NOAA Technical Memorandum NOS OES 8

SPECIAL 1994 TIDAL CURRENT PREDICTIONS FOR ARANSAS PASS, CORPUS CHRISTI, TEXAS

Silver Spring, Maryland
January 1994

noaa National Oceanic and Atmospheric Administration

U. S. DEPARTMENT OF COMMERCE
National Ocean Service

Office of Ocean and Earth Science
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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United States
Department of Commerce
Ronald H. Brown, Secretary

National Oceanic and
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National Ocean Service
W. Stanley Wilson
Assistant Administrator

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ABSTRACT

Improved tidal current predictions in Corpus Christi, Texas, are essential to enhance the safety level for large tankers navigating through Aransas Pass. The National Ocean Service (NOS) of the National Oceanic and Atmospheric Administration (NOAA) conducted a quality assurance miniproject to assess the adequacy of current predictions at Aransas Pass and Port Ingleside during April and May 1990, using acoustic Doppler current profilers. Results indicated that NOAA's existing Tidal Current Tables were outside of established NOS working standards and prompted a notice to mariners regarding the traditional tables. New predictions derived from standard harmonic analysis techniques show improvement over historical predictions. Descriptive statistics of differences between observed and predicted currents showed slight improvement from a mean of 0.16 knots and standard deviation of 0.51 knots for the 1966-based predictions to an average of 0.00 knots and standard deviation of 0.44 knots for the 1990-based predictions. Predictions for Aransas Pass that are based on a 29-day harmonic analysis from April 9 to May 7, 1990, will be published in NOAA's, **Tidal Current Tables 1995-Atlantic Coast of North America** and ensuing years. Recommendations are given for additional data acquisition to improve the quality of the predictions and for installation of a real-time system.

1. INTRODUCTION

The forerunners of the National Oceanic and Atmospheric Administration (NOAA) began measuring and reporting current information for the nation's waterways during the 1890's. Today's tidal current tables include predictions for the times of slack water and the times and velocities of maximum flood and ebb currents for reference stations with differences and ratios for estimating the currents at nearby secondary sites. Improved predictions of tidal currents in estuarine areas are essential to support navigation of supertankers; to provide a starting point for the mitigation of hazardous material spills, and to help improve the margin of safety for heavily trafficked ports and harbors. This is particularly true along the Texas Gulf coast where an increase in commercial operations results in the need for improved prediction of current speeds and where National Ocean Service (NOS) predictions are based on very old data, much of it acquired during the 1930's.

In 1934, Aransas Pass tidal current predictions were referenced to predictions from Galveston Bay Entrance, Texas. Galveston Bay current predictions were computed from harmonic constants derived from two 29-day current pole and Price current meter time series beginning on April 5, 1935. The present Aransas Pass secondary station, on Galveston Bay, is based on a 29-day survey which commenced on February 13, 1966, using Geodyne current meters. These early surveys determined that both the ebb and flood speed ratios between Galveston Entrance and Aransas Pass were 0.5. The maximum predicted flood and ebb speeds at Aransas Pass during the years from 1990 through 1993 are 1.7 and 2.1 knots, respectively. Since the 1966 survey, various morphological changes to Corpus Christi Bay have changed circulation patterns. In fact, mariners report current speeds in Aransas Pass in excess of 2.5 knots (NOS, 1992).

Predicted tidal currents are based on astronomical forces and to a lesser extent, morphometry. They do not include the effects of meteorological conditions. For this reason mariners should be cautioned that circulation patterns change with respect to unusual weather conditions or when the basin is physically changed by severe weather, dredge operations, or the development of new structures. Wherever practical, efforts are presently underway to modernize tidal current predictions by adding new reference or secondary stations, modeling estuarine environments, and installing physical oceanographic real-time systems (Appell et al., 1991, Frey, 1991, and Nichols, 1993).

2. ARANSAS PASS TIDAL CURRENTS

Tidal currents along the South Texas coast are principally diurnal (Smith, 1974). The current velocity increases for about 6 hours until the strength of current is reached and then decreases for approximately 6 hours to the following slack water. Except when the moon is near the equator, a complete flood and ebb period should occur within one lunar day (i.e., approximately 24.8 hours). Tidal current speeds are significantly modulated by the moon's declination. Currents indigenous to Corpus Christi are also modified by morphometry and transiently influenced by the weather. Typical tropic and equatorial tidal currents during spring 1990 are highlighted in Figure 1.

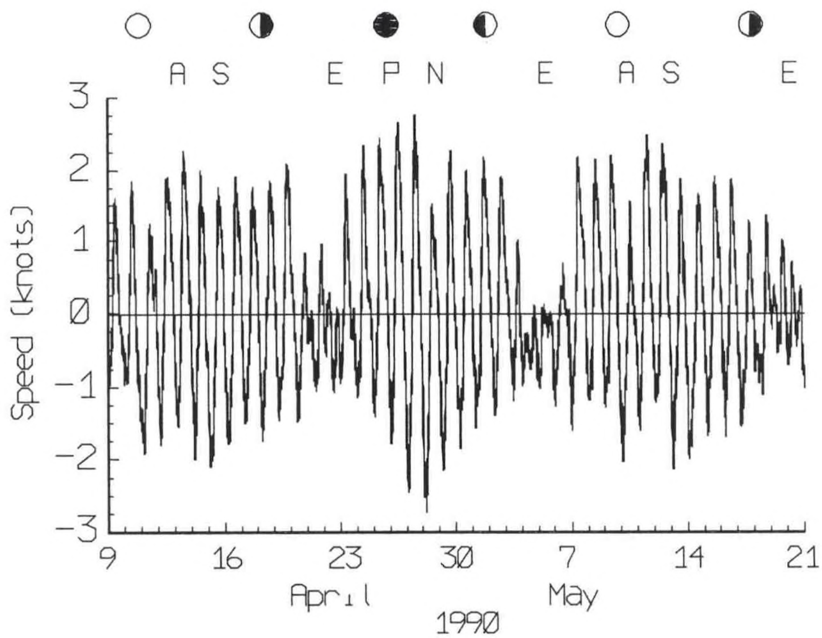

Figure 1. Aransas Pass currents. Flood velocities are positive and ebb velocities are negative. The abscissa is in Greenwich Mean Time (GMT). Lunar symbols are listed on the inside back cover.

Reports by mariners of deviations between predicted and observed tidal currents (Figure 2) in the Corpus Christi area prompted the NOS to conduct a current prediction quality assurance (QA) miniproject. A QA miniproject involves the deployment of the minimum number of instruments to obtain sufficient data for objective statistical analysis of existing current predictions. As part of the Corpus Christi Bay QA miniproject, two 1200 kHz bottom-mounted acoustic Doppler current profilers (ADCPs) were deployed at Port Aransas and Port Ingleside from April through May, 1990 (Figure 3). The ADCPs measured currents in 1-m layers or bins from the near bottom to the near surface with a sampling interval of 5 minutes. Maximum current speeds at Aransas Pass reference depth of 35 ft during the QA miniproject were 2.8 knots in the flood direction of 320° T. Statistical analysis of the differences between the published NOAA tidal current table parameters and those computed from the ADCP measurements, based on approximately 40 days of data, highlighted the inadequacy of existing tidal current predictions (Williams et al. 1991). Results indicated that NOAA's existing Tidal Current Tables were underestimating current speeds by as much as 1.5 knots and deviating from the times of actual tidal current maxima by up to 2 hours (Williams et al., 1991). Current variability in Corpus Christi Bay was due in part to morphometric changes occurring since 1966 and to wind-induced nontidal currents.

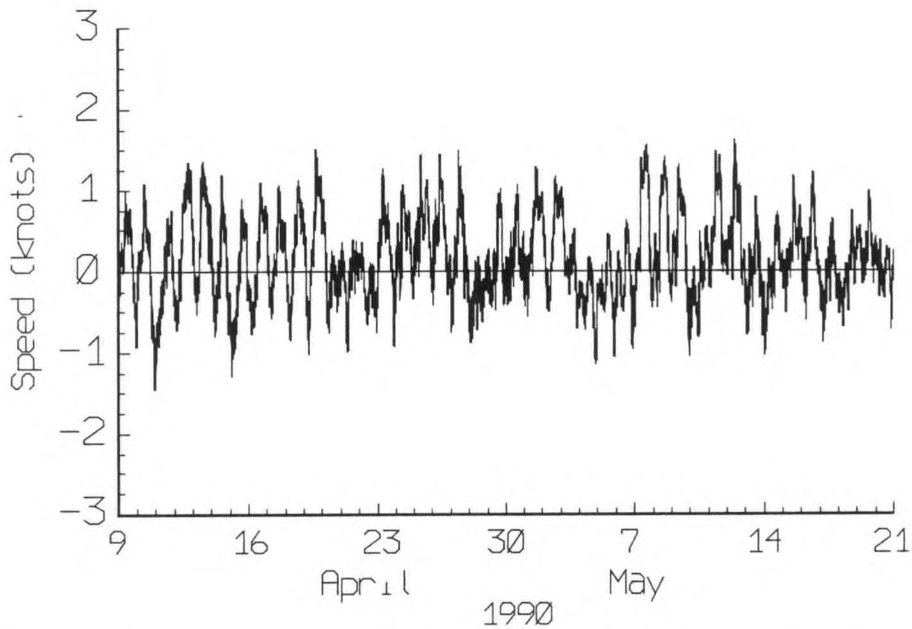

Figure 2. Aransas Pass Residual Currents. Observed tidal currents minus the 1966 based predictions are provided in GMT for spring 1990.

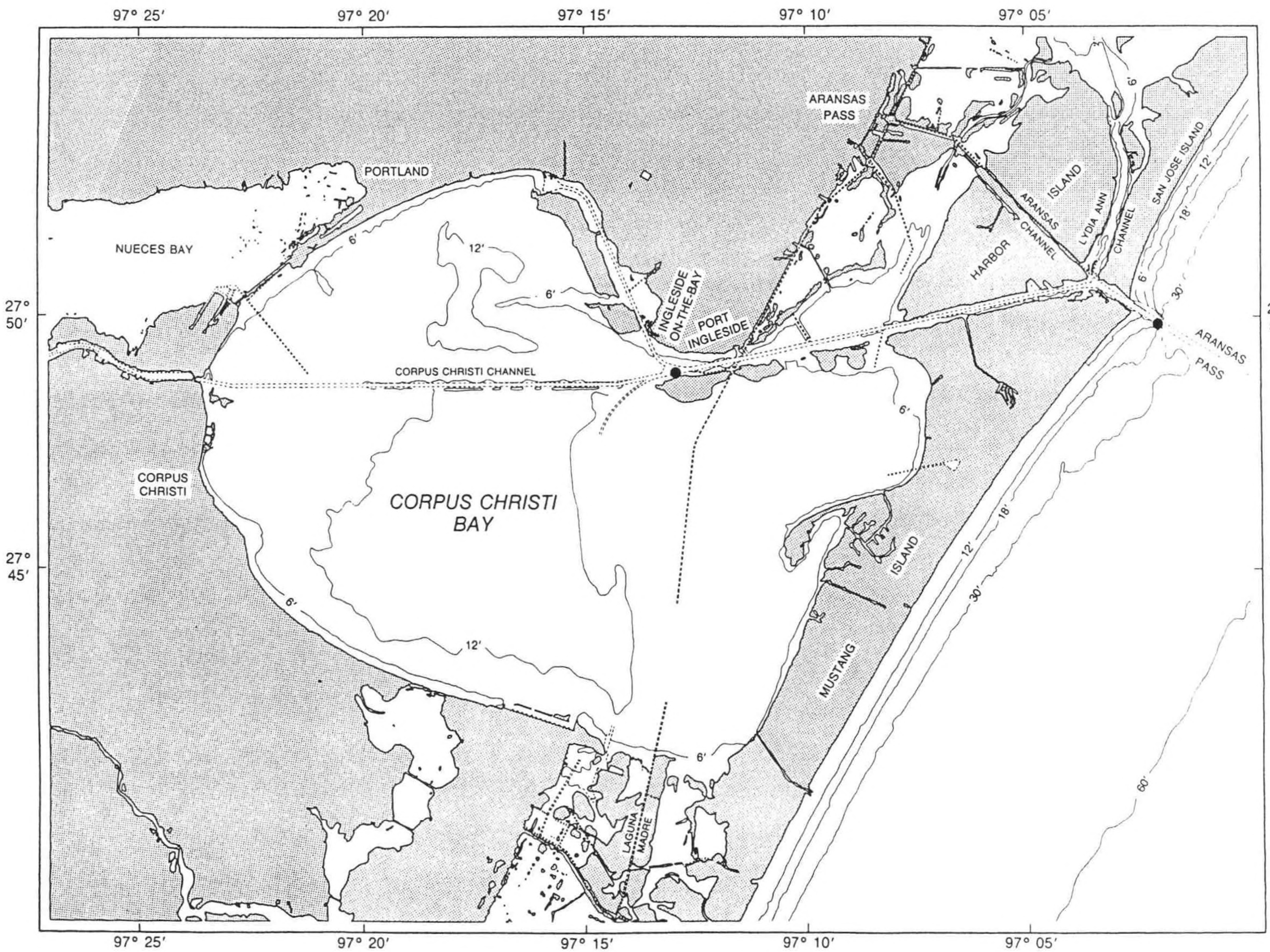

Figure 3. Corpus Christi Bay Current Meter Sites (•). The Aransas Pass station was near historic sites from April 8 to May 21, 1990. Port Ingleside data were collected from April 9 to 25, 1990.

3. DATA ANALYSIS

Data collected in support of the QA miniproject were used to develop an Aransas Pass reference station and a Port Ingleside secondary station for NOAA's **Tidal Current Tables-Atlantic Coast of North America**. In order to support deep draft vessels, the 35-ft depth at Aransas Pass was chosen as reference for comparison with other tidal current measurements from Corpus Christi Bay. The profiling ability of the ADCP allowed the establishment of 15- and 50-ft depth secondary sites at Aransas Pass and the 5 ft depth secondary site at Port Ingleside. Standard harmonic analysis techniques were used to obtain tidal current constituents from the data, to orient constituents with astronomical elements, and to eliminate the disturbing effects of one tidal current constituent upon another (Schureman, 1958, Dennis and Long, 1971, and Zetler, 1982).

Aransas Pass currents at a depth of 35-ft from April 8 to May 20, 1990, were found to be reversing with speeds up to 2.8 knots. Currents were well established by the time that flood or ebb speeds exceeded 0.1 knots. Therefore, slack water during this investigation is defined as weak currents having speeds less than or equal to 0.1 knots. Periods of zero velocity were momentary. A scatter diagram from velocity measurements at Aransas Pass shows symmetric reversing flow aligned with the navigation channel (Figure 4). The direction of flood currents at Aransas Pass is oriented toward 300° T and ebb flow is directed toward 120° T. Mean flood and ebb speeds are approximately 1.2 and 1.3 knots, respectively.

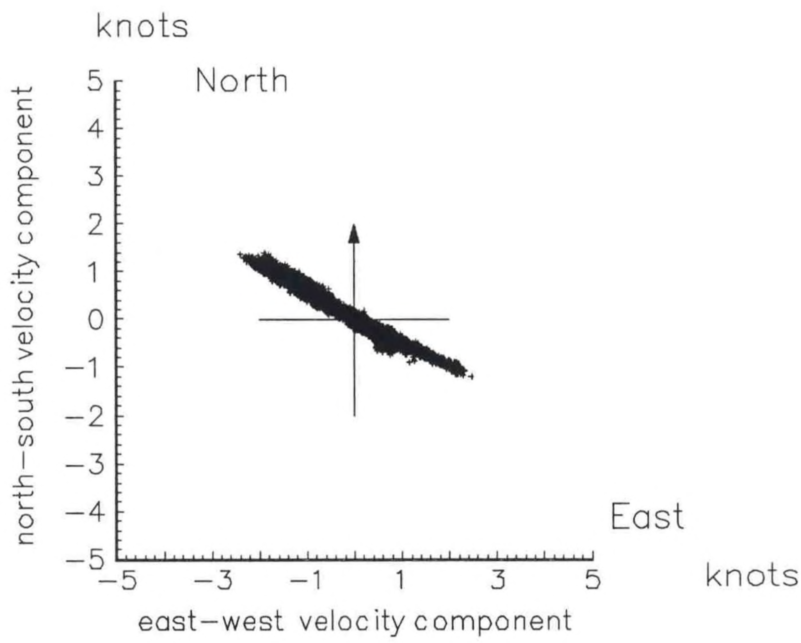

Figure 4. Velocity scatter diagram for Aransas Pass. The plot illustrates the alignment and the degree of scatter in the current direction.

Although the NOS strives to perform harmonic analysis in support of reference stations using 6-months of data, a record length of 29 days is sufficient to resolve the amplitudes and phase lags of 24 tidal current constituents. The amplitudes and phase lags of tidal current constituents at Aransas Pass were analyzed both parallel and perpendicular to the principal flood direction of 300° T. The mean tidal current was in the flood direction with an amplitude of 0.03 knots. The primary constituents are M_2, S_2, K_1, and O_1 which represent the tide producing forces of the sun-earth-moon system. Ten of the constituents are determined directly from the data (i.e., M_2, S_2, N_2, O_1, K_1, M_4, M_6, M_8, S_4, and S_6), and the remaining 14 are derived from M_2, S_2, N_2, O_1, and K_1 since they follow theoretical relationships (Schureman, 1958). The M_2, S_2, and N_2 constituents are corrected for the disturbing effects of other semidiurnal constants while O_1 and K_1 are corrected for the disturbing effects of other diurnal constituents. Flood and ebb directions are calculated by averaging every direction within 20° of the principal component direction. Table 1 lists harmonic analysis results.

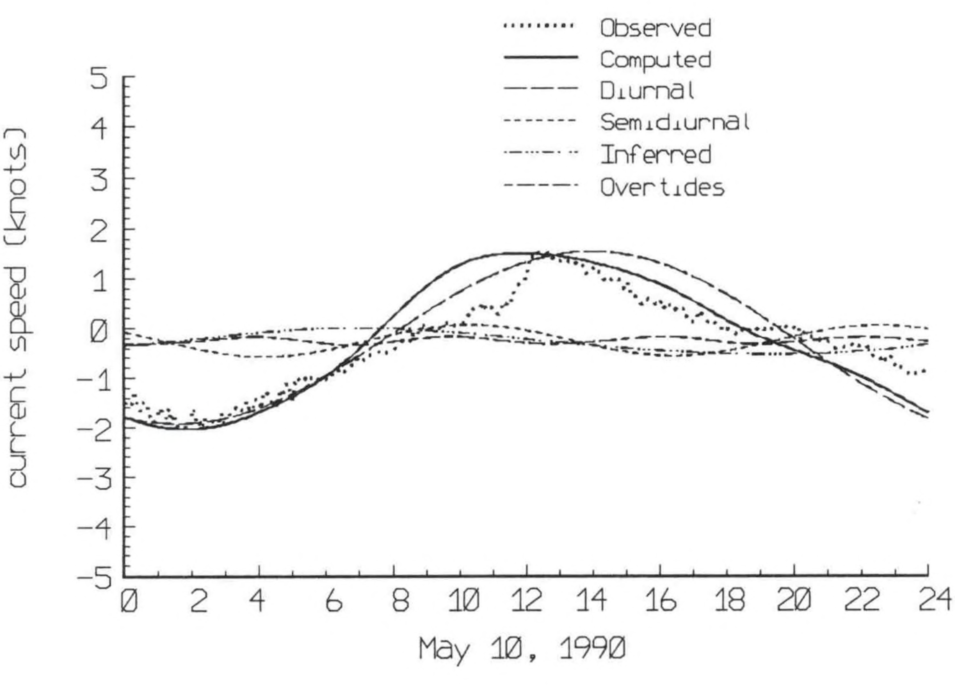

Figure 5. Computed tidal currents. By determining correct harmonic constants one can compute expected tidal currents, which now agree well with the observed tidal current.

Harmonic prediction involves relating computed constituents (Figure 5) with prevailing astronomical conditions such as the rotation of the earth, the revolution of the earth around the sun, the inclination of the moon's orbit to the earth's equator, and the obliquity of the ecliptic into the resultant velocity. Average Greenwich epochs and amplitudes were determined from the observed current record. The lag between constituents of the tidal current and the moon's crossing of 0° longitude, the prime meridian, is classified as the Greenwich epoch. Longitude and time meridian corrections were applied to the Greenwich epochs to obtain a modified epoch designated K´. Current amplitudes and K´s form a basis for both reference and secondary station tidal current predictions. The mean and standard deviation for residual currents at Aransas Pass improved from 0.16 and 0.51 knots for 1966 predictions (Figure 2) to 0.00 and 0.44 knots for 1990 predictions (Figure 6). Beginning in 1995, predictions from harmonic analysis of data from April 9 to May 7, 1990, will be published in NOAA's **Tidal Current Tables-Atlantic Coast of North America**.

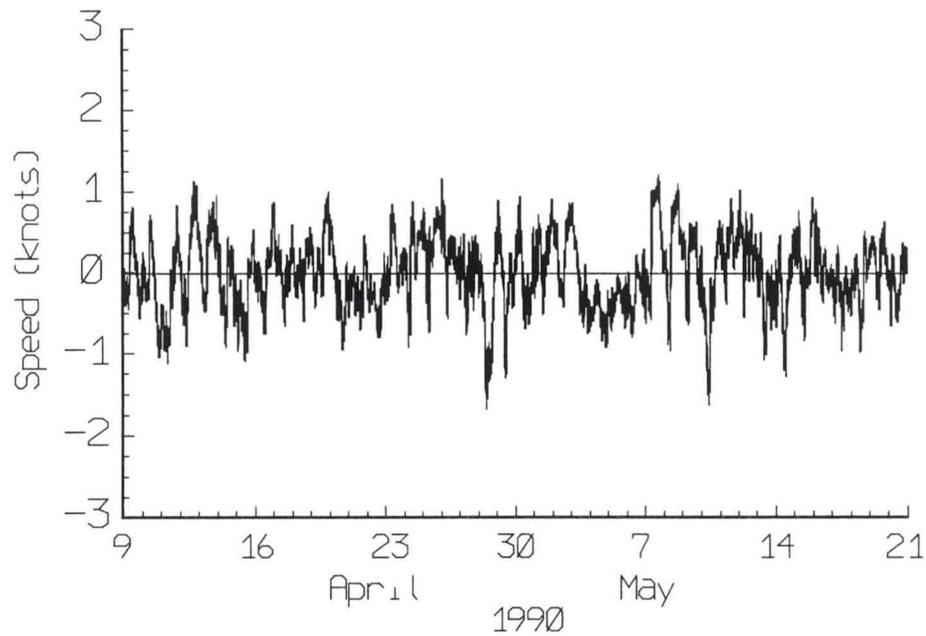

Figure 6. Aransas Pass Residual Currents. Observed tidal currents minus the 1990 based predictions are provided in GMT for Spring 1990.

Table 1. Summary of results from 29-day harmonic analysis of currents for Aransas Pass, April 9 to May 7, 1990. Measurements were taken at approximately 35 ft below MLLW in the 58 ft deep navigation channel. Flood direction is 300° T. A negligible permanent current was measured during the deployment period.

Constituent	Speed (knots)	K' (degrees)	Constituent	Speed (knots)	K' (degrees)
J_1	0.070	286.7	OO_1	0.038	290.4
K_1	0.958	282.9	P_1	0.317	282.4
K_2	0.026	80.2	Q_1	0.172	271.7
L_2	0.010	79.8	$2Q_1$	0.023	268.1
M_1	0.063	279.2	R_2	0.001	81.2
M_2	0.310	105.6	S_2	0.095	82.1
M_4	0.057	184.9	S_4	0.029	167.2
M_6	0.010	282.2	S_6	0.011	191.3
M_8	0.002	38.9	T_2	0.006	83.1
N_2	0.071	79.8	λ_2	0.002	94.7
$2N_2$	0.009	54.0	ν_2	0.014	83.3
O_1	0.884	275.5	ρ_1	0.034	272.3

4. DAILY CURRENT PREDICTIONS

Predicted times of slack water and the predicted times and speeds of maximum current-flood and ebb-for each day during 1994 at Aransas Pass are found in Appendix A. The predictions are for the 35-ft depth. The data in this Appendix supersedes Aransas Pass Table 2 values listed in the traditional tables for Station 8606. Local standard times are given in hours and minutes. Current amplitudes are in knots.

5. SECONDARY STATION RATIOS AND DIFFERENCES

The Port Ingleside secondary station location is sited approximately 10 miles west of Aransas Pass on the northern edge of Corpus Christi channel. Currents were on the order of a knot from 9 through 24 April 1990 and oriented along the channel in an east-west fashion as shown in Figure 7. The principal direction is oriented along 105° T. The mean current was 0.20 knots in the flood direction. Flood conditions were more robust than the ebb. Time differences and velocity ratios were determined by examining corresponding tidal current periods during the fortnightly period from April 10 to April 25, 1990 (Figure 8). A typical cycle-by-cycle analysis of Aransas Pass and Port Ingleside currents for April 12, 1990 is provided in Figure 9. During the time of equatorial tidal currents (Hicks, 1989), the amplitudes at both Port Ingleside and Aransas Pass were below 0.7 knots and Port Ingleside currents tended to be larger than Aransas Pass currents.

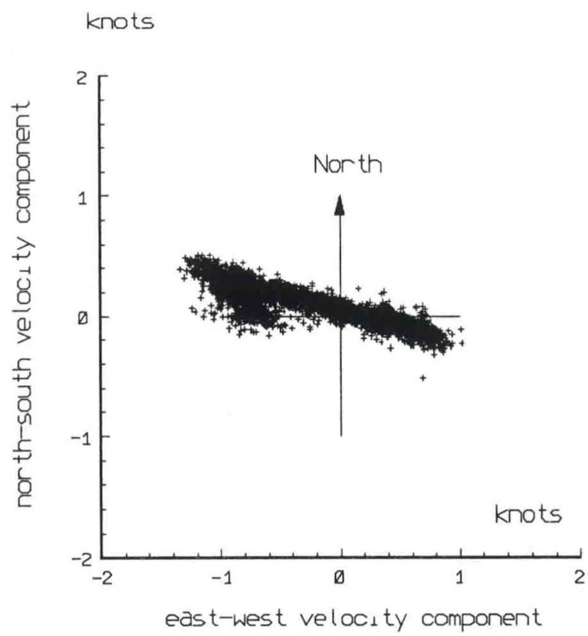

Figure 7. Velocity scatter diagram for Port Ingleside. Currents 8 ft from the bottom are rectilinear and on the order of one knot.

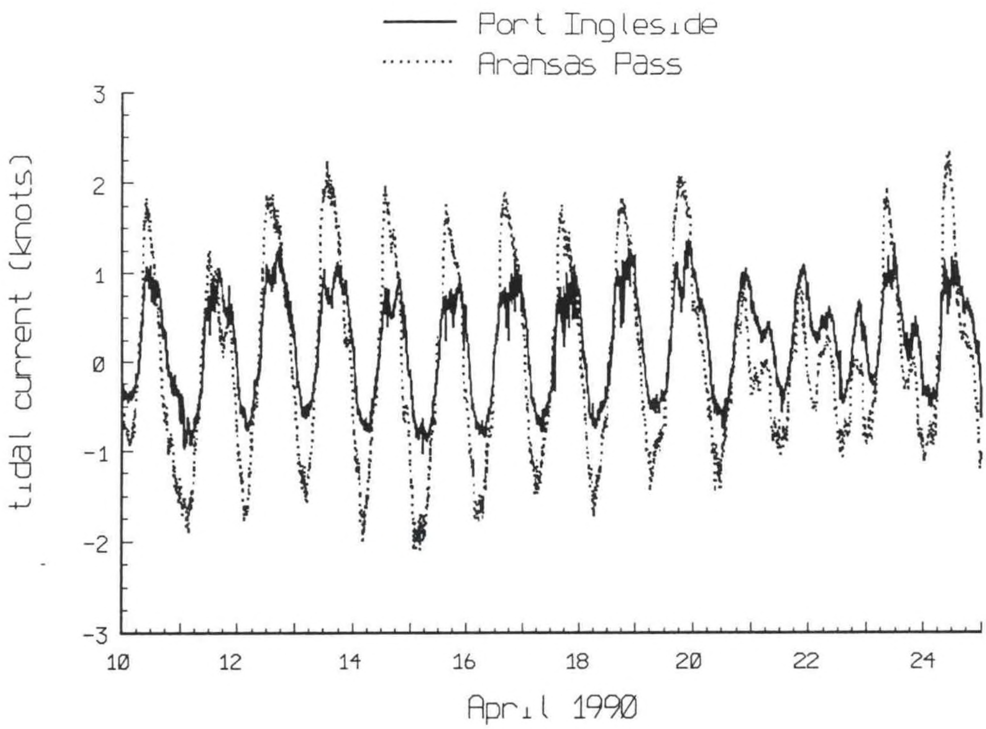

Figure 8. Tidal currents at Aransas Pass and Port Ingleside from 9 through 24 April 1990. Both time series are in GMT.

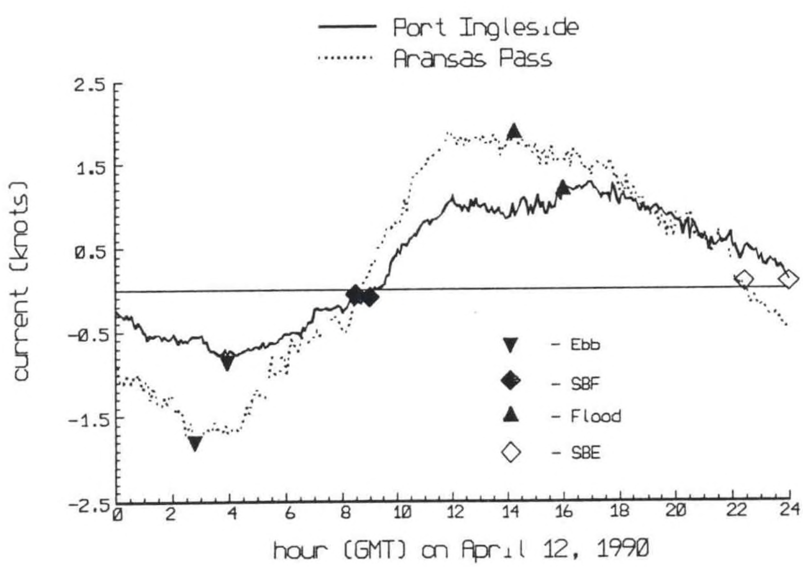

Figure 9. Cycle-by-cycle tidal current comparisons. Time differences and velocity ratios were determined by comparing Port Ingleside and Aransas Pass currents.

Secondary stations are also provided at Aransas Pass for the near-surface (15 ft) and near-bottom (50 ft) depths. Based on current observations during mid April 1990 under normal weather conditions (i.e., barometric pressure was between 1015 and 1020 mb and temperature was increasing from 21° to 23° C), current speed differences on the order of 1 knot were measured during the ebb from the near-surface to near-bottom with a negligible change in phase (Figure 10). Flood differences were much less energetic and approached 0.3 knots. Speed ratios are derived from the entire deployment and are provided in Table 2.

Secondary station velocity ratios and time differences are provided in Table 2. This information enables one to estimate times of minimum currents and the times and speeds of maximum currents at each subordinate station based on its relationship to currents at the 35 ft depth in Aransas Pass. By applying the specific corrections given in Table 2 to the predicted times and speeds of the current at the reference station, approximations of the current can be derived for any subordinate station.

The listed speed ratios are multipliers and are used to approximate daily maximum flood and ebb speeds at a subordinate station. The ratios should always be applied to the corresponding current phases at the reference station. Speeds at the reference station and those resulting from the use of these ratios are expressed in knots. Directions of the four current phases are in degrees true clockwise from 000° North to 359° and are the directions toward which the water is flowing.

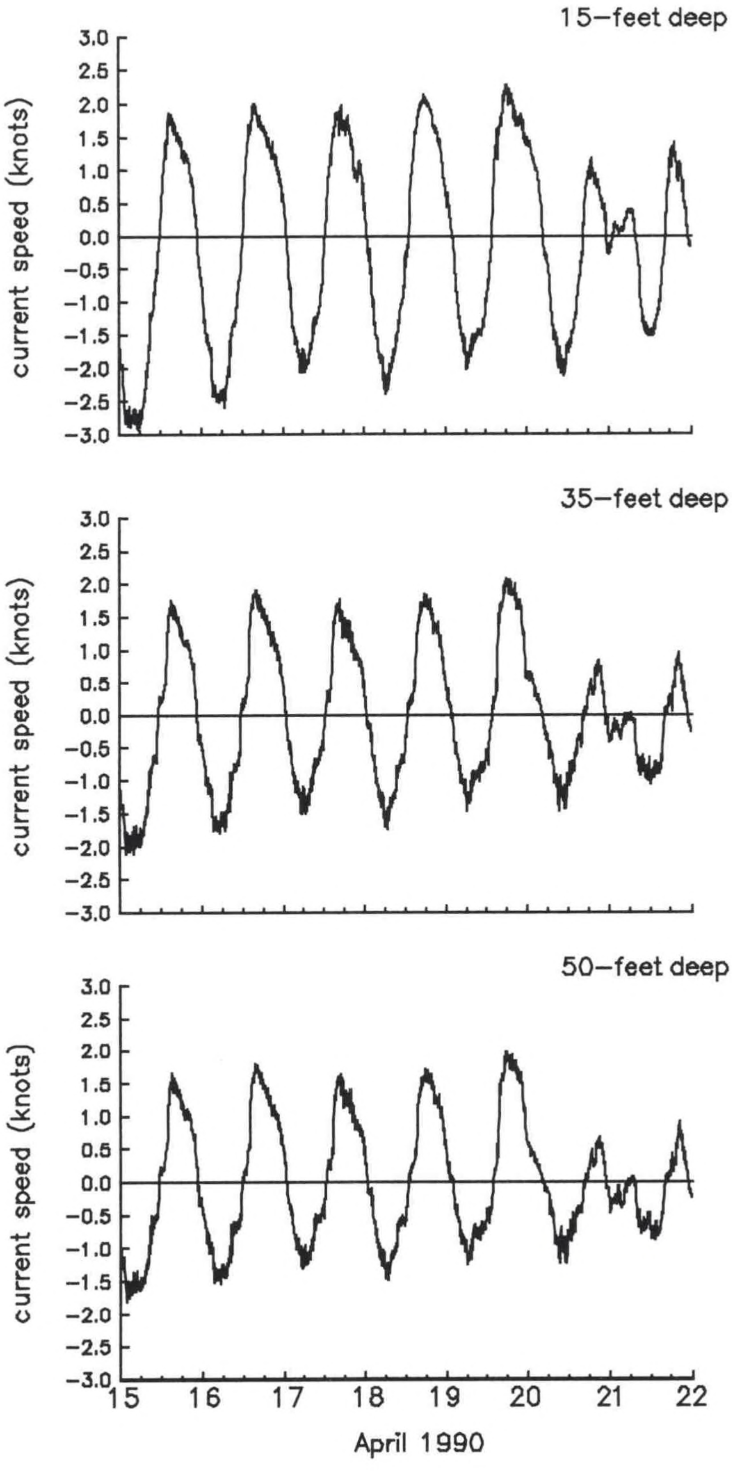

Figure 10. Multiple Depth Current Profiles at Aransas Pass. The top, middle, and bottom panels range respectively from -2.90 to 2.30, -2.10 to 2.08, and -1.80 to 1.99 knots.

6. DATA AND INFORMATION PRODUCT

The data used to develop these special predictions are archived and available to the public from NOAA. **The Tidal Current Tables 1995-Atlantic Coast of North America** will be revised to include the data in this publication. Additional copies of this publication can be obtained by writing or calling:

NOAA/National Ocean Service
Coastal and Estuarine Oceanography Branch
ATTN: Information, Products, and Services Section, N/OES334
1305 East-West Highway
Silver Spring, Maryland 20910
Telephone: 301-713-2812
Facsimile: 301-713-4500.

7. CONCLUSION

The 29-day analysis of ADCP measurements in 1-m layers or bins from the near-bottom to the near-surface with a sampling interval of 5 minutes serves as a much better base for tidal current predictions than the 1966 survey. Ideally, NOS would base tidal current predictions on time series of current speeds and directions lasting over a 6-month to 1-year period. Deviations from tidal current predictions in Corpus Christi Bay are due in part to morphology and wind induced nontidal currents. For this reason, it has been recommended that a physical oceanographic real-time system be installed to support navigation along the South Texas coast (Williams et al., 1991). Future oceanographic efforts in the Corpus Christi Bay area should address hydraulic flow through Aransas channel and the relationships between varying wind directions and the occurrence of exaggerated tidal currents and water level fluctuations. Year-long data sets of currents, pressure, water temperature, air temperature, salinity, water level, and winds would be most useful for development of improved prediction and forecasting products.

The updated tidal current predictions at Aransas Pass along with the secondary station at Port Ingleside should be beneficial to dockmasters, harbor pilots, and US Navy sailors attempting to maneuver large vessels through the various connecting channels which couple Corpus Christi Bay with the Gulf of Mexico. This information is designed to assist vessels with the maintenance of course and speed while conforming to a channel having confined waters. Results from this investigation will be published in NOAA's **Tidal Current Tables 1995-Atlantic Coast of North America**.

Table 2. Current differences and other constants. Results were derived from data collected during April and May, 1990 QA miniproject.

No.	PLACE	Meter Depth	POSITION		TIME DIFFERENCES				SPEED RATIOS		AVERAGE SPEEDS AND DIRECTIONS							
			Latitude	Longitude	Min. before Flood	Flood	Min. before Ebb	Ebb	Flood	Ebb	Minimum before Flood		Maximum Flood		Minimum before Ebb		Maximum Ebb	
		ft	North	West	h m	h m	h m	h m			knots	Dir.	knots	Dir.	knots	Dir.	knots	Dir.
	TEXAS COAST Time meridian, 90° W				on Aransas Pass													
8607	Aransas Pass	15d	27° 50.03'	97° 02.65'	0 00	0 00	0 00	0 00	1.1	1.5	0.0	- -	1.9	300°	0.0	- -	2.0	118°
	. . . do.	35d	27° 50.03'	97° 02.65'	*Daily predictions*						0.0	- -	1.6	300°	0.0	- -	1.5	118°
	. . . do.	50d	27° 50.03'	97° 02.65'	0 00	0 00	0 00	0 00	0.9	0.8	0.0	- -	1.0	300°	0.0	- -	0.7	118°
8610	Port Ingleside	5d	27° 48.90'	97° 13.80'	+0 24	+1 48	+2 11	+1 09	0.7	0.5	0.0	- -	0.7	286°	0.0	- -	0.5	102°

8. ACKNOWLEDGMENTS

This study was done as a follow-up to the Corpus Christi Bay Current Prediction Quality Assurance Miniproject that was conducted by the Coastal and Estuarine Oceanography Branch of the NOS during 1990. Data collection support was provided by the U.S. Coast Guard Base in Corpus Christi and U.S. Army SCUBA divers from Fort Sam Houston. Useful insights and technical support for establishing reference and secondary stations were provided by Drs. Robert Williams and Chris Zervas, Mr. Richard Sillcox, Mr. Joseph Welch, Mr. Elmo E. Long, and Mr. Geoffrey French.

9. REFERENCES

Appell, G.F.; Mero, T.M., and Sprenke, J.J., 1991. Design of a Current, Water Level and Meteorological Information System For Tampa Bay, **IEEE Oceans Proceedings**, Volume 2, pp. 859-863.

Dennis, R.E. and Long, E.E., 1971. **A User's Guide to a Computer Program for Harmonic Analysis of Data at Tidal Frequencies**., NOAA Technical Report, NOS 41, 31p.

Frey, H.R., Physical Oceanographic Real-Time Systems for Operational Purposes, **Oceans '91 Proceedings**, 2, 859-863, October, 1991.

Hicks, S.D., **Tide and Current Glossary**, National Ocean Service, National Oceanic and Atmospheric Administration, Rockville, Maryland, October, 1989, pp. 30.

Nichols, C.R., 1993. Operational characteristics of the Tampa Bay Physical Oceanographic Real-Time System, **Proceedings, 1993 International Conference on Hydro Science & Engineering**, Volume 1, part B, Washington, D.C., pp. 1491-1498.

NOS, 1992. **United States Coast Pilot, Atlantic Coast: Gulf of Mexico, Puerto Rico, and Virgin Islands**. Charting and Geodetic Services, National Oceanic and Atmospheric Administration, Rockville, Maryland, 348p.

Schureman, P., 1958. **Manual of Harmonic Analysis and Prediction of Tides**, U.S. Department of Commerce, Coast and Geodetic Survey Special Publication No. 98, Revised (1940 edition, reprinted 1988), Washington, D.C., 317p.

Smith, N.P. 1974, **Intracoastal Tides of Corpus Christi Bay, Contributions in Marine Science**, University of Texas, 18, pp. 205-219.

Williams, R.G.; Bethem, T.D.; French, G.W., and Frey, H.R., 1991. **Corpus Christi Bay Current Prediction Quality Assurance Miniproject**. NOAA Technical Memorandum NOS OMA 60, National Ocean Service, Office of Oceanography and Marine Assessment, Rockville, Maryland, 46p.

Zetler, B.D., 1982. **Computer Applications to Tides in the National Ocean Survey**, Supplement to the Manual of Harmonic Analysis and Prediction of Tides (Special Publication No. 98), U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, Maryland, 85p.

APPENDIX

Special 1994 Tidal Current Predictions for Aransas Pass, Corpus Christi, Texas

Aransas Pass (between jetties), Texas, 1994

F–Flood, Dir. 300° True   E–Ebb, Dir. 120° True

January

Day	Slack h m	Maximum h m	knots
1 Sa	0247	0949	1.4E
	1445	1902	1.4F
2 Su	0243	1043	0.9E
	1504	1929	1.1F
3 M	0104	0443	0.3E
		0745	*
		1118	0.4E
	1425	1951	0.8F
	2310		
4 Tu ◑		0407	0.6E
	0733	0936	0.3F
		1139	*
		1505	0.4F
		1636†	0.4F
5 W		0354	1.0E
	0756	1415	0.9F
	2216		
6 Th		0410	1.4E
	0835	1414	1.4F
	2216		
7 F		0433	1.8E
	0920	1431	1.8F
	2233		
8 Sa		0513	2.1E
	1009	1506	2.0F
	2306		
9 Su		0554	2.2E
	1059	1541	2.1F
	2348		
10 M		0637	2.2E
	1147	1626	2.1F
11 Tu ●	0041	0720	2.1E
	1231	1704	1.9F
12 W	0140	0800	1.9E
	1311	1736	1.7F
13 Th	0228	0842	1.6E
	1347	1751	1.5F
14 F	0255	0918	1.3E
	1418	1809	1.2F
15 Sa	0245	1006	1.0E
	1444	1832	1.0F
16 Su		0416	*
		0536	*
		1036	0.6E
	1452	1858	0.8F
	2357		
17 M		0402	0.3E
		0718	*
		1105	*
		1919	0.6F
	2236		
18 Tu		0357	0.4E
		0900	*
		1105	*
		1438	0.3F
		1659†	0.3F
19 W ◐		0352	0.6E
	0729	1018	0.5F
		1106	0.5F
		1419	0.7F
	2154		
20 Th		0356	0.9E
	0805	1415	1.0F
	2153		
21 F		0409	1.2E
	0844	1424	1.2F
	2200		
22 Sa		0432	1.4E
	0925	1439	1.5F
	2220		
23 Su		0501	1.6E
	1008	1500	1.6F
	2251		
24 M		0536	1.8E
	1052	1519	1.7F
	2330		
25 Tu		0617	1.9E
	1135	1542	1.8F
26 W	0018	0659	1.9E
	1216	1615	1.7F
27 Th ○	0122	0741	1.8E
	1254	1647	1.6F
28 F	0233	0824	1.6E
	1329	1719	1.4F
29 Sa	0340	0913	1.2E
	1401	1740	1.1F
30 Su	0530	1022	0.8E
	1424	1808	0.8F
31 M		0032	*
		0618	*
		1117	0.3E
	1353	1824	0.5F
	2105		

February

Day	Slack h m	Maximum h m	knots
1 Tu		0027	0.6E
	0512	0801	0.5F
		1200	0.3F
		1424	0.4F
		1654†	0.3F
2 W		0048	1.0E
	0611	0944	0.9F
		1200	0.8F
		1205	0.8F
	2031		
3 Th ◑		0142	1.3E
	0709	1328	1.3F
	2046		
4 F		0313	1.6E
	0805	1351	1.7F
	2124		
5 Sa		0413	1.8E
	0900	1426	1.8F
	2212		
6 Su		0502	1.9E
	0954	1453	1.9F
	2303		
7 M		0551	1.9E
	1047	1525	1.8F
8 Tu	0003	0645	1.8E
	1137	1547	1.6F
9 W	0128	0728	1.6E
	1220	1604	1.4F
10 Th ●	0244	0809	1.4E
	1258	1622	1.2F
11 F		0034	*
		0213	*
		0851	1.1E
	1331	1645	0.9F
12 Sa		0030	*
		0305	*
		0953	0.8E
	1359	1707	0.7F
13 Su		0017	*
		0425	*
		1049	0.5E
	1420	1736	0.5F
14 M		0004	*
		0547	0.3F
		1126	*
		1756	0.3F
	2015	2354	0.4E
15 Tu	0403	0700	0.4F
		1152	*
		1811	*
		2355	0.6E
16 W	0509	0830	0.6F
		1202	0.5F
		1206	0.5F
	1936		
17 Th		0010	0.8E
	0606	0939	0.8F
		1148	0.7F
		1325	0.8F
	1920		
18 F ◐		0046	1.0E
	0701	1343	1.0F
	1947		
19 Sa		0151	1.1E
	0754	1358	1.3F
	2034		
20 Su		0342	1.3E
	0844	1417	1.4F
	2129		
21 M		0430	1.5E
	0933	1430	1.5F
	2223		
22 Tu		0517	1.6E
	1022	1440	1.5F
	2323		
23 W		0605	1.6E
	1112	1458	1.5F
24 Th	0113	0656	1.5E
	1159	1519	1.3F
25 F ○		0024	*
		0124	*
		0750	1.3E
	1243	1544	1.0F
		2343	*
26 Sa		0229	0.4F
	0433	0845	0.9E
	1323	1606	0.7F
		2302	*
27 Su		0338	0.6F
	0630	1030	0.5E
	1358	1629	0.4F
	1900	2238	0.4E
28 M	0126	0511	0.7F
		1158	*
		1643	*
		2253	0.8E

March

Day	Slack h m	Maximum h m	knots
1 Tu	0245	0633	1.0F
	1732	2322	1.2E
2 W	0406	0808	1.2F
	1731		
3 Th		0000	1.5E
	0519	0939	1.4F
	1819		
4 F ◑		0043	1.6E
	0628	1115	1.5F
	1916		
5 Sa		0157	1.6E
	0733	1317	1.6F
	2025		
6 Su		0354	1.6E
	0833	1356	1.6F
	2146		
7 M		0448	1.5E
	0930	1423	1.5F
	2305		
8 Tu		0557	1.4E
	1024	1441	1.3F
9 W	0054	0653	1.2E
	1116	1445	1.1F
		2245	*
10 Th		0106	*
		0748	1.0E
	1202	1456	0.9F
		2239	*
11 F		0201	0.4F
	0404	0844	0.7E
	1243	1506	0.6F
		2241	*
12 Sa ●		0244	0.5F
	0535	1007	0.5E
	1321	1527	0.4F
		2230	*
13 Su		0334	0.6F
	0734	1124	0.3E
		1547	*
		2115	0.4E
14 M	0106	0437	0.7F
		1221	*
		1556	*
		2124	0.6E
15 Tu	0147	0544	0.8F
	1447	2200	0.8E
16 W	0237	0648	0.9F
	1536	2242	1.0E
17 Th	0340	0757	1.0F
	1621	2324	1.1E
18 F	0447	0906	1.1F
	1711	2357	1.2E
19 Sa	0550	0958	1.2F
	1803		
20 Su ◐		0036	1.3E
	0651	1055	1.3F
	1858		
21 M		0145	1.2E
	0749	1322	1.3F
	1958		
22 Tu		0349	1.2E
	0844	1331	1.3F
	2120		
23 W		0451	1.2E
	0939	1347	1.2F
24 Th	0013	0553	1.1E
	1038	1401	1.0F
		2138	*
25 F		0108	0.3F
	0255	0710	0.8E
	1140	1422	0.7F
		2012	*
26 Sa		0208	0.7F
	0456	0838	0.5E
	1240	1439	0.4F
	1647	1953	0.4E
	2324		
27 Su ○		0306	1.0F
	0745	1111	0.3E
		1452	*
		2014	0.8E
28 M	0027	0410	1.3F
		1242	*
		1433	*
		2044	1.2E
29 Tu	0123	0531	1.5F
	1404	2137	1.5E
30 W	0223	0646	1.6F
	1516	2235	1.7E
31 Th	0331	0804	1.7F
	1610	2323	1.8E

Time meridian 90° W. 0000 is midnight. 1200 is noon.
If three or more consecutive entries are marked (F) or (E) the middle ones are not true maximums but intermediate values to show the current pattern.
* Current weak and variable.
† See page A-7 for the remaining currents on this day.

Aransas Pass (between jetties), Texas, 1994

F–Flood, Dir. 300° True   E–Ebb, Dir. 120° True

April

Day	Slack (h m)	Maximum (h m)	knots
1 F	0441 1703	0919	1.7F
2 Sa ◑	0548 1754	0009 1010	1.7E 1.6F
3 Su	0652 1839	0056 1115	1.4E 1.4F
4 M	0753	0327 1303 2021 2118	1.2E 1.2F * *
5 Tu	0848	0439 1324 2014 2238	1.0E 1.0F * *
6 W	0940	0559 1328 2017	0.8E 0.8F *
7 Th	1035 1736 2237	0026 0721 1334 2011	* 0.6E 0.6F 0.3E
8 F	0504 1136 1615 2314	0134 0832 1349 1958	0.5F 0.4E 0.4F 0.4E
9 Sa	2348	0219 1028 1405 1945	0.8F * * 0.6E
10 Su ●		0301 1142 1418 1941	1.0F * * 0.8E
11 M	0020	0349 1251 1422 1953	1.1F * * 1.0E
12 Tu	0052 1227	0445 2017	1.2F 1.2E
13 W	0127 1350	0541 2053	1.3F 1.3E
14 Th	0206 1444	0635 2140	1.4F 1.4E
15 F	0253 1529	0732 2233	1.4F 1.4E
16 Sa	0349 1611	0832 2320	1.4F 1.4E
17 Su	0448 1653	0921 2357	1.4F 1.3E
18 M ◐	0546 1734	0959	1.4F
19 Tu	0643 1807	0041 1039	1.2E 1.2F
20 W	0740	0149 1125 2010 2229	0.9E 1.0F * *
21 Th	0837	0419 1208 1930	0.6E 0.8F *
22 F	0252 0938 1519 2204	0019 0615 1243 1843	0.3F 0.3E 0.4F 0.5E
23 Sa	2247	0136 0840 1309 1839	0.8F * * 0.9E
24 Su	2336	0231 1149 1317 1902	1.3F * * 1.3E
25 M ○	1120	0322 1929	1.6F 1.7E
26 Tu	0026 1236	0431 2009	1.9F 2.0E
27 W	0117 1351	0541 2052	2.0F 2.1E
28 Th	0210 1449	0643 2158	2.1F 2.0E
29 F	0308 1534	0751 2257	2.0F 1.9E
30 Sa	0408 1611	0850 2342	1.8F 1.6E

May

Day	Slack (h m)	Maximum (h m)	knots
1 Su	0507 1636	0927	1.6F
2 M ◑	0601 1643	0017 0957 1906 2024	1.2E 1.3F 0.3E 0.3E
3 Tu	0651 1630	0046 1020 1854 2155	0.8E 1.0F 0.3E *
4 W	0737 1556	0438 1044 1856 2320	0.4E 0.7F 0.4E *
5 Th	1458 2205	0620 1113 1857	* 0.5F 0.6E
6 F	2233	0150 0803 1141 1851	0.5F * * 0.8E
7 Sa	2304	0211 1033 1210 1845	0.9F * * 1.0E
8 Su	1045 2336	0240 1846	1.1F 1.2E
9 M	1114	0315 1903	1.3F 1.3E
10 Tu ●	0008 1154	0357 1922	1.5F 1.5E
11 W	0041 1243	0446 1951	1.6F 1.6E
12 Th	0114 1334	0542 2026	1.6F 1.6E
13 F	0150 1420	0624 2107	1.7F 1.7E
14 Sa	0229 1458	0712 2154	1.7F 1.6E
15 Su	0312 1532	0801 2249	1.6F 1.5E
16 M	0358 1559	0842 2326	1.6F 1.3E
17 Tu	0444 1613	0916	1.4F
18 W ◐	0526 1553	0001 0943 1856 2148	0.9E 1.1F 0.4E *
19 Th	0555 1437	0042 1011 1810 2314	0.5E 0.8F 0.5E *
20 F	1309 2133	0436 1027 1735	* 0.5F 0.8E
21 Sa	1219 2204	0118 1736	0.8F 1.2E
22 Su	1108 2247	0206 1754	1.3F 1.7E
23 M	1115 2335	0254 1829	1.8F 2.0E
24 Tu ○	1157	0344 1909	2.1F 2.3E
25 W	0023 1251	0447 1955	2.2F 2.3E
26 Th	0111 1348	0549 2040	2.3F 2.3E
27 F	0159 1435	0638 2133	2.2F 2.0E
28 Sa	0248 1508	0727 2232	2.0F 1.7E
29 Su	0337 1525	0808 2318	1.7F 1.3E
30 M	0422 1524	0837 2338	1.4F 0.9E
31 Tu ◑	0459 1504	0900 1746 2049 2353	1.1F 0.4E * 0.4E

June

Day	Slack (h m)	Maximum (h m)	knots
1 W	0518 1419	0918 1748 2212 2349	0.9F 0.6E * *
2 Th	1259 2119	0236 0452 0939 1749	* * 0.6F 0.8E
3 F	1212 2142	0223 0711 0952 1750	0.5F * 0.4F 1.0E
4 Sa	1152 2212	0238 1745	0.9F 1.2E
5 Su	1126 2246	0253 1800	1.2F 1.4E
6 M	1113 2321	0308 1815	1.4F 1.5E
7 Tu	1131 2357	0329 1839	1.6F 1.7E
8 W	1204	0406 1908	1.7F 1.8E
9 Th ●	0031 1245	0448 1937	1.8F 1.8E
10 F	0105 1327	0535 2011	1.8F 1.8E
11 Sa	0138 1406	0612 2049	1.8F 1.8E
12 Su	0212 1438	0647 2135	1.7F 1.6E
13 M	0246 1501	0722 2218	1.6F 1.4E
14 Tu	0319 1507	0754 2306	1.4F 1.0E
15 W	0343 1428	0823 1748 2045 2336	1.2F 0.4E 0.3E 0.5E
16 Th ◐	0323 1228	0849 1708 2205 2357	0.8F 0.6E * *
17 F	1131 2042	0859 1638	0.5F 0.9E
18 Sa	1106 2112	0219 1637	0.8F 1.4E
19 Su	1047 2153	0220 1659	1.3F 1.8E
20 M	1053 2241	0241 1735	1.8F 2.1E
21 Tu	1124 2331	0310 1820	2.1F 2.3E
22 W	1209	0405 1903	2.3F 2.4E
23 Th ○	0019 1302	0455 1949	2.3F 2.3E
24 F	0105 1355	0544 2031	2.1F 2.1E
25 Sa	0148 1433	0619 2120	1.9F 1.8E
26 Su	0228 1449	0648 2218	1.7F 1.4E
27 M	0305 1438	0709 2252	1.4F 1.0E
28 Tu	0334 1401	0735 1643 1907 2319	1.1F 0.3E * 0.5E
29 W	0339 1244	0801 1641 2058 2323	0.9F 0.5E * *
30 Th ◑	1130 2013	0819 1640	0.6F 0.7E

Time meridian 90° W. 0000 is midnight. 1200 is noon.
If three or more consecutive entries are marked (F) or (E) the middle ones are **not** true maximums but intermediate values to show the current pattern.
* Current weak and variable.

Aranssas Pass (between jetties), Texas, 1994

F–Flood, Dir. 300° True   E–Ebb, Dir. 120° True

July

Day	Slack h m	Maximum h m	knots
1 F	1059 2037	0230 0551 0837 1644	0.5F 0.3F 0.4F 0.9E
2 Sa	1051 2108	0225 1648	0.8F 1.1E
3 Su	1048 2144	0238 1700	1.1F 1.3E
4 M	1052 2223	0249 1724	1.4F 1.5E
5 Tu	1107 2304	0310 1747	1.5F 1.7E
6 W	1133 2343	0331 1822	1.7F 1.8E
7 Th	1208	0400 1855	1.7F 1.9E
8 F ●	0020 1249	0434 1931	1.8F 1.9E
9 Sa	0054 1332	0512 2003	1.7F 1.8E
10 Su	0126 1409	0536 2043	1.7F 1.6E
11 M	0157 1435	0610 2132	1.5F 1.3E
12 Tu	0225 1433	0639 2218	1.3F 0.9E
13 W	0242 1235	0706 1626 1909 2301	1.0F 0.3E * 0.4E
14 Th	0212 1043 1858	0721 1539 2057 2336	0.7F 0.5E 0.3F *
15 F ◐	1003 1923	0321 0402 0729 1509 2228†	0.4F 0.4F 0.5F 0.9E 0.7F
16 Sa	0948 2003	0212 1524	0.8F 1.3E
17 Su	0947 2050	0159 1559	1.3F 1.7E
18 M	1007 2140	0220 1642	1.7F 2.0E
19 Tu	1044 2232	0241 1726	2.0F 2.2E
20 W	1129 2324	0316 1817	2.1F 2.2E
21 Th	1225	0357 1903	2.1F 2.2E
22 F ○	0012 1334	0444 1951	1.9F 2.0E
23 Sa	0055 1437	0513 2033	1.7F 1.7E
24 Su	0133 1526	0534 2115	1.4F 1.3E
25 M	0207 1601	0549 2218	1.2F 0.9E
26 Tu	0235	0612 1510 1733 2306	0.9F * * 0.5E
27 W	0247	0633 1503 1901 2330	0.7F * * *
28 Th	0957 1817	0654 1506 2043 2331	0.5F 0.4E 0.3F *
29 F	0930 1858	0209 0500 0710 1507 2206†	0.3F * 0.3F 0.7E 0.6F
30 Sa ◑	0927 1941	0156 1522	0.7F 0.9E
31 Su	0933 2025	0200 1554	1.0F 1.1E

August

Day	Slack h m	Maximum h m	knots
1 M	0948 2109	0215 1626	1.2F 1.3E
2 Tu	1015 2154	0234 1656	1.4F 1.5E
3 W	1049 2239	0251 1733	1.5F 1.6E
4 Th	1127 2322	0314 1809	1.6F 1.7E
5 F	1216	0329 1850	1.6F 1.7E
6 Sa	0003 1327	0352 1928	1.5F 1.6E
7 Su ●	0040 1442	0419 2000	1.4F 1.4E
8 M	0114 1555	0448 2056	1.2F 1.1E
9 Tu	0146	0517 1242 1531 2200	1.0F * * 0.7E
10 W	0208	0540 1203 1750 2317	0.7F * 0.3F *
11 Th	0821 1619	0600 1156 1924	0.4F 0.6E 0.6F
12 F		0003 0204 0503 0541 1212†	* 0.3F * * 1.0E
13 Sa ◐	0737 1828	1254 2230	1.3E 1.2F
14 Su	0752 1928	1357	1.6E
15 M	0838 2026	0126 1528	1.6F 1.8E
16 Tu	0937 2122	0203 1631	1.8F 1.9E
17 W	1037 2218	0228 1726	1.9F 1.9E
18 Th	1143 2311	0255 1821	1.8F 1.8E
19 F	1316 2359	0324 1911	1.6F 1.6E
20 Sa		0339 1216 1307 1959	1.4F * * 1.3E
21 Su ○	0041 1555	0354 1158 1410 2048	1.1F * 0.3F 1.0E
22 M	0118 1714	0415 1159 1508 2157	0.8F * 0.3F 0.7E
23 Tu	0150 1855	0436 1147 1614 2319	0.6F * 0.4F 0.4E
24 W	0216 0801 1412	0505 1136 1735	0.4F 0.3E 0.5F
25 Th	1524	0002 0527 1130 1850	* * 0.5E 0.6F
26 F	1635	0439 0542 1139 2013	* * 0.7E 0.7F
27 Sa	0559 1737	1159 2127	0.9E 0.9F
28 Su	0616 1835	1225 2225 2347	1.0E 1.0F 1.0F
29 M ◑	0703 1931	0116 1318	1.0F 1.1E
30 Tu	0800 2023	0141 1530	1.2F 1.2E
31 W	0907 2113	0203 1619	1.3F 1.3E

September

Day	Slack h m	Maximum h m	knots
1 Th	1011 2202	0216 1700	1.4F 1.4E
2 F	1117 2251	0223 1743	1.4F 1.4E
3 Sa	1321 2339	0230 1844	1.3F 1.3E
4 Su	1503	0250 1144 1326 1933	1.1F * 0.3F 1.1E
5 M ●	0025 1634	0314 1106 1424 2036	0.9F * 0.5F 0.8E
6 Tu	0107 1833	0335 0924 1524 2227	0.6F * 0.6F 0.4E
7 W	0146 0600 1258	0357 0919 1646	0.3F 0.4E 0.8F
8 Th	1406	0009 0352 1003 1809	* * 0.9E 1.1F
9 F	0345 1520	1043 1933	1.2E 1.3F
10 Sa	0425 1636	1126 2102	1.5E 1.5F
11 Su	0519 1747	1209 2218	1.7E 1.6F
12 M ◐	0620 1854	1301	1.7E
13 Tu	0724 1957	0009 1457	1.6F 1.6E
14 W	0845 2056	0125 1620	1.6F 1.5E
15 Th	1031 2151	0154 1727	1.5F 1.4E
16 F	1232 2246	0213 1829	1.3F 1.2E
17 Sa	1440 2338	0225 0940 1249 1933	1.0F * 0.3F 0.9E
18 Su	1617	0232 0937 1352 2036	0.8F * 0.5F 0.6E
19 M ○	0025 1813	0241 0924 1438 2224	0.5F * 0.6F 0.4E
20 Tu	0108 0514 1220	0301 0845 1530 2340	0.3F 0.3E 0.8F *
21 W	1258	0316 0833 1627	* 0.6E 0.9F
22 Th	1336	0041 0318 0848 1736	* * 0.8E 1.0F
23 F	0156 1420	0922 1837	0.9E 1.0F
24 Sa	0303 1516	1012 1948	1.0E 1.1F
25 Su	0349 1621	1101 2049	1.1E 1.2F
26 M	0435 1725	1136 2139	1.2E 1.2F
27 Tu ◑	0524 1825	1217 2227	1.2E 1.2F
28 W	0615 1923	1308 2324	1.1E 1.2F
29 Th	0707 2017	1518	1.0E
30 F	0803 2110	0049 1635	1.1F 1.0E

Time meridian 90° W. 0000 is midnight. 1200 is noon.
If three or more consecutive entries are marked (F) or (E) the middle ones are not true maximums but intermediate values to show the current pattern.
* Current weak and variable.
† See page A-7 for the remaining currents on this day.

Aransas Pass (between jetties), Texas, 1994

F–Flood, Dir. 300° True E–Ebb, Dir. 120° True

October

Day	Slack h m	Maximum h m	knots
1 Sa		0110	1.0F
		0927	*
		1104	*
		1730	0.9E
	2205		
2 Su		0131	0.8F
		0827	*
		1257	0.3F
	1456	1900	0.6E
	2308		
3 M		0154	0.6F
		0735	*
		1354	0.7F
	1707	2024	0.4E
4 Tu ●	0018	0209	0.3F
	0356	0730	0.5E
	1109	1451	1.0F
		2321	*
5 W		0223	*
		0738	1.0E
	1205	1550	1.3F
6 Th		0101	*
		0158	*
		0807	1.4E
	1258	1706	1.6F
7 F	0125	0855	1.7E
	1353	1818	1.8F
8 Sa	0242	0951	1.8E
	1455	1933	1.8F
9 Su	0336	1050	1.9E
	1603	2050	1.9F
10 M	0426	1139	1.8E
	1711	2139	1.8F
11 Tu ◐	0514	1227	1.6E
	1815	2224	1.6F
12 W	0553	1330	1.2E
	1916	2311	1.3F
13 Th		0758	*
		0901	*
		1606	0.9E
	2012	2354	1.0F
14 F		0746	*
		1027	*
		1730	0.7E
	2104		
15 Sa		0037	0.8F
	0528	0745	0.3E
		1209	*
		1858	0.4E
	2155		
16 Su		0052	0.5F
	0426	0742	0.4E
	1030	1332	0.6F
		2021	*
17 M		0118	0.3F
	0323	0736	0.6E
	1105	1415	0.8F
		2227	*
18 Tu		0134	*
		0723	0.8E
	1139	1456	1.1F
		2350	*
19 W ○		0150	*
		0725	1.0E
	1212	1540	1.2F
20 Th		0108	*
		0137	*
		0739	1.2E
	1244	1641	1.3F
21 F	0027	0800	1.3E
	1317	1731	1.4F
22 Sa	0134	0830	1.4E
	1353	1820	1.4F
23 Su	0226	0913	1.4E
	1436	1915	1.4F
24 M	0308	1006	1.4E
	1527	2018	1.4F
25 Tu	0347	1059	1.4E
	1622	2058	1.4F
26 W	0423	1134	1.3E
	1716	2139	1.4F
27 Th ◑	0454	1218	1.1E
	1809	2211	1.2F
28 F	0516	0812	0.4E
		0909	0.3E
		1258	0.8E
	1901	2248	1.0F
29 Sa	0509	0740	0.3E
		1026	*
		1551	0.5E
	1952	2323	0.7F
30 Su	0401	0707	0.3E
	0949	1206	0.3F
		1747	*
31 M		0001	0.4F
	0239	0621	0.6E
	0958	1322	0.8F
		2037	*

November

Day	Slack h m	Maximum h m	knots
1 Tu		0026	*
		0613	1.0E
	1031	1417	1.3F
	2231		
2 W		0637	1.4E
	1116	1506	1.7F
	2320		
3 Th ●		0706	1.8E
	1204	1608	2.0F
4 F	0020	0742	2.1E
	1253	1717	2.1F
5 Sa	0128	0827	2.2E
	1344	1819	2.2F
6 Su	0226	0924	2.2E
	1439	1921	2.1F
7 M	0313	1023	2.0E
	1538	2022	1.9F
8 Tu	0350	1112	1.7E
	1636	2104	1.7F
9 W	0413	1155	1.3E
	1729	2131	1.4F
10 Th ◐	0416	0642	0.3E
		0801	0.3E
		1223	0.8E
	1817	2152	1.1F
11 F	0358	0631	0.4E
		0941	*
		1244	0.3E
		1424	0.3E
		1615†	0.3E
12 Sa	0318	0633	0.6E
		1109	*
		1758	*
		2239	0.5F
13 Su	0217	0632	0.7E
	0954	1412	0.6F
		1954	*
		2300	0.3F
14 M	0120	0633	0.9E
	1022	1436	0.9F
15 Tu	0048	0628	1.1E
	1054	1451	1.2F
	2320		
16 W		0638	1.3E
	1127	1513	1.4F
	2324		
17 Th		0653	1.5E
	1200	1555	1.5F
	2355		
18 F ○		0711	1.6E
	1232	1637	1.6F
19 Sa	0037	0737	1.7E
	1305	1732	1.6F
20 Su	0124	0809	1.7E
	1339	1812	1.7F
21 M	0207	0846	1.7E
	1415	1855	1.6F
22 Tu	0243	0932	1.6E
	1452	1936	1.6F
23 W	0314	1021	1.4E
	1533	2016	1.5F
24 Th	0337	1104	1.2E
	1612	2051	1.3F
25 F	0346	1139	0.9E
	1645	2120	1.1F
26 Sa ◑	0325	0638	0.4E
		0934	*
		1212	0.5E
	1654	2148	0.8F
27 Su	0203	0559	0.5E
		1051	*
		1509	*
		2159	0.5F
28 M	0039	0521	0.8E
	0921	1341	0.7F
	2356		
29 Tu		0513	1.2E
	0946	1402	1.3F
	2305		
30 W		0534	1.7E
	1025	1439	1.8F
	2306		

December

Day	Slack h m	Maximum h m	knots
1 Th		0606	2.1E
	1112	1521	2.1F
	2342		
2 F ●		0646	2.3E
	1201	1622	2.3F
3 Sa	0033	0732	2.5E
	1249	1724	2.3F
4 Su	0132	0821	2.4E
	1337	1816	2.3F
5 M	0222	0909	2.2E
	1425	1859	2.1F
6 Tu	0259	1011	1.9E
	1513	1939	1.8F
7 W	0317	1100	1.4E
	1557	2008	1.5F
8 Th	0310	1129	0.9E
	1634	2032	1.2F
9 F ◐	0240	0528	0.4E
		0832	*
		1144	0.4E
	1647	2056	0.9F
10 Sa	0141	0525	0.6E
		1001	*
		1638	*
		2115	0.6F
11 Su	0023	0526	0.8E
	0904	1425	0.6F
		1900	0.3F
		2128	0.4F
	2347		
12 M		0533	1.1E
	0929	1435	1.0F
	2335		
13 Tu		0542	1.3E
	1000	1450	1.3F
	2324		
14 W		0549	1.4E
	1035	1511	1.5F
	2317		
15 Th		0612	1.6E
	1112	1532	1.6F
	2332		
16 F		0633	1.7E
	1148	1603	1.7F
17 Sa ○	0002	0702	1.8E
	1223	1643	1.7F
18 Su	0040	0733	1.8E
	1256	1718	1.7F
19 M	0121	0801	1.8E
	1328	1755	1.7F
20 Tu	0158	0837	1.7E
	1358	1827	1.6F
21 W	0228	0912	1.5E
	1427	1859	1.5F
22 Th	0248	0955	1.3E
	1454	1931	1.3F
23 F	0252	1036	0.9E
	1510	1957	1.1F
24 Sa	0210	0533	0.4E
		0820	0.3E
		1118	0.5E
	1442	2026	0.8F
25 Su ◑	0000	0453	0.5E
		0949	*
		1147	*
		2034	0.5F
	2307		
26 M		0421	0.8E
	0823	1436	0.7F
	2243		
27 Tu		0422	1.3E
	0850	1415	1.3F
	2226		
28 W		0442	1.7E
	0929	1432	1.7F
	2233		
29 Th		0514	2.1E
	1016	1501	2.1F
	2305		
30 F		0557	2.4E
	1107	1536	2.3F
	2350		
31 Sa		0644	2.5E
	1157	1625	2.3F

Time meridian 90° W. 0000 is midnight. 1200 is noon.
If three or more consecutive entries are marked (F) or (E) the middle ones are not true maximums but intermediate values to show the current pattern.
* Current weak and variable.

Aransas Pass, Texas

January

	Slack h m	Maximum h m	knots
4		1959	0.5F
	2230		
18		1939	0.4F
	2203		

February

	Slack h m	Maximum h m	knots
1		1818	0.3F
	2037		

July

	Slack h m	Maximum h m	knots
15		2331	0.7F
29		2239	0.6F

August

	Slack h m	Maximum h m	knots
12	1727	2107	0.9F

November

	Slack h m	Maximum h m	knots
11	1858	2215	0.8F

STAPLE HERE

Place
Postage
Stamp
Here

National Oceanic and Atmospheric Administration
Coastal and Estuarine Oceanography Branch
ATTN: Information Products and Services Section
1305 East-West Highway Rm 6500
Silver Spring, MD 20910

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ASTRONOMICAL DATA, 1995

January

	d.	h	m
●	1	10	56
E	6	11	..
◐	8	15	46
A	11	22	..
N	13	23	..
○	16	20	26
E	21	02	..
◑	24	04	58
S	27	12	..
P	27	23	..
●	30	22	48

February

	d.	h	m
E	2	22	..
◐	7	12	54
A	8	18	..
N	10	07	..
○	15	12	15
E	17	09	..
◑	22	13	04
P	23	02	..
S	23	19	..

March

	d.	h	m
●	1	11	48
E	2	08	..
A	8	15	..
◐	9	10	14
N	9	16	..
E	16	18	..
○	17	01	26
P	20	13	..
⊙1	21	02	14
S	23	01	..
◑	23	20	10
E	29	16	..
●	31	02	09

April

	d.	h	m
A	5	10	..
N	6	0	..
◐	8	05	35
E	13	04	..
○	15	12	08
P	17	08	..
S	19	07	..
◑	22	03	18
E	25	21	..
●	29	17	36

May

	d.	h	m
A	3	01	..
N	3	07	..
◐	7	21	44
E	10	13	..
○	14	20	48
P	15	15	..
S	16	17	..
◑	21	11	36
E	23	03	..
●	29	09	27
A	30	08	..
N	30	14	..

June

	d.	h	m
◐	6	10	26
E	6	22	..
P	13	01	..
○	13	04	03
S	13	04	..
E	19	11	..
◑	19	22	01
⊙2	21	20	34
A	26	11	..
N	26	20	..
●	28	00	50

July

	d.	h	m
E	4	06	..
◐	5	20	02
S	10	15	..
P	11	10	..
○	12	10	49
E	16	20	..
◑	19	11	10
A	23	20	..
N	24	04	..
●	27	15	13
E	31	12	..

August

	d.	h	m
◐	4	03	16
S	7	01	..
P	8	14	..
○	10	18	15
E	13	06	..
◑	18	03	04
A	20	12	..
N	20	12	..
●	26	04	31
E	27	19	..

September

	d.	h	m
◐	2	09	03
S	3	08	..
P	5	01	..
○	9	03	37
E	9	16	..
N	16	20	..
◑	16	21	09
A	17	06	..
⊙3	23	12	13
E	24	03	..
●	24	16	55
P	30	04	..
S	30	13	..

October

	d.	h	m
◐	1	14	36
E	7	01	..
○	8	15	52
N	14	04	..
A	15	02	..
◑	16	16	26
E	21	12	..
●	24	04	36
P	26	21	..
S	27	20	..
◐	30	21	17

November

	d.	h	m
E	3	07	..
○	7	07	20
N	10	12	..
A	11	21	..
◑	15	11	40
E	17	22	..
●	22	15	43
P	23	23	..
S	24	05	..
◐	29	06	28
E	30	13	..

December

	d.	h	m
○	7	01	27
N	7	20	..
A	9	10	..
◑	15	05	31
E	15	08	..
S	21	17	..
●	22	02	22
⊙4	22	08	17
P	22	10	..
E	27	21	..
◐	28	19	06

LUNAR DATA

● – new Moon
◐ – first quarter
○ – full Moon
◑ – last quarter

A – Moon in apogee
P – Moon in perigee
N – Moon farthest north of Equator
E – Moon on Equator
S – Moon farthest south of Equator

SOLAR DATA

⊙1 – March equinox
⊙2 – June solstice
⊙3 – September equinox
⊙4 – December solstice

Greenwich mean time (GMT) or universal time (UT) is the mean solar time on the Greenwich meridian reckoned in days of 24 mean solar hours written as 00^h at midnight and 12^h at noon. To convert the above times to those of other standard time meridians, add 1 hour for each 15° of east longitude of the desired meridian and subtract 1 hour for each 15° of west longitude. This table was compiled from data supplied by the Nautical Almanac Office, United States Naval Observatory.