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TIDES, CURRENTS, MAGNETIC VARIATION,

AND

GEOGRAPHICAL POSITIONS OF LIGHT-HOUSES.

CHESAPEAKE BAY AND ITS RIVERS.

1861.

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ASSISTANTS UNITED STATES COAST SURVEY.

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TIDES IN CHESAPEAKE BAY AND ITS TRIBUTARIES.

NUMEROUS tidal stations were occupied for longer or shorter periods during the progress of the hydrographic survey of Chesapeake bay. The results have been collected in the following table, (Table I,) which gives the name of the station, the mean interval between the time of the moon's transit and the time of high water, the mean rise and fall of tides, and of spring and neap tides, and the mean duration of the rise and of the fall of the tide, reckoned from the middle of one stand to the middle of the next.

By means of this table, and of an Almanac, the time and height of high water may be obtained for any particular day.

When greater accuracy is desired, the corrections given in Table II are to be applied. This table applies more particularly to Old Point Comfort and Baltimore, but can also be used for places in the lower and upper half of the bay, respectively.

TABLE I.

Tide tables for Chesapeake bay and rivers.

Localities.	Mean interval between time of moon's transit and time of high water.	Rise and fall.			Mean duration of—	
		Mean.	Spring.	Neap.	Rise.	Fall.
East shore of bay.	*h. m.*	*Feet.*	*Feet.*	*Feet.*	*h. m.*	*h. m.*
Fisherman's inlet, Cape Charles	7 45	3.2	.....	.....	.....	.....
Hunger's creek	9 0	1.8	.....	.....	.....	.....
Sharp's island †	2 49	1.1	.....	.....	.....	.....
Cambridge, (Choptank river) †	3 18	1.7	.....	.....	.....	.....
Poplar island	3 54	1.2	.....	.....	.....	.....
Harrison's wharf, Chester river	6 22	1.7	.....	.....	.....	.....
Harris's wharf, below Swan Point	5 22	1.3	.....	.....	.....	.....
Sassafras river	9 0	1.7	.....	.....	.....	.....
Elk river, (mouth of Bohemia creek)†	8 1	2.2	.....	.....	.....	.....
Frenchtown	8 37	.....	.....	.....	.....	.....
Northeast river	8 49	2.1	.....	.....	.....	.....
Susquehanna river	9 24	2.4	.....	.....	.....	.....
West shore of bay.						
Cape Henry	7 25	2 4	.....	.....	.....	.....
Old Point Comfort *	8 17	2.5	3.0	2.0	6 1	6 25
Norfolk†	8 49	2.8	3.3	2.3	5 43	6 43
Newport News †	9 9	2.5	3.4	1.7	6 3	6 18
York river entrance	8 39	2.4	.....	.....	.....	.....
Piankatank river entrance †	10 5	1.3	1.9	0.7	5 51	6 36
Point Lookout *	0 32	1.4	1.9	0.7	5 59	6 19
Patuxent river entrance, (Drum Point) †	1 16	1.4	1.9	0.7	5 48	6 45
Fairhaven, Herring bay †	3 24	1.1	.....	.....	.....	.....
Annapolis *	4 38	0.9	1.0	0.8	6 11	6 15
Bodkin Point *	5 42	1.0	1.3	0.8	5 23	7 8
Baltimore *	6 33	1.3	1.5	0.9	5 54	6 33
Gunpowder river †	7 1	1.2	.....	.....	.....	.....
Pool's island †	7 13	1.3	.....	.....	.....	.....
Bush river	7 50	1.3	.....	.....	.....	.....
Havre de Grace	8 47	2.4	.....	.....	.....	.....

TABLE I.—*Tide tables for Chesapeake bay and rivers*—Continued.

Localities.	Mean interval between time of moon's transit and time of high water.	Rise and fall.			Mean duration of—	
		Mean.	Spring.	Neap.	Rise.	Fall.
Rivers.	*h. m.*	*Feet.*	*Feet.*	*Feet.*	*h. m.*	*h. m.*
City Point, James river †	2 11	2.8	3.0	2.5	5 14	6 58
Curl's Neck, James river †	3 31	3.2	3.4	2.8	5 32	6 54
Richmond, James river †	4 28	2.9	3.4	2.3	4 53	7 31
Petersburg, Appomattox river †	4 45	2.6	.....	.....	4 57	7 35
Moody's wharf, York river	9 35	3.0	.....	.....	.....	.....
Tappahannock, Rappahannock river *	0 42	1.6	1.8	1.3	5 21	7 6
Saunders' wharf, Rappahannock river †	3 2	1.5	.....	.....	5 47	7 12
Washington Navy Yard *	7 44	3.0	3.4	2.5	5 37	6 49
Hunting creek, Patuxent river	2 38	1.6	.....	.....	.....	.....

NOTE.—The stations marked with a * are the most reliable, being derived from several months observations; in most cases even more than a year's. Those marked with a † are good; the other ones rough approximations, being based on few observations. The rise and fall of spring tides is greater and of neap tides smaller than the mean by about half a foot. The duration of rise and of fall of the tide may be deduced from such places where it is not given, from the nearest complete station, recollecting, however, that the further up a river the shorter the duration of rise and the longer the duration of fall.

The following table gives the corrections to be applied to the mean interval between the time of the moon's transit and the time of high water, and also to the mean rise and fall at Old Point Comfort and Baltimore for every half hour of the moon's transit:

TABLE II.

Time of moon's transit or southing.	Old Point Comfort.				Baltimore.			
	Correction to mean interval.		Correction to mean rise and fall.		Correction to mean interval.		Correction to mean rise and fall.	
h. m.		*m.*		*ft.*		*m.*		*ft.*
0 0	Add	16	Add	0.4	Add	14	Add	0.2
0 30		10				9		
1 0		4		0.5		4		0.2
1 30	Subtract	2			Subtract	2		
2 0		8		0.4		7		0.2
2 30		13				12		
3 0		17		0.1		16		0.1
3 30		21				20		
4 0		25	Subtract	0.2		22		0.0
4 30		28				23		
5 0		29		0 4		23	Subtract	0.2
5 30		27				20		
6 0		24		0.5		14		0.4
6 30		17				8		
7 0		10		0.5		1		0.4
7 30		2			Add	6		
8 0	Add	7		0.3		11		0.3
8 30		16				16		
9 0		23		0.0		19		0.2
9 30		28				21		
10 0		31	Add	0.3		21		0.0
10 30		31				21		
11 0		29		0.5		17	Add	0.1
11 30		23				15		

By means of these numbers, Tables III, IV, and V have been computed, giving the times of high water at Old Point Comfort, Annapolis, and Baltimore, for the months of June, July, and

August, 1861. The average probable error of the times given in them is about 20 minutes; but the error may amount to more than an hour when the tide is disturbed by the wind. This is more likely to be the case near the head of the bay and rivers than near the mouth. At Washington northerly and westerly winds depress, and southerly and easterly elevate, the level of the water in the river. As a general rule, northerly winds will depress or southerly winds elevate the mean level of the water in the upper part of the bay. In the rivers and lateral bays this effect will be slightly modified by their direction.

TABLE III.

Approximate mean time of high water at Old Point Comfort, Virginia, for June, July, and August, 1861.

Day of month.	June.		July.		August.	
	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
1	2 25	2 50	2 24	2 50	3 35	4 7
2	3 15	3 40	3 16	3 45	4 41	5 16
3	4 7	4 35	4 15	4 45	5 48	6 18
4	5 2	5 25	5 16	5 46	6 48	7 15
5	5 55	6 21	6 16	6 45	7 41	8 2
6	6 47	7 11	7 12	7 37	8 22	8 42
7	7 35	7 57	8 1	8 21	9 12	9 22
8	8 17	8 37	8 41	9 3	9 42	10 1
9	8 59	9 20	9 24	9 44	10 22	10 43
10	9 41	10 2	10 4	10 25	11 5	11 28
11	10 24	10 45	10 45	11 7	11 52	.....
12	11 6	11 29	11 28	11 48	0 14	0 40
13	11 50	.....	.....	0 10	1 9	1 41
14	0 11	0 34	0 33	0 58	2 15	2 52
15	0 58	1 24	1 25	1 55	3 30	4 9
16	1 51	2 20	2 28	3 2	4 46	5 23
17	2 51	3 23	3 39	4 16	5 57	6 28
18	3 57	4 33	4 55	5 33	6 56	7 22
19	5 9	5 44	6 9	6 43	7 44	8 4
20	6 20	6 53	7 13	7 40	8 22	8 39
21	7 23	7 52	8 4	8 26	8 57	9 13
22	8 16	8 40	8 46	9 5	9 30	9 47
23	9 4	9 26	9 25	9 44	10 4	10 21
24	9 49	10 11	10 2	10 20	10 39	10 57
25	10 31	10 52	10 38	10 56	11 17	11 35
26	11 13	11 32	11 15	11 33	11 54	.....
27	11 51	.....	11 51	.....	0 15	0 38
28	0 10	0 29	0 10	0 29	1 3	1 29
29	0 50	1 11	0 50	1 13	1 57	2 29
30	1 34	2 8	1 38	2 4	3 1	3 34
31	.....	.....	2 34	3 3	4 9	4 42

NOTE.—It is low water 6*h.* 25*m.* after the time of high water.

TABLE IV.

Approximate mean time of high water at Baltimore, Md., for June, July, and August, 1861.

Day of month.	June.		July.		August.	
	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
1	0 50	1 15	0 49	1 15	1 59	2 29
2	1 39	2 4	1 40	2 9	2 59	3 30
3	2 29	2 53	2 36	3 2	4 0	4 27
4	3 18	3 41	3 30	3 57	4 52	5 19
5	4 5	4 29	4 25	4 50	5 44	6 9
6	4 52	5 15	5 16	5 41	6 33	6 57
7	5 38	6 2	6 6	6 32	7 18	7 39
8	6 26	6 51	6 56	7 19	7 59	8 18
9	7 14	7 36	7 40	8 0	8 39	9 1
10	7 57	8 19	8 21	8 42	9 22	9 45
11	8 41	9 2	9 2	9 24	10 9	10 35
12	9 25	9 46	9 45	10 7	11 2	11 32
13	10 9	10 32	10 30	10 55	.....	0 5
14	10 56	11 21	11 21	11 49	0 41	1 18
15	11 48	.....	.....	0 20	1 54	2 30
16	0 17	0 45	0 53	1 27	3 4	3 37
17	1 17	1 48	2 3	2 37	4 7	4 36
18	2 20	2 52	3 12	3 46	5 1	5 25
19	3 25	3 56	4 19	4 48	5 48	6 11
20	4 28	4 58	5 17	5 44	6 32	6 54
21	5 27	5 56	6 10	6 37	7 13	7 30
22	6 25	6 55	7 1	7 10	7 47	8 4
23	7 19	7 42	7 42	8 0	8 21	8 38
24	8 5	8 27	8 19	8 37	8 56	9 14
25	8 47	9 9	8 55	9 13	9 33	9 53
26	9 30	9 49	9 32	9 50	10 14	10 36
27	10 10	10 30	10 10	10 30	11 0	11 25
28	10 51	11 12	10 51	11 12	11 53	.....
29	11 34	11 58	11 36	.....	0 25	0 54
30	.....	0 24	0 2	0 30	1 26	1 57
31	.....	.....	0 59	1 29	2 30	3 0

NOTE.—It is low water 6*h.* 33*m.* after the time of high water.

TABLE V.

Approximate mean time of high water at Annapolis, Md., June, July, and August, 1861.

Day of month.	June.		July.		August.	
	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
1	11 20	11 44	11 20	11 45	0 4	0 34
2	.....	12 09	.....	12 14	1 4	1 35
3	0 34	12 59	0 41	1 08	2 5	2 32
4	1 23	1 46	1 35	2 02	2 58	3 24
5	2 10	2 34	2 30	2 55	3 50	4 13
6	2 57	3 20	3 21	3 47	4 38	5 2
7	3 44	4 07	4 12	4 37	5 23	5 45
8	4 32	4 56	5 01	5 24	6 4	6 23
9	5 19	5 42	5 46	6 05	6 44	7 6
10	6 02	6 24	6 26	6 47	7 27	7 50
11	6 45	7 07	7 07	7 29	8 14	8 40
12	7 30	7 51	7 50	8 12	9 7	9 37
13	8 14	8 37	8 35	9 00	10 11	10 46
14	9 01	9 26	9 26	9 54	11 22	11 59
15	9 53	10 22	10 25	10 58	.....	0 36
16	10 51	11 21	11 32	.....	1 9	1 42
17	11 53	.....	0 07	12 42	2 12	2 41

TABLE V—Continued.

Day of month.	June.		July.		August.	
	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
18	0 25	12 57	1 17	1 21	3 6	3 31
19	1 30	2 01	2 24	2 53	3 53	4 15
20	2 33	3 03	3 22	3 49	4 37	4 59
21	3 33	4 01	4 15	4 42	5 17	5 35
22	4 31	5 00	5 06	5 26	5 52	6 9
23	5 26	5 49	5 48	6 05	6 26	6 44
24	6 10	6 33	6 24	6 43	7 1	7 19
25	6 54	7 14	7 00	7 18	7 38	7 58
26	7 35	7 55	7 37	7 55	8 19	8 41
27	8 15	8 35	8 15	8 35	9 5	9 30
28	8 56	9 17	8 56	9 17	9 58	10 28
29	9 39	10 04	9 41	10 07	10 58	11 31
30	10 29	10 54	10 34	11 04	.....	0 3
31	.....	.....	11 33	.....	0 36	1 5

NOTE.—It is low water at Annapolis 6*h.* 15*m.* after the time of high water. It is high water at Havre de Grace about 4*h.* 9*m.* after the time of high water at Annapolis.

Co-tidal lines of Chesapeake bay.

The co-tidal lines are drawn on the chart from the observed mean tidal establishments of the coast, bay, and rivers. They show the mean interval between high water (middle of stand) and the moon's transit immediately preceding, and thus serve, in connection with the table of the half-monthly inequality of this interval, (Table II,) to determine the time of high water anywhere within the limits of the curves. The curves are drawn for intervals of half hours, and it will be seen that the tide-wave takes over twelve hours to go up the bay. If it is high water at the entrance and near the head of the bay, there will be at the same time a low water somewhere above the middle of the bay, and *vice versa.* These co-tidal lines also serve for the purpose of predicting the establishment of the current, (the horizontal component of the tidal wave,) according to the rules given under the head "Current."

The numbers in brackets, below the co-tidal hours, indicate the mean rise and fall in feet and decimals. For other periods of the half-monthly inequality Table II gives the necessary small correction for any particular case. The average uncertainty in the position of the curves may be estimated at about half an hour, and at about three-quarters of an hour in localities where observations are scanty. In the rivers much depends upon interpolation.

The tidal, as well as the current establishments here presented, should be considered as approximate, the observations being as yet incomplete.

Currents in Chesapeake bay.

Time.—At the entrance of the bay the ebb current begins three hours after the high water stand, (or nearly midway between high and low water;) between the mouths of the Rappahannock and York rivers this interval is about 1h. 45m.; in the vicinity of Annapolis it is but one hour, and at the head of the bay there is only half an hour between the high water stand and the commencement of the ebb current. The epoch of the beginning of the ebb, or outgoing stream, can be predicted, as well as the tides, (vertical motion,) by means of the ordinary tidal high water computation with the data furnished by the chart and the above stated differences,

according to the position in the bay. To find the beginning of the flood, add to the time so found the duration of the ebb and the duration of slack water between ebb and flood current, as given below. The average uncertainty in the current epoch may be estimated as one hour, the principal disturbing agency being the wind.

Direction.—The true direction of the ebb and flood current is indicated on the chart, the former by a half arrow ↓ the latter by a full arrow ↑. This direction refers to the time when the current runs with its greatest velocity.

Velocity.—The maximum velocity expressed in miles (nautical) per hour is written against the arrow, for ebb and flood respectively. The average greatest velocity of the ebb stream is 0.92m. and of the flood stream 0.86m., showing the slight effect due to the discharge of river water. At the entrance the maximum velocity of the ebb and flood is on the average 1.1m. Further up the bay it diminishes to 0.9m. and at the head of the bay it again increases to 1.0m.

Duration of slack water and of ebb and flood current.—The duration of slack water, preceding the ebb and flood, is sensibly equal, and does not appear to vary much from 20 minutes between the entrance and the head of the bay. At the entrance, and in Hampton Roads, the duration of the ebb and flood stream is nearly the same, namely, 5h. 50m.; but as we go up the bay the duration of ebb increases, while the flood diminishes. North of the mouth of the Potomac, these intervals are nearly as 6h. 26m. and 5h. 20m.; and near the head of the bay the duration of ebb may reach 7h. and the duration of the flood current be as short as 4h. 45m.

Magnetic Variation.—Chesapeake bay.

The curves (nearly straight lines) with the magnetic variation marked on the chart in half degrees represent the combined results of the separate determinations, given in the accompanying table. The epoch to which the observations have been referred is July, 1861, and by adding $2\frac{1}{2}$ minutes for each year following, the variation may be ascertained at any station for any year within the limits of the curves, during the next ten years.

The curves referred to are first approximations, and will be subject to future correction as our data become more complete. The greatest uncertainty may be taken as a quarter of a degree; but for the two lower curves ($1\frac{1}{2}°$ and 2° W.) it may amount to half a degree.

Table of observed variations of the magnetic needle between Delaware bay and the entrance to Chesapeake bay, inclusive of the Chesapeake bay and rivers, with results brought up to the middle of the year 1861.

Station.	Latitude N.	Longitude W.	Date.	Observed declination W.	Reduction to 1861.5.	Decl'n W. 1861.5.
	° ′	° ′		° ′	′	° ′
Wilmington	39 45	75 34	1846.4	2 31	+37	3 08
Sawyer	43	75 34	1846.5	2 48	37	3 25
Fort Delaware	35	75 34	1846.5	3 17	37	3 54
Susquehanna Light	32	76 05	1847.5	2 14	35	2 49
Osborn's Ruin	28	76 17	1845.5	2 32	40	3 12
Hawkins	26	75 17	1846.5	2 59	37	3 36
Pine Mount	25	75 20	1846.5	3 14	37	3 51
Finlay	24	76 31	1845.5	2 15	40	2 55
Bombay Hook	22	75 30	1846.5	3 18	37	3 55
Rosanne	17	76 43	1845.4	2 11	40	2 51
Pool's Island	17	76 15	1847.5	2 29	35	3 04
Fort McHenry	16	76 35	1856.7	2 29	12	2 41
Port Norris	15	75 01	1846.5	3 04	37	3 41
North Point	12	76 26	1846.5	1 37	37	2 14
Egg Island	10	75 08	1846.5	3 03	37	3 40

Table of observed variations of the magnetic needle between Delaware bay and the entrance to Chesapeake bay—Continued.

Station.	Latitude N.	Longitude W.	Date.	Observed declination W.	Reduction to 1861.5.	Decl'n W. 1861.5.
	° ′	° ′		° ′	′	° ′
Bodkin	39 08	76 25	1847.4	2 02	35	2 37
Soper	05	76 57	1850.6	2 07	27	2 34
Webb	05	76 40	1850.9	2 08	26	2 34
Kent Island (1)	02	76 19	1849.5	2 30	30	3 00
Taylor	00	76 28	1847.4	2 18	35	2 53
Town Bank	38 59	74 57	1846.5	2 59	37	3 36
Cape May Light	56	74 57	1855.6	3 45	15	4 00
Causten	55	77 04	1855.8	1 06	15	1 21
Hill	54	76 52	1850.7	2 19	27	2 46
South Base, Kent Island	54	76 22	1845.4	2 24	40	3 04
Washington, C. S. O.	53	77 00	1860.8	2 27	2	2 29
Marriott	52	76 36	1849.5	2 05	30	2 35
Lewes Landing	49	75 12	1846.5	2 45	37	3 22
Pilot Town	47	75 09	1846.5	2 43	37	3 20
Cape Henlopen	46	75 05	1856.6	3 04	12	3 16
Oxford	41	76 10	1856.7	2 41	12	2 53
Dagsborough	35	75 15	1856.6	2 41	12	2 53
Davis	20	75 06	1853.7	2 33	20	2 53
Brown's Island, Fredericksburg	18	77 27	1856.7	1 02	12	1 14
Mason's Landing	14	75 15	1856.6	2 23	12	2 35
Snead	37 58	75 26	1856.7	2 18	12	2 30
Joynes	42	75 37	1856.7	2 03	12	2 15
Mayo's Island, Richmond	32	77 26	1856.7	0 15	12	0 27
Scott	20	75 54	1856 7	1 37	12	1 49
Roslyn, Petersburg	14	77 24	1852.7	0 26	22	0 48
Cape Charles	07	75 58	1856 7	1 35	12	1 47
Old Point Comfort	00	76 18	1853.7	1 15	12	1 27
Cape Henry	36 56	76 00	1856.7	1 28	12	1 40
Norfolk	50	76 17	1856 7	1 36	12	1 48

NOTE.—The present annual increase is nearly 2¼′, and will probably not sensibly change for the next ten years.

*List of lights on Chesapeake bay and vicinity.**

Name of lights.	Latitude.	Longitude. In arc.	Longitude. In time.	Visibility in nautical miles, eye elevated 13 feet.
Approaches to the Chesapeake.				
Assateague	N. 37 54 37	W. 75 21 04	5 01 24.2	14.6
Hog Island	37 23 16	75 41 35	5 02 46.4	13.2
Cape Charles, or Smith's island	37 07 48	75 52 12	5 03 28.8	14.0
Cape Henry	36 55 29	76 00 12	5 04 00.8	17.5
Hampton Roads.				
Willoughby's Spit Light-vessel	37 00.1	76 14.8	5 04 59	12.3 / 11.1
Old Point Comfort	37 00 02	76 18 06	5 05 12.4	12.3
Old Point Comfort Beacon Light, (approximate)	37 00.0	76 18.5	5 05 14	9.5
Craney Island, (approximate)	36 53.3	76 20.6	5 05 22	12.5
Naval Hospital, (approximate)	36 50.8	76 17.8	5 05 11	.....
James river.				
White Shoal, (approximate)	37 01.4	76 31.5	5 06 06	10.3
Point of Shoals, Burwell's Bay, (approximate)	37 03.8	76 39.2	5 06 37	10.3
Deep Water Shoals, (approximate)	37 08.2	76 38.0	5 06 32	10.3
Jordan's Point	37 18 43	77 13 06	5 08 52.4	11.1
Chesapeake bay.				
Back River	37 05 10	76 15 54	5 05 03.6	11.1
Cherry Stone, (approximate)	37 15.6	76 01.8	5 04 07	11.2

* Names taken from list of the Light-house Board.

List of lights on Chesapeake bay and vicinity—Continued.

Name of lights.	Latitude.	Longitude. In arc.	Longitude. In time.	Visibility in nautical miles, eye elevated 13 feet.
Chesapeake bay—Continued.	° ′ ″	° ′ ″	h. m. s.	
York Spit Light-vessel	N. 37 12.0	W. 76 13.7	5 04 55	11.6
New Point Comfort	37 18 00	76 16 22	5 05 05.5	13.2
Wolf Trap Light-vessel	37 23.3	76 10.0	5 04 40	11.4 10.6
Stingray Point, (approximate)	37 33.6	76 16.0	5 05 04	11.2
Windmill Point Light-vessel	37 34.8	76 11.5	5 04 46	11.0
Rappahannock river.				
Bowler's Rock Light-vessel	37 49.2	76 43.3	5 06 53	.....
Chesapeake bay.				
Watt's Island	37 46 53	75 53 18	5 03 33.2	12.1
Smith's Point Light-vessel	37 52.7	76 10.1	5 04 40	11.1 11.5
Jane's Island Light-vessel	37 57.6	75 55.4	5 03 42	10.6
Point Lookout	38 02 16	76 19 01	5 05 16.1	11.3
Potomac river.				
Piney Point	38 08 03	76 31 29	5 06 05.9	11.1
Blackstone Island	38 12 23	76 44 24	5 06 57.6	12.1
Lower Cedar Point Light-vessel	38 21	77 00.5	5 08 02	9.7
Upper Cedar Point Light-vessel	38 24	77 03.5	5 08 14	10.4
Fort Washington, (approximate)	38 43.4	77 01.2	5 08 05	.....
Jones's Point, (approximate)	38 47.4	77 01.4	5 08 06	11.1
Chesapeake bay.				
Fog Point	38 02 04	76 02 15	5 04 09.0	10.6
Hooper's Straits Light-vessel	38 13.0	76 05.0	5 04 20	11.0
Clay Island	38 13 53	75 58 08	5 03 52.6	11.2
Cove Point	38 23 07	76 22 36	5 05 30.4	12.1
Sharp's Island	38 37 44	76 21 55	5 05 27.7	11.7
Thomas's Point	38 54 25	76 26 53	5 05 47.6	13.5
Greenbury's Point, (approximate)	38 58.5	76 27.0	5 05 48	12.5
Sandy Point, (approximate)	39 01.0	76 23.5	5 05 34	12.5
Patapsco river.				
Bodkin Tower, (light discontinued)	39 08 02	76 25 10	5 05 40.6	.....
Seven-foot Knoll, (approximate)	39 09.3	76 23.9	5 05 36	11.9
North Point Lower Light	39 11 36	76 26 12	5 05 44.8	10.9
North Point Upper Light	39 11 46	76 26 36	5 05 46.4	11.8
Fort Carroll	39 12 50	76 30 55	5 06 03.7	11.3
Lazaretto Point	39 15 42	76 33 59	5 06 15.9	11.1
Upper Chesapeake bay.				
Pool's Island	39 17 23	76 15 41	5 05 02.7	11.1
Turkey Point	39 26 56	76 00 12	5 04 00.8	13.6
Fishing battery, (approximate)	39 29.6	76 04.7	5 04 19	11.2
Havre de Grace	39 32 23	76 04 47	5 04 19.1	11.6

NOTE.—Many of these lights are now probably extinguished, and light-boats may have been removed. The towers may still serve as day marks.

TIDE TABLES

FOR

THE USE OF NAVIGATORS,

PREPARED BY

PROFESSOR A. D. BACHE,

SUPERINTENDENT UNITED STATES COAST SURVEY.

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APPENDIX No. 33.

ON THE HEIGHTS OF THE TIDES OF THE ATLANTIC COAST OF THE UNITED STATES, FROM OBSERVATIONS IN THE COAST SURVEY, BY A. D. BACHE, SUPERINTENDENT.

[Communicated, by authority of the Treasury Department, to the American Association for the Advancement of Science]

It is well known that where a bay or indentation of the coast presents its opening favorably to the tide wave, and decreases in width from the entrance towards its head, that the tides rise higher and higher from the mouth upwards. The Rev. Mr. Whewell has stated that, in a general way, the same fact is deduced from the observations on the coast of Great Britain and Ireland, discussed by him.

The Coast Survey observations of the tides of the Atlantic coast, the results of which, from time to time, I have brought before the Association, furnish the means of a complete discussion of heights as well as of times, and very simple generalizations result from their examination. Through the kindness of Captain Shortland, R. N., and of Admiral Bayfield, R. N., I have been enabled to extend these results to the coasts of New Brunswick, Nova Scotia, and to part of Newfoundland.

I beg leave to make my best acknowledgements to these distinguished hydrographers for the prompt and liberal communication of the results of their observations.

The Coast Survey observations have been worked up in the Tidal Division under the direction of Assistant L. F. Pourtales, and I am indebted to him for giving the results the shape desired, and for the diagrams representing them.

The following table of stations on or near the exterior coast line of the United States is taken from the more extended tables of the Coast Survey, omitting stations which are up rivers or bays, except in special cases, the object of inserting which will be obvious.

Table A contains a number for reference, the locality of the tidal station, the State to which it belongs, the latitude, longitude, the mean height of the tide in feet and tenths, and a column of remarks.

TABLE A.

Heights of tides on the Atlantic coast of the United States.

No.	Locality.	State.	Latitude.	Longitude.	Heights in feet.	Remarks.
			° ′	° ′		
1	Portland	Maine	43 39	70 14	8.8	
2	Portsmouth	N. Hampshire	43 04	70 42	8.6	
3	Newburyport	Massachusetts	42 48	70 52	7.8	
4	Gloucester	do	42 37	70 40	8.9	
5	Salem	do	42 31	70 54	9.2	
6	Boston	do	42 22	71 03	10.0	
7	Plymouth	do	41 57	70 40	10.2	
8	Provincetown	do	42 03	70 11	9.2	Major Graham, U. S. A.
9	George's Shoals		41 40	67 45	7.0	Captain Wilkes, U. S. N.
10	Monomoy	Massachusetts	41 33	69 59	3.8	
11	Siasconsett	do	41 15	70 00	2.2	
12	Weweeder	do	41 15	70 05	1.2	
13	Smith's Point	do	41 17	70 16	2.1	
14	Wasque	do	41 21	70 30	1.7	
15	Menemsha	do	41 20	70 45	2.7	
16	Point Judith	Rhode Island	41 22	71 29	3.1	
17	Newport	do	41 29	71 20	3.9	
18	Block Island	do	41 10	71 34	2.8	
19	Montauk Point	New York	41 04	71 51	1.9	
20	Stonington	Connecticut	41 20	71 54	2.7	
21	New Haven	do	41 18	72 54	5.8	
22	Fire Island	New York	40 38	73 13	2.1	
23	Sands' Point	do	40 52	73 43	7.7	
24	Sandy Hook	do	40 28	74 00	4.8	
25	Cold Spring Inlet	New Jersey	38 57	74 45	4.4	
26	Cape May	do	38 56	74 57	4.8	
27	Old Point Comfort	Virginia	37 00	76 18	2.5	
28	Hatteras Inlet	N. Carolina	35 12	75 43	2.0	
29	Beaufort	do	34 42	76 40	2.8	
30	Cape Fear	do	33 52	78 00	4.4	
31	Winyah bay	S. Carolina	33 14	79 08	3.8	
32	Charleston	do	32 46	79 54	5.1	
33	North Edisto river	do	32 33	80 13	5.8	
34	Port Royal	do	32 17	80 40	6.4	
35	Savannah entrance	Georgia	32 02	80 53	7.0	
36	Sapelo	do	31 21	81 24	7.0	
37	St. Simon's	do	31 08	81 36	6.8	
38	St. Mary's river	do	30 42	81 36	5.9	
39	St. John's river	Florida	30 20	81 33	4.6	
40	St. Augustine	do	29 52	81 25	4.2	
41	Indian River Inlet	do	27 28	80 19	2.5	
42	Cape Florida	do	25 40	80 09	1.5	

The following table of tides of localities on the coast of Cape Breton, Nova Scotia, and New Brunswick, is from the observations of Admiral Bayfield and Captain Shortland. The authorities are given in the column of remarks, which also contains the remarks of Admiral Bayfield on the tidal results communicated by him. I have taken from his table the heights which were derived from the greatest number of observations. The column of means is the average of the heights of spring and neap tides in feet and tenths. The localities are arranged from the north, southward on the outer coast, and in the Bay of Fundy from the entrance up the bay.

From the table of Captain Shortland I have selected only a few localities as specimens, having no wish to anticipate, through his generosity, the use which he will doubtless make of his own results.

TABLE B.

Heights of tides on the Coast of Cape Breton, Nova Scotia, and New Brunswick.

No.	Localities.	Remarks on localities.	Latitude.	Longitude.	Rise of tide.					Remarks.
					Ordinary spring.		Ordinary neap.		Mean.	
	*Isl'd of Cape Breton.**		° ′	° ′	ft.	in.	ft.	in.	ft.	
1	St. Ann's Harbor...	Entrance	46 17	60 33	5	0	3	3	4 1	A complete semi-lunation observed.
2	Sydney Harbor	SE. bar.....	46 12	60 13	3	9	2	4	3.1	At full moon, and a day or two before and after.
3	Menadou Harbor...	Near Scataria Island.....	46 00	59 50	5	6	3	4	4.4	Good. A complete semi-lunation observed.
4	St. Peter's Island ..	.....	45 36	60 49	6	0	4	0	5.0	At new moon, and a day or two before and after.
5	St. Peter's Bay.....	Haulover, at head of bay.	45 39	60 52	5	9	4	1	4.9	Good observations, four times observed, twice at the full, and twice at the new moon, with several days before and after each.
6	Grandigue	In Lennox Passage.....	45 36	61 01	6	4	4	6	5.4	Good. A complete semi-lunation observed.
7	Arichat Harbor	Jerseyman Island, North Point.	45 30	61 03	5	0	4	0	4.5	Good. A complete semi-lunation observed. Extraordinary tides rise six feet.
	*Nova Scotia.**									
8	Canso Harbor	E. end of Cutler Island...	45 21	60 59	6	6	4	6	5.5	A complete semi-lunation observed, but tides very irregular.
9	White Haven.....	Marshall Cove.....	45 15	61 11	6	1	4	1	5.1	A complete semi-lunation observed. Good observations.
10	Harbor Island	NE Point.....	45 08	61 36	6	6	4	6	5.5	A complete semi-lunation observed, extraordinary tides rise seven feet.
11	Liscomb Harbor ...	Pye's Wharf.....	45 00	62 01	6	0	4	0	5.0	Three times observed; at full and new moon, and several days before and after.
12	Sheet Harbor	Watering Cove.....	44 54	62 30	6	8	4	6	5.6	Good. Two complete semi-lunations observed.
13	Pope Harbor.....	Harbor Island, NE. Point..	44 48	62 39	6	6	4	2	5.3	Three times observed; at full and new moon.
14	Ship Harbor.....	Salmon Point.....	44 47	62 49	6	5	4	10	5.6	Good. A complete semi-lunation, extraordinary spring-tides rise seven feet, and extraordinary neaps, only four feet.
15	Jeddore Harbor	Marsh Point.....	44 43	63 00	6	6	4	8	5.6	Two good and complete semi-lunations observed.
16	Halifax Harbor.....	Naval Yard.....	44 40	63 35	6	0	4	6	5.2	Mean of a complete year's observations with a tide-gauge.
	Bay of Fundy.†									
17	Cape Sable.....	Cape Sable Isl'ds, Clark's Harbor.	43 25	65 39	11	6	4	11	8.2	
18	Ellenwood's Island.	Bird Rock.....	43 39	66 04	12	7	7	0	9.7	
19	Yarmouth Harbor..	Fourchue Island Light-house.	43 47	66 10	16	0	8	7	12.6	
20	Bryer's Island	Peter's Island Light-house.	44 15	66 21	20	6	9	3	14.8	
21	Campobello Island.	Owen's House.....	44 54	66 58	25	0	11	0	18.0	
22	St. John's, N. B....	Battery Point Rock	45 16	66 04	26	6	12	0	19.3	
23	Shadwood Point...	Cumberland Basin.....	45 54	64 22	50	0	22	0	36.0	

* Admiral Bayfield, R. N. Capt. Shortland, R. N.

These numbers may be extended beyond the turn of Cape Race, where the coast trends to the west of north, by further results of Admiral Bayfield, though the remarks which he makes show them to be only approximate. Thus two stations on the coast of Labrador, St. Lewis bay, in latitude 52° 19′ and longitude 55° 37′, and Henley island in latitude 52° 00′ and longitude 55° 53′, give each for the mean of the height of spring and neap tides 2.3 feet. St. John's, Newfoundland, gives 5.0 feet. Trepassey harbor, south of it, 5.8 feet.

Beginning with the southern end of Table A, and following the results northward and eastward, we find, from Cape Florida to Savannah and Port Royal, a gradual increase of the tides, and then a gradual decrease to Cape Hatteras, with a single contradiction, easily explained. Next following the stations on the coast, and omitting those in the bays and sounds, we have a less regular increase to Sandy Hook, and a decrease to Weweeder, on Nantucket island. Next is a less regular regimen, requiring a more detailed examination.

By developing the curved line of the coast into a straight line and marking upon it the tide stations, which will thus be at nearly their proper distances from each other, and by erecting ordinates at each of the station points, and setting off on a suitable vertical scale the heights of the tides at those points, and connecting the extremities of the several ordinates, we have the broken line shown in Diagram A. In drawing this line the stations of the coast only are joined, and the irregularities are cut off by the curve.

This curve shows distinctly the *physical* division of the coast between Cape Florida and Cape Sable into three great bays. The great Southern from Cape Florida to Cape Hatteras. The great Middle from Cape Hatteras to Siasconsett; the great Eastern from Siasconsett to Cape Sable. Perhaps this latter may be considered as only a portion of a great bay from Siasconsett to Cape Race, but this generalization is at present hardly safe, and I confine myself, therefore, to the more limited view. The tide wave setting into the southern bay rises as the bay contracts, and the heights of the tides along the shores increase as the places are more distant from the chord spanning the entrance.

If we suppose the lines of equal height to be straight lines, and draw them upon the diagram transferring them to a map of the coast. we shall find that they are more crowded on the more curved side, and more open on the less curved. The curve indicates Cape Hatteras and not the inlet, which was the tidal station, as the point of least height. The physical cause of this phenomenon is well understood if it has not yet been reduced to measure.

The next curve shows us plainly the Middle bay, having Hatteras for its southwestern cape, and Smith's Point or Weweeder for its northeastern entrance. The form of the shore is less favorable to regularity, but the result is nevertheless well marked. The interference of tidal waves which takes place off Nantucket tends also in a degree to confuse the results.

The chart shows how simple the system of co-tidal lines is in the three bays, running nearly parallel to the shores.

The eastern bay lies between the eastern part of Nantucket (Siasconsett) and Cape Sable, Massachusetts bay being subsidiary to this. The tide wave entering the eastern bay follows the deep water, and thus the co-tidal lines take generally the direction of the shores, until the tide wave enters the Bay of Fundy. The most probable form of the co-tidal lines, from XI to XV hours, inclusive, is shown upon the chart, which is merely an extension of the chart of co-tidal lines of the United States coast, formerly presented to the Association. The heights increase rapidly from Nantucket to Cape Cod, being 2 feet at Siasconsett, and 9.2 feet at Pro-

vincetown. At Cape Ann they are nearly of this same height, and increase in passing up and into the bay to 10.0 feet at Boston, and 10.1 feet at Plymouth.

The height at Newburyport is probably local, depending upon the position of the tide-gauge. There is but little change from Portsmouth to Portland, and from Cape Sable to Ellenwood's island.

Shall we look to the greater bay between the Nantucket and Newfoundland shoals for the cause of the 8-feet rise at Cape Sable, and of the heights from Admiral Bayfield's table? We find the heights along the coast of Nova Scotia to vary from 7 to 6 feet; not with regularity, however. At Cape Breton island they vary from 6.4 to 4.6 feet, decreasing thus in going northward and eastward. Are these heights due to the crowding of the waters into this greater bay? If so, why are not the heights of Cape Breton greater than those of Nova Scotia? We require results on the south shores of Newfoundland, and on the Great Bank, to give us clear ideas on these points, and I hesitate to extend the generalizations to this tempting field.

The shoals from Nantucket and broken ground near George's Bank, and the comparatively shoal water in their vicinity, on the one side, and the Great Bank of Newfoundland on the other, look as if full of meaning of this sort. Further results may, however, show that this is not the interpretation of the phenomena. The tides of Labrador are but 2.3 feet, bringing us back to the standard of Hatteras and of Montauk Point, and what probably would be that of Nantucket but for interference. Soon after passing Mount Desert on the west side, and Ellenwood's island on the east side, the tide wave has turned into the Bay of Fundy, and the rise increases with extraordinary rapidity.

The complicated character of the co-tidal lines in this immediate vicinity is indicated by the chart, the lines from XII to XV hours being crowded into the very small space of a few miles, on the south side of Nantucket.

To return to the more limited scale, within which our inductions are safe: Delaware bay, New York bay, Long Island sound, Narragansett and Buzzard's bays, Nantucket and the Vineyard sounds, present, on a smaller scale, the same phenomena of increase in the height of the tide in ascending. On the contrary, in Chesapeake bay, which widens and changes direction at a right angle immediately from the entrance, the tides diminish in height, as a general rule, in going up the bay.

The results of the heights of tides along the coast are very satisfactorily shown upon a model which is now before the Association, for superintending the execution of which I am indebted to Mr. Pourtales. The basis is a map of the Atlantic coast, from Cape Florida to Cape Race, upon which the co-tidal lines of the United States are traced. The tidal stations are marked upon this, and rods, cut to length, and proportionate to the rise and fall of the tides at the several stations, are inserted in holes drilled at the station points. The steel rods refer to the heights at exterior stations, and the brass rods to interior ones. Paper cut to the form of the general curve of heights which has already been explained, and placed behind these rods, serves to show the generalizations with great distinctness.

I propose to call the bay between Cape Florida and Cape Hatteras the southern bay; that between Cape Hatteras and Nantucket the middle bay; and that between Nantucket and Cape Sable the eastern bay, of the coast of the United States. The general figure of the coast line has, of course, heretofore attracted the attention of geographers. The connection with the heights of the tides could only satisfactorily be made out by such a series of tidal observations as those embraced in the Coast Survey.

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APPENDIX NO. 16.

TIDE TABLES FOR THE USE OF NAVIGATORS, PREPARED FROM THE COAST SURVEY OBSERVATIONS BY A. D. BACHE, SUPERINTENDENT.

[Furnished by authority of the Treasury Department to E. and G. W. Blunt, New York, and revised October, 1860.]

THE following tables will enable navigators to ascertain the time and height of high and low water in some of the principal ports of the United States. The results are approximate, the observations being still in progress, but they may safely be used for practical purposes. The number of places of observation, and the time during which many of them have been made, are steadily on the increase as the Coast Survey advances.

The tides on the coast of the United States, on the Atlantic, Gulf of Mexico, and Pacific, are of three different classes. Those of the Atlantic are of the most ordinary type, ebbing and flowing twice in twenty-four hours, and having but moderate differences in height between the two successive high waters or low waters, one occurring before noon, the other after noon.

Those of the Pacific coast also ebb and flow twice during twenty-four hours, but the morning and afternoon tides differ very considerably in height, so much so that at certain periods a rock which has three feet and a half water upon it at low tide may be awash on the next succeeding low water. The intervals, too, between successive high and successive low waters may be very unequal.

The tides of ports in the Gulf of Mexico, west of Cape St. George, ebb and flow, as a rule, but once in twenty-four hours, or are single day tides. At particular parts of the month there are two small tides in the twenty-four hours. The rise and fall in all these ports is small. East of Cape St. George the rise and fall increases ; there are two tides, as a rule, during the twenty-four hours, and the daily inequality referred to in the Pacific tides is large.

These peculiarities require a different way of treating the cases, and in some of them separate tables.

I propose to enable the navigator to find, from the Nautical Almanac and the following tables, the time and height of high and low water at any date within the ordinary range of difference produced by winds and other variable circumstances. I will endeavor to divest the matter of unfamiliar technical expressions as far as practicable, though for shortness' sake, some such terms may be employed after defining them. The discussion of the Gulf tides has not been carried so far as to enable me to present the results in as definite a form as the others.

As is well known, the interval between the time of the moon's crossing the meridian (moon's transit) and the time of high water at a given place is nearly constant; that is, this interval varies between moderate limits, which can be assigned. The interval at full and change of the moon is known as the establishment of the port, and is ordinarily marked on the charts. As it is not generally the average of the interval during a month's tides, it is a less convenient and less accurate quantity for the use of the navigation than the average interval which is used on

the Coast Survey Charts, and is sometimes called the "mean" or "corrected establishment."* The following table gives the principal tidal quantities for the different ports named in the first column, where they are arranged under specific heads. The third column of the table gives the mean interval, in hours and minutes, between the moon's transit and the time of high water next after the transit; the fourth, the difference between the greatest and the least interval occurring in different parts of the month, (lunar.) A simple inspection of this column will show how important it is to determine these changes in many of the ports where they amount to more than half an hour, or to more than fifteen minutes from the average interval. The fifth, sixth, and seventh columns refer to the height of the tide. The fifth gives, in feet, the average rise and fall, or average difference between high and low water. The sixth gives the greatest difference commonly known as the rise and fall of spring tides; and the seventh the least difference known as the rise and fall of the neap tides.

The average duration of the flood or rising tide is given in the eighth column; of the ebb or falling tide in the ninth; and of the period during which the tide neither rises nor falls, or the "stand," in the tenth. The duration of the flood is measured from the middle of the stand at low water to the middle of the stand at high water, so that the whole duration from one high water to the next, or from one low water to the next, should be given by the sum of the numbers in the eighth and ninth columns. At most of these places given in the list a mark of reference has been established for the height of the tide. I have omitted the description of these marks, (except in the following localities,) as of no particular interest in this connection.

BENCH-MARKS.

Boston.—The top of the wall or quay at the entrance of the dry dock in the Charlestown navy yard is fourteen feet $\frac{69}{100}$ (or 14.69 feet) above mean low water.†

New York.—The lower edge of a straight line cut in a stone wall, at the head of a wooden wharf on Governor's island, is thirteen feet $\frac{97}{100}$ (or 13.97 feet) above mean low water. The letters U. S. C. S. are cut in the same stone.

Old Point Comfort, Va.—A line cut in the wall of the light-house, one foot from the ground, on the southwest side, is eleven feet (11 feet) above mean low water.

Charleston, S. C.—The outer and lower edge of embrasure of gun No. 3, at Castle Pinckney, is ten feet $\frac{13}{100}$ (10.13 feet) above mean low water.

* This term was introduced by the Rev. Dr. Whewell, who has done so much for the investigation of the laws of the tides.

† In consequence of alterations made to the wall during the year 1860, the coping is seven hundredths of a foot lower than formerly.

TABLE I.

Tide table for the coast of the United States.

PORT.	STATE.	INTERVAL BETWEEN TIME OF MOON'S TRANSIT AND TIME OF HIGH WATER.		RISE AND FALL.			MEAN DURATION OF—		
		Mean interval.	Diff. between greatest and least int'val.	Mean.	Spring tides.	Neap tides.	Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
COAST FROM PORTLAND TO NEW YORK.		*h. m.*	*h. m.*	*Feet.*	*Feet.*	*Feet.*	*h. m.*	*h. m.*	*h. m.*
Hanniwell's Point, Kennebec river	Maine	11 15	1 14	8.1	9.3	7.0	6 16	6 11	0 22
Portland	....do	11 25	0 44	8.9	9.9	7.6	6 14	6 12	20
Portsmouth	New Hampshire	11 23	53	8.6	9.9	7.2	6 22	6 7	21
Newburyport	Massachusetts	11 22	50	7.8	9.1	6.6	5 16	7 9	24
Rockport	....do	10 57	42	8.6	10.2	7.1	6 17	6 9	30
Salem	....do	11 13	50	9.2	10.6	7.6	6 19	6 6	6
Boston Light	....do	11 12	35	9.3	10.9	8.1	6 20	6 6	15
Boston	....do	11 27	43	10.0	11.3	8.5	6 13	6 13	9
Plymouth	....do	11 19	51	10.2	11.4	9.0	6 13	6 17	29
Wellfleet	....do	11 5	1 13	11.2	13.2	9.2	6 6	6 17	15
Provincetown*	....do	11 22	40	9.2	10.8	7.7	6 16	6 10	21
Monomoy	....do	11 58	37	3.8	5.3	2.6	6 25	5 59	36
Nantucket	....do	12 24	37	3.1	3.6	2.6	6 23	5 44	9
Hyannis	....do	12 22	30	3.2	3.9	1.8	6 44	5 41	9
Edgartown	....do	12 16	34	2.0	2.5	1.6	6 51	5.29	24
Holmes's Hole	....do	11 43	31	1.7	1.8	1.3	6 41	5 21	12
Tarpaulin Cove	....do	8 4	49	2.3	2.8	1.8	6 9	6 17	34
Wood's Hole, north side	....do	7 59	53	4.0	4.7	3.1	6 51	5 31	38
Wood's Hole, south side	....do	8 34	45	1 6	2.0	1.2	5 17	7 10	59
Menemsha Bight	...do	7 45	1 0	2.7	3.9	1.8	6 14	6 14	4
Quick's Hole, north side	....do	7 31	1 15	3.7	4.3	2.9	6 31	5 54	39
Quick's Hole, south side	....do	7 36	1 10	3.1	3.8	2.3	6 29	5 55	40
Cuttyhunk	....do	7 40	49	3.5	4.2	2.9	6 31	5 54	39
Kettle Cove	....do	7 48	1 0	4.3	5.0	3.7	6 17	6 4	29
Bird Island light	....do	7 59	45	4.4	5.3	3.5	6 51	5 58	... .
New Bedford entrance, (Dumpling Rock)	...do	7 57	41	3.8	4.6	2.8	6 50	5 33	42
Newport	Rhode Island	7 45	24	3.9	4.6	3.1	6 21	6 3	23
Point Judith	....do	7 32	46	3.1	3.7	2.6	6 12	6 10	1 0
Block Island	....do	7 36	41	2.8	3.5	2.0	6 23	6 2	5
Montauk Point, L. I.	New York	8 20	1 11	1.9	2.4	1.8	6 17	6 7	31
Sandy Hook	....do	7 29	47	4.8	5.6	4.0	6 10	6 15	21
New York	....do	8 13	43	4.3	5.4	3.4	6 0	6 25	28
HUDSON RIVER.									
Dobb's Ferry	New York	9 19	44	3.6	4.4	2.7	6 5	6 18	17
Tarrytown	....do	9 57	58	3.5	4.0	2.7	6 6	6 20	43
Verplanck's Point	....do	10 8	34	3.1	3.8	2.5	5 25	7 12	16
West Point	....do	11 2	37	2 7	3.2	2.0	5 28	7 10	20
Poughkeepsie	....do	12 34	54	3 2	3.9	2.4	5 41	6 44	22
Tivoli	....do	1 24	51	4.0	4.6	3.2	5 40	6 54	25
Stuyvesant	....do	3 23	48	3.8	4.4	3.0	5 18	7 2	31
Castleton	....do	4 29	55	2.7	3.0	2.3	5 1	7 23	20
Greenbush	....do.	5 22	40	2.3	2.5	1.9	4 26	7 59	.....
LONG ISLAND SOUND.									
Watch Hill	Rhode Island	9 0	23	2.7	3.1	2.4	6 35	5 56	14
Stonington	Connecticut	9 7	30	2.7	3.2	2.2	6 15	6 10	25
Little Gull island	New York	9 38	1 7	2.5	2.9	2.3	6 1	6 21	37
New London	Connecticut	9 28	52	2.6	3.1	2.1	5 56	6 26	22
New Haven	....do	11 16	1 8	5.9	6.2	5.2	6 24	6 5	33
Bridgeport	....do	11 11	1 3	6.5	8.0	4.7	6 1	6 7	30

* From Major J. D. Graham's observations.

TABLE I—Continued.

PORT.	STATE.	INTERVAL BETWEEN TIME OF MOON'S TRANSIT AND TIME OF HIGH WATER.		RISE AND FALL.			MEAN DURATION OF—		
		Mean interval.	Diff. between greatest and least int'val.	Mean.	Spring tides.	Neap tides.	Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
LONG ISLAND SOUND—Continued.		h. m.	h. m.	Feet.	Feet.	Feet.	h. m.	h. m.	h. m.
Oyster Bay, L. I.	New York	11 7	0 51	7.3	9.2	5.4	6 8	6 24	0 25
Sand's Point, L. I.	....do	11 13	31	7.7	8.9	6.4	5 55	6 30	14
New Rochelle	....do	11 22	32	7.6	8.6	6.6	5 51	6 35	12
Throg's Neck	....do	11 20	39	7.3	9.2	6.1	5 50	6 33	43
COAST OF NEW JERSEY.									
Cold Spring inlet	New Jersey	7 32	51	4.4	5.4	3.6	6 8	6 18	19
Cape May landing	....do	8 19	47	4.8	6.0	4.3	6 11	6 15	20
DELAWARE BAY AND RIVER.									
Delaware breakwater	Delaware	8 0	50	3.5	4.5	3.0	6 15	6 6	26
Higbee's, Cape May	New Jersey	8 33	43	4.9	6.2	3.9	6 26	6 0	19
Egg Island light	do	9 4	51	6.0	7.0	5.1	5 52	6 27	36
Mahon's river	Delaware	9 52	48	5.9	6.9	5.0	6 11	6 11	26
Newcastle	....do	11 53	24	6.5	6.9	6.6	5 6	6 43	47
Philadelphia	Pennsylvania	13 44	44	6.0	6.8	5.1	4 52	7 6	15
CHESAPEAKE BAY AND RIVERS.									
Old Point Comfort	Virginia	8 17	60	2.5	3.0	2.0	6 1	6 25	14
Point Lookout	Maryland	12 58	45	1.4	1.9	0.7	5 59	6 19	35
Annapolis	....do	17 4	40	0.9	1.0	0.8	6 11	6 15	32
Bodkin light	....do	18 8	48	1.0	1.3	0.8	5 23	7 8	15
Baltimore	....do	18 59	44	1.3	1.5	0.9	5 54	6 33	44
Washington	Dist. of Columbia	20 10	52	3.0	3.4	2.6	5 37	6 49	.....
James river, (City Point)	Virginia	14 37	1 0	2.8	3.0	2.5	5 14	6 58	32
Richmond	....do	16 54	1 6	2.9	3.4	2.3	4 53	7 31	35
Tappahannock	....do	12 58	46	1.6	1.9	1.3	5 21	7 6	.....
COAST OF NORTH AND SOUTH CAROLINA, GEORGIA, AND FLORIDA.									
Hatteras inlet	North Carolina	7 4	57	2.0	2.2	1.8	6 7	6 7	50
Beaufort	....do	7 26	50	2.8	3.3	2.2	6 11	6 10	42
Bald Head	....do	7 26	34	4.3	5.0	3.4	6 18	6 17	31
Smithville	....do	7 19	38	4.5	5.5	3.8	6 1	6 26	26
Wilmington	....do	9 6	1 0	2.7	3.1	2.2	4 45	7 40	30
Georgetown entrance	South Carolina	7 56	42	3.8	4.7	2.7	6 4	6 19	35
Bull's Island bay	....do	7 16	57	4.8	5.7	3.7	6 20	6 6	30
Charleston, (custom-house wharf)	....do	7 26	48	5.1	6.0	4.1	6 19	6 7	33
St. Helena sound	....do	7 8	1 0	5.9	7.4	4.4	6 13	6 12	23
Fort Pulaski, (Savannah entrance)	Georgia	7 20	40	7.0	8.0	5.9	5 49	6 35	26
Savannah, (dry dock wharf)	....do	8 13	51	6.5	7.6	5.5	5 4	7 22	14
Doboy Light-house	....do	7 33	55	6.6	7.8	5.4	6 2	6 20	.....
St. Simons	....do	7 43	46	6.8	8.2	5.4	6 10	6 16	20
Fort Clinch	Florida	7 53	1 6	5 9	6.7	5.3	6 9	6 17	.....
St. John's river	....do	7 28	48	4.5	5.5	3.7	5 58	6 28	16
St. Augustine	....do	8 21	43	4.2	4.9	3.6	6 5	6 11	32
Cape Florida	....do	8 34	51	1.5	1.8	1.2	6 0	6 26	45
Indian key	....do	8 23	49	1.8	2.2	1.3	6 25	5 59	19
Sand key	....do	8 40	.....	1.2	2.0	0.6	6 31	5 55	13
Key West	Florida	9 30	1 15	1.3	1.5	0.9	6 55	5 29	12
Tortugas	....do	9 56	1 32	1.2	1.5	0.6	6 43	5 40	.....
Tampa Bay, (Egmont key)	....do	11 21	1 33	1.4	1.8	1.0	6 36	6 11	43
Cedar Keys, (Depot key)	....do	13 15	1 55	2.6	3.2	1.6	6 12	6 13	.....
St. Mark's	....do	13 38	2 0	2.2	2.9	1.4	6 12	6 11	.....

TABLE I—Continued.

PORT.	STATE.	INTERVAL BETWEEN TIME OF MOON'S TRANSIT AND TIME OF HIGH WATER.		RISE AND FALL.			MEAN DURATION OF—		
		Mean interval.	Diff. between greatest and least int'val.	Mean.	Spring tides.	Neap tides.	Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
WESTERN COAST.		*h. m.*	*h. m.*	*Feet.*	*Feet.*	*Feet.*	*h m.*	*h. m.*	*h. m.*
San Diego	California	9 38	1 35	3.7	5.0	2 3	6 22	6 0	0 30
San Pedro	....do	9 39	1 48	3.7	4.7	2.2	6 18	6 5	30
Cuyler's harbor	....do	9 25	1 2	3.7	5.1	2.8	6 13	6 5	.....
San Luis Obispo	....do	10 8	1 52	3.6	4.8	2.4	6 25	5 58	.....
Monterey	....do	10 22	49	3.4	4.3	2.5	6 31	6 2	35
South Farallone	....do	10 37	1 16	3.6	4 4	2.8	6 18	6 9	.....
San Francisco, (north beach)	....do	12 6	1 4	3.6	4.3	2.8	6 39	5 51	34
Mare Island, (San Francisco bay)	....do	13 40	1 15	4.8	5.2	4.1	6 13	6 7	.....
Benicia	....do	14 10	1 0	4.5	5.1	3.7	6 26	5 59	.....
Ravenswood	....do	12 36	57	6.3	7.3	4.9	6 15	6 11	.....
Bodega	....do	11 17	1 54	3.6	4.7	2.7	6 19	5 59	.....
Humboldt bay	....do	12 2	1 11	4.4	5.5	3.5	6 19	6 0	.....
Port Orford	Oregon Territory	11 26	1 6	5.1	6.8	3.7	6 19	6 7	39
Astoria	....do	12 42	1 13	6.1	7.4	4.6	6 3	6 28	33
Nee-ah harbor	Washington Ter'y	12 33	1 28	5.6	7.4	4.8	6 20	6 6	.....
Port Townshend*	...do	3 49	1 3	4.6	5.5	4.0	6 34	5 52	.....
Steilacoom*	....do	4 46	1 6	9.2	11.1	7.2	6 3	6 25	28
Semi-ah-moo bay*	....do	4 50	1 2	5.7	6.6	4.8	6 11	6 19	26

* See remarks on page 22 and following.

Note.—The mean interval in column 3 has been increased by 12*h.* 26*m.*, (half a mean lunar day,) for some of the ports in Delaware river and Chesapeake bay, so as to show the succession of times from the mouth. Therefore 12*h.* 26*m.* ought to be subtracted from the establishments which are greater than that quantity before using them.

The foregoing Table I gives the means of determining, roughly, the time and height of high water at the several ports named. The hour of transit of the moon preceding the time of high water is to be taken from the Almanac, and the mean establishment being added the time of high water results. Thus:

Example I.—It is required to find the time of high water at New York on November 5, 1854. The American Almanac gives 0*h.* 0*m.* as the time of transit of the moon on that day. The mean interval for New York, from Table I, column 3, is 8*h.* 13*m.*, which, as the transit was at 0*h.*, is, roughly, the time of high water. The moon being full, the height is that of spring tides of column 6, viz: 5.4 feet. If the soundings on the chart are reduced to low water spring tides, 5.4 feet are to be added to them to give the depth at high water. If the soundings are reduced to mean low water, the rise and fall of mean tides being 1.1 foot less than for springs, the rise or increase of depth will be half of this, or 0.6 of a foot less than 5.4 feet, which is 4.8 feet, or nearly four feet ten inches.

Example II.—Required the time of high water at Boston on January 23, 1851. From the American Almanac we find the time of the moon's southing or transit on that day 5*h.* 18*m.* a. m., and from Table I the mean interval at Boston dry dock is 11*h.* 27*m.*

We have then 5*h*. 18*m*. time of transit.
To which add 11 27 mean interval from Table I.

16 45 time of high water, or 4*h*. 45*m*. p. m.

If the Greenwich Nautical Almanac is used, add 2*m*. to the time of transit of Greenwich for every hour of west longitude and its proportional part for less than an hour. It will suffice to take the half hour which may be over any number of hours, as the correction for less than this would be less than one minute, and need not be taken into account. Thus, Boston is 4*h*. 44*m*. west of Greenwich. The correction to be applied to the time of transit of the moon is, for the four hours, eight minutes, and for the forty-four minutes, one minute. The time of transit on the date assumed in the preceding example is 17*h*. 9*m*. of the 22d, or 5*h*. 9*m*. a. m. of the 23d, to which add nine minutes; the correction just found gives 5*h*. 18*m*., as before ascertained from the American Almanac.

In using the United States Nautical Almanac, in the astronomical part of which the transits of the moon are given for the meridian of Washington, the corrections required may, in this first approximation for the Atlantic coast, be neglected. To find the time of the next following low water add, from Table I, the duration of ebb tide.

This gives 4*h*. 45*m*. p. m. time of high water.
6 13 duration of ebb tide from Table I.

10 58 p. m.

By subtracting the duration of flood tide we obtain the time of the preceding low water, 10*h*. 32*m*. a. m., recollecting that 4*h*. 45*m*. p. m. is the same as 16*h*. 45*m*. reckoned from midnight.

The height of this tide, corresponding to the transit of 5*h*., will bring it nearly to a neap tide, and the rise and fall obtained from column 7, Table I, is 8.5 feet. The next following high water may be had by adding to the time of low water the duration of flood from Table I. Thus:

10*h*. 58*m*. p. m. time of low water January 23.
6 13 duration of flood from Table I.

Sum 17 11 or 5*h*. 11*m*. on January 24.

Or, having found the time of high water, the time of the next following high water may be found by adding the duration of flood and ebb together, and their sum to the time of high water found, thus:

6*h*. 13*m*. duration of ebb tide, from Table I.
6 13 duration of flood.

Sum 12 26 duration of whole tide.
4 45 p. m., January 23, time of high water.

Sum 17 11 or 5*h*. 11*m*. a. m., January 24, time of the next succeeding high water.

Subtracting the same quantity will give the time of the preceding high water, thus:

4*h*. 45*m*. p. m., or 16*h*. 45*m*. from midnight, is the time of high water.
12 26 duration of flood and ebb tide.

4 19 a. m. of the 23d for the preceding high water.

The duration of the flood and the ebb being reckoned from the middle of one stand or slack

water to the middle of the next, the time of beginning of stand of ebb or flood will be found by subtracting half the duration of stand or slack water given by column 10, Table I, from the time of high or low water, and the time of the end of the stand of ebb or flood by adding the same. A nearer approximation to the times and heights of high water may be obtained by the use of Tables II and III.

TABLE II.

Interval between the time of moon's transit and the time of high water for different hours of transit, and for several different ports.

Time of moon's transit.	Boston, Mass.	New York, N. Y.	Philadelphia, Pa.	Old Pt. Comfort, Va.	Baltimore, Md.	Smithville, N. C.	Charleston, S. C.	Ft. Pulaski, Savannah, Ga.	Key West, Fla.	San Francisco Cal.
h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
0 0	11 38	8 20	1 31	8 33	6 47	7 26	7 38	7 30	9 33	12 5
0 30	11 33	8 18	1 28	8 27	6 42	7 21	7 33	7 25	9 26	11 59
1 0	11 28	8 15	1 25	8 21	6 37	7 16	7 27	7 19	9 19	11 53
1 30	11 24	8 10	1 21	8 15	6 31	7 13	7 21	7 15	9 13	11 47
2 0	11 20	8 6	1 18	8 9	6 26	7 9	7 16	7 11	9 6	11 41
2 30	11 16	8 0	1 14	8 4	6 21	7 6	7 12	7 8	9 1	11 36
3 0	11 13	7 55	1 11	8 0	6 17	7 4	7 8	7 6	8 57	11 33
3 30	11 10	7 52	1 8	7 56	6 13	7 3	7 5	7 5	8 53	11 33
4 0	11 7	7 52	1 6	7 52	6 11	7 2	7 2	7 4	8 53	11 38
4 30	11 6	7 52	1 3	7 49	6 10	7 3	7 2	7 3	8 56	11 46
5 0	11 6	7 53	1 0	7 48	6 10	7 4	7 3	7 4	9 2	11 55
5 30	11 9	7 56	0 59	7 50	6 13	7 6	7 7	7 6	9 10	12 3
6 0	11 13	7 59	0 59	7 53	6 19	7 9	7 12	7 8	9 22	12 11
6 30	11 19	8 5	1 1	8 0	6 25	7 13	7 19	7 12	9 33	12 16
7 0	11 25	8 11	1 7	8 7	6 32	7 17	7 24	7 16	9 49	12 23
7 30	11 32	8 17	1 15	8 15	6 39	7 23	7 32	7 22	10 0	12 29
8 0	11 38	8 23	1 23	8 24	6 44	7 28	7 38	7 28	10 6	12 34
8 30	11 43	8 27	1 29	8 33	6 49	7 33	7 45	7 34	10 7	12 37
9 0	11 47	8 32	1 34	8 40	6 52	7 37	7 48	7 39	10 6	12 36
9 30	11 48	8 34	1 39	8 45	6 54	7 39	7 50	7 42	10 3	12 34
10 0	11 49	8 35	1 42	8 48	6 53	7 40	7 50	7 43	9 59	12 30
10 30	11 48	8 34	1 43	8 48	6 52	7 40	7 47	7 41	9 56	12 24
11 0	11 47	8 31	1 41	8 46	6 50	7 36	7 44	7 37	9 48	12 17
11 30	11 43	8 25	1 37	8 40	6 48	7 30	7 41	7 34	9 40	12 9

TABLE III.

Showing the rise and fall of tides, and corrections to be applied to determine the depth at high water of soundings on charts referred to mean low water, and to low water spring tides.

Time of moon's transit.	Boston. Mass.			New York, N. Y.			Philadelphia, Pa.			Old Point Comfort, Va.			Baltimore, Md.			Time of moon's transit.
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Hour.*
0	11.2	10.6	11.3	4.9	4.5	4 9	6.3	6.2	6.3	2.9	2.6	2.9	1.5	1 4	1.6	0
1	11.3	10.6	11 3	4.9	4.5	4.9	6.4	6.4	6.5	3.0	2.7	3.0	1.5	1.4	1.6	1
2	11.2	10.5	11.2	4.7	4.4	4 8	6.6	6.5	6.6	2.9	2.7	2.9	1.5	1.3	1.5	2
3	10.6	10.3	10.0	4.3	4.2	4.6	6.6	6.5	6.6	2.6	2 6	2.8	1.4	1.3	1.5	3
4	10.0	10.0	10.7	3.8	4.0	4.4	6.4	6.4	6.5	2.3	2.4	2.7	1.3	1.2	1.4	4
5	9.2	9.7	10.4	3.5	3.8	4.2	6.1	6 2	6.3	2.1	2.3	2 6	1.1	1.1	1.3	5
6	8.8	9.4	10.1	3.3	3.7	4.1	5.7	5.9	6.0	2.0	2.2	2.5	0.9	1.1	1.3	6
7	8.6	9.3	10.0	3.3	3.7	4.1	5.4	5.6	5.7	2.0	2.3	2.5	0.9	1.1	1.3	7
8	8.9	9.5	10 2	3.6	3.8	4.2	5.2	5.3	5.4	2.2	2.4	2 6	1.0	1.2	1.4	8
9	9.4	9.7	10.4	4 0	4.0	4.4	5.4	5.4	5.5	2.5	2.5	2.8	1.1	1.3	1.5	9
10	10.1	10.0	10.7	4.5	4.3	4 7	5.7	5.7	5.8	2.8	2.7	2.9	1.3	1.4	1.6	10
11	10.7	10 3	11.0	4.8	4.5	4.9	6.0	6.0	6.1	3.0	2.8	3.0	1 4	1.4	1.6	11

TABLE III.—Continued.

Time of moon's transit.	Smithville, N. C.			Charleston, S. C.			Fort Pulaski, Savannah entrance.			Key West, Fla.			San Francisco, Cal.			Time of moon's transit.
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Hour.*
0	5.2	4.8	5.1	6.0	5.5	6.0	7.8	7.4	7.8	1.5	1.4	1.5	4.5	4.0	4.4	0
1	5.1	4.8	5.1	5.9	5.5	5.9	7.9	7.4	7.9	1.5	1.4	1.5	3.9	3.7	4.1	1
2	5.0	4.7	5.0	5.7	5.4	5 8	7.6	7.3	7.7	1.5	1.4	1.5	3.7	3.6	4.1	2
3	4.6	4.5	4.8	5.3	5.2	5.6	7.1	7.0	7.5	1.4	1.3	1.4	3.5	3.5	4.0	3
4	4.3	4.4	4.7	4.7	4.9	5.4	6.5	6.7	7.2	1.2	1.2	1.3	3.1	3.3	3.8	4
5	4.0	4.3	4.6	4.4	4.8	5.2	6.1	6.5	7.0	1.0	1.1	1.2	2.8	3.1	3.6	5
6	3.8	4.2	4.5	4.2	4.6	5.1	5.8	6.4	6.8	0.9	1.0	1.1	2.7	3.1	3.6	6
7	3.8	4.1	4.4	4.3	4.7	5.1	6.0	6.5	6.9	0.9	1.1	1.2	3.0	3.3	3.7	7
8	4.0	4.2	4.5	4.5	4.8	5.3	6.4	6.7	7.1	1.0	1.2	1.3	3.4	3.5	3.9	8
9	4.3	4.3	4.6	5.0	5.0	5.5	6.9	6.9	7.4	1.2	1.3	1.4	3.8	3.6	4.1	9
10	4.7	4.6	4.9	5.5	5.3	5.8	7.4	7.0	7.6	1.4	1.4	1.5	4.0	3.8	4.2	10
11	5.0	4.7	5.0	5.9	5.5	5.9	7.8	7.2	7.8	1.5	1.4	1.5	4.2	3.8	4.3	11

In these the variations in the interval between the moon's transit and high water are shown for some of the principal ports contained in Table I. These variations of intervals depend upon the age of the moon, and, as they go through their values in half a lunar month, are known as the half-monthly inequality of interval. The table extends from the 0*h.* of transit, midnight of the calendar day, or full of the moon, to $11\frac{1}{2}$ hours. The numbers for change of the moon correspond to those of 0*h.*, and for 13 hours (or 1*h.* p. m. of the calendar day) to 1 hour, and so on up to 23 hours. The ports for which the numbers are given are designated by the heading of the column.

The mean interval, it will be seen, does not occur at full and change, but nearly two days afterwards, on the Atlantic coast. At Key West it occurs more nearly at full and change, and at San Francisco still more nearly.

The same remark applies to the heights; spring tides occur about two days after the full and change of the moon, and neaps two days after the first and last quarters. The use of this table of nearer approximation is quite as simple as that of Table I.

Rule to find the time of high water.—Look in the Almanac for the time of moon's transit (or southing) for the date required. In the table corresponding to that time will be found the number to be added to the time of transit.

Example III.—Required the time of high water at New York October 1, 1856. Using the United States Nautical Almanac, we find the time of moon's transit 1*h.* 24*m.* astronomical reckoning, or 1*h.* 24*m.* p. m. calendar time. From Table II we have, under the heading of New York, for 1*h.* 30*m.* (the nearest number to 1*h.* 24*m.* in the table) 8*h.* 10*m.*

Thus, to 1*h.* 24*m.*, time of moon's transit,

Add 8 10 interval found in Table III.

The sum 9 34 p. m. is the time of high water on the 1st of October, 1856.

If the sum of these numbers had exceeded twelve, the tide would have belonged to October 2, and we must have gone back to the transit of the day before and computed with it to obtain the tide of October 1.

Rule to find the height of high water.—Enter table III, column 1, with the time of moon's transit. In the column headed with the name of the place, and marked A, will be found the rise and fall corresponding to the time of transit; in column B the number to be added to

soundings on the chart, where the soundings are given for mean low water; in column C the number to be added to charts of which the soundings are given for low water spring tides.

In the foregoing example, (III,) the time of transit being 1 and 2 hours, we find from Table III the rise and fall of tides on the 1st of October, 1856, between 4.9 and 4.7; the number to be added to soundings given for mean low water 4.5 feet, (column B,) and for low water spring tides (column C) 4.9 feet.

Having found the time of high water, that of low water may be obtained, nearly, by adding the duration of ebb from column 9, Table I. The time of the next preceding low water may be found by subtracting the duration of flood from column 8, Table I. The time of the next following high water may be found by adding the duration of both flood and ebb; and of the next preceding high water by subtracting the same duration of the whole tide.

Example IV.—To find the next high water following that of Example III.

The duration of flood, column 8, Table I, for New York is 6*h.* 0*m.*, and of ebb, from column 9, is 6*h.* 25*m.*; the sum is 12*h* 25*m.*

To	9*h.*	34*m.*	p. m., October 1, time of high water found,
Add	12	25	duration of flood and ebb.
Sum	21	59	or 9*h.* 59*m.* a. m. of October 2, the time of the next high water.

TIDES OF THE PACIFIC COAST AND OF PART OF THE COAST OF FLORIDA.

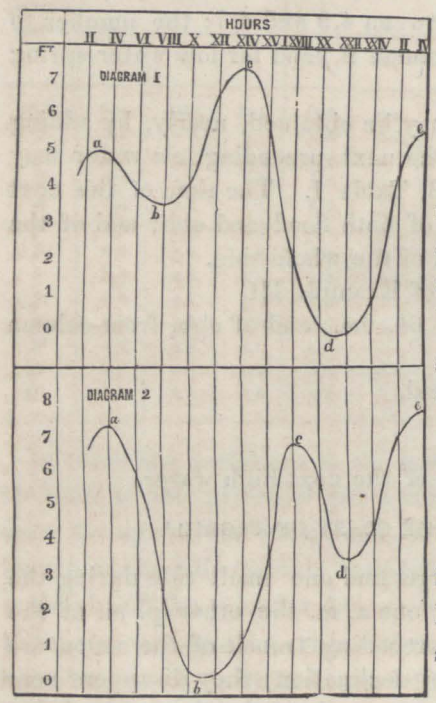
On the Pacific coast there are, as a general rule, one large and one small tide during the day, the height of the two successive high waters occurring one a. m. the other p. m. of the same twenty-four hours, and the intervals from the next preceding transit of the moon are very different. The inequalities depend upon the moon's declination; they disappear near the time of the moon's declination being nothing, and are greatest about the time of its being greatest. The inequalities for low water are not the same as for high, though they disappear and have the greatest value at nearly the same times. The tides of the southern part of Florida and of the western coast of that peninsula, as far as St. Mark's, are of the same character.

In Puget's sound the inequalities for the interval of high water and for the height of low water follow this rule; but those for the interval of low water and height of high water disappear about one day before the moon's declination is greatest, and are greatest about four or five days before the greatest declination.

When the moon's declination is north, the highest of the two tides of the twenty-four hours occurs at San Francisco about eleven and a half hours after the moon's southing, (transit;) and when the declination is south, the lowest of the two high tides occurs about that interval.

The lowest of the two low waters of the day is one which follows next the highest high water. The nature of these tides will probably appear more plainly from the annexed diagrams. In them the height of the tide is set off at the side on a scale of feet, and the hours of the day are at the top. At 12 noon, for example, the tide-gauge marked 6.7 feet. Joining all the heights observed in the twenty-four hours we have a curve like that marked in the figure. The two high waters are *a* and *c*, the two low waters *b* and *d*. If *a* is the high water which occurs about twelve hours after the transit of the moon, when the declination is south, the ebb *a b* is quite small, and the high water, *a*, is much lower than the next high water, *c*. If the moon's declination is north, it is the large high water, *a*, of the second diagram which occurs next after the transit, and about twelve hours from it. At Key West the contrary obtains, diagram 1 applying when the moon's declination is north, and diagram 2 when south. Tables IV and V give the number to be added to the time of moon's transit to find the time of high water almost as readily as in the former case. They are of double entry, the time of transit being, as before, placed in the first column.

The number of days from the day at which the moon had the greatest declination is arranged at the top of the table. Entering the first column with the time of transit, and following the line horizontally until we come under the column containing the days from the greatest declination, we find the number to be added to the time of the transit to give time of high water. If the moon's declination is south, Table IV is to be used; if north, Table V.



Tables IV to IX, inclusive, have been recomputed, using more complete data for the inequalities above referred to, and to those for San Francisco similar tables have been added for San Diego, Astoria, Port Townshend, and Key West, Fla. For the other places on the Western Coast given in Table I the following rules will give sufficiently close approximations.

To obtain the times of high or low water for San Pedro, Cuyler's harbor, and San Luis Obispo, compute first the time for San Diego by Tables IV, V, or VIII; then add to the time thus obtained 30 minutes to obtain the time for San Luis Obispo, and subtract 13 minutes for Cuyler's harbor. At San Pedro the time of high or low water is sensibly the same as at San Diego.

For Monterey, South Farallone, Mare Island, Benicia, Ravenswood, and Bodega, compute first the time for San Francisco, then subtract from the time thus obtained 1*h.* 44*m.* for Monterey, 1*h.* 29*m.* for the South Farallon, and 49*m.* for Bodega; and add 34*m.* for Mare island, 1*h.* 4*m.* for Benicia, and 30*m.* for Ravenswood. For Humboldt bay, Port Orford, and Neeah harbor, compute first the time for Astoria, then subtract from it 40*m.* for Humboldt bay, 1*h.* 16*m.* for Port Orford, and 9*m.* for Neeah harbor.

For Steilacoom and Semiahmoo bay, compute first the time for Port Townshend, and add to it 57*m.* for Steilacoom, and 1*h.* for Semiahmoo. The approximation will be only a rough one for Steilacoom.

For the heights, Tables VI, VII, and IX for San Diego can be used without change for San Pedro, Cuyler's harbor, and San Luis Obispo. These tables for San Francisco are also applicable to Monterey, South Farallon, and Bodega. For Mare Island add 1.2 foot, for Benicia, 0.9 foot, and for Ravenswood, 2.7 feet to the quantities for San Francisco.

For Humboldt bay, Port Orford, and Neeah harbor, the tables for Astoria may be used, subtracting 1.7 foot for Humboldt bay, and 1.0 foot for Port Orford. For Neeah harbor the tables will give approximate results without change.

For Semiahmoo bay, add one foot to the quantities in the tables for Port Townshend. For Steilacoom, a rough approximation may be obtained by adding 4.6 feet to them.

For the coast of Florida, compute the times of high or low water for Key West, and subtract 12*m.* for Indian key, and add 26*m.* for Tortugas and 1*h.* 51*m.* for Egmont key, 3*h.* 45*m.* for Cedar keys, and 4*h.* 8*m.* for St. Mark's. For the heights, add half a foot for Indian key, and use the tables without change for Tortugas and Egmont key. For Cedar keys and St. Mark's, the results could not be obtained with much accuracy in this way; special tables will be prepared for those places.

TABLE IV.—KEY WEST.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m	h. m.	h. m.
0 00	9 40	9 30	9 18	9 07	9 01	8 49	8 44	8 40	8 40	8 46	8 54	9 06	9 16	9 27	9 37
0 30	9 33	9 23	9 11	9 00	8 54	8 42	8 37	8 33	8 33	8 39	8 47	8 59	9 09	9 20	9 30
1 00	9 26	9 16	9 04	8 53	8 47	8 35	8 30	8 26	8 26	8 32	8 40	8 52	9 02	8 13	9 23
1 30	9 20	9 10	8 58	8 47	8 41	8 29	8 24	8 20	8 20	8 26	8 34	8 46	8 56	9 07	9 17
2 00	9 13	9 03	8 51	8 40	8 34	8 22	8 17	8 13	8 13	8 19	8 27	8 39	8 49	9 00	9 10
2 30	9 08	8 58	8 46	8 35	8 29	8 17	8 12	8 08	8 08	8 14	8 22	8 34	8 44	8 55	9 05
3 00	9 04	8 54	8 42	8 31	8 25	8 13	8 08	8 04	8 04	8 10	8 18	8 30	8 40	8 51	9 01
3 30	9 00	8 50	8 38	8 27	8 21	8 09	8 04	8 00	8 00	8 06	8 14	8 26	8 36	8 47	8 57
4 00	9 00	8 50	8 38	8 27	8 21	8 09	8 04	8 00	8 00	8 06	8 14	8 26	8 36	8 47	8 57
4 30	9 03	8 53	8 41	8 30	8 24	8 12	8 07	8 03	8 03	8 09	8 17	8 29	8 39	8 50	9 00
5 00	9 09	8 59	8 47	8 36	8 30	8 18	8 13	8 09	8 09	9 15	8 23	8 35	8 45	8 56	9 06
5 30	9 17	9 07	8 55	8 44	8 38	8 26	8 21	8 17	8 17	8 23	8 31	8 43	8 53	9 04	9 14
6 00	9 29	9 19	9 07	8 56	8 50	8 38	8 33	8 29	8 29	8 35	8 43	8 55	9 05	9 16	9 26
6 30	9 40	9 30	9 18	9 07	9 01	8 49	8 44	8 40	8 40	8 46	8 54	9 06	9 16	9 27	9 37
7 00	9 56	9 46	9 34	9 23	9 17	9 05	9 00	8 56	8 56	9 02	9 10	9 22	9 32	9 43	9 53
7 30	10 07	9 57	9 45	9 34	9 28	9 16	9 11	9 07	9 07	9 13	9 21	9 33	9 43	9 54	10 04
8 00	10 13	10 03	9 51	9 40	9 34	9 22	9 17	9 13	9 13	9 19	9 27	9 39	9 49	10 00	10 00
8 30	10 14	10 04	9 52	9 41	9 35	9 23	9 18	9 14	9 14	9 20	9 28	9 40	9 50	10 01	10 11
9 00	10 13	10 03	9 51	9 40	9 34	9 22	9 17	9 13	9 13	9 19	9 27	9 39	9 49	10 00	10 10
9 30	10 10	10 00	9 48	9 37	9 31	9 19	9 14	9 10	9 10	9 16	9 24	9 36	9 46	9 57	10 07
10 00	10 06	9 56	9 44	9 33	9 27	9 15	9 10	9 06	9 06	9 12	9 20	9 32	9 42	9 53	10 03
10 30	10 03	9 53	9 41	9 30	9 24	9 12	9 07	9 03	9 03	9 09	9 17	9 29	9 39	9 50	10 00
11 00	9 55	9 45	9 33	9 22	9 16	9 04	8 59	8 55	8 55	9 01	9 09	9 21	9 31	9 42	9 52
11 30	9 47	9 37	9 25	9 14	9 08	8 56	8 51	8 47	8 47	8 53	9 01	9 13	9 23	9 34	9 44

TABLE V.—KEY WEST.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	9 29	9 36	9 43	9 53	10 06	10 16	10 22	10 22	10 22	10 18	10 06	9 56	9 43	9 34	9 27
0 30	9 22	9 29	9 36	9 46	9 59	10 09	10 15	10 15	10 15	10 11	9 59	9 49	9 36	9 27	9 20
1 0	9 15	9 22	9 29	9 39	9 52	10 02	10 08	10 08	10 08	10 04	9 52	9 42	9 29	9 20	9 13
1 30	9 09	9 16	9 23	9 33	9 46	9 56	10 02	10 02	10 02	9 58	9 46	9 36	9 23	9 14	9 07
2 0	9 02	9 09	9 16	9 26	9 39	9 49	9 55	9 55	9 55	9 51	9 39	9 29	9 16	9 07	9 00
2 30	8 57	9 04	9 11	9 21	9 34	9 44	9 50	9 50	9 50	9 46	9 34	9 24	9 11	9 02	8 55
3 0	8 53	9 00	9 07	9 17	9 30	9 40	9 46	9 46	9 46	9 42	9 30	9 20	9 07	8 58	8 51
3 30	8 49	8 56	9 03	9 13	9 26	9 36	9 42	9 42	9 42	9 38	9 26	9 16	9 03	8 54	8 47
4 0	8 49	8 56	9 03	9 13	9 26	9 36	9 42	9 42	9 42	9 38	9 26	9 16	9 03	8 54	8 47
4 30	8 52	8 59	9 06	9 16	9 29	9 39	9 45	9 45	9 45	9 41	9 39	9 29	9 06	8 57	8 50
5 0	8 58	9 05	9 12	9 22	9 35	9 45	9 51	9 51	9 51	9 47	9 35	9 25	9 12	9 03	8 56
5 30	9 06	9 13	9 20	9 30	9 43	9 53	9 59	9 59	9 59	9 55	9 43	9 33	9 20	9 11	9 04
6 0	9 18	9 25	9 32	9 42	9 55	10 05	10 11	10 11	10 11	10 07	9 55	9 45	9 32	9 23	9 16
6 30	9 29	9 36	9 43	9 53	10 06	10 16	10 22	10 22	10 22	10 18	10 06	9 56	9 43	9 34	9 27
7 0	9 45	9 52	9 59	10 09	10 22	10 32	10 38	10 38	10 38	10 34	10 22	10 12	9 59	9 50	9 43
7 30	9 56	10 03	10 10	10 20	10 33	10 43	10 49	10 49	10 49	10 45	10 33	10 23	10 10	10 01	9 54
8 0	10 02	10 09	10 16	10 26	10 39	10 49	10 55	10 55	10 55	10 51	10 39	10 29	10 16	10 07	10 00
8 30	10 03	10 10	10 17	10 27	10 40	10 50	10 56	10 56	10 56	10 52	10 40	10 30	10 17	10 08	10 01
9 0	10 02	10 09	10 16	10 26	10 39	10 49	10 55	10 55	10 55	10 51	10 39	10 29	10 16	10 07	10 00
9 30	9 59	10 06	10 13	10 23	10 36	10 46	10 52	10 52	10 52	10 48	10 36	10 26	10 13	10 04	9 57
10 0	9 55	10 02	10 09	10 19	10 32	10 42	10 48	10 48	10 48	10 44	10 32	10 22	10 09	10 00	9 53
10 30	9 52	9 59	10 06	10 16	10 29	10 39	10 45	10 45	10 45	10 41	10 29	10 19	10 06	9 57	9 50
11 0	9 44	9 51	9 58	10 08	10 21	10 31	10 37	10 37	10 37	10 33	10 21	10 11	9 58	9 49	9 42
11 30	9 36	9 43	9 50	10 00	10 13	10 23	10 29	10 29	10 29	10 25	10 13	10 03	9 50	9 41	9 34

TABLE IV.—SAN DIEGO

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	9 25	9 40	9 52	10 3	10 12	10 20	10 25	10 29	10 29	10 25	10 19	10 10	10 0	9 47	9 30
0 30	9 15	9 30	9 42	9 53	10 2	10 10	10 15	10 19	10 19	10 15	10 9	10 0	9 50	9 27	9 20
1 0	9 8	9 23	9 35	9 46	9 55	10 3	10 8	10 12	10 12	10 8	10 2	9 53	9 43	9 30	9 13
1 30	9 1	9 16	9 28	9 39	9 48	9 56	10 1	10 5	10 5	10 1	9 55	9 46	9 36	9 23	9 6
2 0	8 54	9 9	9 21	9 32	9 41	9 49	9 54	9 58	9 58	9 54	9 48	9 39	9 29	9 16	8 59
2 30	8 49	9 4	9 16	9 27	9 36	9 44	9 49	9 53	9 53	9 49	9 43	9 34	9 24	9 11	8 54
3 0	8 48	9 3	9 15	9 26	9 35	9 43	9 48	9 52	9 52	9 48	9 42	9 33	9 23	9 10	8 53
3 30	8 48	9 3	9 15	9 26	9 35	9 43	9 48	9 52	9 52	9 48	9 42	9 33	9 23	9 10	8 53
4 0	8 52	9 7	9 19	9 30	9 39	9 47	9 52	9 56	9 56	9 52	9 46	9 37	9 27	9 14	8 57
4 30	8 56	9 11	9 23	9 34	9 43	9 51	9 56	10 0	10 0	9 56	9 50	9 41	9 31	9 18	9 1
5 0	9 15	9 30	9 42	9 53	10 2	10 10	10 15	10 19	10 19	10 15	10 9	10 0	9 50	9 37	9 20
5 30	9 37	9 52	10 4	10 15	10 24	10 32	10 37	10 41	10 41	10 37	10 31	10 22	10 12	9 59	9 42
6 0	9 55	10 10	10 22	10 33	10 42	10 50	10 55	10 59	10 59	10 55	10 49	10 40	10 30	10 17	10 0
6 30	10 12	10 27	10 39	10 50	10 59	11 7	11 12	10 16	10 16	11 12	11 6	10 57	10 47	10 34	10 17
7 0	10 18	10 33	10 45	10 56	11 5	11 13	11 18	11 22	11 22	11 18	11 12	11 3	10 53	10 40	10 23
7 30	10 20	10 35	10 47	10 58	11 7	11 15	11 20	11 24	11 24	11 20	11 14	11 5	10 55	10 42	10 25
8 0	10 22	10 37	10 49	11 0	11 9	11 17	11 22	11 26	11 26	11 22	11 16	11 7	10 57	10 44	10 27
8 30	10 24	10 39	10 51	11 2	11 11	11 19	11 24	11 28	11 28	11 24	11 18	11 9	10 59	10 46	10 29
9 0	10 18	10 33	10 45	10 56	11 5	11 13	11 18	11 22	11 22	11 18	11 12	11 3	10 53	10 40	10 23
9 30	10 10	10 25	10 37	10 48	10 57	11 5	11 10	11 14	11 14	11 10	11 4	10 55	10 45	10 32	10 15
10 0	10 0	10 15	10 27	10 38	10 47	10 55	11 0	11 4	11 4	11 0	10 54	10 45	10 35	10 22	10 5
10 30	9 53	10 8	10 20	10 31	10 40	10 48	10 53	10 57	10 57	10 53	10 47	10 38	10 28	10 15	9 58
11 0	9 45	10 0	10 12	10 23	10 32	10 40	10 45	10 49	10 49	10 45	10 39	10 30	10 20	10 7	9 50
11 30	9 36	9 51	10 3	10 14	10 23	10 31	10 36	10 40	10 40	10 36	10 30	10 21	10 11	9 58	9 41

TABLE V.—SAN DIEGO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	9 30	9 16	9 4	8 53	8 44	8 36	8 31	8 27	8 27	8 31	8 37	8 46	8 56	9 9	9 26
0 30	9 21	9 6	8 54	8 43	8 34	8 26	8 21	8 17	8 17	8 21	8 27	8 36	8 46	8 59	9 16
1 0	9 14	8 59	8 47	8 36	8 27	8 19	8 14	8 10	8 10	8 14	8 20	8 29	8 39	8 52	9 9
1 30	9 7	8 52	8 40	8 29	8 20	8 12	8 7	8 3	8 3	8 7	8 13	8 22	8 32	8 45	9 2
2 0	9 0	8 45	8 33	8 22	8 13	8 5	8 0	7 56	7 56	8 0	8 6	8 15	8 25	8 38	8 55
2 30	8 55	8 40	8 28	8 17	8 8	8 0	7 55	7 51	7 51	7 55	8 1	8 10	8 20	8 33	8 50
3 0	8 54	8 39	8 27	8 16	8 7	7 59	7 54	7 50	7 50	7 54	8 0	8 9	8 19	8 32	8 49
3 30	8 54	8 39	8 27	8 16	8 7	7 59	7 54	7 50	7 50	7 54	8 0	8 9	8 19	8 32	8 49
4 0	8 58	8 43	8 31	8 20	8 11	8 3	7 58	7 54	7 54	7 58	8 4	8 13	8 23	8 36	8 53
4 30	9 2	8 47	8 35	8 24	8 15	8 7	8 2	7 58	7 58	8 2	8 8	8 17	8 27	8 40	8 57
5 0	9 21	9 6	8 54	8 43	8 34	8 26	8 21	8 17	8 17	8 21	8 27	8 36	8 46	8 59	9 16
5 30	9 43	9 28	9 16	9 5	8 56	8 48	8 43	8 39	8 39	8 43	8 49	8 58	9 8	9 21	9 38
6 0	10 1	9 46	9 34	9 23	9 14	9 6	9 1	8 57	8 57	9 1	9 7	9 16	9 26	9 39	9 56
6 30	10 18	10 3	9 51	9 40	9 31	9 23	9 18	9 14	9 14	9 18	9 24	9 33	9 43	9 56	10 13
7 0	10 24	10 9	9 57	9 46	9 37	9 29	9 24	9 20	9 20	9 24	9 30	9 39	9 49	10 2	10 19
7 30	10 26	10 11	9 59	9 48	9 39	9 31	9 26	9 22	9 22	9 26	9 32	9 41	9 51	10 4	10 21
8 0	10 28	10 13	10 1	9 50	9 41	9 33	9 28	9 24	9 24	9 28	9 34	9 43	9 53	10 6	10 23
8 30	10 30	10 15	10 3	9 52	9 43	9 35	9 30	9 26	9 26	9 30	9 36	9 45	9 55	10 8	10 25
9 0	10 24	10 9	9 57	9 46	9 37	9 29	9 24	9 20	9 20	9 24	9 30	9 39	9 49	10 2	10 19
9 30	10 16	10 1	9 49	9 38	9 29	9 21	9 16	9 12	9 12	9 16	9 22	9 31	9 41	9 54	10 11
10 0	10 6	9 51	9 39	9 28	9 19	9 11	9 6	9 2	9 2	9 6	9 12	9 21	9 31	9 44	10 1
10 30	9 59	9 44	9 32	9 21	9 12	9 4	8 59	8 55	8 55	8 59	9 5	9 14	9 24	9 37	9 54
11 0	9 51	9 36	9 24	9 13	9 4	8 56	8 51	8 47	8 47	8 51	8 57	9 6	9 16	9 29	9 46
11 30	9 42	9 27	9 15	9 4	8 55	8 47	8 42	8 38	8 38	8 42	8 48	8 57	9 7	9 20	9 37

TABLE IV.—SAN FRANCISCO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	11 43	11 59	12 15	12 33	12 50	13 03	13 17	13 20	13 19	13 14	13 07	12 57	12 45	12 32	12 18
0 30	11 37	11 53	12 09	12 27	12 44	12 57	13 11	13 14	13 13	13 08	13 01	12 51	12 39	12 26	12 12
1 0	11 31	11 47	12 03	12 21	12 38	12 51	13 05	13 08	13 07	13 02	12 55	12 45	12 33	12 20	12 06
1 30	11 25	11 41	11 57	12 15	12 32	12 45	12 59	13 02	13 01	12 56	12 49	12 39	12 27	12 14	12 00
2 0	11 19	11 35	11 51	12 09	12 26	12 39	12 53	12 56	12 55	12 50	12 43	12 33	12 21	12 08	11 54
2 30	11 14	11 30	11 46	12 04	12 21	12 34	12 48	12 51	12 50	12 45	12 38	12 28	12 16	12 03	11 49
3 0	11 11	11 27	11 43	12 01	12 18	12 31	12 45	12 48	12 47	12 42	12 35	12 25	12 13	12 00	11 46
3 30	11 11	11 27	11 43	12 01	12 18	12 31	12 45	12 48	12 47	12 42	12 35	12 25	12 13	12 00	11 46
4 0	11 16	11 32	11 48	12 06	12 23	12 36	12 50	12 53	12 52	12 47	12 40	12 30	12 18	12 05	11 51
4 30	11 24	11 40	11 56	12 14	12 31	12 44	12 58	13 01	13 00	12 55	12 48	12 38	12 26	12 13	11 59
5 0	11 33	11 49	12 05	12 23	12 40	12 53	13 07	13 10	13 09	13 04	12 57	12 47	12 35	12 22	12 08
5 30	11 41	11 57	12 13	12 31	12 48	13 01	13 15	13 18	13 17	13 12	13 05	12 55	12 43	12 30	12 16
6 0	11 49	12 05	12 21	12 39	12 56	13 09	13 23	13 26	13 25	13 20	13 13	13 03	12 51	12 38	12 24
6 30	11 54	12 10	12 26	12 44	13 01	13 14	13 28	13 31	13 30	13 25	13 18	13 08	12 56	12 43	12 29
7 0	12 01	12 17	12 33	12 51	13 08	13 21	13 35	13 38	13 37	13 32	13 25	13 15	13 03	12 50	12 36
7 30	12 07	12 23	12 39	12 57	13 14	13 27	13 41	13 44	13 43	13 38	13 31	13 21	13 09	12 56	12 42
8 0	12 12	12 28	12 44	13 02	13 19	13 32	13 46	13 49	13 48	13 43	13 36	13 26	13 14	13 01	12 47
8 30	12 15	12 31	12 47	13 05	13 22	13 35	13 49	13 52	13 51	13 46	13 39	13 29	13 17	13 04	12 50
9 0	12 14	12 30	12 46	13 04	13 21	13 34	13 48	13 57	13 50	13 45	13 38	13 28	13 16	13 03	12 49
9 30	12 12	12 28	12 44	13 02	13 19	13 32	13 46	13 49	13 48	13 43	13 36	13 26	13 14	13 01	12 47
10 0	12 08	12 24	12 40	12 58	13 15	13 28	13 42	13 45	13 44	13 39	13 32	13 22	13 10	12 57	12 43
10 30	12 02	12 18	12 34	12 52	13 09	13 22	13 36	13 39	13 38	13 33	13 26	13 16	13 04	12 51	12 37
11 0	11 55	12 11	12 27	12 45	13 02	13 15	13 29	13 32	13 31	13 26	13 19	13 09	12 57	12 44	12 30
11 30	11 47	12 03	12 19	12 37	12 54	13 07	13 21	13 24	13 23	13 18	13 11	13 01	12 49	12 36	12 22

TABLE V.—SAN FRANCISCO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	12 27	12 11	11 55	11 37	11 20	11 07	10 53	10 50	10 51	10 56	11 03	11 13	11 25	11 38	11 52
0 30	12 21	12 05	11 49	11 31	11 14	11 01	10 47	10 44	10 45	10 50	10 57	11 07	11 19	11 32	11 46
1 0	12 15	11 59	11 43	11 25	11 08	10 55	10 41	10 38	10 39	10 44	10 51	11 01	11 13	11 26	11 40
1 30	12 09	11 53	11 37	11 19	11 02	10 49	10 35	10 32	10 33	10 38	10 45	10 55	11 07	11 20	11 34
2 0	12 03	11 47	11 31	11 13	10 56	10 43	10 29	10 26	10 27	10 32	10 39	10 49	11 01	11 14	11 28
2 30	11 58	11 42	11 26	11 08	10 51	10 38	10 24	10 21	10 22	10 27	10 34	10 44	10 56	11 09	11 23
3 0	11 55	11 39	11 23	11 05	10 48	10 35	10 21	10 18	10 19	10 24	10 31	10 41	10 53	11 06	11 20
3 30	11 55	11 39	11 23	11 05	10 48	10 35	10 21	10 18	10 19	10 24	10 31	10 41	10 53	11 06	11 20
4 0	12 00	11 44	11 28	11 10	10 53	10 40	10 26	10 23	10 24	10 29	10 36	10 46	10 58	11 11	11 25
4 30	12 08	11 52	11 36	11 18	11 01	10 48	10 34	10 31	10 32	10 37	10 44	10 54	11 06	11 19	11 33
5 0	12 17	12 01	11 45	11 27	11 10	10 57	10 43	10 40	10 41	10 46	10 53	11 03	11 15	11 28	11 42
5 30	12 25	12 09	11 53	11 35	11 18	11 05	10 51	10 48	10 49	10 54	11 01	11 11	11 23	11 36	11 50
6 0	12 33	12 17	12 01	11 43	11 26	11 13	10 59	10 56	10 57	11 02	11 09	11 19	11 31	11 44	11 58
6 30	12 38	12 22	12 06	11 48	11 31	11 18	11 04	11 01	11 02	11 07	11 14	11 21	11 36	11 49	12 03
7 0	12 45	12 29	12 13	11 55	11 38	11 25	11 11	11 08	11 09	11 14	11 21	11 31	11 43	11 56	12 10
7 30	12 51	12 35	12 19	12 01	11 44	11 31	11 17	11 14	11 15	11 20	11 27	11 37	11 49	12 02	12 16
8 0	12 56	12 40	12 24	12 06	11 49	11 36	11 22	11 19	11 20	11 25	11 32	11 42	11 54	12 07	12 21
8 30	12 59	12 43	12 27	12 09	11 52	11 39	11 25	11 22	11 23	11 28	11 35	11 45	11 57	12 10	12 24
9 0	12 58	12 42	12 26	12 08	11 51	11 38	11 24	11 21	11 22	11 27	11 34	11 44	11 56	12 09	12 23
9 30	12 56	12 40	12 24	12 06	11 49	11 36	11 22	11 19	11 20	11 25	11 32	11 42	11 54	12 07	12 21
10 0	12 52	12 36	12 20	12 02	11 45	11 32	11 18	11 15	11 16	11 21	11 28	11 38	11 50	12 03	12 17
10 30	12 46	12 30	12 14	11 56	11 39	11 26	11 12	11 09	11 10	11 15	11 22	11 32	11 44	11 57	12 11
11 0	12 39	12 23	12 07	11 49	11 32	11 19	11 05	11 02	11 03	11 08	11 15	11 25	11 37	11 50	12 04
11 30	12 31	12 15	11 59	11 41	11 24	11 11	10 57	10 54	10 55	11 00	11 07	11 17	11 29	11 42	11 56

TABLE IV.—ASTORIA.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	12 42	12 55	13 5	13 18	13 28	13 38	13 41	13 45	13 46	13 44	13 40	13 34	13 24	13 14	13 2
0 30	12 36	12 49	12 59	13 12	13 22	13 32	13 35	13 39	13 40	13 38	13 34	13 28	13 18	13 8	12 56
1 0	12 29	12 42	12 52	13 5	13 15	13 25	13 28	13 32	13 33	13 31	13 27	13 21	13 11	13 1	12 49
1 30	12 23	12 36	12 46	12 59	13 9	13 19	13 22	13 26	13 27	13 25	13 21	13 15	13 5	12 55	12 43
2 0	12 15	12 28	12 38	12 51	13 1	13 11	13 14	13 18	13 19	13 17	13 13	13 7	12 57	12 47	12 35
2 30	12 9	12 22	12 32	12 45	12 55	13 5	13 8	13 12	13 13	13 11	13 7	13 1	12 51	12 41	12 29
3 0	12 3	12 16	12 26	12 39	12 49	12 59	13 2	13 6	13 7	13 5	13 1	12 55	12 45	12 35	12 23
3 30	11 58	12 11	12 21	12 34	12 44	12 54	12 57	13 1	13 2	13 0	12 56	12 50	12 40	12 30	12 18
4 0	11 57	12 10	12 20	12 33	12 43	12 53	12 56	13 0	13 1	12 59	12 55	12 49	12 39	12 29	12 17
4 30	12 0	12 13	12 23	12 36	12 46	12 56	12 59	13 3	13 4	13 2	12 58	12 52	12 42	12 32	12 20
5 0	12 8	12 21	12 31	12 44	12 54	13 4	13 7	13 11	13 12	13 10	13 6	13 0	12 50	12 40	12 28
5 30	12 15	12 28	12 38	12 51	13 1	13 11	13 14	13 18	13 19	13 17	13 13	13 7	12 57	12 47	12 35
6 0	12 25	12 38	12 48	13 1	13 11	13 21	13 24	13 28	13 29	13 27	13 23	13 17	13 7	12 57	12 45
6 30	12 36	12 49	12 59	13 12	13 22	13 32	13 35	13 39	13 40	13 38	13 34	13 28	13 18	13 8	12 56
7 0	12 45	12 58	13 8	13 21	13 31	13 41	13 44	13 48	13 49	13 47	13 43	13 37	13 27	13 17	13 5
7 30	12 55	13 8	13 18	13 31	13 41	13 51	13 54	13 58	13 59	13 57	13 53	13 47	13 37	13 27	13 15
8 0	13 3	13 16	13 26	13 39	13 49	13 59	14 2	14 6	14 7	14 5	14 1	13 55	13 45	13 35	13 23
8 30	13 8	13 21	13 31	13 44	13 54	14 4	14 7	14 11	14 12	14 10	14 6	14 0	13 50	13 40	13 28
9 0	13 10	13 23	13 33	13 46	13 56	14 6	14 9	14 13	14 14	14 12	14 8	14 2	13 52	13 42	13 30
9 30	13 9	13 22	13 32	13 45	13 55	14 5	14 8	14 12	14 13	14 11	14 7	14 1	13 51	13 41	13 29
10 0	13 5	13 18	13 28	13 41	13 51	14 1	14 4	14 8	14 9	14 7	14 3	13 57	13 47	13 37	13 25
10 30	12 59	13 12	13 22	13 35	13 45	13 55	13 58	14 2	14 3	14 1	13 57	13 51	13 41	13 31	13 19
11 0	12 53	13 6	13 16	13 29	13 39	13 49	13 52	13 56	13 57	13 55	13 51	13 45	13 35	13 25	15 13
11 30	12 46	12 59	13 9	13 22	13 32	13 42	13 45	13 49	13 50	13 48	13 44	13 38	13 28	13 18	13 6

TABLE V.—ASTORIA.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m	h. m.	h. m	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	13 10	12 57	12 47	12 34	12 24	12 14	12 11	12 7	12 6	12 8	12 12	12 18	12 28	12 38	12 50
0 30	13 4	12 51	12 41	12 28	12 18	12 8	12 5	12 1	12 0	12 2	12 6	12 12	12 22	12 32	12 44
1 0	12 57	12 44	12 34	12 21	12 11	12 1	11 58	11 54	11 53	11 55	11 59	12 5	12 15	12 25	12 37
1 30	12 51	12 38	12 28	12 15	12 5	11 55	11 52	11 48	11 47	11 49	11 53	11 59	12 9	12 19	12 31
2 0	12 43	12 30	12 20	12 7	11 57	11 47	11 44	11 40	11 39	11 41	11 45	11 51	12 1	12 11	12 23
2 30	12 37	12 24	12 14	12 1	11 51	11 41	11 38	11 34	11 33	11 35	11 39	11 45	11 55	12 5	12 17
3 0	12 31	12 18	12 8	11 55	11 45	11 35	11 32	11 28	11 27	11 29	11 33	11 39	11 49	11 59	12 11
3 30	12 26	12 13	12 3	11 50	11 40	11 30	11 27	11 23	11 22	11 24	11 28	11 34	11 44	11 54	12 6
4 0	12 25	12 12	12 2	11 49	11 39	11 29	11 26	11 22	11 21	11 23	11 27	11 33	11 43	11 53	12 5
4 30	12 28	12 15	12 5	11 52	11 42	11 32	11 29	11 25	11 24	11 26	11 30	11 36	11 46	11 56	12 8
5 0	12 36	12 23	12 13	12 0	11 50	11 40	11 37	11 33	11 32	11 34	11 38	11 44	11 54	12 4	12 16
5 30	12 43	12 30	12 20	12 7	11 57	11 47	11 44	11 40	11 39	11 41	11 45	11 51	12 1	12 11	12 23
6 0	12 53	12 40	12 30	12 17	12 7	11 57	11 54	11 50	11 49	11 51	11 55	12 1	12 11	12 21	12 33
6 30	13 4	12 51	12 41	12 28	12 18	12 8	12 5	12 1	12 0	12 2	12 6	12 12	12 22	12 32	12 44
7 0	13 13	13 0	12 50	12 37	12 27	12 17	12 14	12 10	12 9	12 11	12 15	12 21	12 31	12 41	12 53
7 30	13 23	13 10	13 0	12 47	12 37	12 27	12 24	12 20	12 19	12 21	12 25	12 31	12 41	12 51	13 3
8 0	13 31	13 18	13 8	12 55	12 45	12 35	12 32	12 28	12 27	12 29	12 33	12 39	12 49	12 59	13 11
8 30	13 36	13 23	13 13	13 0	12 50	12 40	12 37	12 33	12 32	12 34	12 38	12 44	12 54	13 4	13 16
9 0	13 38	13 25	13 15	13 2	12 52	12 42	12 39	12 35	12 34	12 36	12 40	12 46	12 56	13 6	13 18
9 30	13 37	13 24	13 14	13 1	12 51	12 41	12 38	12 34	12 33	12 35	12 39	12 45	12 55	13 5	13 17
10 0	13 33	13 20	13 10	12 57	12 47	12 37	12 34	12 30	12 29	12 31	12 35	12 41	12 51	13 1	13 13
10 30	13 27	13 14	13 4	12 51	12 41	12 31	12 28	12 24	12 23	12 25	12 29	12 35	12 45	12 55	13 7
11 0	13 21	13 8	12 58	12 45	12 35	12 25	12 22	12 18	12 17	12 19	12 23	12 29	12 39	12 49	13 1
11 30	13 14	13 1	12 51	12 38	12 28	12 18	12 15	12 11	12 10	12 12	12 16	12 22	12 32	12 42	12 54

TABLE IV.—PORT TOWNSHEND.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	3 45	3 21	2 51	2 2	1 32	1 13	1 26	1 44	2 2	2 21	2 42	2 57	3 15	3 33	3 45
0 30	3 38	3 14	2 44	1 55	1 25	1 6	1 19	1 37	1 55	2 14	2 35	2 50	3 8	3 26	3 38
1 0	3 32	3 8	2 38	1 49	1 19	1 0	1 13	1 31	1 49	2 8	2 29	2 44	3 2	3 20	3 32
1 30	3 26	3 2	2 32	1 43	1 13	0 54	1 7	1 25	1 43	2 2	2 23	2 38	2 56	3 14	3 26
2 0	3 21	2 57	2 27	1 38	1 8	0 49	1 2	1 20	1 38	1 57	2 18	2 33	2 51	3 9	3 21
2 30	3 18	2 54	2 24	1 35	1 5	0 46	0 59	1 17	1 35	1 54	2 15	2 20	2 48	3 6	3 18
3 0	3 16	2 52	2 22	1 33	1 3	0 44	0 57	1 15	1 33	1 52	2 13	2 28	2 46	3 4	3 16
3 30	3 17	2 53	2 23	1 34	1 4	0 45	0 58	1 16	1 34	1 53	2 14	2 29	2 47	3 5	3 17
4 0	3 21	2 57	2 27	1 38	1 8	0 49	1 2	1 20	1 38	1 57	2 18	2 33	2 51	3 9	3 21
4 30	3 26	3 2	2 32	1 43	1 13	0 54	1 7	1 25	1 43	2 2	2 23	2 38	2 56	3 14	3 26
5 0	3 32	3 8	2 38	1 49	1 19	1 0	1 13	1 31	1 49	2 8	2 29	2 44	3 2	3 20	3 32
5 30	3 41	3 17	2 47	1 58	1 28	1 9	1 22	1 40	1 58	2 17	2 38	2 53	3 11	3 29	3 41
6 0	3 52	3 28	2 58	2 9	1 39	1 20	1 33	1 51	2 9	2 28	2 49	3 4	3 22	3 40	3 52
6 30	4 1	3 37	3 7	2 18	1 48	1 29	1 42	2 0	2 18	2 37	2 58	3 13	3 31	3 49	4 1
7 0	4 8	3 44	3 14	2 25	1 55	1 36	1 49	2 7	2 25	2 44	3 5	3 20	3 38	3 56	4 8
7 30	4 15	3 51	3 21	2 32	2 2	1 43	1 56	2 14	2 32	2 51	3 12	3 27	3 45	4 3	4 15
8 0	4 18	3 54	3 24	2 35	2 5	1 46	1 59	2 17	2 35	2 54	3 15	3 30	3 48	4 6	4 18
8 30	4 19	3 55	3 25	2 36	2 6	1 47	2 0	2 18	2 36	2 55	3 16	3 31	3 49	4 7	4 19
9 0	4 18	3 54	3 24	2 35	2 5	1 46	1 59	2 17	2 35	2 54	3 15	3 30	3 48	4 6	4 18
9 30	4 15	3 51	3 21	2 32	2 2	1 43	1 56	2 14	2 32	2 51	3 12	3 27	3 45	4 3	4 15
10 0	4 10	3 46	3 16	2 27	1 57	1 38	1 51	2 9	2 27	2 46	3 7	3 22	3 40	3 58	4 10
10 30	4 6	3 42	3 12	2 23	1 53	1 34	1 47	2 5	2 23	2 42	3 3	3 18	3 36	3 54	4 6
11 0	4 0	3 36	3 6	2 17	1 47	1 28	1 41	1 59	2 17	2 36	2 57	3 12	3 30	3 48	4 0
11 30	3 54	3 30	3 0	2 11	1 41	1 22	1 35	1 53	2 11	2 30	2 51	3 6	3 24	3 42	3 54

TABLE V.—PORT TOWNSHEND.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h m.	h. m.
0 0	3 45	4 9	4 39	5 28	5 58	6 17	6 4	5 46	5 28	5 9	4 48	4 33	4 15	3 57	3 45
0 30	3 38	4 2	4 32	5 21	5 51	6 10	5 57	5 39	5 21	5 2	4 41	4 26	4 8	3 50	3 38
1 0	3 32	3 56	4 26	5 15	5 45	6 4	5 51	5 33	5 15	4 56	4 35	4 20	4 2	3 44	3 32
1 30	3 26	3 50	4 20	5 9	5 39	5 58	5 45	5 27	5 9	4 50	4 29	4 14	3 56	3 38	3 26
2 0	3 21	3 45	4 15	5 4	5 34	5 53	5 40	5 22	5 4	4 45	4 24	4 9	3 51	3 33	3 21
2 30	3 18	3 42	4 12	5 1	5 31	5 50	5 37	5 19	5 1	4 42	4 21	4 6	3 48	3 30	3 18
3 0	3 16	3 40	4 10	4 59	5 29	5 48	5 35	5 17	4 59	4 40	4 19	4 4	3 46	3 28	3 16
3 30	3 17	3 41	4 11	5 0	5 30	5 49	5 36	5 18	5 0	4 41	4 20	4 5	3 47	3 29	3 17
4 0	3 21	3 45	4 15	5 4	5 34	5 53	5 40	5 22	5 4	4 45	4 24	4 9	3 51	3 33	3 21
4 30	3 26	3 50	4 20	5 9	5 39	5 58	5 45	5 27	5 9	4 50	4 29	4 14	3 56	3 38	3 26
5 0	3 32	3 56	4 26	5 15	5 45	6 4	5 51	5 33	5 15	4 56	4 35	4 20	4 2	3 44	3 32
5 30	3 41	4 5	4 35	5 24	5 54	6 13	6 0	5 42	5 24	5 5	4 44	4 29	4 11	3 53	3 41
6 0	3 52	4 16	4 46	5 35	6 5	6 24	6 11	5 53	5 35	5 16	4 55	4 40	4 22	4 4	3 52
6 30	4 1	4 25	4 55	5 44	6 14	6 33	6 20	6 2	5 44	5 25	5 4	4 49	4 31	4 13	4 1
7 0	4 8	4 32	5 2	5 51	6 21	6 40	6 27	6 9	5 51	5 32	5 11	4 56	4 38	4 20	4 8
7 30	4 15	4 39	5 9	5 58	6 28	6 47	6 34	6 16	5 58	5 39	5 18	5 3	4 45	4 27	4 15
8 0	4 18	4 42	5 12	6 1	6 31	6 50	6 37	6 19	6 1	5 42	5 21	5 6	4 48	4 30	4 18
8 30	4 19	4 43	5 13	6 2	6 32	6 51	6 38	6 20	6 2	5 43	5 22	5 7	4 49	4 31	4 19
9 0	4 18	4 42	5 12	6 1	6 31	6 50	6 37	6 19	6 1	5 42	5 21	5 6	4 48	4 30	4 18
9 30	4 15	4 39	5 9	5 58	6 28	6 47	6 34	6 16	5 58	5 39	5 18	5 3	4 45	4 27	4 15
10 0	4 10	4 34	5 4	5 53	6 23	6 42	6 29	6 11	5 53	5 34	5 13	4 58	4 40	4 22	4 10
10 30	4 6	4 30	5 0	5 49	6 19	6 38	6 25	6 7	5 49	5 30	5 9	4 54	4 36	4 18	4 6
11 0	4 0	4 24	4 44	5 43	6 13	6 32	6 19	6 1	5 43	5 24	5 3	4 48	4 30	4 12	4 0
11 30	3 54	4 18	4 48	5 37	6 7	6 26	6 13	5 55	5 37	5 18	4 57	4 42	4 24	4 6	3 54

If we disregard the daily inequality, the column headed San Francisco in Table II would give us, as in the examples on the Atlantic coast, the means of determining the time of high water.

Example V.—Required the time of high water at North Beach, San Francisco, Cal., on the 7th of February, 1853.

1st. The time of the moon's transit at Greenwich, from the Nautical Almanac, is 11*h.* 41*m.*; the longitude of San Francisco 8*h.* 10*m.*, requiring a correction of 16*m.* to the time of transit for San Francisco, which is thus found to be 11*h.* 57*m.*

2d. The moon's declination is south, and at the time of transit about two days after the greatest. Entering Table IV, we find 12*h.* (or 0*h.*) of transit, the nearest number to 11*h.* 57*m.* which the table gives; and following the line horizontally, until we come to two days after the greatest declination, we find 13*h.* 14*m.*

To 11*h.* 57*m.*, time of transit of the moon, February 7, San Francisco, add 13*h.* 14*m.*, from column 0*h.*, transit, and two days after greatest declination; the sum, 25*h.* 11*m*, or 1*h.* 11*m.*, February 8, is the time of high water, corresponding to the transit which we took of February 7. If we desire the tide of February 7 we must go back to the moon's transit of the 6th. The example was purposely assumed to show this case.

	11*h.* 01*m.*,	time of transit February 6, 1853.
	13 31	number for 11*h.* transit, and one day from greatest declination.
Sum	24 32	time of high water 0*h.* 32*m.* a. m. February 7.

The height of high water.—The height of high water is obtained in a similar manner by the use of Table VI and Table VII, entering these in the same way with the time of transit and days from the greatest declination. Table VI is for south declination, and Table VII for north.

TABLE VI.—KEY WEST.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
1	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
2	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
3	1.4	1.5	1.7	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.4
4	1.3	1.4	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1 6	1.5	1.3
5	1.2	1.3	1.5	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.4	1.2
6	1.1	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.4	1.3	1.1
7	1.1	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.4	1.3	1 1
8	1.2	1.3	1.5	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.4	1.2
9	1.3	1.4	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.6	1.5	1.3
10	1.4	1.5	1.7	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.4
11	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5

TABLE VII.—KEY WEST.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
1	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
2	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
3	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.5	1.7
4	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.4	1.6
5	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.5
6	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.4
7	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.4
8	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.5
9	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.4	1.6
10	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.5	1.7
11	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8

TABLE VI.—SAN DIEGO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	4.7	4.5	4.3	4.2	4.1	4.1	4.1	4.1	4.2	4.3	4.5	4.8	5.1	5.5	5.8
1	4.6	4.4	4.2	4.1	4.0	4.0	4.0	4.0	4.1	4.2	4.4	4.7	5.0	5.4	5.7
2	4.4	4.2	4.0	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.2	4.5	4.8	5.2	5.5
3	4.1	3.9	3.7	3.6	3.5	3.5	3.5	3.5	3.6	3.7	3.9	4.2	4.5	4.9	5.2
4	3.8	3.6	3.4	3.3	3.2	3.2	3.2	3.2	3.3	3.4	3.6	3.9	4.2	4.6	4.9
5	3.6	3.4	3.2	3.1	3.0	3.0	3.0	3.0	3.1	3.2	3.4	3.7	4.0	4.4	4.7
6	3.6	3.4	3.2	3.1	3.0	3.0	3.0	3.0	3.1	3.2	3.4	3.7	4.0	4.4	4.7
7	3.7	3.5	3.3	3.2	3.1	3.1	3.1	3.1	3.2	3.3	3.5	3.8	4.1	4.5	4.8
8	3.8	3.6	3.4	3.3	3.2	3.2	3.2	3.2	3.3	3.4	3.6	3.9	4.2	4.6	4.9
9	4.4	4.2	4.0	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.2	4.5	4.8	5.2	5.5
10	4.7	4.5	4.3	4.2	4.1	4.1	4.1	4.1	4.2	4.3	4.5	4.8	5.1	5.5	5.8
11	4.8	4.6	4.4	4.3	4.2	4.2	4.2	4.2	4.3	4.4	4.6	4.9	5.2	5.6	5.9

TABLE VII.—SAN DIEGO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	5.7	5.9	6.1	6.2	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.6	5.3	4.9	4.6
1	5.6	5.8	6.0	6.1	6.2	6.2	6.2	6.2	6.1	6.0	5.8	5.5	5.2	4.8	4.5
2	5.4	5.6	5.8	5.9	6.0	6.0	6.0	6.0	5.9	5.8	5.6	5.3	5.0	4.6	4.3
3	5.1	5.3	5.5	5.6	5.7	5.7	5.7	5.7	5.6	5.5	5.3	5.0	4.7	4.3	4.0
4	4.8	5.0	5.2	5.3	5.4	5.4	5.4	5.4	5.3	5.2	5.0	4.7	4.4	4.0	3.7
5	4.6	4.8	5.0	5.1	5.2	5.2	5.2	5.2	5.1	5.0	4.8	4.5	4.2	3.8	3.5
6	4.6	4.8	5.0	5.1	5.2	5.2	5.2	5.2	5.1	5.0	4.8	4.5	4.2	3.8	3.5
7	4.7	4.9	5.1	5.2	5.3	5.3	5.3	5.3	5.2	5.1	4.9	4.6	4.3	3.9	3.6
8	4.8	5.0	5.2	5.3	5.4	5.4	5.4	5.4	5.3	5.2	5.0	4.7	4.4	4.0	3.7
9	5.4	5.6	5.8	5.9	6.0	6.0	6.0	6.0	5.9	5.8	5.6	5.3	5.0	4.6	4.3
10	5.7	5.9	6.1	6.2	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.6	5.3	4.9	4.6
11	5.8	6.0	6.2	6.3	6.4	6.4	6.4	6.4	6.3	6.2	6.0	5.7	5.4	5.0	4.7

TABLE VI.—SAN FRANCISCO.

Time of moon's transit.	SOUTH DECLINATION—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	4.8	4.7	4.5	4.3	4.3	4.2	4.3	4.3	4.4	4.5	4.7	4.8	5.0	5.3	5.5
1	4.7	4.6	4.4	4.2	4.2	4.1	4.2	4.2	4.3	4.4	4.6	4.7	4.9	5.2	5.4
2	4.6	4.5	4.3	4.1	4.1	4.0	4.1	4.1	4.2	4.3	4.5	4.6	4.8	5.1	5.3
3	4.5	4.4	4.2	4.0	4.0	3.9	4.0	4.0	4.1	4.2	4.4	4.5	4.7	5.0	5.2
4	4.3	4.2	4.0	3.8	3.8	3.7	3.8	3.8	3.9	4.0	4.2	4.3	4.5	4.8	5.0
5	4.1	4.0	3.8	3.6	3.6	3.5	3.6	3.6	3.7	3.8	4.0	4.1	4.3	4.6	4.8
6	4.1	4.0	3.8	3.6	3.6	3.5	3.6	3.6	3.7	3.8	4.0	4.1	4.3	4.6	4.8
7	4.2	4.1	3.9	3.7	3.7	3.6	3.7	3.7	3.8	3.9	4.1	4.2	4.4	4.7	4.9
8	4.4	4.3	4.1	3.9	3.9	3.8	3.9	3.9	4.0	4.1	4.3	4.4	4.6	4.9	5.1
9	4.5	4.4	4.2	4.0	4.0	3.9	4.0	4.0	4.1	4.2	4.4	4.5	4.7	5.0	5.2
10	4.7	4.6	4.4	4.2	4.2	4.1	4.2	4.2	4.3	4.4	4.6	4.7	4.9	5.2	5.4
11	4.8	4.7	4.5	4.3	4.3	4.2	4.3	4.3	4.4	4.5	4.7	4.8	5.0	5.3	5.5

TABLE VII.—SAN FRANCISCO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	5.4	5.5	5.7	5.9	5.9	6.0	5.9	5.9	5.8	5.7	5.5	5.4	5.2	4.9	4.7
1	5.3	5.4	5.6	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5.4	5.3	5.1	4.8	4.6
2	5.2	5.3	5.5	5.7	5.7	5.8	5.7	5.7	5.6	5.5	5.3	5.2	5.0	4.7	4.5
3	5.1	5.2	5.4	5.6	5.6	5.7	5.6	5.6	5.5	5.4	5.2	5.1	4.9	4.6	4.4
4	4.9	5.0	5.2	5.4	5.4	5.5	5.4	5.4	5.3	5.2	5.0	4.9	4.7	4.4	4.2
5	4.7	4.8	5.0	5.2	5.2	5.3	5.2	5.2	5.1	5.0	4.8	4.7	4.5	4.2	4.0
6	4.7	4.8	5.0	5.2	5.2	5.3	5.2	5.2	5.1	5.0	4.8	4.7	4.5	4.2	4.0
7	4.8	4.9	5.1	5.3	5.3	5.4	5.3	5.3	5.2	5.1	4.9	4.8	4.6	4.3	4.1
8	5.0	5.1	5.3	5.5	5.5	5.6	5.5	5.5	5.4	5.3	5.1	5.0	4.8	4.5	4.3
9	5.1	5.2	5.4	5.6	5.6	5.7	5.6	5.6	5.5	5.4	5.2	5.1	4.9	4.6	4.4
10	5.3	5.4	5.6	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5.4	5.3	5.1	4.8	4.6
11	5.4	5.5	5.7	5.9	5.9	6.0	5.9	5.9	5.8	5.7	5.5	5.4	5.2	4.9	4.7

TABLE VI.—ASTORIA.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	8.0	8.3	8.4	8.5	8.6	8.6	8.6	8.6	8.5	8.4	8.3	8.1	7.7	7.4	7.0
1	8.0	8.2	8.4	8.5	8.6	8.6	8.6	8.6	8.5	8.4	8.2	8.1	7.7	7.4	7.0
2	7.8	8.1	8.2	8.4	8.4	8.4	8.4	8.4	8.3	8.2	8.1	7.9	7.5	7.2	6.8
3	7.5	7.8	7.9	8.1	8.1	8.1	8.1	8.1	8.0	7.9	7.8	7.6	7.2	6.9	6.5
4	7.1	7.6	7.5	7.7	7.7	7.7	7.7	7.7	7.6	7.5	7.4	7.2	6.8	6.5	6.1
5	6.7	7.0	7.2	7.3	7.3	7.3	7.3	7.3	7.2	7.1	7.0	6.8	6.5	6.1	5.7
6	6.5	6.8	7.0	7.1	7.1	7.1	7.1	7.1	7.0	6.9	6.8	6.6	6.3	5.9	5.5
7	6.7	7.0	7.1	7.2	7.3	7.3	7.3	7.3	7.2	7.1	7.0	6.8	6.4	6.1	5.7
8	7.0	7.3	7.5	7.6	7.6	7.6	7.6	7.6	7.5	7.4	7.3	7.1	6.8	6.4	6.0
9	7.5	7.8	8.0	8.1	8.1	8.1	8.1	8.1	8.0	7.9	7.8	7.6	7.3	6.9	6.5
10	7.9	8.2	8.4	8.5	8.5	8.5	8.5	8.5	8.4	8.3	8.2	8.0	7.7	7.3	6.9
11	8.1	8.4	8.6	8.7	8.7	8.7	8.7	8.7	8.6	8.5	8.4	8.2	7.9	7.5	7.1

TABLE VII.—ASTORIA.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.8	6.9	7.0	7.1	7.3	7.6	8.0	8.4
1	7.4	7.1	6.9	6 8	6 8	6.8	6.8	6.8	6.9	7.0	7.1	7.3	7.6	8.0	8 4
2	7.2	6.9	6.8	6.6	6.6	6.6	6.6	6.6	6.7	6.8	6.9	7.1	7.5	7.8	8.2
3	6.9	6.6	6.5	6.3	6.3	6.3	6.3	6.3	6.4	6.5	6.6	6.8	7.2	7.5	7.9
4	6.5	6.2	6.1	5.9	5.9	5.9	5.9	5.9	6.0	6.1	6.2	6.4	6.7	7.1	7.5
5	6.1	5.9	5.7	5.6	5.5	5.5	5.6	5.6	5.7	5.7	5.9	6.0	6.4	6.7	7.1
6	5.9	5 7	5.5	5.4	5 3	5.3	5.3	5.4	5.5	5.5	5.7	5.9	6.2	6.5	6.9
7	6.1	5.8	5.6	5.5	5.5	5.5	5.5	5.5	5.6	5.7	5.8	6.0	6.3	6.7	7.1
8	6.4	6.2	6.0	5.9	5.8	5.8	5.8	5.8	5.9	6.0	6.2	6.3	6.7	7.0	7.4
9	6.9	6.7	6.5	6 4	6.3	6 3	6.3	6.4	6.4	6.5	6.7	6.8	7.2	7.5	7.9
10	7.3	7.1	6.9	6.8	6.7	6.7	6 7	6.8	6.9	6.9	7.0	7.2	7.6	7.9	8.3
11	7.5	7.2	7.1	7.0	6.9	6.9	6.9	6.9	7.0	7.1	7.2	7.4	7 8	8.1	8.5

TABLE VII.—PORT TOWNSHEND.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	6 6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
1	6.7	6.4	6.0	6.2	6.5	7.0	7.3	7.5	7.6	7.6	7.6	7.6	7.7	7.8	8.0
2	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
3	6.3	6 0	5.6	5.8	6.1	6.6	6.9	7.1	7.2	7.2	7.2	7.4	7.3	7.4	7.6
4	6.0	5.7	5.3	5.5	5.8	6.3	6.6	6.8	6.9	6.9	6.9	6.9	7.0	7.1	7.3
5	5.9	5.6	5.2	5.4	5.7	6.2	6.5	6.7	6.8	6.8	6.8	6.8	6.9	7.0	7.2
6	6.1	5.8	5.4	5.6	5.9	6.4	6.7	6.9	7.0	7.0	7.0	7.0	7.1	7.2	7.4
7	6.4	6.1	5.7	5.9	6.2	6.7	7.0	7.2	7.3	7.3	7.3	7.3	7.4	7.5	7.7
8	6.5	6.2	5.8	6.0	6.3	6.8	7.1	7.3	7.4	7.4	7.4	7.4	7.5	7.6	7.8
9	6.5	6.2	5.8	6.0	6.3	6.8	7.1	7.3	7.4	7.4	7.4	7.4	7.5	7.6	7.8
10	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
11	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9

TABLE VII.—PORT TOWNSHEND.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
1	7.7	8.0	8.4	8.2	7.9	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.7	6.6	6.4
2	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
3	7.3	7.6	8.0	7.8	7.5	7.0	6.7	6.5	6.4	6.4	6.4	6.4	6.3	6.2	6.0
4	7.0	7.3	7.7	7.5	7.2	6.7	6.4	6.2	6.1	6.1	6.1	6.1	6.0	5.9	5.7
5	6.9	7.2	7.6	7.4	7.1	6.6	6.3	6.1	6.0	6.0	6.0	6.0	5.9	5.8	5.6
6	7.1	7.4	7.8	7.6	7.3	6.8	6.5	6.3	6.2	6.2	6.2	6.2	6.1	6.0	5.8
7	7.4	7.7	8.1	7.9	7.6	7.1	6.8	6.6	6.5	6.5	6.5	6.5	6.4	6.3	6.1
8	7.5	7.8	8.2	8.0	7.7	7.2	6.9	6.7	6.6	6.6	6.6	6.6	6.5	6.4	6.2
9	7.5	7.8	8.2	8.0	7.7	7.2	6.9	6.7	6.6	6.6	6.6	6.6	6.5	6.4	6.2
10	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
11	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3

NOTE.—To use these tables with a chart on which the soundings are referred to mean low water, subtract 1.2 foot from the numbers in the tables from San Diego to Astoria, 1.7 foot for Nee-ah harbor, 2.3 for Port Townshend, and 2.7 for Semiahmoo and Steilacoom.

Example VI.—In Example V, to obtain the height of tide on February 7, the declination being south, we enter Table VI for San Francisco, with 0*h.* of transit, and two days after greatest declination, and find that the tide will be 4.5 feet above the mean of the lowest low water, or that 4.5 feet are to be added to the soundings of a chart reduced to the mean of the lowest low waters of each day. If the soundings of the chart are given for mean low water, then 1.2 feet ought to be subtracted from the Tables VI and VII; thus, in this example, it would be 3.3 feet.

The approximate time of the successive low and high waters of the day will be found by adding the numbers in Table VIII to the time of the first high water already determined. The table gives the numbers for the different days from the greatest declination.

Tables containing numbers to be added to the time of high water found from Tables IV and V, to obtain the successive high and low waters.

TABLE VIII.—KEY WEST.

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water. (Large.)	High water. (Small.)	Low water. (Small.)	Low water. (Small.)	High water. (Large.)	Low water. (Large.)		
		h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*		
Before.	7	5 22	12 10	17 38	5 36	12 33	17 46	7	Before.
	6	5 42	12 31	17 40	5 18	12 18	17 50	6	
	5	6 05	12 55	17 41	4 58	12 03	17 56	5	
	4	6 24	13 17	17 44	4 35	11 44	17 59	4	
	3	6 39	13 28	17 39	4 11	11 18	17 58	3	
	2	7 02	13 52	17 40	3 50	10 58	17 58	2	
	1	7 13	14 01	17 39	3 39	10 46	17 56	1	
	0	7 18	14 10	17 42	3 37	10 46	17 59	0	
After.	1	7 12	14 10	17 48	3 44	10 46	17 52	1	After.
	2	6 57	13 58	17 51	3 57	10 54	17 47	2	
	3	6 39	13 41	17 53	4 21	11 19	17 48	3	
	4	6 15	13 18	17 53	4 43	11 38	17 45	4	
	5	5 57	12 59	17 53	5 09	12 03	17 44	5	
	6	5 32	12 36	17 54	5 26	12 22	17 46	6	
	7	5 13	12 16	17 53	5 40	12 36	17 46	7	

TABLE VIII.—SAN DIEGO.

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water. (Small.)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)		
		h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*		
Before.	7	5 44	12 28	18 44	6 16	12 16	18 00	7	Before.
	6	5 18	11 58	18 40	6 42	12 46	18 04	6	
	5	5 00	11 34	18 34	7 00	13 10	18 10	5	
	4	4 47	11 12	18 25	7 13	13 32	18 19	4	
	3	4 34	10 54	18 20	7 26	13 50	18 24	3	
	2	4 24	10 38	18 14	7 36	14 06	18 30	2	
	1	4 17	10 28	18 11	7 43	14 16	18 33	1	
	0	4 12	10 20	18 08	7 48	14 24	18 36	0	
After.	1	4 14	10 20	18 06	7 46	14 24	18 38	1	After.
	2	4 21	10 28	18 04	7 36	14 16	18 40	2	
	3	4 38	10 40	18 02	7 22	14 04	18 42	3	
	4	5 01	10 58	17 57	6 59	13 46	18 47	4	
	5	5 25	11 18	17 53	6 35	13 26	18 51	5	
	6	5 49	11 44	17 55	6 11	13 00	18 49	6	
	7	6 18	12 18	18 00	5 42	12 26	18 44	7	

TABLE VIII.—SAN FRANCISCO.

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water. (Small.)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)		
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.		
Before.	7	5 58	13 14	18 58	5 44	11 46	17 44	7	Before.
	6	5 36	12 42	18 48	6 06	12 18	17 54	6	
	5	5 14	12 10	18 38	6 28	12 50	18 04	5	
	4	4 55	11 34	18 21	6 47	13 26	18 21	4	
	3	4 37	11 00	18 05	7 05	14 00	18 37	3	
	2	4 24	10 34	17 52	7 18	14 26	18 50	2	
	1	4 12	10 06	17 36	7 30	14 54	19 06	1	
	0	4 12	10 00	17 30	7 30	15 00	19 12	0	
After.	1	4 17	10 02	17 27	7 25	14 58	19 15	1	After.
	2	4 27	10 12	17 27	7 15	14 48	19 15	2	
	3	4 41	10 26	17 27	7 01	14 34	19 15	3	
	4	4 56	10 46	17 32	6 46	14 14	19 10	4	
	5	5 14	11 10	17 38	6 28	13 50	19 04	5	
	6	5 36	11 36	17 42	6 06	13 24	19 00	6	
	7	5 57	12 04	17 49	5 45	12 56	18 53	7	

TABLE VIII.—ASTORIA.

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water. (Small)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)		
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.		
Before.	7	6 38	12 59	19 17	6 18	12 03	18 41	7	Before.
	6	6 14	12 33	19 15	6 42	12 29	18 43	6	
	5	5 55	12 13	19 14	7 01	12 49	18 44	5	
	4	5 34	11 47	19 09	7 22	13 15	18 49	4	
	3	5 20	11 27	19 03	7 36	13 35	18 55	3	
	2	5 09	11 07	18 54	7 47	13 55	19 04	2	
	1	5 05	11 01	18 52	7 51	14 01	19 06	1	
	0	5 03	10 53	18 46	7 53	14 09	19 12	0	
After.	1	5 05	10 51	18 42	7 51	14 11	19 16	1	After.
	2	5 11	10 55	18 40	7 45	14 07	19 18	2	
	3	5 18	11 03	18 41	7 38	13 59	19 17	3	
	4	5 32	11 15	18 39	7 24	13 47	19 19	4	
	5	5 50	11 35	18 41	7 06	13 27	19 17	5	
	6	6 11	11 55	18 40	6 45	13 07	19 18	6	
	7	6 35	12 19	18 40	6 21	12 43	19 18	7	

TABLE VIII.—PORT TOWNSHEND.

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water.	High water.	Low water.	Low water.	High water.	Low water.		
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.		
Before.	7	6 05	12 26	18 05	5 39	12 26	18 31	7	Before.
	6	6 38	13 14	18 20	5 06	11 38	18 16	6	
	5	7 18	14 14	18 40	4 26	10 38	17 56	5	
	4	8 13	15 52	19 23	3 31	9 00	17 13	4	
	3	8 36	16 52	20 00	3 08	8 00	16 36	3	
	2	8 43	17 30	20 31	3 01	7 22	16 05	2	
	1	8 12	17 04	20 36	3 32	7 48	16 00	1	
	0	7 40	16 28	20 32	4 04	8 24	16 04	0	
After.	1	7 18	15 52	20 18	4 26	9 00	16 18	1	After.
	2	6 59	15 14	19 59	4 45	9 38	16 37	2	
	3	6 38	14 32	19 38	5 06	10 20	16 58	3	
	4	6 24	14 02	19 22	5 20	10 50	17 14	4	
	5	6 10	13 26	19 00	5 34	11 26	17 36	5	
	6	5 59	12 50	18 35	5 45	12 02	18 01	6	
	7	5 42	12 26	18 28	6 02	12 26	18 08	7	

The days from the greatest declination are written in the first and last columns of the table. The second, third, and fourth columns refer to south declination, and fifth, sixth, and seventh to north, and the reverse for Key West. The second column gives the number which is to be added, according to the declination, to the time of high water, obtained by means of Tables IV and V, to give the next low water, which is the small low water, *b*, of diagram I. The third contains the numbers to be added to the same to give the second or large high water, *c*, of diagram I. The fourth, the numbers to be added to the same to give the second or large low water, *d*, of diagram I. The succeeding columns give the numbers to be used in the same way for north declination to obtain the low water, *b*, (large,) of diagram II; the high water, *c*, (small,) and the low water, *d*, (small,) of the same diagram. The rise and fall of the same successive tides may be obtained by inspection from Table IX, in which the first column at the side contains the time of transit, and the successive columns the numbers corresponding to that time, and to the number of days from greatest declination. The arrangement of this table is like that already given.

The numbers for the small ebb tide, *a b*, of diagram I, or *c d*, of diagram II, are first given; then those for small low and large high waters, *b c*, for diagram I, and *d e*, of diagram II; next, the large ebb tide, *c d*, of diagram I, or *a b*, of diagram II; and lastly, from the large low water to the small high water, *d e*, of diagram I, or *b c*, of diagram II.

TABLE IX —KEY WEST.

Time of moon's transit.	SMALL EBB TIDE. Days from moon's greatest declination. Before—								After—							SMALL LOW TO LARGE HIGH WATER. Days from moon's greatest declination. Before—								After—							Time of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H	Ft	Ft.	Ft.	Ft	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft	Ft	H.
0	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	0
1	1 6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	1
2	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0 9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	2
3	1.5	1.3	1.0	0.9	0.7	0 6	0.6	0.6	0.6	0.7	0.8	1.0	1.1	1.4	1.7	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.5	1.6	1 6	1.5	1.4	1.3	3
4	1.3	1.1	0.8	0.7	0.5	0.4	0.4	0.4	0.4	0.5	0.6	0.8	0.9	1.2	1.5	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.3	1.4	1.4	1 3	1.2	1.1	4
5	1.1	0.9	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.6	0.7	1.0	1.3	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.1	1.0	0.9	5
6	1.0	0.8	0.5	0.4	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.2	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.0	1.1	1.1	1.0	0 9	0.8	6
7	1.0	0.8	0.5	0.4	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.2	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.0	1.1	1.1	1.0	0.9	0.8	7
8	1.1	0.9	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.6	0.7	1.0	1.3	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.1	1.0	0.9	8
9	1.3	1.1	0.8	0.7	0.5	0.4	0.4	0 4	0.4	0.5	0.6	0.8	0.9	1.2	1.5	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.2	1.1	9
10	1.5	1.3	1.0	0.9	0.7	0.6	0.6	0.6	0.6	0.7	0.8	1.0	1.1	1.4	1.7	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.5	1.6	1.6	1.5	1.4	1.3	10
11	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	11

TABLE IX – KEY WEST—Continued.

Time of moon's transit.	LARGE EBB TIDE. Days from moon's greatest declination. Before—								After—							LARGE LOW TO SMALL HIGH WATER. Days from moon's greatest declination. Before—								After—							Time of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft	Ft	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	H.
0	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	0
1	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1 3	1.4	1.5	1.6	1
2	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1 5	1.5	1.4	1.4	1.3	1.3	1 3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	2
3	1.3	1.5	1.8	1.9	2.1	2.2	2.2	2.2	2.2	2.1	2.0	1.8	1.7	1.4	1.1	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.3	1.4	1.5	3
4	1.1	1.3	1.6	1.7	1.9	2.0	2.0	2.0	2.0	1.9	1.8	1.6	1.5	1.2	0.9	1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1 0	1.1	1.0	1.0	1.1	1.2	1.3	4
5	0.9	1.1	1.4	1.5	1.7	1.8	1.8	1.8	1.8	1.7	1.6	1.4	1.3	1.0	0.7	1.1	1 0	1.0	0.9	0.9	0 8	0.8	0.8	0.8	0.9	0.8	0.8	0.9	1.0	1.1	5
6	0.8	1.0	1.3	1.4	1.6	1.7	1.7	1.7	1.7	1.6	1.5	1.3	1.2	0 9	0.6	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0 8	0.7	0.7	0.8	0.9	1.0	6
7	0.8	1.0	1.3	1.4	1.6	1.7	1.7	1.7	1.7	1.6	1.5	1.3	1.2	0.9	0.6	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.8	0.9	1.0	7
8	0.9	1.1	1.4	1 5	1.7	1.8	1.8	1.8	1 8	1.7	1 6	1.4	1.3	1.0	0.7	1.1	1.0	1.0	0.9	0.9	0.8	0.8	0 8	0.8	0.9	0.8	0.8	0.9	1.0	1.1	8
9	1.1	1.3	1.6	1.7	1.9	2.0	2.0	2 0	2.0	1.9	1.8	1.6	1 5	1.2	0.9	1.3	1 2	1.2	1.1	1 1	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.2	1.3	9
10	1.3	1.5	1.8	1.9	2.1	2.2	2.2	2.2	2 2	2.1	2.0	1.8	1.7	1.4	1.1	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1 2	1.2	1.3	1.2	1.2	1.3	1.4	1.5	10
11	1.4	1.6	1.9	2.0	2.2	2.3	2 3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	11

TABLE IX.—SAN DIEGO.

Time of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER. Days from moon's greatest declination. Before—								After—							FROM SMALL LOW WATER TO LARGE HIGH WATER. Days from moon's greatest declination. Before—								After—							Time of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
0	4.0	3.4	3.0	2.6	2.3	2 1	2.0	2.0	2.1	2.3	2.7	3.2	3.8	4.6	5.2	5.1	4.9	4.7	4.5	4.4	4.3	4.2	4.2	4.1	4.1	4.0	4.0	3.9	3.9	4.0	0
1	3.8	3.2	2.8	2.4	2 1	1 9	1.8	1.8	1.9	2.1	2.5	3.0	3.6	4.4	5 0	4.9	4.7	4.5	4.3	4.2	4.1	4.0	4.0	3.9	3.9	3.8	3.8	3.7	3.7	3.8	1
2	3.5	2.9	2.5	2.1	1.8	1.6	1.5	1.5	1.6	1.8	2.2	2.7	3.3	4.1	4.7	4.6	4 4	4.2	4.0	3.9	3.8	3.7	3.7	3.6	3.6	3.5	3.5	3.4	3.4	3.5	2
3	3.0	2.4	2 0	1.6	1.3	1.1	1.0	1.0	1.1	1.3	1.7	2.2	2.8	3.6	4.2	4.1	3.9	3.7	3.5	3.4	3.3	3 2	3.2	3.1	3.1	3.0	3.0	2.9	2.9	3.0	3
4	2.2	1.6	1.2	0.8	0.5	0.3	0.2	0.2	0 3	0.5	0.9	1.4	2.0	2.8	3.4	3.3	3.1	2.9	2.7	2.6	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.2	4
5	1.7	1.1	0.7	0.3	0.0	−.2	−.3	−.3	−.2	0 0	0.4	0.9	1.5	2.3	2.9	2.8	2.6	2 4	2.2	2.1	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.7	5
6	1.8	1.2	0.8	0.4	0.1	−.1	−.2	−.2	−.1	0.1	0.5	1.0	1.6	2.4	3.0	2.9	2.7	2.5	2.3	2.2	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.8	6
7	2.3	1.7	1.3	0.9	0.6	0.4	0.3	0.3	0.4	0.6	1.0	1.5	2.1	2.9	3.5	3.4	3.2	3.0	2.8	2.7	2.6	2.5	2.5	2.4	2.4	2 3	2.3	2.2	2.2	2.3	7
8	2.9	2.3	1.9	1.5	1.2	1.0	0.9	0.9	1.0	1.2	1 6	2.1	2.7	3 5	4.1	4.0	3.8	3.6	3.4	3.3	3.2	3.1	3.1	3.0	3.0	2.9	2.9	2.8	2.8	2.9	8
9	3.7	3.1	2.7	2.3	2.0	1.8	1.7	1.7	1.8	2.0	2.4	2.9	3.5	4.3	4.9	4.8	4.6	4.4	4.2	4.1	4.0	3.9	3.9	3.8	3.8	3 7	3.7	3 6	3.6	3.7	9
10	4.2	3.6	3.2	2.8	2.5	2.3	2.2	2.2	2.3	2.5	2.9	3.4	4.0	4.8	5.4	5.3	5.1	4.9	4.7	4.6	4.5	4.4	4.4	4.3	4.3	4.2	4 2	4.1	4.1	4.2	10
11	4.3	3.7	3.3	2.9	2 6	2.4	2.3	2.3	2.4	2.6	3.0	3.5	4.1	4.9	5.5	5.4	5.2	5.0	4.8	4.7	4.6	4.5	4.5	4.4	4.4	4.3	4.3	4.2	4.2	4.3	11

From *a* to *b*.....Diagram I.
From *c* to *d*.....Diagram II.

From *b* to *c*.....Diagram I.
From *d* to *e*.....Diagram II.

TABLE IX.—SAN DIEGO—Continued.

Time of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER. Days from moon's greatest declination. Before—								After—							FROM LARGE LOW WATER TO SMALL HIGH WATER. Days from moon's greatest declination. Before—								After—							Time of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
0	5.2	5.8	6.2	6.6	6.9	7.1	7.2	7 2	7.1	6.9	6.5	6 0	5.4	4.6	4.0	4.1	4.3	4.5	4.7	4.8	4 9	5.0	5.0	5.1	5.1	5.2	5.2	5.3	5.3	5.2	0
1	5 0	5.6	6.0	6.4	6.7	6.9	7 0	7.0	6.9	6.7	6.3	5.8	5.2	4.4	3.8	3.9	4.1	4.3	4.5	4.6	4.7	4.8	4.8	4.9	4.9	5.0	5.0	5.1	5.1	5.0	1
2	4.7	5.3	5.7	6.1	6.4	6.6	6.7	6.7	6.6	6 4	6.0	5.5	4.9	4.1	3.5	3 6	3.8	4.0	4.2	4.3	4.4	4.5	4.5	4.6	4.6	4.7	4.7	4.8	4.8	4.7	2
3	4.2	4.8	5 2	5.6	5.9	6.1	6.2	6.2	6.1	5.9	5.5	5.0	4.4	3.6	3.0	3.1	3.3	3.5	3.7	3.8	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.3	4.3	4.2	3
4	3.4	4.0	4.4	4.8	5 1	5 3	5.4	5.4	5.3	5.1	4.7	4.2	3.6	2.8	2.2	2.3	2.5	2.7	2.9	3.0	3.1	3 2	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.4	4
5	2.9	3.5	3.9	4.3	4.6	4.8	4.9	4.9	4.8	4.6	4.2	3.7	3 1	2.3	1.7	1.8	2.0	2.3	2.4	2.5	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.0	2.9	5
6	3.0	3.6	4.0	4.4	4.7	4.9	5.0	5.0	4.9	4 7	4 3	3.8	3 2	2.4	1.8	1.9	2.1	2.3	2 5	2.6	2.7	2.8	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.0	6
7	3.5	4.1	4.5	4.9	5.2	5.4	5.5	5.5	5.4	5.2	4.8	4.3	3.7	2.9	2.3	2.4	2.6	2.8	3.0	3.1	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.6	3.6	3.5	7
8	4.1	4.7	5.1	5.5	5.8	6.0	6.1	6.1	6.0	5.8	5.4	4.9	4.3	3.5	2.9	3.0	3 2	3.4	3.6	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.1	8
9	4.9	5.5	5.9	6.3	6.6	6.8	6.9	6 9	6.8	6.6	6.2	5.7	5.1	4.3	3.7	3.8	4.0	4.2	4.4	4 5	4.6	4.7	4.7	4.8	4.8	4.9	4.9	5.0	5.0	4.9	9
10	5.4	6.0	6.4	6.8	7.1	7.3	7.4	7.4	7.3	7.1	6.7	6.2	5.6	4.8	4.2	4.3	4.5	4.7	4.9	5.0	5.1	5.2	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.4	10
11	5.5	6.1	6.5	6 9	7.2	7.4	7.5	7.5	7.4	7.2	6.8	6.3	5.7	4.9	4.3	4.4	4.6	4.8	5.0	5.1	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.6	5.6	5.5	11

From *c* to *d*.....Diagram I.
From *a* to *b*.....Diagram II.

From *d* to *e*.....Diagram I.
From *b* to *c*.....Diagram II.

TABLE IX.—SAN FRANCISCO.

Hours of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER. Days from moon's greatest declination. Before—								After—							FROM SMALL LOW WATER TO LARGE HIGH WATER. Days from moon's greatest declination. Before—								After—							Hours of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	
0	4.7	4.0	3.4	2.9	2.4	2.0	1.8	1.7	1.7	1 9	2.2	2.6	3 1	3.7	4.4	5.2	4 9	4.6	4.5	4 0	3.7	3.4	3.2	3.1	3.0	3.1	3.1	3.3	3.4	3.5	0
1	4 5	3.8	3.2	2.7	2.2	1.8	1.6	1.5	1.5	1.7	2.0	2.4	2 9	3 5	4.2	5.0	4.7	4.4	4.3	3.8	3.5	3.2	3.0	2 9	2 8	2 9	2 9	3.1	3.2	3.3	1
2	4.3	3.6	3.0	2 5	2 0	1.6	1.4	1.3	1.3	1.5	1.8	2 2	2.7	3.3	4.0	4.8	4.5	4.2	4.1	3.6	3.3	3.0	2.8	2.7	2.6	2.7	2.7	2 9	3.0	3.1	2
3	4.0	3 3	2.7	2.2	1.7	1.3	1.1	1.0	1.0	1.2	1.5	1.9	2.4	3.0	3 7	4.5	4 ?	3 9	3.8	3.3	3.0	2.7	2.5	2.4	2.3	2.4	2.4	2.6	2.7	2.8	3
4	3.6	2.9	2 3	1 8	1 3	0.9	0.7	0 6	0.6	0.8	1.1	1.5	2.0	2.6	3.3	4.1	3.8	3 5	3.4	2.9	2.6	2.3	2.1	2.0	1.9	2.0	2.0	2.2	2.3	2.4	4
5	3.2	2.5	1.9	1.4	0.9	0.5	0.3	0.2	0.2	0.4	0 7	1.1	1.6	2.2	2.9	3.7	3.4	3.1	3.0	2.5	2.2	1.9	1.7	1.6	1.5	1.6	1.6	1.8	1 9	2.0	5
6	3.2	2.5	1.9	1.4	0.9	0.5	0.3	0.2	0.2	0.4	0.7	1.1	1.6	2.2	2.9	3.7	3.4	3.1	3.0	2.5	2.2	1.9	1.7	1.6	1.5	1.6	1.6	1.8	1.9	2.0	6
7	3.4	2.7	2.1	1.6	1.1	0.7	0.5	0.4	0.4	0 6	0.9	1.3	1.8	2.4	3 1	3.9	3.6	3.3	3.2	2.7	2.4	2.1	1.9	1.8	1.7	1.8	1.8	2.0	2.1	2 2	7
8	3.8	3.1	2.5	2.0	1.5	1.1	0.9	0.8	0.8	1.0	1.3	1.7	2.2	2.8	3.5	4.3	4.0	3.7	3.6	3.1	2.8	2.5	2.3	2.2	2.1	2.2	2 2	2.4	2.5	2.6	8
9	4.1	3.4	2.8	2 3	1.8	1.4	1.2	1.1	1.1	1.3	1.6	2.0	2.5	3.1	3.8	4.6	4.3	4.0	3.9	3.4	3.1	2.8	2 6	2 5	2.4	2.5	2.5	2.7	2 8	2.9	9
10	4.5	3.8	3.2	2.7	2.2	1.8	1.6	1.5	1 5	1.7	2.0	2.4	2 9	3.5	4.2	5.0	4.7	4.4	4.3	3.8	3.5	3.2	3.0	2.9	2.8	2.9	2.9	3.1	3.2	3.3	10
11	4.7	4.0	3.4	2.9	2.4	2.0	1.8	1.7	1.7	1 9	2.2	2.6	3.1	3.7	4.4	5.2	4.9	4.6	4.5	4.0	3.7	3.4	3.2	3.1	3.0	3.1	3.1	3.3	3.4	3.5	11

From *a* to *b*.....Diagram I.
From *c* to *d*.....Diagram II.

From *b* to *e*.....Diagram I.
From *d* to *c*.....Diagram II.

TABLE IX.—SAN FRANCISCO—Continued.

Time of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER. Days from moon's greatest declination. Before—								After—							FROM LARGE LOW WATER TO SMALL HIGH WATER. Days from moon's greatest declination. Before—								After—							Time of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	Ft	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft	H.
0	3.9	4.6	5.2	5.7	6.2	6.6	6.8	6 9	6.9	6.7	6 4	6.0	5.5	4.9	4.2	3 4	3.7	4.0	4.1	4.6	4.9	5.2	5.4	5.5	5 6	5.6	5.5	5.3	5 2	5.2	0
1	3 7	4.4	5.0	5 5	6.0	6.4	6 6	6.7	6.7	6.5	6.2	5.8	5.3	4.7	4.0	3.2	3.5	3.8	3.9	4.4	4.7	5.0	5.2	5.3	5.4	5.3	5.3	5.1	5.0	5.0	1
2	3.5	4.2	4.8	5.3	5.8	6.2	6.4	6.5	6.5	6 3	6.0	5.6	5.1	4.5	3 8	3.0	3.3	3.6	3.7	4.2	4.5	4.8	5.0	5.1	5.2	5.1	5 1	4.9	4.8	4 8	2
3	3.2	3.9	4.5	5.0	5.5	5.9	6.1	6.2	6.2	6.0	5 7	5.3	4.8	4.2	3.5	2.7	3 0	3.3	3.4	3 9	4.2	4.5	4.7	4.8	4.9	4 8	4.8	4 6	4.5	4 5	3
4	2.8	3.5	4 1	4.6	5 1	5 5	5.7	5.8	5.8	5.6	5.3	4.9	4.4	3.8	3.1	2.3	2.6	2.9	3.0	3.5	3.8	4.1	4.3	4.4	4.5	4.4	4.4	4.2	4.1	4.1	4
5	2.4	3.1	3 7	4.2	4.7	5.1	5.3	5.4	5 4	5.2	4.9	4.5	4.0	3.4	2.7	1.9	2 2	2.5	2.6	3.1	3.4	3.7	3.9	4.0	4 1	4.0	4.0	3.8	3.7	3 7	5
6	2.4	3.1	3.7	4.2	4.7	5.1	5.3	5.4	5.4	5.2	4.9	4.5	4.0	3.4	2.7	1.9	2.2	2.5	2 6	3.1	3.4	3.7	3 9	4.0	4.1	4.0	4.0	3 8	3.7	3.7	6
7	2.6	3.3	3.9	4.4	4.9	5.3	5.5	5.6	5.6	5.4	5.1	4.7	4 2	3.6	2.9	2.1	2.4	2.7	2.8	3.3	3.6	3.9	4.1	4.2	4.3	4.2	4.2	4.0	3 9	3.9	7
8	3 0	3.7	4.3	4.8	5 3	5.7	5.9	6.0	6.0	5.8	5.5	5.1	4.6	4 0	3.3	2.5	2.8	3.1	3.2	3.7	4.0	4.3	4.5	4.6	4.7	4.6	4.6	4.4	4.3	4.3	8
9	3.3	4.0	4 6	5.1	5.6	6.0	6.2	6.3	6.3	6.1	5.8	5 4	4.9	4.3	3.6	2 8	3.1	3.4	3.5	4.0	4.3	4.6	4.8	4.9	5.0	4.9	4.9	4.7	4.6	4.6	9
10	3.7	4.4	5.0	5.5	6.0	6.4	6.6	6.7	6.7	6.5	6.2	5.8	5.3	4.7	4.0	3.2	3.5	3.8	3.9	4.4	4.7	5.0	5 2	5.3	5.4	5 3	5.3	5.1	5 0	5.0	10
11	3.9	4.6	5.2	5.7	6.2	6.6	6.8	6.9	6.9	6.7	6.4	6.0	5.5	4.9	4.2	3.4	3.7	4.0	4.1	4.6	4.9	5.2	5.4	5.5	5.6	5.5	5.5	5.3	5.2	5.2	11

From *c* to *d*.....Diagram I.
From *a* to *b*.....Diagram II.

From *d* to *e*.....Diagram I.
From *b* to *c*.....Diagram II.

TABLE IX.—ASTORIA.

Hours of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER. Days from moon's greatest declination. Before--								After—							FROM SMALL LOW WATER TO LARGE HIGH WATER. Days from moon's greatest declination. Before—								After—							Hours of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	6	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	
0	7.4	6.7	6.0	5.4	5.0	4.6	4.5	4.5	4.6	4.7	5.1	5.5	6.2	6.9	7.8	8.0	7.8	7.5	7.2	6.8	6.4	6.3	6.2	6.1	6.2	6.2	6.3	6.3	6.3	6.4	0
1	7.5	6.8	6.1	5 5	5.1	4.7	4 6	4.6	4.7	4.8	5.2	5.6	6.3	7.0	7.9	8.1	7.9	7.6	7.3	6.9	6.5	6.4	6.3	6.2	6.3	6.3	6.4	6.4	6.4	6.5	1
2	7.2	6.5	5.8	5.2	4.8	4.4	4.3	4.3	4.4	4 5	4.9	5.3	6.0	6.7	7.6	7 8	7.6	7.3	7.0	6.6	6.2	6.1	6.0	5.9	6.0	6.0	6.1	6.1	6.1	6.2	2
3	6.6	5.9	5.2	4.6	4.2	3.8	3.7	3.7	3.8	3.9	4.3	4.7	5.4	6.1	7.0	7.2	7.0	6.7	6 4	6.0	5.6	5.5	5.4	5.3	5.4	5.4	5.5	5.5	5.5	5.6	3
4	5.9	5.2	4.5	3.9	3.5	3.1	3 0	3.0	3.1	3.2	3.6	4.0	4.7	5.4	6 3	6.5	6.3	6.0	5.7	5.3	4.9	4.8	4.7	4.6	4.7	4.7	4.8	4.8	4.8	4.9	4
5	5.2	4.5	3.8	3.2	2.8	2.4	2.3	2 3	2.4	2.5	2.9	3.3	4.0	4.7	5.6	5.8	5.6	5.3	5.0	4.6	4.2	4.1	4.0	3.9	4.0	4.0	4.1	4.1	4.1	4.2	5
6	4.8	4.1	3.4	2.8	2.4	2.0	1.9	1.9	2.0	2.1	2.5	2.9	3.6	4.3	5.2	5.4	5.2	4.9	4 6	4.2	3.8	3.7	3 6	3 5	3 6	3.6	3.7	3.7	3.7	3.8	6
7	5.0	4.3	3.6	3.0	2.6	2.2	2.1	2.1	2.2	2.3	2.7	2.1	3.8	4.5	5 4	5.6	5.4	5.1	4.8	4.4	4.0	3.9	3 8	3.7	3.8	3.8	3.9	3.9	3.9	4.0	7
8	5.5	4.8	4.1	3 5	3.1	2.7	2.6	2.6	2.7	2.8	3.2	3.6	4.3	5.0	5.9	6.1	5.9	5.6	5.3	4.9	4.5	4.4	4.3	4.2	4.3	4.3	4.4	4.4	4.4	4.5	8
9	6.3	5.6	4.9	4.3	3.9	3.5	3 4	3.4	3.5	3.6	4.0	4 4	5.1	5.8	6.7	6.9	6.7	6.4	6.1	5 7	5.3	5.2	5.1	5.0	5.1	5.1	5.2	5 2	5.2	5.3	9
10	7.0	6.3	5.6	5.0	4.6	4.2	4.1	4.1	4.2	4.3	4.7	5.1	5.8	6.5	7.4	7.6	7.4	7.1	6.8	6.4	6.0	5.9	5 8	5.7	5.8	5.8	5 9	5.9	5.9	6.0	10
11	7.3	6.6	6.9	5.3	4.9	4.5	4.4	4.4	4.5	4.6	5.0	5.4	6.1	6.8	7.7	7.9	7.7	7.4	7.1	6.7	6.3	6.2	6.1	6.0	6.1	6.1	6.2	6.2	6.2	6.3	11

From *a* to *b*.....Diagram I.
From *c* to *d*.....Diagram II.

From *b* to *c*.....Diagram I.
From *d* to *e*.....Diagram II.

TABLE IX.—ASTORIA—Continued.

Hours of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER. Days from moon's greatest declination. Before—								After—							FROM LARGE LOW WATER TO SMALL HIGH WATER. Days from moon's greatest declination. Before—								After—							Hours of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	
0	7.0	7.7	8.4	9.0	9.4	9.8	9.9	9.9	9.8	9.7	9.3	8.9	8.2	7.5	6.6	6.4	6.6	6.9	7.2	7.6	8.0	8.1	8.2	8.3	8.2	8.2	8.1	8.1	8.1	8.0	0
1	7.1	7.8	8.5	9.1	9.5	9.9	10.0	10.0	9.9	9.8	9.4	9.0	8.3	7 6	6.7	6.5	6.7	7.0	7.3	7 7	8.1	8.2	8.3	8.4	8 3	8.3	8.2	8.2	8.2	8.1	1
2	6.8	7.5	8.2	8.8	9.2	9.6	9.7	9.7	9.6	9.5	9.1	8.7	8.0	7.3	6.4	6.2	6.4	6.7	7.0	7.4	7.8	7.9	8.0	8.1	8.0	8.0	7.9	7.9	7.9	7.8	2
3	6.2	6.9	7.6	8.2	8.6	9.0	9.1	9.1	9.0	8.9	8.5	8.1	7.4	6.7	5.8	5.6	5.8	6.1	6.4	6.8	7.2	7.3	7.4	7.5	7.4	7.4	7.3	7.3	7.3	7.2	3
4	5.5	6.2	6.9	7.5	7.9	8.3	8.4	8.4	8.3	8.2	7.8	7.4	6.7	6.0	5.1	4 9	5.1	5.4	5.7	6.1	6.5	6.6	6.7	6 8	6.7	6.7	6.6	6.6	6.6	6.5	4
5	4.8	5.5	6.2	6.8	7.2	7.6	7.7	7.7	7.6	7.5	7.1	6.7	6.0	5.3	4.4	4.2	4.4	4.7	5.0	5.4	5.8	5.9	6.0	6.1	6.0	6.0	5.9	5.9	5.9	5 8	5
6	4.4	5.1	5.8	6.4	6.8	7.2	7.3	7.3	7.2	7.1	6.7	6.3	5.6	4.9	4.0	3.8	4.0	4.3	4.6	5.0	5 4	5.5	5.6	5.7	5.6	5.6	5.5	5.5	5.5	5.4	6
7	4.6	5.3	6.0	6.6	7.0	7.4	7.5	7.5	7.4	7.3	6.9	6.5	5.8	5.1	4.2	4.0	4.2	4.5	4.8	5.2	5.6	5.7	5.8	5 9	5.8	5.8	5.7	5.7	5.7	5.6	7
8	5.1	5.8	6.5	7.1	7.5	7.9	8.0	8.0	7.9	7.8	7 4	7.0	6.3	5.6	4.7	4.5	4.7	5.0	5.3	5.7	6.1	6.2	6.3	6.4	6.3	6.3	6.2	6.2	6.2	6.1	8
9	5.9	6.6	7.3	7.9	8.3	8.7	8.8	8.8	8.7	8.6	8 2	7.8	7.1	6.4	5.5	5.3	5.5	5.8	6.1	6.5	6.9	7.0	7.1	7 2	7.1	7.1	7.0	7.0	7.0	6.9	9
10	6.6	7.3	8.0	8.6	9.0	9.4	9.5	9.5	9.4	9.3	8.9	8.5	7.8	7.1	6.2	6.0	6.2	6.5	6 8	7.2	7.6	7.7	7.8	7.9	7.8	7.8	7.7	7.7	7.7	7.6	10
11	6.9	7.6	8.3	8.9	9.3	9.7	9.8	9.8	9.7	9 6	9.2	8.8	8.1	7.4	7.5	6.3	6.5	6.8	7.1	7.5	7.9	8.0	8.1	8.2	8.1	8.1	8.0	8.0	8.0	7.9	11

From *c* to *d*.....Diagram I.
From *a* to *b*.....Diagram II.

From *d* to *e*.....Diagram I.
From *b* to *c*.....Diagram II.

TABLE IX.—PORT TOWNSHEND.

Hours of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER. Days from moon's greatest declination. Before—								After—							FROM SMALL LOW WATER TO LARGE HIGH WATER. Days from moon's greatest declination. Before—								After—							Hours of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
	Feet.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	
0	4.5	5.6	6.9	8.0	8.6	8 9	8 8	8 8	8.7	8.7	8.5	8 0	7.3	6 6	5.5	3.5	3.9	4.6	6.0	7.2	8.4	9.0	9 5	9.6	9.4	9.2	8.7	8.2	7.9	7.1	0
1	4.5	5.6	6.9	8.0	8.6	8.9	8.8	8.8	8.7	8.7	8.5	8.0	7.3	6.6	5.5	3.5	3.9	4.6	6.0	7.2	8.4	9.0	9.5	9.6	9.4	9 2	8.7	8 2	7 9	7 1	1
2	4.4	5.5	6.8	7.9	8.5	8.8	8.7	8.7	8.6	8.6	8.4	7.9	7.2	6.5	5.4	3.4	3.8	4.5	5.9	7.1	8.3	8.9	9.4	9.5	9.3	9.1	8.6	8.1	7.8	7.0	2
3	4.1	5.2	6.5	7.6	8.2	8.5	8.4	8.4	8.3	8.3	8.1	7.6	6.9	6.2	5.1	3.1	3.5	4.2	5.6	6.8	8.0	8.6	9.1	9.2	9.0	8.8	8.3	7.8	7.5	6 7	3
4	3.5	4.6	5 9	7.6	7.6	7.9	7.8	7.8	7.7	7.7	7.5	7.0	6.3	5.6	4.5	2.5	2 9	3 6	5.0	6 2	7.4	8.0	8.5	8.6	8.4	8.2	7.7	7.2	6.9	6.1	4
5	3 1	4.2	5.5	6.6	7.2	7.5	7.4	7.4	7.3	7.3	7.1	6.6	5.9	5.2	4.1	2.1	2.5	3.2	4.6	5.8	7.0	7.6	8 1	8.2	8.0	7.8	7.3	6.8	6.5	5.7	5
6	3.1	4.2	5.5	6.6	7.2	7.5	7.4	7.4	7.3	7.3	7.1	6.6	5.9	5.2	4.1	2.1	2.5	3.2	4.6	5.8	7.0	7.6	8.1	8.2	8.0	7 8	7.3	6.8	6.5	5.7	6
7	3.3	4.4	5.7	6.8	7.4	7.7	7.6	7.6	7.5	7.5	7.3	6.8	6.1	5.4	4.3	2.3	2.7	3.4	4.8	6.0	7.2	7.8	8.3	8.4	8.2	8.0	7.5	7.0	6.7	5.9	7
8	3.5	4.6	5.9	7.0	7.6	7.9	7.8	7.8	7.7	7.7	7 5	7.0	6.3	5.6	4.5	2.5	2.9	3.6	5.0	6.2	7.4	8.0	8 5	8.6	8.4	8.2	7.7	7.2	6.9	6.1	8
9	3.7	4.8	6.1	7.2	7.8	8.1	8.0	8.0	7.9	7.9	7.7	7.2	6.5	5.8	4.7	2.7	3.1	3.8	5.2	6.4	7.6	8.2	8.7	8.8	8 6	8.4	7.9	7.4	7.1	6.3	9
10	4.1	5.2	6 5	7 6	8.2	8.5	8.4	8.4	8.3	8.3	8.1	7.6	6.9	6.2	5.1	3.1	3.5	4.2	5.6	6.8	8.0	8.6	9.1	9 2	9.0	8.8	8.3	7.8	7.5	6.7	10
11	4.4	5.5	6.8	7.9	8 5	8.8	8.7	8.7	8.6	8.6	8.4	7.9	7.2	6.5	5.4	3.4	3.8	4.5	5.9	7.1	8.3	8 9	9.4	9.5	9.3	9.1	8.6	8.1	7.8	7.0	11

TABLE IX.—PORT TOWNSHEND—Continued.

Hours of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER. Days from moon's greatest declination. Before—								After—							FROM SMALL LOW WATER TO LARGE HIGH WATER. Days from moon's greatest declination. Before—								After—							Hours of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
	Feet.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
0	6.5	5.4	4.1	3.0	2.4	2.1	2.2	2.2	2.3	2.3	2.5	3.0	3 7	4.4	5.5	7.5	7.1	6.4	5.0	3.8	2.6	2.0	1.5	1.4	1.6	1.8	2.3	2.8	3.1	3.9	0
1	6.5	5.4	4.1	3.0	2.4	2.1	2.2	2.2	2.3	2.3	2 5	3.0	3.7	4.4	5.5	7.5	7.1	6.4	5.0	3.8	2.6	2.0	1.5	1.4	1.6	1.8	2.3	2.8	3 1	3.9	1
2	6.4	5.3	4.0	2.9	2.3	2.0	2.1	2.1	2.2	2.2	2.4	2.9	3.6	4.3	5.4	7.4	7.0	6.3	4.9	3.7	2.5	1.9	1.4	1.3	1.5	1.7	2 2	2.7	3.0	3.8	2
3	6.1	5.0	3.7	2.6	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.6	3.3	4.0	5.1	7.1	6.7	6.0	4.6	3.4	2.2	1.6	1.1	1.0	1.2	1.4	1.9	2.4	2.7	3.5	3
4	5.5	4.4	3.1	2.0	1.4	1.1	1.2	1.2	1.3	1.3	1.5	2.0	2.7	3.4	4.5	6.5	6.1	5.4	4.0	2.8	1.6	1.0	0 5	0.4	0.6	0.8	1.3	1.8	2.1	2.9	4
5	5.1	4.0	2.7	1 6	1.0	0.7	0.8	0.8	0.9	0.9	1.1	1.6	2.3	3.0	4.1	6.1	5.7	5.0	3.6	2.4	1.2	0.6	0.1	0.0	0.2	0.4	0.9	1.4	1.7	2.5	5
6	5.1	4.0	2.7	1.6	1.0	0.7	0.8	0.8	0.9	0.9	1.1	1.6	2.3	3.0	4.1	6.1	5.7	5.0	3.6	2.4	1.2	0.6	0.1	0.0	0.2	0.4	0.9	1.4	1.7	2.5	6
7	5.3	4.2	2.9	1.8	1.2	0.9	1.0	1.0	1.1	1.1	1.3	1.8	2.5	3.2	4.3	6.3	5.9	5.2	3.8	2.6	1.4	0.8	0.3	0.2	0.4	0.6	1.1	1.6	1.9	2.7	7
8	5.5	4.4	3.1	2.0	1.4	1.1	1.2	1.2	1.3	1.3	1.5	2 0	2.7	3.4	4.5	6.5	6.1	5.4	4 0	2.8	1.6	1.0	0.5	0.4	0.6	0.8	1.3	1.8	2.1	2.9	8
9	5.7	4.6	3.3	2.2	1.6	1.3	1.4	1.4	1 5	1.5	1.7	2.2	2.9	3.6	4.7	6.7	6.3	5.6	4.2	3.0	1.8	1 2	0.7	0.6	0.8	1.0	1 5	2.0	2.3	3.1	9
10	6.1	5.0	3.7	2.6	2.0	1.7	1.8	1.8	1.9	1.9	2 1	2.6	3.3	4.0	5.1	7.1	6 7	6.0	4.6	3.4	2.2	1.6	1.1	1.0	1 2	1 4	1.9	2.4	2.7	3.5	10
11	6.4	5.3	4.0	2.9	2.3	2.0	2.1	2.1	2.2	2.2	2.4	2.9	3.6	4.3	5.4	7.4	7.0	6.3	4.9	3.7	2.5	1.9	1.4	1.3	1.5	1.7	2.2	2.7	3.0	3.8	11

Example VII.—Thus, in Example VI, the high water of February 7th was found to be 3.3 feet above mean low water. The declination being south, Diagram I applies, and this high water is the small one. To obtain the fall of the next low water or small low water, we enter Table IX, for San Francisco, with 0*h.* of moon's transit, and two days after the greatest declination in the first part of the table, and find 1.9 foot, which will be the difference in the height of this high and low water. Entering with the same transit and day in the second part, we find 3.0 feet, which is the rise of the large high above the small low water; the difference between 1.9 and 3.0 or 1.1 foot is the difference of height of the two successive high waters.

It is easy to see how, in this way, the soundings of a chart can be reduced to what they would be approximately at all the successive high and low waters.

TIDES OF THE GULF OF MEXICO.

On the coast of Florida, from Cape Florida around the peninsula to St. Mark's, the tides are of the ordinary kind, but with a daily inequality which, small at Cape Florida, goes on increasing as we proceed westward to Tortugas. From the Tortugas to St. Mark's the daily inequality is large and sensibly the same, giving the tides a great resemblance to those of the

Pacific coast, though the rise and fall is much smaller. Between St. Mark's and St. George's island, Apalachicola entrance, the tides change to the single day class, ebbing and flowing but once in the twenty-four (lunar) hours.

At St. George's island there are two tides a day, for three or four days, about the time of the moon's declination being zero. At other times there is but one tide a day, with a long stand at high water of from six to nine hours. From Cape St. Blas to and including the mouth of the Mississippi, the single day tides are very regular, and the small and irregular double tides appear only for two or three days, (and frequently even not at all,) about the time of zero declination of the moon. The stand at high and low water is comparatively short, seldom exceeding an hour.

To the west of the mouth of the Mississippi the double tides reappear. At Isle Dernière they are distinct, though a little irregular for three or four days near the time of the moon's zero declination. At all other times the single day type prevails, the double tides modifying it, however, in the shape of a long stand of from six to ten hours at high water. This stand is shortest at the time of the moon's greatest declination, sometimes being reduced to but one hour. At Calcasieu the tides are distinctly double, but with a large daily inequality. The rise and fall being small, they would often present to the ordinary observer the same appearance as at Isle Dernière. At Galveston the double tides are plainly perceptible, though small, for five or six days at the time of moon's zero declination. At other times they present the single day type, with the peculiarity that, after standing at high water for a short time, the water falls a small distance, and stands again at that height for several hours, then continues to fall to low water. Sometimes it falls very slowly for nine or ten hours following high water, and then acquires a more rapid rate to low water. At Aransas Pass and Brazos Santiago the single day tides prevail. Small, irregular, double tides are only perceived for two or three days at the moon's zero declination. At all other times there is but one high water in the day, with a long stand of from six to nine hours, during which there are often small, irregular fluctuations or a very slow fall. In the following table the mean rise and fall of tides at the above stations are given.

The highest high and the lowest low waters occur when the greatest declination of the moon happens at full or change; the least tide when the moon's declination is nothing at the first or last quarter. The rise and fall being so small, the times and heights are both much influenced by the winds, and are thus rendered quite irregular.

TABLE X.

Rise and fall at several stations on the Gulf of Mexico.

Stations.	Mean rise and fall of tides.		
	Mean.	At moon's greatest declination.	At moon's least declination.
	Feet.	*Feet.*	*Feet.*
St. George's island, Florida	1.1	1.8	0.6
Pensacola, Florida	1.0	1.5	0.4
Fort Morgan, Mobile bay, Alabama	1.0	1.5	0.4
Cat island, Mississippi	1.3	1.9	0.6
Southwest Pass, Louisiana	1.1	1.4	0.5
Isle Dernière, Louisiana	1.4	2.2	0.7
Entrance to Lake Calcasieu, Louisiana	1.9	2.4	1.7
Galveston, Texas	1.1	1.6	0.8
Aransas Pass, Texas	1.1	1.8	0.6
Brazos Santiago, Texas	0.9	1.2	0.5

TO DETERMINE THE RISE AND FALL OF THE TIDES FOR ANY GIVEN TIME FROM HIGH OR LOW WATER.

It is sometimes desirable to know how far the tide will rise in a given time from low water, or fall in a given time from high water, or to approximate to the time which has elapsed from low or high water, by knowing the rise and fall of the tide in the interval. If the proportion of the rise and fall in a given time were the same in the different ports, this would easily be shown in a single table, giving the proportional rise and fall, which, by referring to Table I, showing the rise and fall of the tide at the port, would give the rise and fall in feet and decimals. The proportion, however, is not the same in different ports, nor in the same ports for tides of different heights. The following Table XI shows the relation between the heights above low water for each half hour for New York and Old Point Comfort, and for spring and neap tides at each place. Units express the total rise of high water above low water, and the figures opposite to each half hour devote the proportional fall of the tide from high water onward to low water. For example, at New York, three hours after high water, a spring tide has fallen six-tenths (sixty hundredths) of the whole fall. Suppose the whole rise and fall of that day to be 5.4 feet, (Table I;) then, three hours after high water, the tide will have fallen 3.24 feet, or three feet three inches, nearly. Conversely, if we have observed that a spring tide has fallen three feet three inches, we may know that high water has passed about three hours.

TABLE XI.

Giving the height of the tide above low water for every half hour before or after high water, the total range being taken as equal to 1.

Time before or after high water.	New York.		Old Point Comfort.	
	Spring tide.	Neap tide.	Spring tide.	Neap tide.
h. m.				
0 0	1.00	1.00	1.00	1.00
0 30	0.98	0.98	0.98	0.98
1 0	0.94	0.93	0.95	0.94
1 30	0.89	0.86	0.88	0.87
2 0	0.80	0.72	0.80	0.78
2 30	0.72	0.59	0.70	0.68
3 0	0.60	0.45	0.59	0.57
3 30	0.49	0.31	0.49	0.44
4 0	0.39	0.19	0.37	0.34
4 30	0.28	0.10	0.26	0.22
5 0	0.18	0.02	0.17	0.13
5 30	0.09	0.00	0.08	0.05
6 0	0.05	----------	0.03	0.01
6 30	0.00	----------	0.00	0.00

TIDES IN COASTING.

By observing the time of high water and low water along the coast we find the places at which they are the same. The map of co-tidal lines (Sketch No. 65, C. S. Rep., 1857) shows that it is high water nearly at the same hour all along the coast from Sandy Hook to Cape Cañaveral; of course not in bays and harbors and up the rivers, but on the outer coast.

It is high water exactly at the same hour all along the line marked XII, seen on the chart, near Sandy Hook, and north and south of Hatteras, and, with small interruptions at Cape Lookout and Cape Fear, all the way to near Cape Cañaveral. This same line extends eastward to near Block island, and south of Nantucket, and then passes away from our coast. At full and change of the moon, along this line, (approximately,) it is high water at twelve o'clock, Greenwich time, the local time of high water depending upon the longitude of the place; or, to speak more correctly, in the average of a lunar month it is high water so many hours after the time of the moon's passing the meridian of Greenwich. By these lines, called co-tidal lines, we can determine what tidal currents the navigators must expect to meet in coasting; and for this purpose we divide the ports of the coast into two sets, those south and those north of New York.

The sailing lines of coasters, bound to southern ports this side of the straits of Florida, are marked upon the map, and also of those bound through the sounds to eastern ports, and outside to Halifax and European ports.

VESSELS TO AND FROM PORTS SOUTH OF NEW YORK.

South of Sandy Hook, New Jersey, the line of XII hours is nowhere more than 18 miles from the coast; that of XI$\frac{3}{4}$ nowhere more than 35 miles; that of XI$\frac{1}{2}$ nowhere more than 48; and XI nowhere more than 110. The distance of these lines of XII to XI hours, (corresponding within four minutes to VII and VI of New York time,) for different parts of the coast, is shown from Table A, where the first column gives the name of the place, and the second, third, fourth, fifth, respectively, the distances of the co-tidal lines of XII, XI$\frac{3}{4}$, XI$\frac{1}{2}$, and XI hours. The distances are measured from the ports on perpendiculars to the co-tidal lines. They may be taken as if measured on the parallel of latitude at all the points for the line of XII hours, and at all between Sandy Hook and Cape Hatteras for the lines of XI$\frac{3}{4}$ and XI$\frac{1}{2}$ hours.

A.

Names of locations.	Distance from coast, measured on perpendicular to co-tidal lines.			
	At XII hours.	At XI$\frac{3}{4}$ hours.	At XI$\frac{1}{2}$ hours.	At XI hours.
	Nautical miles.	*Nautical miles.*	*Nautical miles.*	*Nautical miles.*
Sandy Hook	12	32	53	100
Barnegat	2	29	39	78
Cape May	15	30	46	92
Cape Henlopen	18	33	47	92
Assateague	7	22	36	82
Cape Henry	12	28	43	100
Cape Hatteras	----------	8	20	63
Ocracoke inlet	----------	11	26	71
Cape Lookout	----------	7	18	56
Beaufort entrance, North Carolina	6	15	24	63
Cape Fear	----------	6	16	55
Cape Roman	----------	10	21	67
Charleston light	3	15	27	70
Port Royal entrance	5	17	29	78
Tybee entrance	6	17	31	82
St. Mary's entrance	12	25	40	110
St. John's entrance	17	35	48	----------
Cape Cañaveral	16	----------	----------	----------
Cape Florida	----------	----------	----------	----------

The co-tidal lines are in such directions that at 10, 20, and 30 miles from the coast, between Sandy Hook and the St. John's, there is but a variation of seven minutes, and even to Cape Cañaveral only of eight minutes.

Keeping ten miles from the shore the coaster would pass from 12 hours at Sandy Hook to 11 hours 45 minutes at Hatteras, and increase again irregularly to 12 hours 7 minutes at the St. John's, as shown more explicitly in table B. These three tracks of 10, 20, and 30 miles are inside of the cold wall of the Gulf Stream, and generally in the cold current, except at Cape Cañaveral.

B.

Names of stations.	Co-tidal hour at 10, 20, and 30 nautical miles from the coast, perpendicular to the coast		
	Ten miles off.	Twenty miles off.	Thirty miles off.
	h. m.	*h. m.*	*h m*
Sandy Hook	12 0	11 52	11 45
Barnegat	11 52	11 44	11 35
Cape May	12 5	11 53	11 45
Cape Henlopen	12 7	11 57	11 48
Assateague	12 0	11 48	11 37
Cape Henry	12 5	11 48	11 42
Cape Hatteras	11 45	11 30	11 22
Ocracoke inlet	11 47	11 36	11 25
Cape Lookout	11 45	11 30	11 20
Beaufort entrance, N. C	11 55	11 38	11 25
Cape Fear	11 38	11 25	11 18
Cape Roman	11 45	11 33	11 24
Charleston light	11 52	11 38	11 25
Port Royal entrance	11 57	11 45	11 32
Tybee entrance	11 55	11 43	11 30
St. Mary's entrance	12 8	11 57	11 47
St. John's entrance	12 7	11 57	11 50
Cape Cañaveral	12 8	----------	----------
Cape Florida	13 10	----------	----------

It follows, then, as a general thing, from these two tables that the coaster, in passing from Sandy Hook to the St. John's would have the tides the same, within some fifteen minutes, as if he remained at Sandy Hook; so that leaving, for example, at high water, he would, according to the elapsed time, have the ebb and flood alternating every six hours and a quarter, nearly, as if he had remained near Sandy Hook. As the flood tide sets in generally to the northward and on shore, and the ebb to the southward and off shore, he would know by the time that elapsed from his departure and the period of the tide at which he started what tidal currents he might expect to meet as he passed along the coast. This, of course, is not peculiar to Sandy Hook as a point of departure, but would be true for any of the entrances given in the table, taking care not to mistake the time of tides within for that at the entrance.

By referring to George W. Blunt, esq., I have obtained the tracks of sailing and steam vessels passing from New York to ports to the south of it, as shown by the lines on the chart accompanying this paper. (See Sketch No. 65, C. S. Rep., 1857.) Tracing these on the map of co-tidal lines, I have determined how the navigator would find the tides as he passes from

port to port. The results are shown in the annexed table, (C,) in which the port between which and Sandy Hook the mariner passes is at the head of the table, and, at the side, the place off which the co-tidal hours will be found, as stated in the table.

C.

Off—	Co-tidal hours on sailing lines measured on parallels of latitude of places named in the first column, between New York and—							
	Delaware bay.	Chesapeake bay.	Ocracoke inlet.	Cape Fear.	Charleston.	Savannah.	St. John's.	Cape Florida.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
Sandy Hook	12 5	12 5	12 5	12 5	12 5	12 5	12 5	12 5
Barnegat	11 57	11 57	11 57	11 57	11 57	11 57	11 57	11 57
Cape May	12 10	11 52	11 45	11 45	11 45	11 45	11 45	11 45
Cape Henlopen	.....	11 51	11 43	11 43	11 43	11 43	11 43	11 43
Assateague	.....	11 55	11 33	11 33	11 33	11 33	11 33	11 33
Cape Henry	.....	12 13	11 24	11 24	11 24	11 24	11 24	11 24
Cape Hatteras	.....	.....	11 48	11 48	11 48	11 48	11 48	11 48
Ocracoke inlet	.....	.....	.....	11 42	11 42	11 42	11 42	11 42
Cape Lookout	.....	.....	.....	11 39	11 39	11 39	11 32	11 24
Beaufort entrance	.....	.....	.....	11 39	11 39	11 39	11 32	11 24
Cape Fear	.....	.....	.....	.....	11 36	11 36	11 24	11 0
Cape Roman	.....	.....	.....	.....	11 46	11 46	11 19	.....
Charleston light	.....	.....	.....	.....	.....	11 52	11 18	.....
Port Royal entrance	.....	.....	.....	.....	.....	12 3	11 18	.....
Tybee entrance	.....	.....	.....	.....	.....	.....	11 16	.....
St. Mary's entrance	.....	.....	.....	.....	.....	.....	11 55	.....
St. John's entrance	.....	.....	.....	.....	.....	.....	12 10	.....
Cape Cañaveral	.....	.....	.....	.....	.....	.....	.....	.....
Cape Florida	.....	.....	.....	.....	.....	.....	.....	.....

Thus, from Sandy Hook to Delaware bay, starting with 12 hours 5 minutes, off Barnegat there would be, at the same instant, 11 hours 57 minutes, and off Cape May 12 hours 10 minutes, so that the navigator would have the same succession of tides whether he remained at Sandy Hook or passed onward to Delaware bay, or whether he came from Delaware bay to Sandy Hook. So from Sandy Hook to Charleston he will find, at the same instant, 12 hours 5 minutes at Sandy Hook, 11 hours 57 minutes off Barnegat, 11 hours 45 minutes off Cape May, and so onward upon the parallels of latitude for the several points. *For all practical purposes, then, of coasting, the succession of the tides, and, of course, of the tidal currents of flood and ebb will be the same as if the navigator remained stationary.* Leaving at low water he will meet the flood for 6 hours 15 minutes, and then the ebb for another 6 hours 15 minutes, and so on. It is the simplest of all rules that has thus come out of this investigation. That remarkable change of the temperature between the waters of the in-shore cold current and the warm waters of the Gulf Stream occurring in so short a distance that Lieutenant Bache called it the "cold wall," takes place at distances off the coast of from 170 to 29 miles, (see Table D,) between Sandy Hook and Cape Cañaveral, measured, from the several points named in the table, at right angles to the direction of the course, or measured along the parallels of latitude of the points, at distances from 195 to 28 miles, between Assateague and Cape Cañaveral, (Table D.) The points where the parallels north of Assateague meet this division line have not been accurately determined.

The annexed table shows these distances measured at right angles and on the parallels.

D.

Distance from coast to "cold wall" of Gulf Stream, off—	Measured at right angles to coast.	Measured on parallel of latitude.
	Naut. miles.	*Naut. miles.*
Sandy Hook	170	----------
Barnegat	135	----------
Cape May	137	----------
Cape Henlopen	137	----------
Assateague	95	195
Cape Henry	92	107
Cape Hatteras	30	31
Ocracoke inlet	53	52
Cape Lookout	53	65
Beaufort entrance	62	----------
Cape Fear	54	97
Cape Roman	57	103
Charleston light	61	95
Port Royal entrance	79	97
Tybee entrance	79	95
St. Mary's	90	87
St. John's	85	82
Cape Cañeveral	29	28
Cape Florida	----------	----------

The coasting line of thirty miles keeps inside of the cold wall all the way to Cañaveral, and all the routes traced on the chart from Sandy Hook to southern ports are on the inside of it. The Gulf Stream lines, as drawn on the chart, show how the route to Bermuda and to the Bahamas cuts the alternate bands of warm and cold water of the Gulf Stream.

Vessels to and from ports east of New York.

The plate shows the sailing lines of vessels bound from New York to eastern ports and to Halifax, outside. The annexed table (E) gives the Greenwich time of high water off the several points named in the first column on the routes to and from the places named in the heading of the table. The distances are measured at right angles to the co-tidal curves.

E.

Off—	Co-tidal hours on sailing lines between New York and—						
	Newport.	New Bedford	Nantucket.	Boston.	Portsmouth.	Portland.	Halifax.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
Sandy Hook	----------	----------	----------	----------	----------	----------	12 5
Throg's Point	16 16	16 16	16 16	16 16	16 16	16 16	----------
Fisher's island	13 48	13 48	13 48	13 48	13 48	13 48	----------
Block island	12 16	12 16	12 16	12 16	12 16	12 16	11 30
Monomoy	----------	----------	----------	16 10	16 10	16 10	----------
Cape Cod	----------	----------	----------	14 35	14 35	14 35	12 15
Cape Ann	----------	----------	----------	----------	15 00	14 40	----------
Portland	----------	----------	----------	----------	----------	15 30	----------

In passing from New York to an eastern port the first great change in the tides and tidal currents is between the East river and Long Island sound; the difference between Governor's island and Negro point, on Ward's island, at the eastern entrance to Hell Gate, is two hours and forty-five minutes. Between this point and Throg's Point the change is small. The mariner is now in the full tide of the sound, and between Throg's Point and Fisher's island there is a difference of time of but two hours and twenty minutes, the greatest part of which is at the head of the sound and at its entrance, that is, near Throg's Point and Fisher's island. From off New London to off Sand's Point the difference is but one hour and forty minutes, so that if the mariner, instead of remaining at Throg's Point, passes onward to Fisher's island he would lose but half a tide in the whole passage. In other words, he would have the same succession of rise and fall, according to the time elapsed, whether stationary or passing onward, within two hours and a half, or less than half a tide.

The tidal current lines show that even a less allowance is to be made for the change of current than for the change of tide; the difference in the change of current between Throg's Point and Fisher's island, along the middle of the sound, being of no practicable importance. Passing out of Long Island sound the tidal hours grow earlier, until off Block island that of Sandy Hook is again reached. The co-tidal line of Sandy Hook and Block island being the same, it is the struggle of the same tide through New York bay and the narrow East river, and obstructed Hell Gate, and through Fisher's island and Long Island sound, and to Throg's Point. The tidal currents meet near Throg's Point.

The lower part of Narragansett bay has the co-tidal hour 12 hours, nearly. Buzzard's bay has nearly the same co-tidal hour, the tide wave reaching the shore at nearly the same time all around the bay.

It would be impossible to give in a small compass a minute account of the tides of Martha's Vineyard and Nantucket sound. In general it may be said that as far as Holmes's Hole and Wood's Hole they resemble those of Block island sound, and afterwards those of Monomoy, at the eastern entrance; but this generalization is unsatisfactory without more details than there is space here to give. In these sounds take place the remarkable change of between three and four hours, the greatest change of our coast, dislocating, as it were, the times of high water at places south and west and east and north of Nantucket. The whole of this change takes place between the eastern entrance of Nantucket sound and the western of Martha's Vineyard, giving rise to quite a complex condition of both tides and currents, which it has occupied much time to unravel. The dominant co-tidal line of our coast, from Block island to Cape Cañaveral, is that of 12 hours of Greenwich time; that of our eastern coast, from Nantucket to Passamaquoddy, is, in general, 15 hours. Passing out of Nantucket sound coasters carry nearly the same co-tidal hour to Cape Cod, and thence vary their time about half an hour in passing to Boston, to Portsmouth, to Portland, or to Passamaquoddy. It has long been known that the tidal almanac for Boston might practically be used for eastern ports. Vessels from New York to Halifax, and New York to Europe, which keep outside, and should keep well off the Nantucket shoals, and off George's, as shown by the track on the chart, vary their co-tidal hour but little, keeping between the lines of 12 and 11½ until quite well on their course, and beyond Cape Sable. The same rule will apply to their case as has been given for vessels between New York and a southern port.