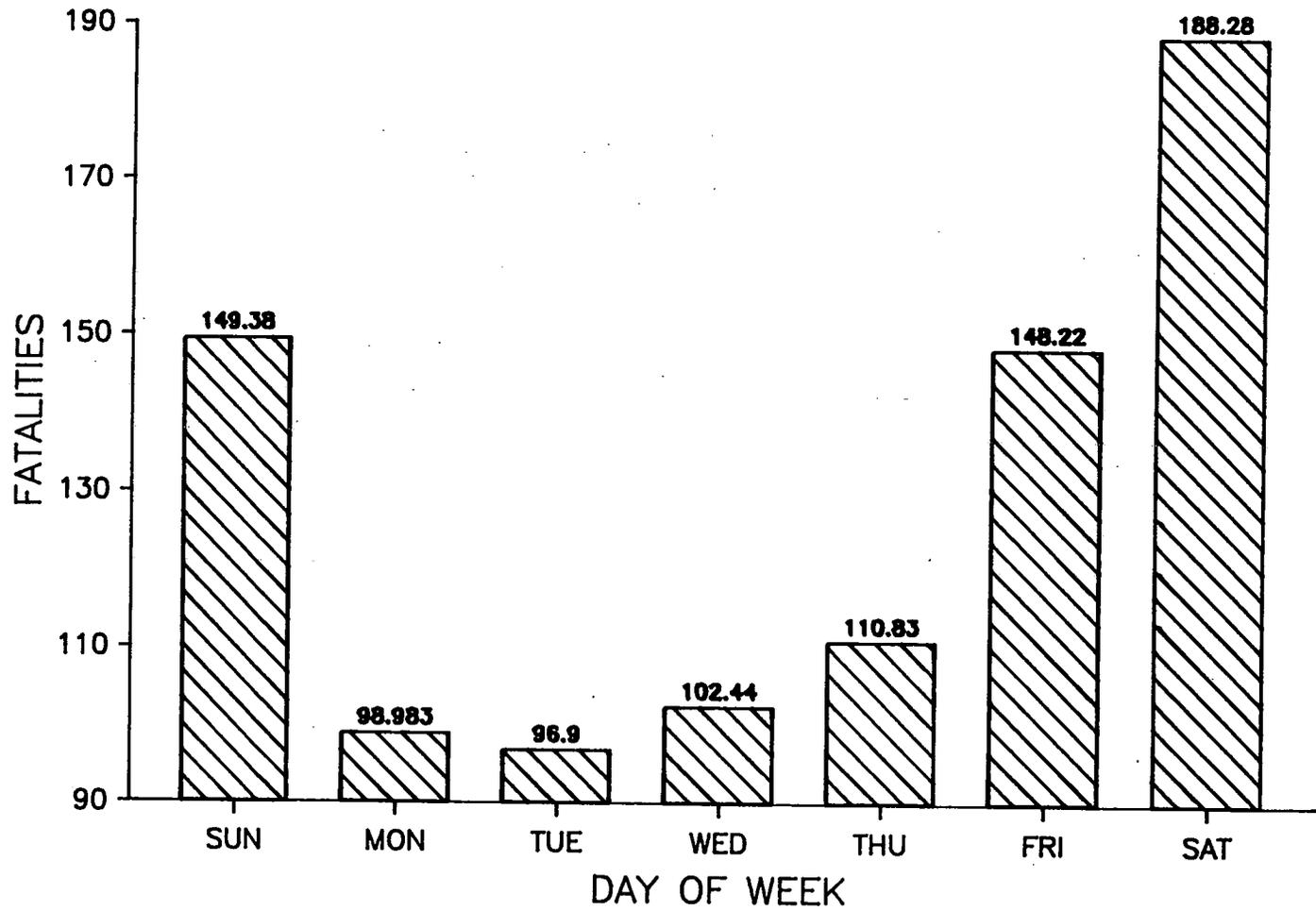


FIGURE 4

ANNUAL FATALITY CYCLE BY DAY OF WEEK  
(RELATIVE TO JANUARY)

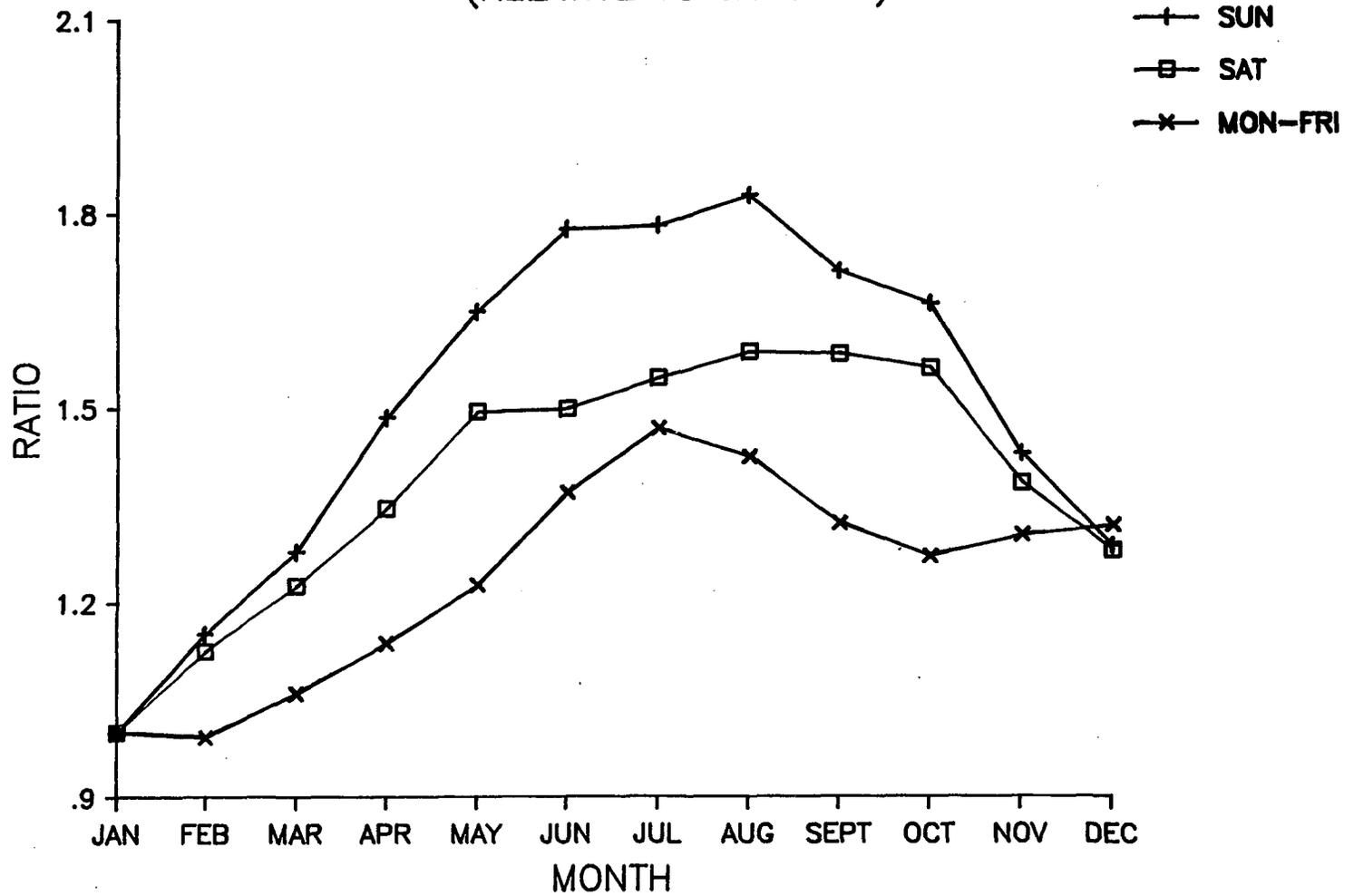


FIGURE 5

WEEKLY FATALITY CYCLE  
BY MONTH

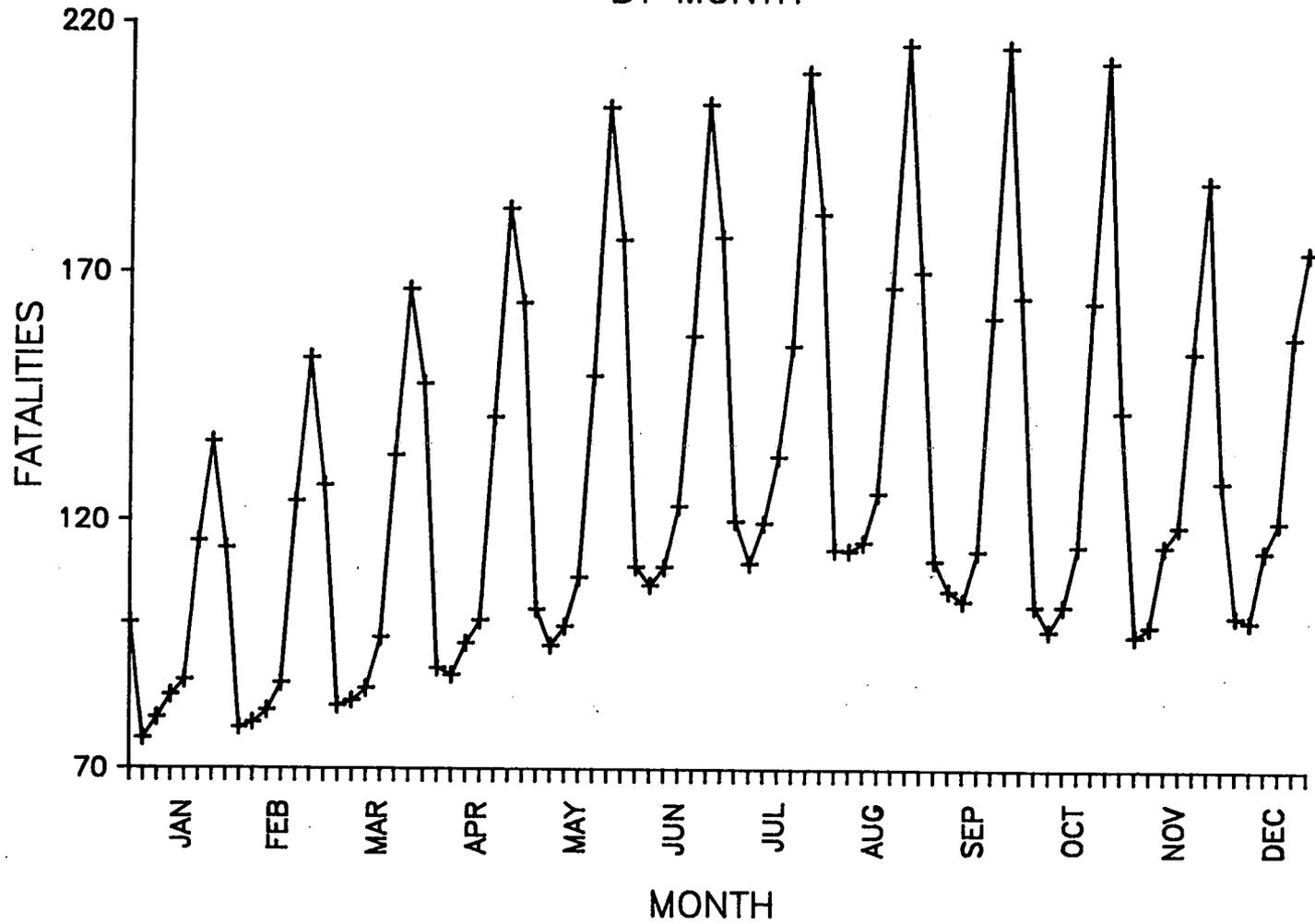


Table A  
Average Fatality Counts by Month and Day of Week

	Day of Week						
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
January	99	76	80	85	88	116	136
February	114	78	79	82	87	124	153
March	127	83	84	86	96	133	167
April	148	90	89	95	100	141	183
May	164	102	95	99	109	149	203
June	177	111	107	111	123	157	204
July	177	120	111	120	133	155	210
August	182	114	114	116	126	167	216
September	170	112	106	104	114	161	215
October	165	103	98	103	115	164	212
November	142	97	99	115	119	154	188
December	128	101	100	114	121	157	174

The table above gives the average number of fatalities occurring in the 84 typical days of the year over the 1975-1985 period. By comparing the actual average number of fatalities observed during the 11-year period for a given day to the average shown in the table for the corresponding typical day, a standard index can be obtained which measures the relative change. The following examples will make the procedure more clear. First, note that, the national holidays are divided into two groups: a) those that fall on the same calendar day, and b) those that fall on the same day of the week. In the first group are New Year's, Independence Day, Veterans' Day and Christmas, while in the second group are Martin Luther King Jr. and George Washington birthdays, Memorial Day, Labor Day, Columbus Day and Thanksgiving.

The procedure for developing the index is slightly different for the two groups. For holidays in the second group the procedure for estimating the holiday effect is based on the percent change between the actual average number of fatalities for the 11 holidays on file and the appropriate count presented in Table A. This change is then inflated by a factor of 1.4 to account for the fact that these holiday counts were also used in computing the averages in Table A. Thanksgiving Day is an example. The expected average number of traffic fatalities for a Thursday in November, over the 11-year period, is shown in the table in the Thursday column and the November line. The value of 119 in this cell represents the average number of fatalities which would have occurred, if Thanksgiving had been a typical Thursday in November during the 1975-1985 period. The actual average number of fatalities during all Thanksgiving Days in that period was 135 fatalities per holiday. The percent change between 135 and 119 is 13.4%. When multiplied by 1.4 the change becomes 18.8%, which measures the difference between a typical Thanksgiving Day count and the count for a typical non-holiday Thursday in November.

For the holidays in the first group, the procedure for obtaining the expected average value is more complex since they fall on a different day of the week each year. For these holidays, the expected average count is obtained by identifying the number of times the holiday occurred in each day of the week during the 11-year period, extracting the corresponding values from the table, and calculating the average of these 11 counts. The actual average and the index is produced in the same way as for holidays in the second group.

## Results

Figures 6 through 14 and the associated discussion summarize the results of the study and offer some interpretation of the findings. All ratios shown in the figures have an expected value of 100, with deviations greater than 10% considered statistically significant.

Figure 6, 7, and 8 are associated with holidays which fall on the same calendar day, while Figures 9 through 14 refer to those holidays falling on specific days of the week.

## Discussion of Figures

Figure 6. Day of Year is defined to include February 29 as Day 60 so March 1 is always Day 61 and December 31 is always Day 366, leap year or not. The vertical grid lines separate the months. Day 60 has only three occurrences in the period 1975-1985; all other Days occur 11 times. Each weekday occurs exactly 574 times in this period. Occurrences of weekday-month combinations vary from 44 to 49. The expected average number of fatalities for a specific day of the year is the average of the counts in Table A for the weekdays on which that day occurred during the 1975-1985 period. The values plotted in Figure 6 are the observed average number of fatalities normalized against the expected average number for each day of the year. Most of the points have values between 90 and 110. The seven highest points, January 1, July 3 and 4, and December 21 through 24, appear to be outliers. December 26, 28, 29, and 30, together with November 30, are outliers on the low side. The remaining 354 points have a standard deviation of 4.5. The grid lines at 90 and 110 are about 2.2 of these standard deviations from 100. The seven high values, and the low ones near the end of the year, are examined in more detail in Figures 7 and 8. In Figure 6 there is a hint of high values at the end of May, near Memorial Day, and at the beginning of September, near Labor Day. There is no notice of the presence of Thanksgiving in this figure. These three holidays are on particular weekdays and should not show up well on this plot because they they are spread over up to seven different days of the year. They are examined in Figures 9 through 11.

Figure 7. The December through February sequence is shown in a single figure to avoid separating the Christmas-New Year holiday season. January 1 thus becomes Day 367. Vertical grids separate months. The standard errors, shown as the half-lengths of the vertical bars, represent sampling errors and are calculated separately for each day. Over the whole year they range from 2.1% of the normalized value for July 4 (the highest

absolute, not normalized, number of fatalities) to 3.3% for January 2 (the lowest number). February 29 is a special case. It has a higher average than does January 2 but, with only 3 occurrences, it has a small sample and its calculated standard error is 5.2%. Other than this one, these sampling errors are smaller than the 4.5% standard deviation calculated as described above for Figure 6. Since the normalization is with respect to the month within which the day occurs, a series of high values, like those at 21 through 24 December, will cause a noticeable depression of the rest of the month to keep the average near 100. This is seen in the first two weeks in December. Christmas Day and the 5 days after it are still lower. They are not only lower than the grand mean of 100 but are lower than "normal" if the first two weeks of the month are considered "normal" for December. New Year's Eve is much lower on this plot than New Year's Day. The former has been normalized against December, the latter against January. January fatalities have averaged about 25% lower than December fatalities during this period.

Figure 8. July 3 is clearly above normal; July 5 is clearly not. Independence Day was celebrated on July 4 in eight out of eleven years, July 5 in 1976 and 1982, and July 3 in 1981.

Figure 9. Since Memorial Day occurs always on Monday and varies between May 25 and May 31, its effect is scattered on a day of year plot like Figure 6. Figure 9 shows the 30 days before and after the holiday. The value for the holiday is about 123 and no other day in this period is outside the 90-110 grid lines. A very large value for the holiday would noticeably depress Mondays in the "before" period because it is normalized against them alone. On average they should go down about one third as much as the holiday goes up. This may be happening on the Monday before the holiday, day -7 on the plot, but the magnitude is too small to separate confidently from the random variation.

Figure 10. Labor Day, another always-Monday holiday, is shown in Figure 10. Its value is about 125. The day after, at about 112, verges on being significant but could easily be on the tail of the distribution of ordinary days about 100. We may be seeing here the depress-other-Mondays effect. Note that days +7, +14, and +21 (these are always Mondays in September; +28 is not necessarily so) are consistently low.

Figure 11. Thanksgiving, an always-Thursday holiday, shows several interesting features. The day itself is at 114, above the noise, but barely. It is the day before that is high, with a value of about 130. This day is Wednesday and a depressed Wednesday effect may be showing at -8 and -15. The unusually low values immediately after the holiday show some similarity to the after-Christmas effect noted earlier. The very high values at +26 through +29 are because these days contain contributions from the high values at 21 through 24 December.

Figure 12. During 1975-85 the third Monday in February has been a federal holiday and has been widely celebrated as George Washington's Birthday. The plot of this day in Figure 12 shows no features. The day itself is slightly below average but not significantly so.

FIGURE 6  
Normalized Daily Fatalities  
Averaged over 1975-1985

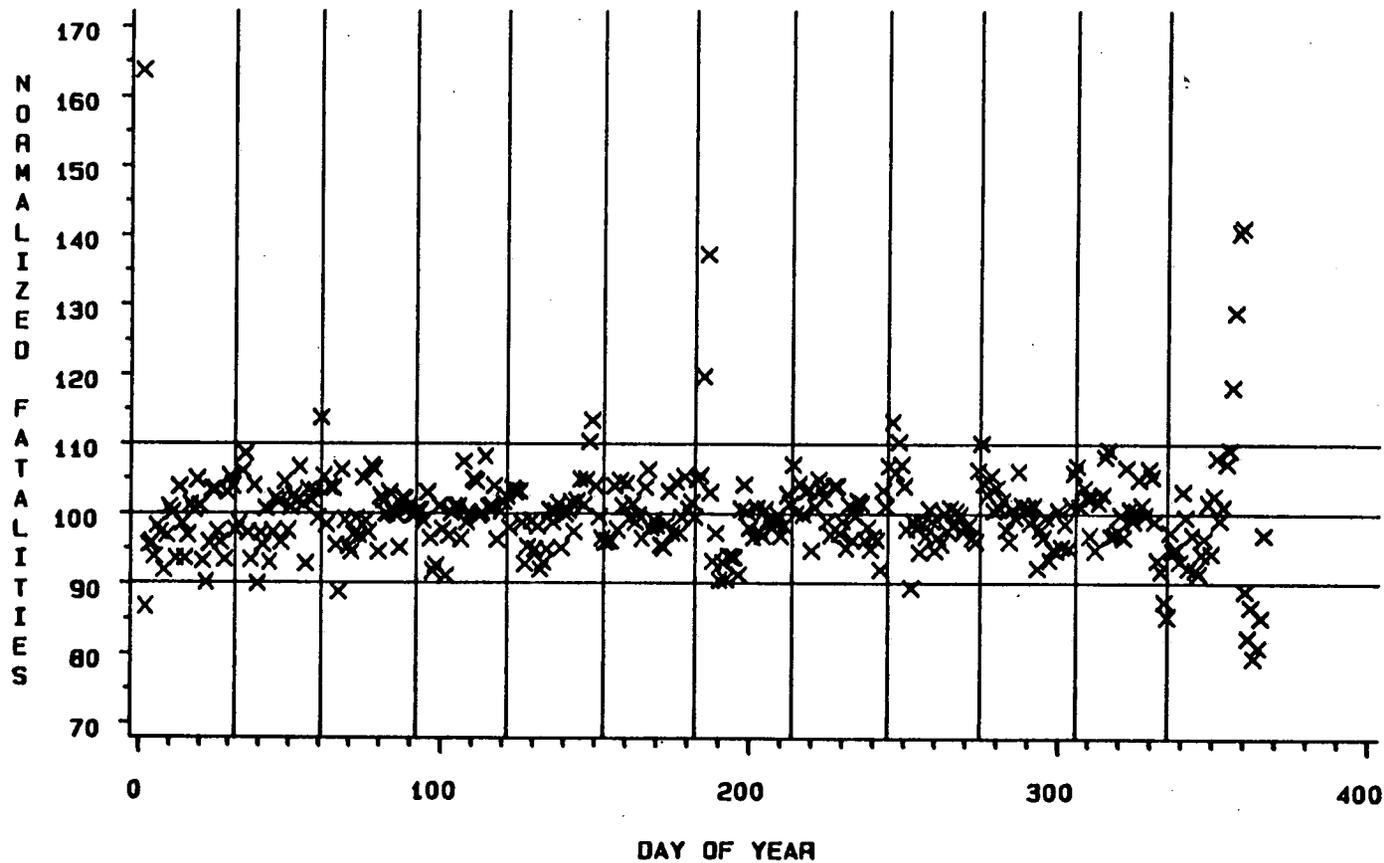
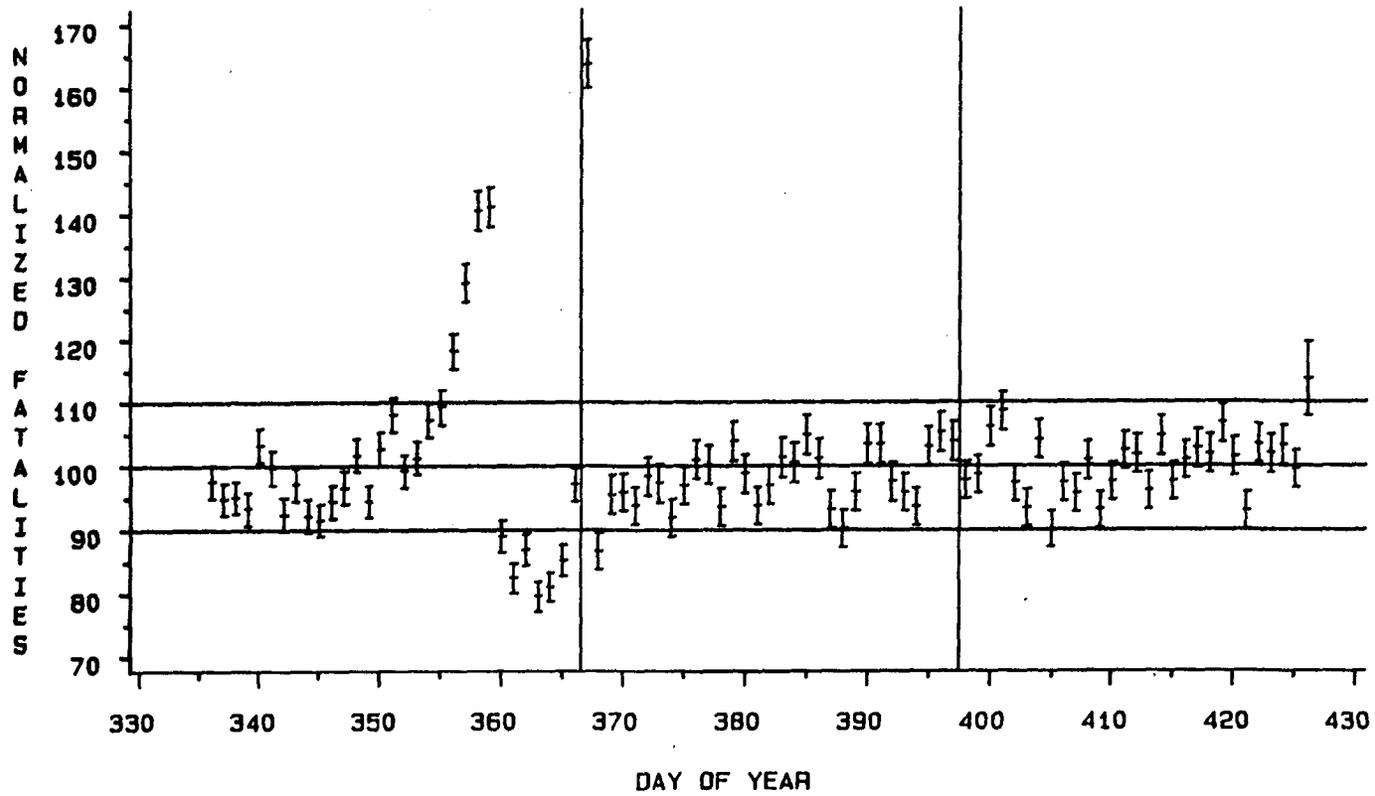
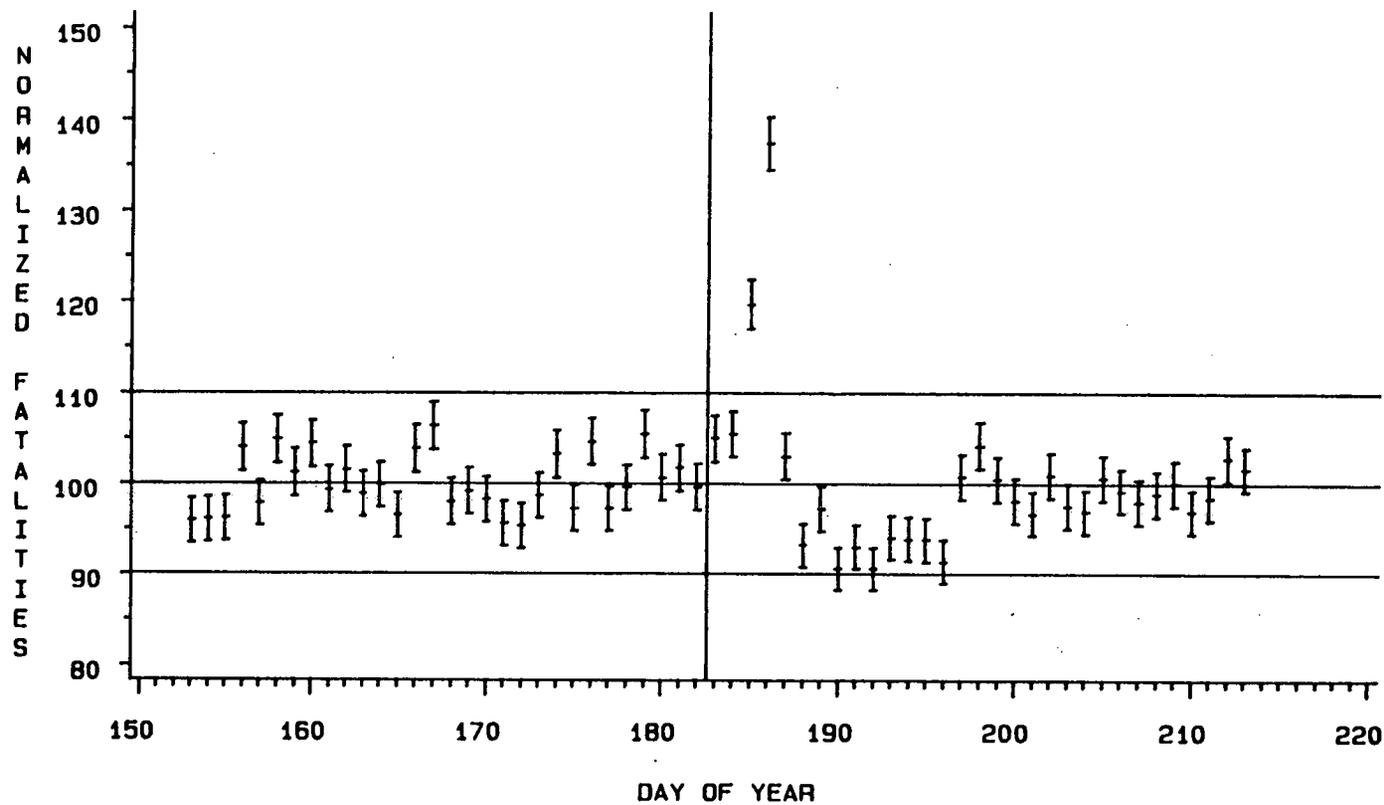


FIGURE 7  
Normalized Daily Fatalities  
in December, January, and February



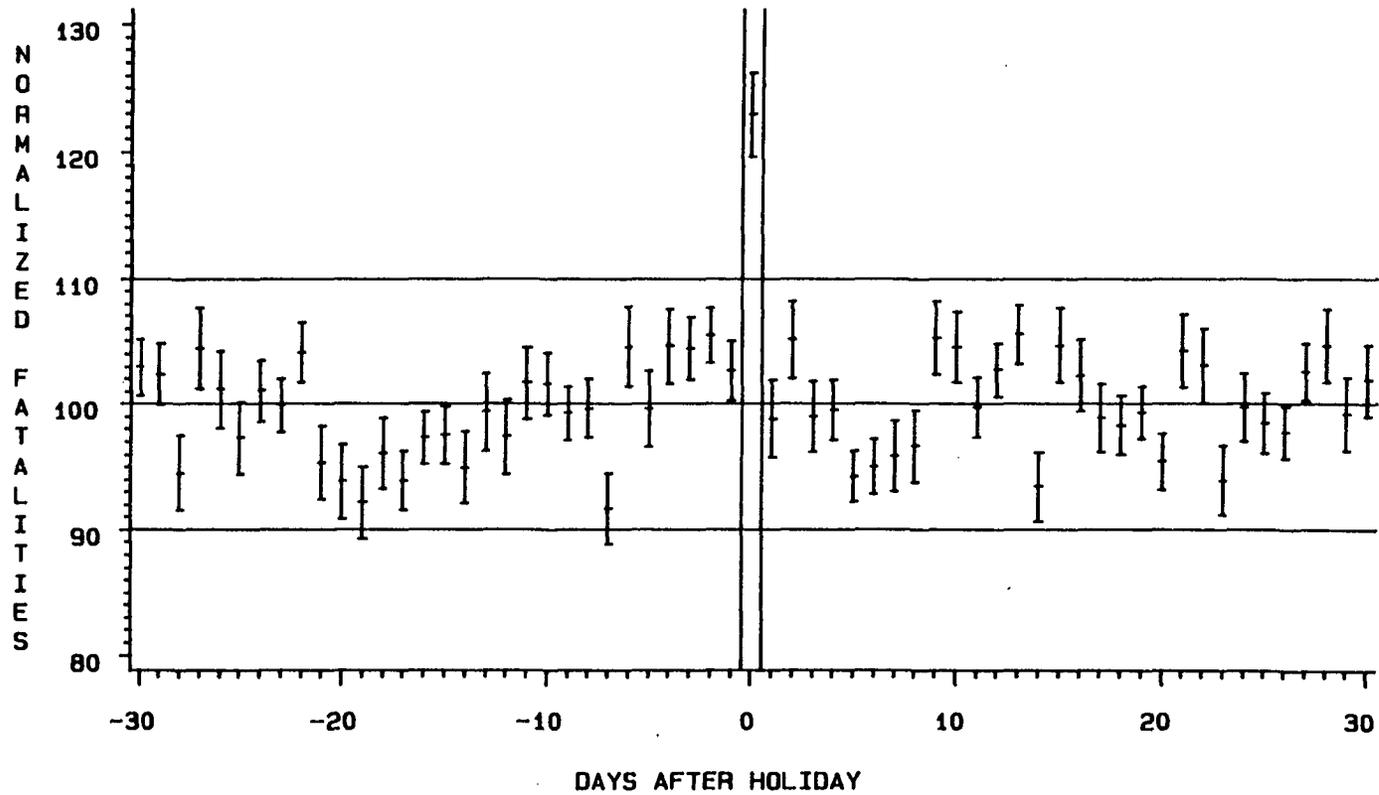
BAR LENGTH IS 2 STANDARD ERRORS

FIGURE 8  
Normalized Daily Fatalities  
in June and July



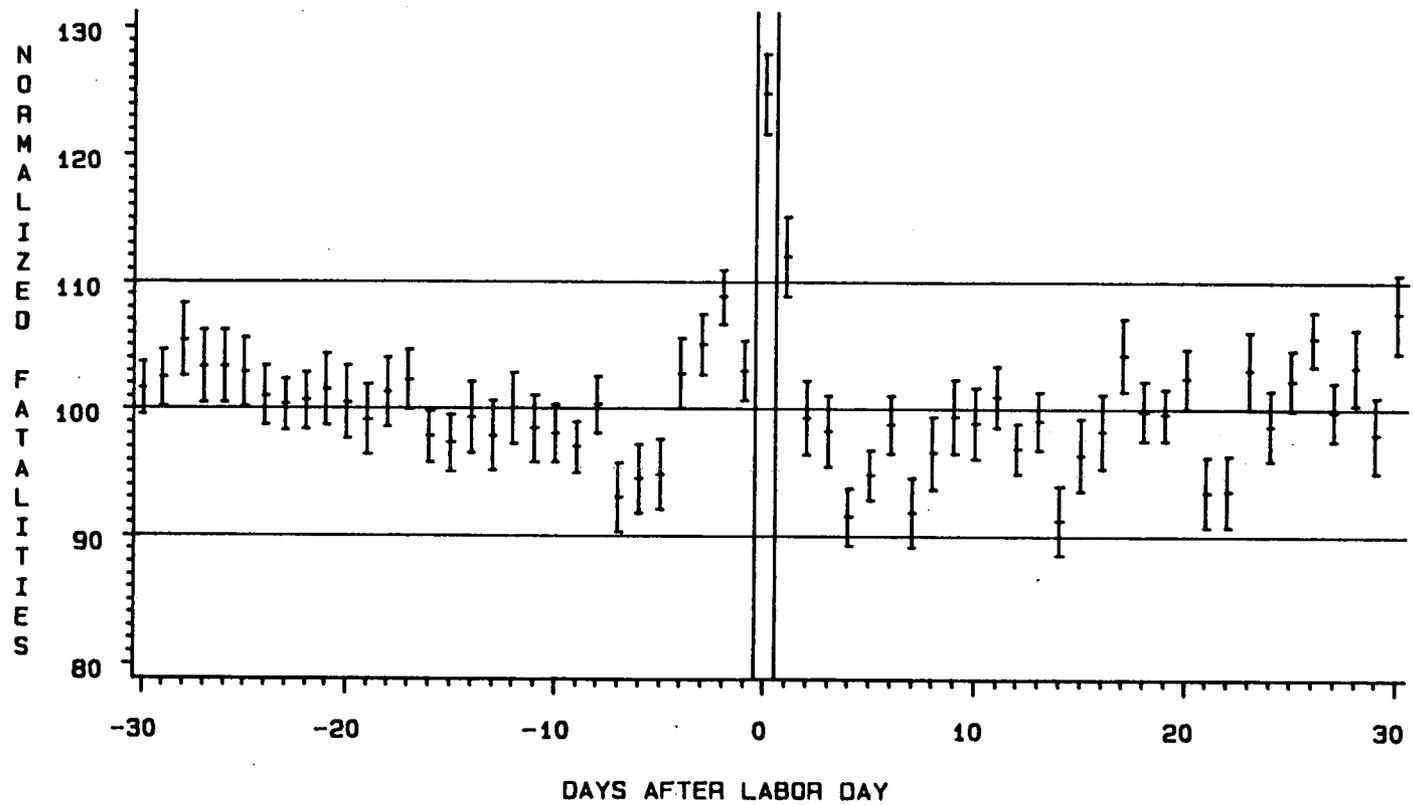
BAR LENGTH IS 2 STANDARD ERRORS

FIGURE 9  
Normalized Fatalities Near Memorial Day  
Averaged over 1975-85



BAR LENGTH IS 2 STANDARD ERRORS

FIGURE 10  
Normalized Fatalities Near Labor Day  
Averaged over 1975-85



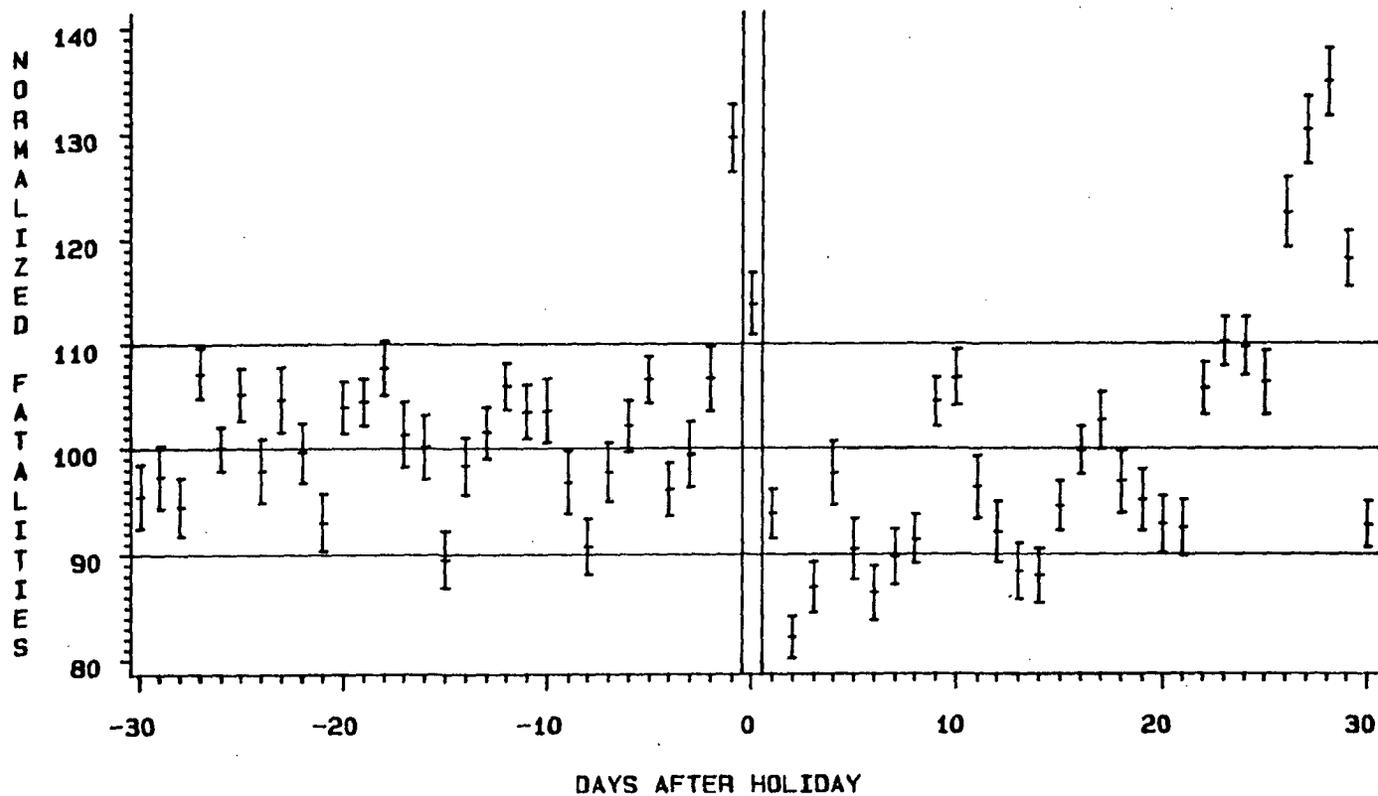
14

BAR LENGTH IS 2 STANDARD ERRORS

FIGURE 11

# Normalized Fatalities Near Thanksgiving Day

Averaged over 1975-85

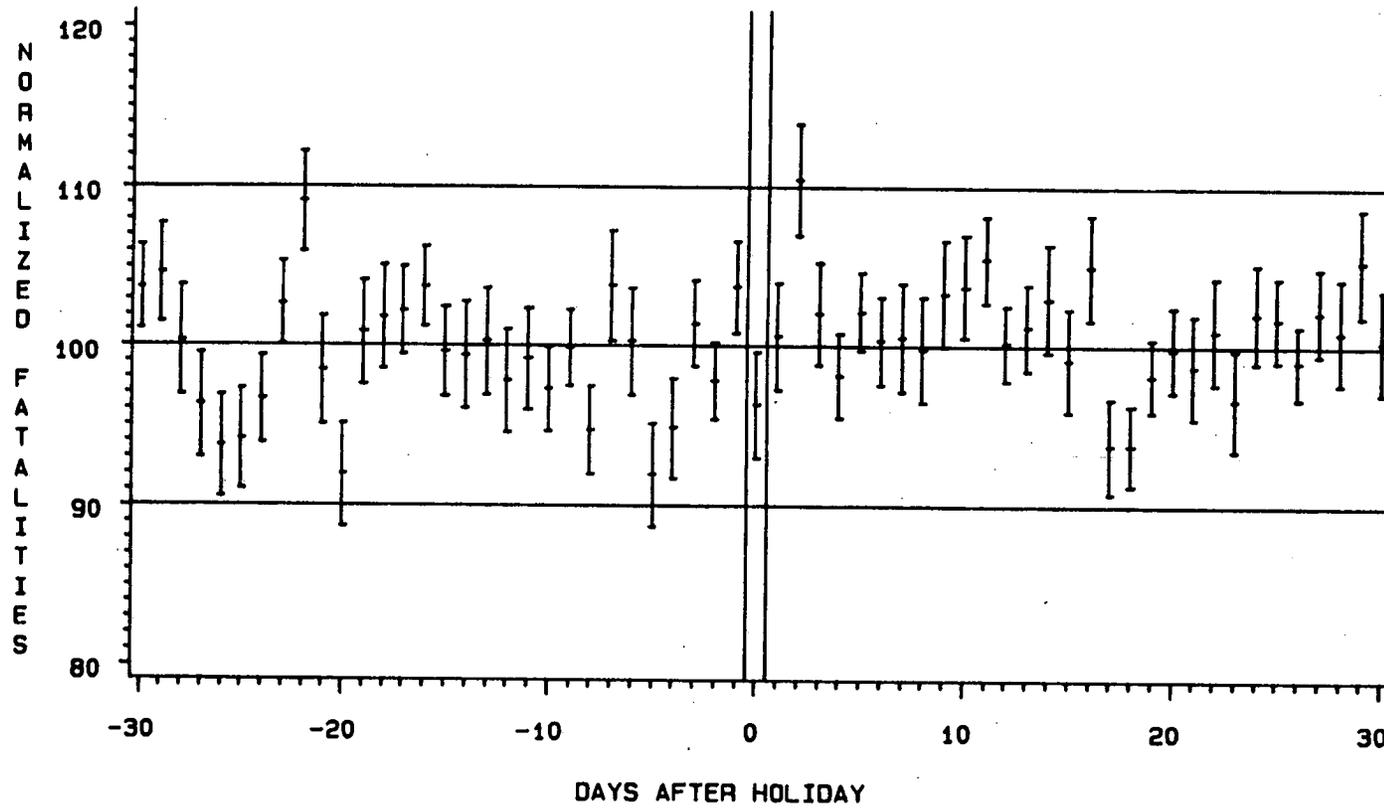


BAR LENGTH IS 2 STANDARD ERRORS

FIGURE 12

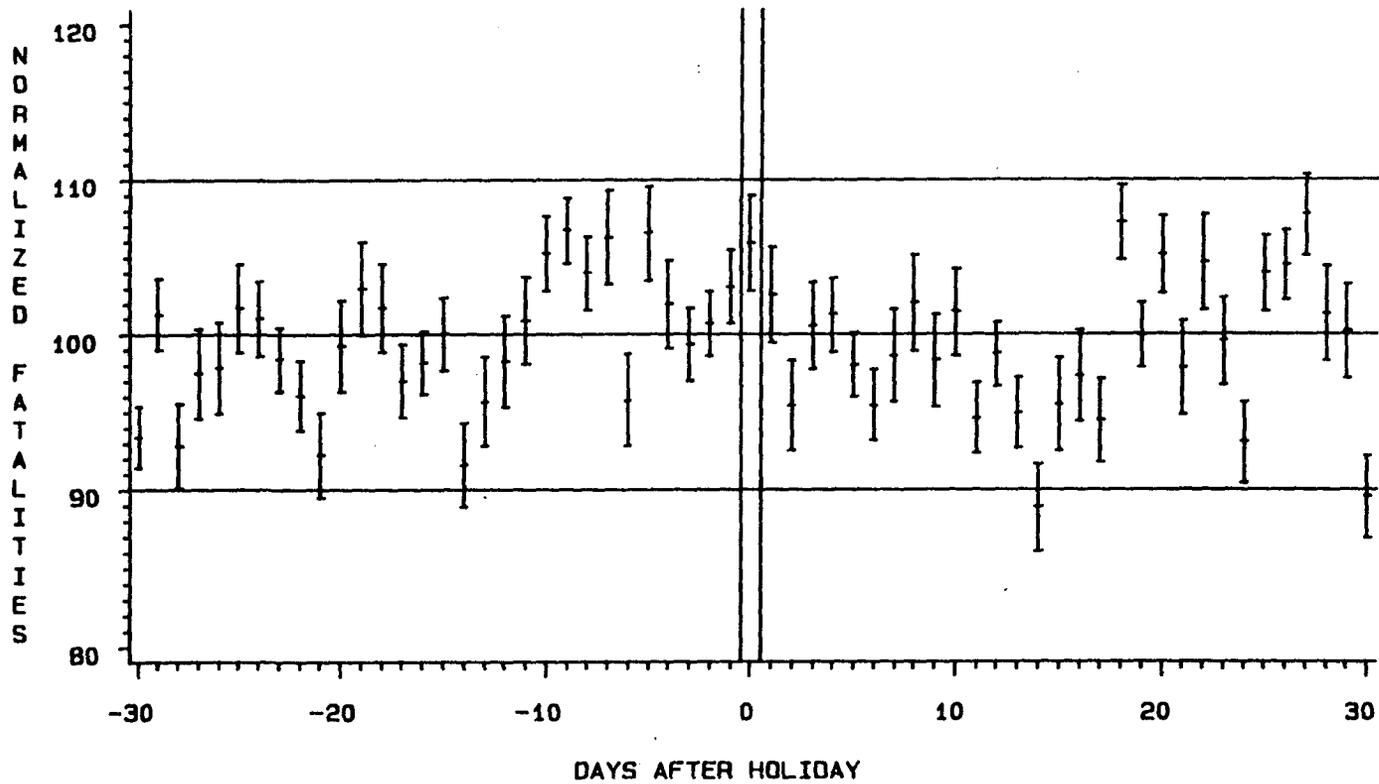
# Normalized Fatalities Near Presidents Day

Averaged over 1975-85



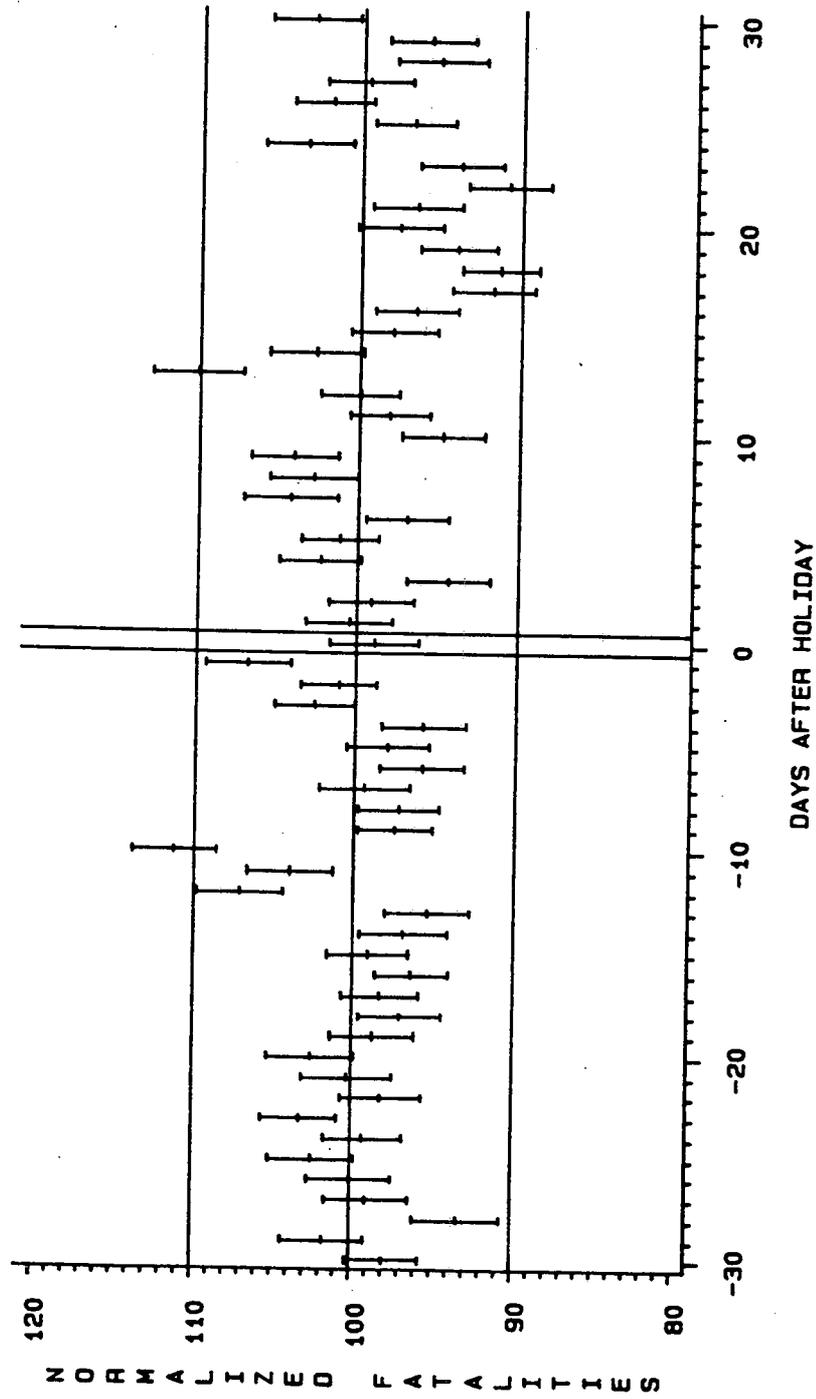
BAR LENGTH IS 2 STANDARD ERRORS

FIGURE 13  
Normalized Fatalities Near Columbus Day  
Averaged over 1975-85



BAR LENGTH IS 2 STANDARD ERRORS

FIGURE 14  
 Normalized Fatalities Near Veterans' Day  
 Averaged over 1975-85



BAR LENGTH IS 2 STANDARD ERRORS

Figure 13. The same can be said for Columbus Day, the second Monday in October, except that the day itself is nonsignificantly above 100.

Figure 14. Another federal holiday, Veterans Day, was on the fourth Monday in October in 1975-77 and on November 11 in 1978-85 but with Friday or Monday substituted for Saturday or Sunday respectively. The plot of this holiday in Figure 14 shows no interesting features.

#### Summary of Findings:

This section summarizes the traffic fatality effects of each national holiday period. These effects are averages over the entire 11-year period and may differ from what may happen in a specific year. In addition, these estimates are subject to statistical variation which places a 95% confidence limit of plus or minus 10% around each estimate. For example, when a holiday shows an average increase of 40% the conclusion that can be reached is that it is highly probable that the average increase falls between 30% and 50%.

No estimate is provided for the Martin Luther King Jr. birthday because no historical data exist for this holiday.

No statistically significant changes occurred during President's Day, Columbus Day, or Veterans Day.

For Memorial Day the effect on traffic fatalities is limited to the holiday itself and is estimated at a 32% increase over non-holiday Mondays in May.

The July 4th holiday produces increases for both the 3rd and the 4th of the month which were estimated at 20% and 37% respectively.

Labor day reflects an increase of 35% for the holiday itself and a marginally significant 16% increase for the day after.

For Thanksgiving, we find that the day before, Wednesday, produces a 42% increase while for Thanksgiving day the increase was 19%.

The effect over the Christmas holiday is quite singular. First there is a significant increase during the four days before Christmas, followed by significant decreases during the period of the 25th to the 30th of December. The increases for the 21st to the 24th were 18%, 29%, 40%, and 41% respectively. The decreases for the 25th to the 30th were 11%, 18%, 13%, 21%, 19%, and 15% respectively. Overall, the increase occurring during the days before Christmas is about twice as large as the decrease shown in the second period.

New Year's Day has the largest effect of any holiday. Fatalities increase by 64% on New Year's Day itself but are at the normal level on adjacent days.

### Predicting fatalities on a particular holiday.

The number of fatalities to be expected on a particular holiday can be roughly forecast by using the averages observed during 1975-1985. The forecast is the product of three quantities: the average for that holiday relative to its weekday, the average for that weekday relative to all days of its month, and the expected daily toll for that month relative to its 11-year average. Two examples illustrate the procedure.

The experience of the 11-years shows that the average Memorial Day produces about 23% more fatalities than does the average Monday in May. At the same time, the average Monday in May produces about 23% fewer fatalities than does the average day in May (the 102 average for May Mondays in Table A is 77% of the 132 average for May in Figure 2). Comparing Memorial day to the rest of May, then, it has about 95% ( $1.23 \times (1 - 0.23)$ ) as many fatalities as the daily average for May.

The daily average for May 1987 can be forecast from a time series model of the monthly fatality history from 1975 up to the latest month available. Such a model accounts for the seasonal variation of fatalities and for the current trend, or underlying level. As of early March 1987, when the most recently available monthly fatality estimate is for January 1987, the time series model forecasts 130 fatalities per day for May 1987. The forecast for Memorial Day is therefore  $130 \times 0.95 = 125$  fatalities. By early May, estimates for February and March will be available so the time series model should more accurately reflect the "current" trend in forecasting May.

A second example is July 4, 1987, which will fall on Saturday. July 4 has averaged 37% higher than its weekday. Saturdays in July average 43% higher than all July days (210 from Table A divided by 147 from Figure 2). July 4 fatalities in 1987 are therefore expected to be almost twice ( $1.43 \times 1.37$ ) the daily average that will be forecast for that month.

These forecasts are subject to considerable uncertainty. An inherent minimum uncertainty arises from forecasting random events. Expressed as a standard error of the estimate, this uncertainty is equal to the square root of the number of events. For the Memorial Day forecast of 125 fatalities, this would be about 11, or about 9% of the estimate. There is also an uncertainty in the factors that are based on 11-year averages and are used in a forecast. The standard error in estimating the average for a particular day of the year is about 4.5%, as was pointed out in the discussion of Figure 6. A one-year estimate has about 3.3 times (square root of 11) the uncertainty of an of 11-year average estimate. This is a 15% standard deviation in the factor used in the forecast. Comparing observed and predicted holiday fatalities for each year in the eleven-year period shows a standard deviation about the same as the theoretical 15%. The time series forecast error will generally be less than 5% if made only one or two months in advance, and will be swamped by the 15% error. Taking all this into account, the approximate 95% confidence band for a holiday prediction will be from 30% below the prediction to 30% above.