Table 8 Constituents of tide in the Upper Gulf of Thailand

Symbol	ω	H/K (cm./deg.)							
		Phompachun	Si Chang	Ao Sattahip	Bangpaklong	Mae Klong	Bangkok Bar	Thachin	Hua Hin
S_a	0.04107	17/268	18/300	19/279	16/282	23/285	15/304	15/292	22/287
S_{sa}	0.08214	1/21	4/344	4/129	3/82	6/79	5/21	1/11	7/69
M_m	0.54437	3/40	0.8/234	3/98	2/67	3/94	1/283	3/91	2/357
M_{sf}	1.01590	1/70	2/255	0.8/342	3/79	3/83	0.7/258	3/98	0.4/138
M_f	1.09803	0.5/58	1/29	1/90	1/152	0.8/126	1/17	3/159	0.8/42
Q_1	13.39866	4/51	7/99	7/93	7/104	6/105	8/102	7/101	7/99
O_1	13.94304	6/17	42/115	39/112	39/121	38/121	43/117	39/119	39/116
M_1	14.49669	1/196	1/183	1/207	1/237	1/252	1/184	0.7/219	1/192
P_1	14.95893	18/165	19/161	17/158	17/164	17/162	20/166	17/163	19/158
S_1	15.00000	2/104	0.4/7	1/91	2/101	2/100	1/78	1/90	0.9/32
K_1	15.04107	65/166	65/161	58/159	61/169	60/169	68/164	62/165	61/162
OO_1	16.13910	3/218	3/205	2/201	2/213	3/209	3/211	3/196	4/212
$2N_2$	27.89536	4/95	3/95	1/258	4/172	4/181	3/103	1/251	1/65
M_2	27.96821	2/207	1/154	0.7/174	2/228	2/212	1/164	2/201	0.9/183
N_2	28.43973	7/117	9/108	4/105	6/119	6/123	10/116	8/121	5/103
N_2	28.51258	2/109	1/94	0.9/101	1/97	1/80	1/110	1/148	1/91
M_2	28.98410	54/143	50/130	26/121	52/149	52/149	56/137	54/146	35/135
Λ_2	29.45563	2/154	2/138	1/140	2/156	2/146	2/134	2/160	1/181
L_2	29.52848	5/132	4/126	1/124	7/137	6/137	6/128	6/161	3/159
T_2	29.95893	2/141	1/138	0.4/133	1/159	2/143	1/142	1/118	1/151
S_2	30.00000	27/206	24/194	12/183	27/213	26/214	27/201	26/210	15/202
K_2	30.08214	11/184	8/180	4/166	11/188	10/185	10/186	12/185	7/187
M_3	43.47616	0.6/277	0.3/111	0.2/123	1/288	1/259	0.4/116	0.7/256	0.2/27
M_4	57.96821	2/189	0.4/132	0.4/327	2/210	3/210	0.8/158	2/213	0.2/333
M_6	86.95232	0.4/200	0.1/159	0.0/95	0.4/234	0.3/217	0.1/225	0.3/203	0.1/60

The 25 computed tidal constituents were shown in Table 8. The amplitude of K_1 was biggest followed by M_2 O_1 and S_2, respectively. Amplitude of M_2 was about 26-56 cm and phase lag was about 121°-149°. Amplitude of S_2 was about 12-27 cm and phase lag was about 183°-214°. Amplitude of K_1 was about 58-68 cm and phase lag was about 159°-164°. Amplitude of O_1 was about 6-43 cm and phase lag was about 17°-221°. According to the co-tidal lines of K_1, M_2, O_1 and S_2 they suggested that flood tide would start in the eastern part of the Gulf at Ao Sattahip. The end of flood tide was at the north-west of the Gulf at Maeklong river mouth as shown in the patterns of co-tidal lines.

The patterns of co-tidal lines agreed well with Yanagi and Takao (1998) who calculated tidal constituents in case of a constant depth of 40 m for the whole gulf and in the absence of the Coriolis force. They showed that the amplidromic point of M_2 tide has co-tidal lines turning counterclockwise. Oonpan (2003) confirmed that the four major harmonic constituents in the Gulf were K_1, M_2, O_1 and S_2. Sea levels were rising from the western part of the Gulf to the eastern part when forcing by M_2 and S_2. While sea levels were rising from the eastern part to the western part when forcing by K_1 and O_1.

3. Hydrodynamic model

POM was developed based on mass conservation and momentum conservation equations. In the Upper Gulf of Thailand, the main influent forces which effected water circulation were tide. In this study, wind effects were negligible since the wind vibrated and fluctuated all the time. TSS concentration which sources and sinks in the water mass was not effected by wind for the short period of runoff. Ninety percent potential of water circulation and TSS dispersion depends upon the tide. Averaged seawater depth, friction and viscosity of seawater were introduced into the model. The initial conditions, boundary condition and stability technical were considered. Finite difference method was used to simulate the hydrodynamic model. Four basic assumptions were used in this study:

1) Water was incompressible.
2) Vertical velocity and acceleration were negligible.
3) Wind stress effects were negligible.
4) Average values were sufficient to describe the properties.

The hydrodynamic models consisted of two nested grids. The area of large grid model covered the from U.T.M. 1400000-1500000 N and U.T.M. 600000-

710000 E. Number of grid was 65x55 with mesh size as 1.86 km. It was surrounded by land in the eastern, northern and western sides and was open to the Gulf of Thailand via the southern border. In northern part, there were 4 main rivers (Mae Klong River, Tha Chin River, Chao Phraya River and Bang Pakong River). It had an area of 100x100 km^2 with the maximum depth of 40 m near Ko Khram.

The small grid model was part of the large grid model. The model covered Ao Si Racha (U.T.M. 1440000-1470000 N and U.T.M. 685000-710000 E). Ao Si Racha, Chon-Buri Province is a small semi-open Gulf. The coast in the eastern part composes of mud flat, sandy beach and rocky shore. The western border of the model was the Upper Gulf of Thailand. The northern border was Laem Samuk and the southern border was Laem Chabang industrial estate. Averaged depth was about 15-20 m and the maximum depth was about 29 m in the southern part. The number of grid was 26x34 with the mesh size as 0.93 km.

Water level at the boundary points were estimated by Eq.(6). The parameters and condition for tidal current simulation and tidal level for large and small grid models were shown in Table 2.

3.1 Model verification

Comparisons of computed value with actual observation ones were necessary for checking the results of the model. The checking points for tidal current were Ao Si Racha, Ko Phai and the Chao Phraya River mouth and for checking the tidal level was at Ao Si Racha

The recorded velocities by mooring current meter at 1458500 N and 707000 E in October 2004, May-June 2005 and August 2005 were used for model calibration. The variation of tidal current showed that the velocity was mainly affected by tide. The direction during flood tide was northward (15°-40°) and during ebb tide was southward (190°-200°) which were parallel with coast. The maximum velocity in the north-south direction was about 0.8 m/sec and about 0.2 m/sec in east-west direction. The period of tidal current according to tide was about 12 hours 25 minutes.

Field surveys by Hydrographic department (1995, 1996a, 1996b), in the Upper Gulf of Thailand at the depth of 3 m, the observed velocity of seawater in the Gulf could be presented in Table 9.

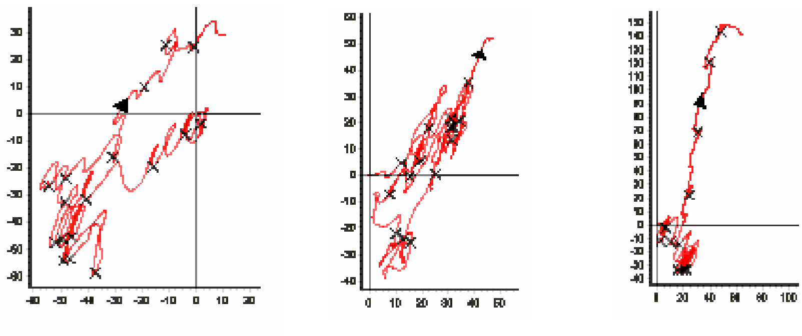
Table 9 The observed velocity in the Upper Gulf of Thailand during 1995-1996 by the Royal Thai Navy

Date	Position	Period	Speed(m/sec)	Direction
10th September	700580E	Flood tide	0.35	20
1995	1447084N	Ebb tide	0.57	185
20th January	605010E	Flood tide	0.25	350
1996	1389408N	Ebb tide	0.40	160
24th January	708422E	Flood tide	0.35	325
1996	1364158N	Ebb tide	0.46	120
26th January	673755E	Flood tide	0.42	10
1996	1400806N	Ebb tide	0.46	160
12th May 1996	704600E	Flood tide	0.4	300
	1391791N	Ebb tide	0.38	140

Chokechalermwat (1990) presented that current in the Upper Gulf of Thailand flowed mainly in the north-south direction except at the edge of the Gulf where the flow direction ended to be parallel to the shoreline with small elliptical circulation. The maximum and averaged velocities in the Gulf were in the order of 0.2-0.8 m/s and 0.06-0.23 m/sec, respectively. Besides the minimum velocity area was found to be at the south of Bangkok Bar and the maximum velocity area was at the mouth of the Gulf near Sattahip.

The progressive vector plots showed that during the first eruise seemed to be in south-west propagration. But for the rest, the direction of the flow were in north-east direction as shown in the Figure 13. According to these, distribution diagram of mean velocity could be ploted in polar coordinate as shown in Figure 14. Main flow direction of seawater in the Gulf is in north-south direction.

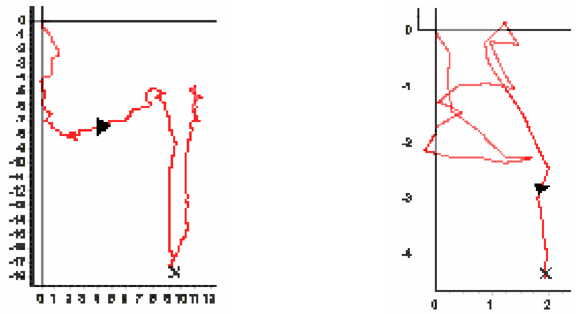
In Ao Si Racha, the tidal current direction during flood tide was north-east and during ebb tide was south-west.



October 2004
at Ao Si Racha

May-Jun2005
at Ao Si Racha

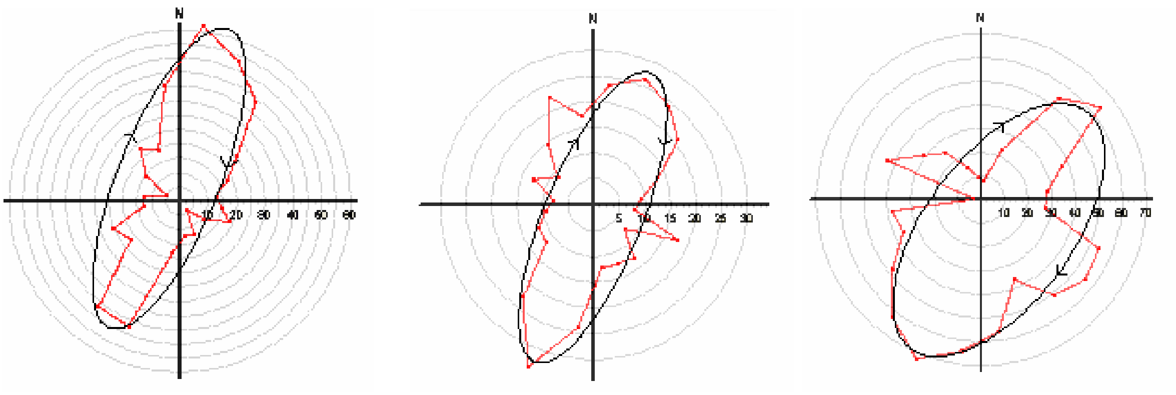
August 2005
at Ao Si Racha



27th January 2005
near Ko Phai

28th January 2005
at Chao Phraya River mouth

Figure 13 Progressive vector plots (km) in the Upper Gulf of Thailand



October 2004 May – Jun 2005 Aug2005

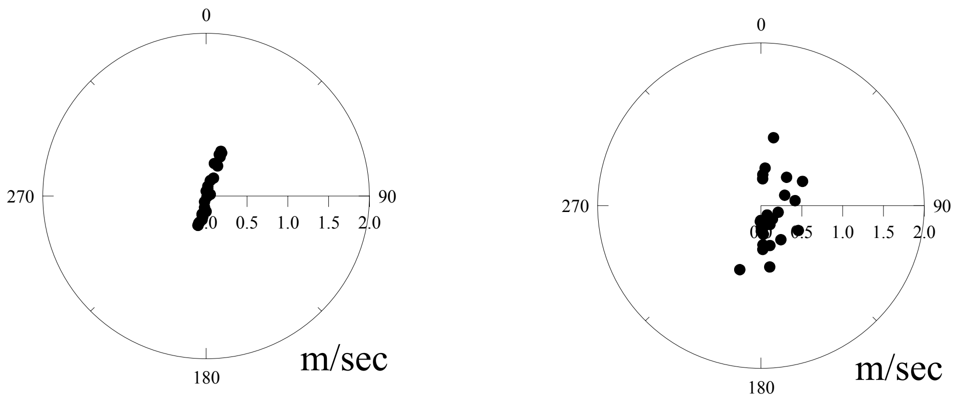
Figure 14 Distribution diagram of mean velocity (cm/sec) per 15 degree sector in Ao Si Racha

This study, POM was simulated for study the tidal current in the Upper Gulf of Thailand. The boundary condition was only tide at southern part by using tidal constituents of Hydrographic Department (2004, 2005) at Hua-Hin and Ao Sattahip. Seawater level between Hua-Hin and Ao Sattahip was interpolated by linear relation and was used as boundary condition of POM.

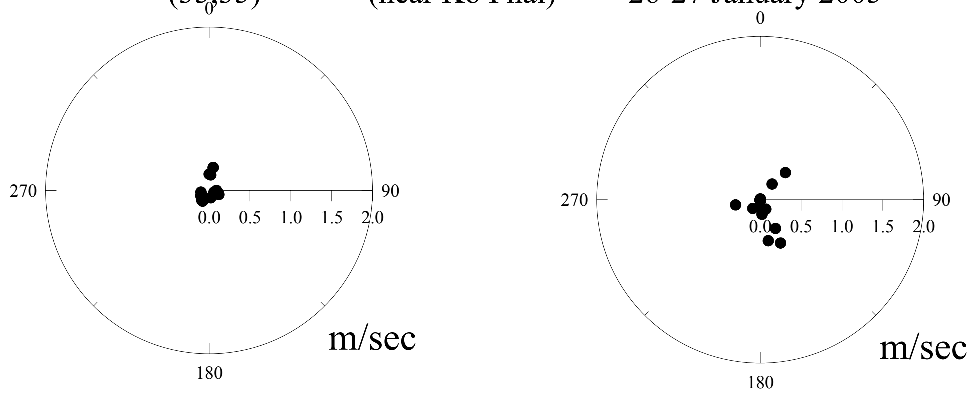
The model was calibrated and verified by comparing the computed results with the current speed and direction of measured data at certain location in the model area for each grid type. The comparatives of tidal current which was computed by POM with recorded data were showed in Figure 15-16. It showed that during flood tide, pattern of flow was northward flow. On the other hand, during ebb tide pattern of flow was southward flow. The predicted velocities which could be plotted in polar coordinate were reliable.

The magnitude of computed velocities was 30 % smaller than recorded data. The reason might be that the external force should be introduced such as stress wind, variation of friction and viscosity coefficient. The stability of model for convergence computation which related to grid size should be concerned. The fluctuation of the computed velocities which were affected by turbulence should be considered. The small grid size was a way to improve the accuracy of the model. On the same time, the suitable boundary condition would let the predicted data close to the nature phenomena.

The figures shown that the magnitude and direction of seawater movement near Ko Phai and Chao Phraya River mouth in Polar scatter plot, respectively. The comparative of the computed values by large grid model with observed value were quite good. The magnitude of computed velocities were smaller than the observed data shown in the figures. They showed that the observed velocity had the high flutuation of turbulance while the computed velocity did not. The magnitude of velocity near Ko Phai represented the off shore circulation and Chao Phraya river mouth represented coastal circulation.



(35,35) (near Ko Phai) 26-27 January 2005



(35,15) (Chao Phraya River mouth) 27-28 January 2005

From observation for 1 tide cycle near Ko Phai, flow pattern was in the north-south direction with the speed about 0.5-1.0 m/sec. And for Chao Phraya river mouth, the flow pattern was effected by coastal topography and type of seabed.

The small grid model was calibrated by using observed velocities which were recorded at Ao Si Racha. The results of the comparison of velocity direciton were quite close as shown in Figure 15. Due to the same reson as of large model, there were turbulence and flutuation in velocity. The magnitude of tidal circulation in Ao Si Racha during ebb and flood tide was about 0.5-1.5 m/sec with north-south direction. The magnitude of predicted values were still smaller that the obseved valued about 30%.

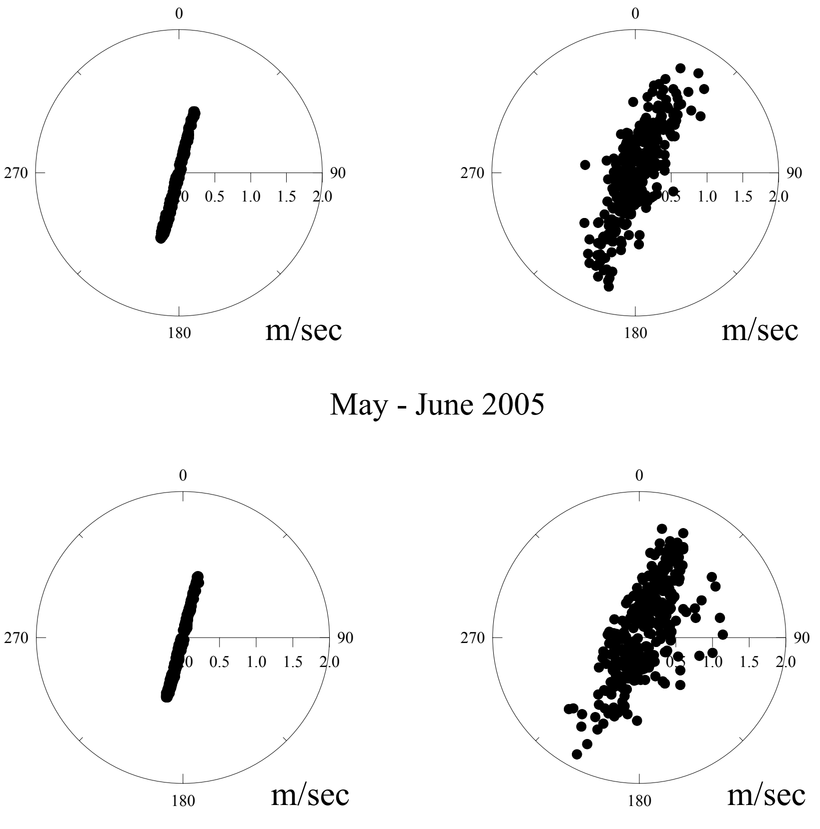
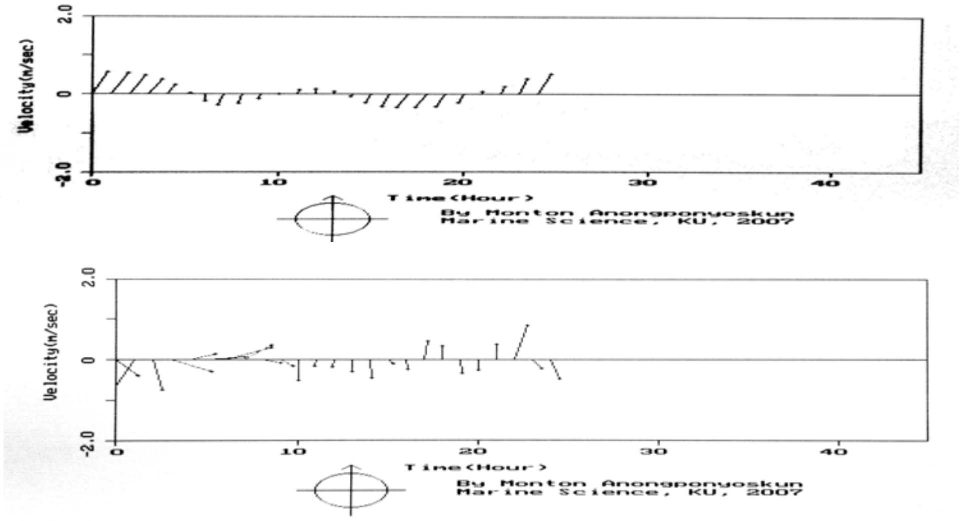
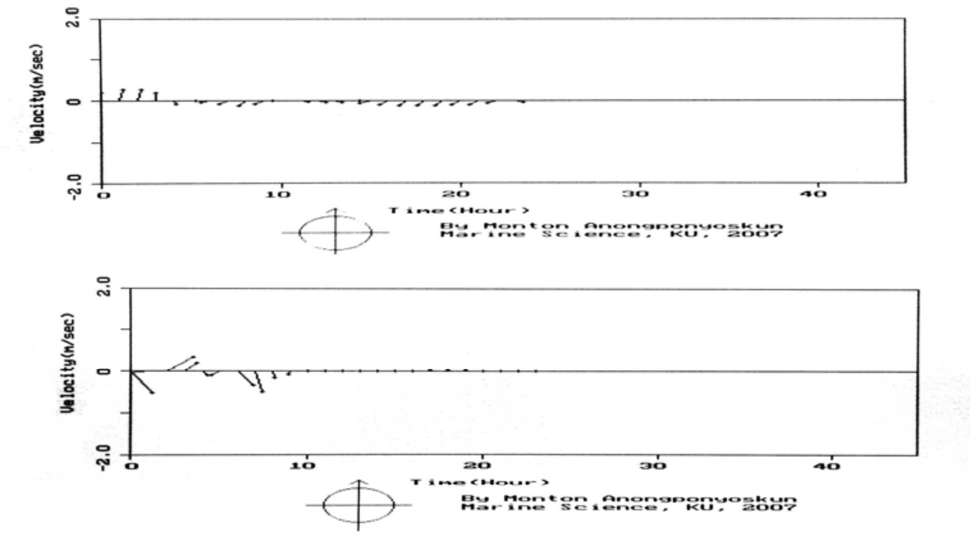


Figure 16 Comparison of polar scatter plot of predicted velocity at grid point 21,13 of small grid model with observed velocity at Ao Si Racha in May - June 2005 and August 2005, respectively



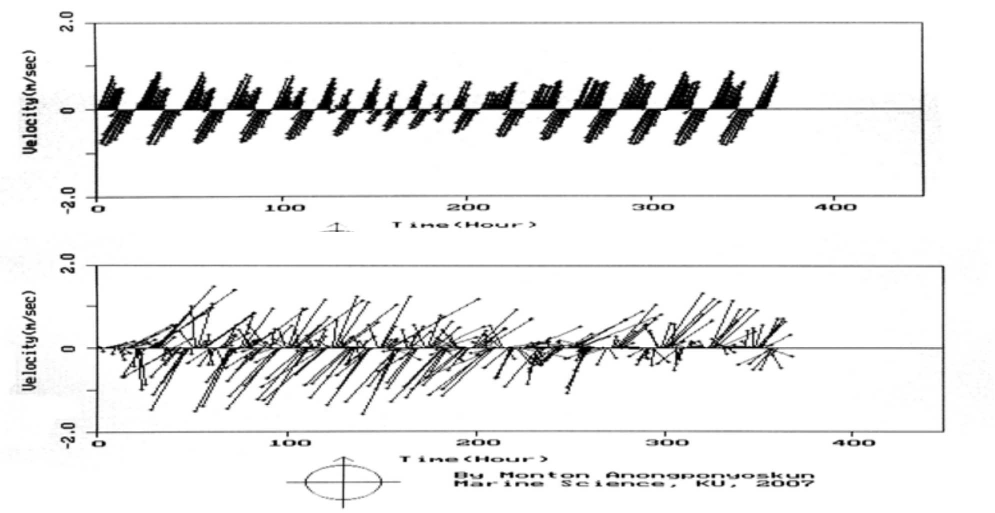
26th -27th January 2005 (near Ko Phai)



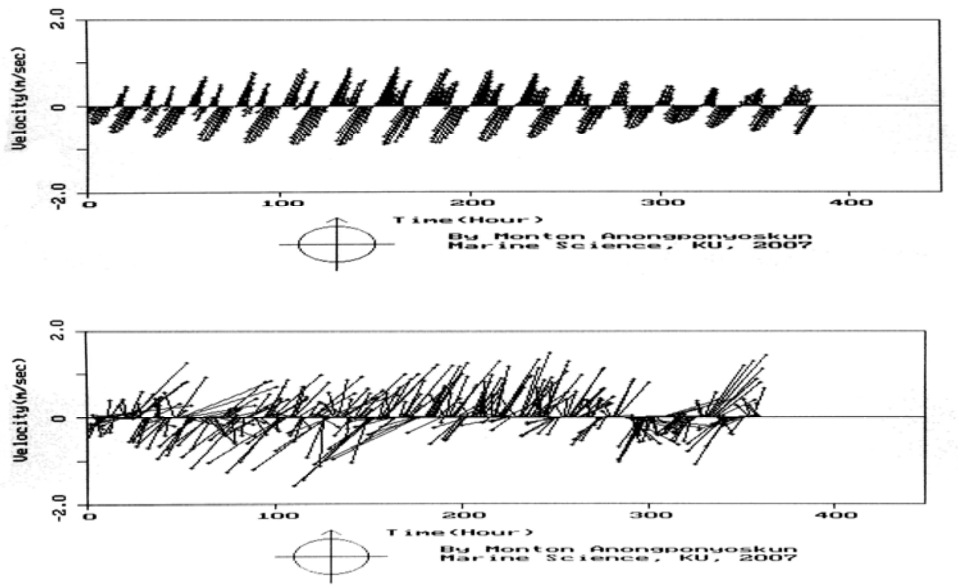
27th -28th January 2005 (Chao Phraya river mouth)

Figure 17 Comparison of predicted stick plots at grid point 35,35 and 35,15 of large grid model with observed velocity near Ko Phai and Chao Phraya river mouth on 26th -28th January 2005, respectively

The comparative of velocity for 1 tidal cycle near Ko Phai and Chao Phraya River mouth with the predicted velocity from the large grid model at grid point 35,35 and 35,15 on 26th -28th January 2005 were shown in Figure 17. The magnitude of observed and predicted velocity in east-west direction was quite small. The main velocity was in north-south direction. The computed and observed velocity had the nearly same period and magnitude. Figure 18 showed the comparative of 14-days observed and predicted velocity with stick plot in Ao Si Racha. The predicted velocity had period similar to the observed velocity.

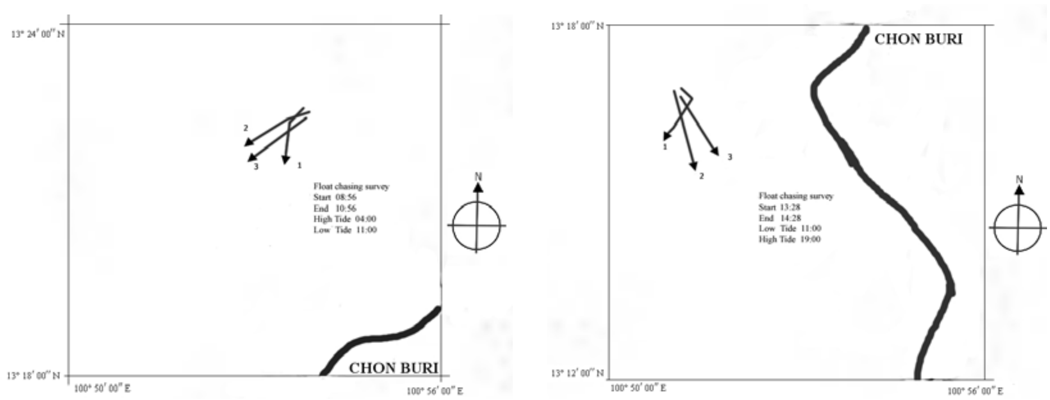


May 2005

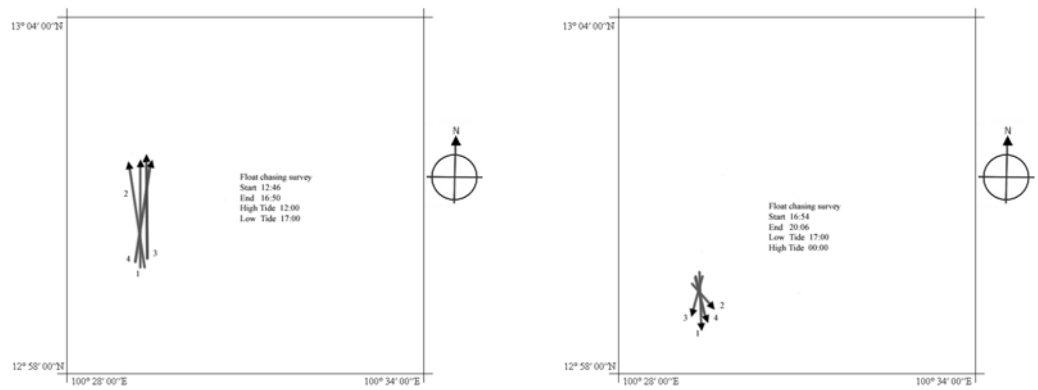


August 2005

The drogues were used for tracking pattern on 18th, 26th -28th January, 15th -16th March, and 19th -20th May 2005. The patterns of flow were similar to the predicted pattern of flow by the hydrodynamic model. During flood tide and ebb tide the direction of flow were northward and southward flow, respectively with 0.3-0.5 m/sec as shown in Figure 19. The magnitudes of velocity and distance were shown in the Table 10-17.



Ebb tide (on January 18th, 2005) Flood tide



Flood tide (on January 26th, 2005) Ebb tide

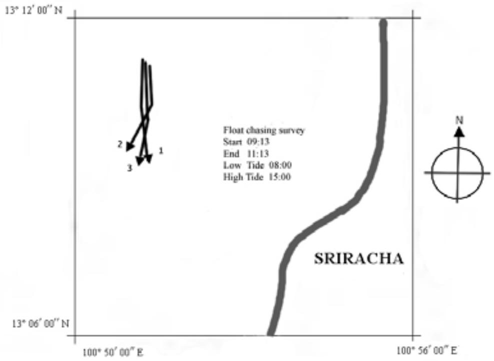
Figure 19 Map of drogue tracking

Flood tide (on January 27th, 2005) Ebb tide

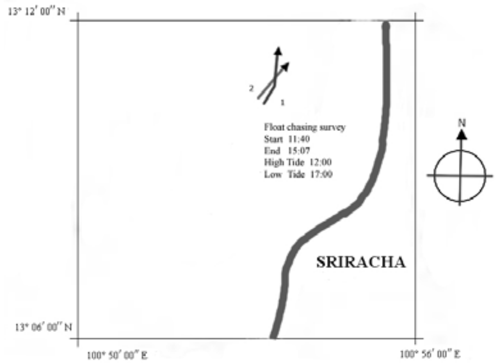
Flood tide (on January 28th, 2005) Ebb tide

Ebb tide (on March 15th, 2005)

Figure 19 (Continued)



Ebb tide (on March 16th, 2005)



Ebb tide (on May 19th, 2005) Flood tide

Flood tide (on May 20th, 2005) Ebb tide

Figure 19 (Continued)

Table 10 Position, distance and speed of buoys on January 18th, 2005

Float No.	Latitude	Longitude	Time	Distance (m)	Velocity (cm/s)
1	13° 22 12.96 N	100° 54′ 18.48 E	8:56		
	13° 22 13.38 N	100° 54′ 13.80 E	9:26	145	8
	13° 22 12.60 N	100° 54′ 11.28 E	9:56	81	4.5
	13° 22 07.38 N	100° 54′ 07.38 E	10:26	201	11.1
	13° 21 56.28 N	100° 54′ 03.42 E	10:56	363	20.2
2	13° 22 13.02 N	100° 54′ 18.58 E	8:57		
	13° 22 13.62 N	100° 54′ 15.42 E	9:27	69	3.8
	13° 22 12.78 N	100° 54′ 13.50 E	9:57	64	3.5
	13° 22 10.20 N	100° 54′ 10.02 E	10:27	133	7.4
	13° 22 06.90 N	100° 54′ 05.10 E	10:57	182	10.1
3	13° 22 13.02 N	100° 54′ 16.98 E	8:58		
	13° 22 13.20 N	100° 54′ 16.62 E	9:28	12	0.6
	13° 22 12.60 N	100° 54′ 14.58 E	9:58	65	3.6
	13° 22 10.02 N	100° 54′ 10.80 E	10:28	141	7.8
	13° 22 05.58 N	100° 54′ 05.58 E	10:58	211	11.7
4	13° 17′ 00.90 N	100° 50′ 56.22 E	13:28		
	13° 16′ 50.82 N	100° 51′ 05.52 E	13:58	423	23.5
	13° 16′ 42.48 N	100° 51′ 01.08 E	14:28	312	17.3
5	13° 16′ 58.08 N	100° 50′ 58.02 E	13:29		
	13° 16′ 49.80 N	100° 51′ 51.42 E	13:59	305	16.9
	13° 16′ 40.80 N	100° 51′ 11.22 E	14:31	367	19.1
6	13° 16′ 57.48 N	100° 50′ 57.42 E	13:30		
	13° 16′ 49.62 N	100° 51′ 03.12 E	14:00	299	16.6
	13° 16′ 39.60 N	100° 51′ 10.92 E	14:32	391	20.4

Table 11 Position, distance and speed of buoys on January 26th, 2005

Float No.	Latitude	Longitude	Time	Distance (m)	Velocity (cm/s)
1	13°00.618N	100°49.831E	13:56		
	13°01.073N	100°50.004E	14:49	894.45	28.1
	13°00.615N	100°49.837E	14:53		
	13°01.119N	100°49.999E	15:42	973.101	33
	13°00.587N	100°49.847E	15:53		
	13°01.022N	100°50.017E	16:50	858.118	25.1
	13°00.574N	100°49.802E	16:54		
	13°00.553N	100°49.957E	18:20	284.739	5.5
	13°00.659N	100°49.822E	18:49		
	13°00.317N	100°49.874E	19:25	636.357	29.5
	13°00.703N	100°49.831E	19:33		
	13°00.280N	100°49.879E	20:06	783.208	29.6
2	13°00.690N	100°49.949E	12:55		
	13°00.975N	100°50.019E	13:43	539.654	18.7
	13°00.625N	100°49.860E	13:57		
	13°01.089N	100°50.037E	14:48	912.512	29.8
	13°00.615N	100°49.868E	14:54		
	13°01.084N	100°50.027E	15:41	910.187	32.3
	13°00.612N	100°49.915E	15:55		
	13°01.041N	100°50.090E	16:48	851.194	26.8
	13°00.576N	100°49.830E	16:56		
	13°00.552N	100°50.014E	18:18	337.776	6.9
3	13°00.691N	100°49.829E	12:57		
	13°01.024N	100°50.016E	13:50	700.898	22
	13°00.636N	100°49.974E	14:07		
	13°01.087N	100°50.102E	14:46	861.92	36.8
	13°00.626N	100°49.904E	14:56		
	13°01.083N	100°50.070E	15:39	893.508	34.6
	13°00.603N	100°49.895E	15:54		
	13°01.031N	100°50.057E	16:49	840.903	25.5
	13°00.572N	100°49.875E	16:55		
	13°00.557N	100°50.015E	18:19	256.289	5.1
	13°00.664N	100°49.882E	18:50		
	13°00.309N	100°49.883E	19:26	653.203	30
	13°00.654N	100°49.915E	19:32		
	13°00.301N	100°49.879E	20:05	652.816	33
4	13°00.726N	100°49.854E	12:56		
	13°01.034N	100°50.031E	13:44	651.877	22.6
	13°00.636N	100°49.883E	13:58		
	13°01.083N	100°50.071E	14:47	890.812	30.3
	13°00.618N	100°49.890E	14:55		
	13°01.072N	100°50.050E	15:40	884.66	32.8
	13°00.622N	100°49.953E	15:56		
	13°01.046N	100°50.131E	16:47	844.749	27.6

Table 11 (Continued)

Float No.	Latitude	Longitude	Time	Distance (m)	Velocity (cm/s)
	13°00.574N	100°49.866E	16:57		
	13°00.554N	100°50.063E	18:17	360.421	7.5
	13°00.630N	100°49.822E	18:52		
	13°00.304N	100°49.878E	19:28	608.437	28.2
	13°00.708N	100°49.844E	19:34		
	13°00.327N	100°49.898E	20:07	707.895	35.8

Table 12 Position, distance and speed of buoys on January 27th, 2005

Float No.	Latitude	Longitude	Time	Distance (m)	Velocity (cm/s)
1	13°00.558N	100°49.833E	7:05		
	13°00.992N	100°49.897E	7:45	807.01	33.6
	13°00.577N	100°49.735E	7:52		
	13°00.692N	100°49.835E	9:20	279.101	5.3
2	13°00.588N	100°49.857E	7:07		
	13°00.979N	100°49.908E	7:46	725.404	31
	13°00.575N	100°49.754E	7:51		
	13°00.712N	100°49.862E	9:18	319.654	6.1
3	13°00.587N	100°49.877E	7:08		
	13°00.971N	100°49.903E	7:47	708.143	30.3
	13°00.576N	100°49.773E	7:50		
	13°00.712N	100°49.859E	9:19	295.161	5.5
4	13°33.391N	100°49.932E	12:35		
	13°33.704N	100°49.876E	14:19	584.868	9.4
	13°33.273N	100°50.026E	14:24		
	13°33.769N	100°50.014E	15:34	912.905	21.7
	13°33.267N	100°49.889E	15:38		
	13°33.761N	100°50.052E	16:36	956.151	27.5
	13°33.310N	100°49.933E	16:40		
	13°33.828N	100°49.999E	17:58	953.178	20.4
	13°34.182N	100°50.066E	18:39		
	13°34.183N	100°50.077E	19:03	20.1	1.4
	13°34.444N	100°49.921E	19:05		
	13°34.399N	100°50.049E	19:36	247.236	13.3
	13°34.629N	100°49.994E	19:38		
	13°34.497N	100°50.075E	20:08	284.12	15.8
	13°34.811N	100°49.875E	20:11		
	13°34.586N	100°49.920E	20:37	422.027	27.1
5	13°33.375N	100°49.958E	12:34		
	13°33.651N	100°49.935E	14:20	509.564	8
	13°33.234N	100°50.049E	14:23		
	13°33.756N	100°50.059E	15:32	960.651	23.2
	13°33.234N	100°49.951E	15:40		

Table 12 (Continued)

Float No.	Latitude	Longitude	Time	Distance (m)	Velocity (cm/s)
	13°33.757N	100°50.014E	16:35	969.125	29.4
	13°33.314N	100°49.946E	16:39		
	13°33.861N	100°50.049E	18:00	1023.79	21.1
6	13°33.401N	100°49.907E	12:36		
	13°33.887N	100°49.902E	14:18	894.286	14.6
	13°33.236N	100°50.013E	14:25		
	13°33.771N	100°50.018E	15:33	984.442	24.1
	13°33.248N	100°49.870E	15:39		
	13°33.770N	100°50.060E	16:34	1020.833	30.9
	13°33.302N	100°49.918E	16:41		
	13°33.847N	100°49.986E	17:53	1010.412	23.4
	13°34.178N	100°50.038E	18:38		
	13°34.183N	100°50.070E	19:01	58.964	4.3
	13°34.457N	100°49.921E	19:06		
	13°34.402N	100°50.060E	19:34	272.471	16.2
	13°34.636N	100°49.966E	19:39		
	13°34.543N	100°50.092E	20:07	286.131	17
	13°34.828N	100°49.886E	20:12		
	13°34.617N	100°49.928E	20:38	395.691	25.4
7	13°33.401N	100°49.979E	12:37		
	13°33.896N	100°49.883E	14:17	927.405	15.5
	13°33.251N	100°49.999E	14:26		
	13°33.759N	100°50.037E	15:35	937.274	22.6
	13°33.275N	100°50.013E	15:37		
	13°33.772N	100°50.086E	16:33	924.076	27.5
	13°33.292N	100°49.905E	16:42		
	13°33.839N	100°50.008E	17:59	1023.79	22.2
	13°34.164N	100°50.041E	18:37		
	13°34.187N	100°50.039E	18:59	42.474	3.2
	13°34.465N	100°49.919E	19:07		
	13°34.399N	100°50.040E	19:32	252.45	16.8
	13°34.652N	100°49.982E	19:40		
	13°34.562N	100°50.095E	20:06	264.048	16.9
	13°34.851N	100°49.897E	20:13		
	13°34.639N	100°49.932E	20:39	395.25	25.3

Table 13 Position, distance and speed of buoys on January 28th, 2005

Float No.	Latitude	Longitude	Time	Distance (m)	Velocity (cm/s)
1	13°33.164N	100°49.960E	6:38		
	13°33.630N	100°49.943E	7:13	857.997	40.1

Table 13 (Continued)

Float No.	Latitude	Longitude	Time	Distance (m)	Velocity (cm/s)
	13°33.153N	100°49.908E	7:19		
	13°33.750N	100°49.960E	8:32	1109.833	25.3
	13°33.359N	100°49.953E	8:36		
	13°33.411N	100°50.010E	10:11	141.123	2.5
	13°33.390N	100°49.970E	10:22		
	13°32.976N	100°50.245E	12:33	911.465	11.6
2	13°33.172N	100°49.991E	6:39		
	13°33.606N	100°49.989E	7:14	798.565	38
	13°33.156N	100°49.863E	7:18		
	13°33.789N	100°49.924E	8:31	1177.777	26.8
	13°33.365N	100°49.974E	8:37		
	13°33.402N	100°50.063E	10:13	175.706	3.1
	13°33.369N	100°49.941E	10:20		
	13°32.982N	100°50.277E	12:34	938.624	11.7
3	13°33.156N	100°49.927E	6:37		
	13°33.636N	100°49.937E	7:12	883.394	42.1
	13°33.145N	100°49.945E	7:20		
	13°33.778N	100°49.998E	8:33	1176.235	26.8
	13°33.353N	100°49.931E	8:35		
	13°33.432N	100°50.040E	10:12	245.935	4.2
	13°33.377N	100°49.946E	10:21		
	13°32.981N	100°50.226E	12:32	889.164	11.3

Table 14 Position, distance and speed of buoys on March 15th, 2005

Float No.	Latitude	Longitude	Time	Distance (m)	Velocity (cm/s)
1	13° 22′ 08.40 N	100° 54′ 46.80 E	8:30		
	13° 22′ 01.02 N	100° 54′ 46.44 E	9:00	250	13.9
	13° 21′ 50.22 N	100° 54′ 36.54 E	9:30	395	21.9
	13° 21′ 38.28 N	100° 54′ 27.96 E	10:00	453	25.2
	13° 20′ 20.16 N	100° 53′ 26.34 E	12:00	3071	42.6
2	13° 22′ 08.04 N	100° 54′ 47.52 E	8:30		
	13° 21′ 59.04 N	100° 54′ 43.56 E	9:00	303	16.8
	13° 21′ 48.24 N	100° 54′ 36.48 E	9:30	398	22.1
	13° 21′ 34.62 N	100° 54′ 28.44 E	10:00	488	27.1
	13° 20′ 12.24 N	100° 53′ 21.36 E	12:00	3279	45.5
3	13° 22′ 06.24 N	100° 54′ 47.64 E	8:30		
	13° 21′ 56.94 N	100° 54′ 42.84 E	9:00	323	17.9
	13° 21′ 46.14 N	100° 54′ 35.52 E	9:30	402	22.3
	13° 21′ 10.14 N	100° 54′ 27.06 E	10:00	1141	63.4
	13° 20′ 09.96 N	100° 53′ 19.74 E	12:00	2787	38.7

Table 15 Position, distance and speed of buoys on March 16th, 2005

Float No.	Latitude	Longitude	Time	Distance (m)	Velocity (cm/s)
1	13° 11′ 10.26 N	100° 51′ 31.02 E	9:11		
	13° 11′ 01.32 N	100° 51′ 29.64 E	9:43	279	15.5
	13° 10′ 49.98 N	100° 51′ 28.20 E	10:13	352	19.6
	13° 10′ 33.84 N	100° 51′ 24.12 E	10:43	513	28.5
	13° 10′ 18.30 N	100° 51′ 20.88 E	11:13	489	27.2
2	13° 11′ 11.76 N	100° 51′ 30.78 E	9:11		
	13° 11′ 02.40 N	100° 51′ 29.82 E	9:43	290	16.1
	13° 10′ 49.68 N	100° 51′ 26.88 E	10:13	402	22.3
	13° 10′ 34.32 N	100° 51′ 27.56 E	10:43	492	27.3
	13° 10′ 19.44 N	100° 51′ 19.32 E	11:13	470	26.1
3	13° 11′ 13.44 N	100° 51′ 30.18 E	9:11		
	13° 11′ 03.18 N	100° 51′ 29.10 E	9:43	318	17.6
	13° 10′ 50.22 N	100° 51′ 25.14 E	10:13	418	23.2
	13° 10′ 26.12 N	100° 51′ 21.30 E	10:43	451	25
	13° 10′ 21.18 N	100° 51′ 18.42 E	11:13	469	26

Table 16 Position, distance and speed of buoys on May 19th, 2005

Float No.	Latitude	Longitude	Time	Distance (m)	Velocity (cm/s)
1	13° 11′ 07.08 N	100° 54′ 49.80 E	7:56		
	13° 11′ 05.70 N	100° 54′ 54.48 E	9:15	150	3.1
	13° 11′ 04.92 N	100° 55′ 00.24 E	10:34	179	3.7
	13° 11′ 09.48 N	100° 55′ 08.28 E	11:25	285	9.3
2	13° 11′ 07.20 N	100° 54′ 47.10 E	7:57		
	13° 11′ 03.00 N	100° 54′ 51.18 E	9:16	180	3.8
	13° 11′ 04.86 N	100° 54′ 56.70 E	10:36	179	3.7
	13° 11′ 08.70 N	100° 55′ 02.82 E	11:28	223	7.1
3	13° 10′ 12.40 N	100° 54′ 40.32 E	11:40		
	13° 10′ 14.32 N	100° 54′ 43.32 E	12:43	108	2.8
	13° 10′ 26.28 N	100° 54′ 44.52 E	13:15	370	19.2
	13° 10′ 29.23 N	100° 54′ 45.78 E	14:08	100	2.6
	13° 10′ 29.26 N	100° 54′ 46.32 E	15:07	16	0.4
4	13° 10′ 18.00 N	100° 54′ 36.78 E	11:42		
	13° 10′ 24.11 N	100° 54′ 39.48 E	12:45	206	5.4
	13° 10′ 26.82 N	100° 54′ 41.22 E	13:16	99	5.3
	13° 10′ 30.34 N	100° 54′ 42.30 E	14:09	112	3.5
	13° 10′ 30.45 N	100° 54′ 42.60 E	15:09	9	0.2

Table 17 Position, distance and speed of buoys on May 20th, 2005

Float No.	Latitude	Longitude	Time	Distance (m)	Velocity (cm/s)
1	13° 11′ 06.54 N	100° 54′ 52.08 E	8:46		
	13° 11′ 09.48 N	100° 54′ 57.00 E	9:34	186	6.4
	13° 11′ 17.82 N	100° 54′ 58.68 E	10:20	262	9.5
2	13° 11′ 11.82 N	100° 54′ 45.78 E	8:48		
	13° 11′ 12.18 N	100° 54′ 54.48 E	9:35	268	9.5
	13° 11′ 21.72 N	100° 54′ 56.52 E	10:21	301	10.9
3	13° 11′ 11.82 N	100° 54′ 45.78 E	8:50		
	13° 11′ 15.62 N	100° 54′ 46.20 E	9:37	117	4.1
	13° 11′ 25.98 N	100° 54′ 45.48 E	10:27	321	10.7
4	13° 11′ 13.98 N	100° 54′ 42.72 E	8:51		
	13° 11′ 19.32 N	100° 54′ 41.88 E	9:38	166	5.9
	13° 11′ 31.32 N	100° 54′ 40.68 E	10:29	372	12.1
5	13° 11′ 09.91 N	100° 54′ 54.42 E	10:36		
	13° 11′ 28.38 N	100° 54′ 57.78 E	11:34	582	16.7
6	13° 11′ 07.08 N	100° 54′ 54.78 E	10:38		
	13° 11′ 23.52 N	100° 54′ 59.74 E	11:33	529	16

From all comparisons, it was found that the results from the prediction agreed well with the results from observation. Therefore the magnitudes and direction of velocities of this model could be reliable. The output graphic of flow pattern in the Upper Gulf of Thailand and in Ao Si Racha were shown in Figure 20 and Figure 21.