Bioavailability and Sources of Nutrients and the Linkages to Nuisance Drift Algae

Final Technical Report

Volume 2: Tables, Figures and Appendices

Prepared for

The City of Sanibel in Partnership with Lee County

February 2011

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(Deliverable 10)

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Table 1.1. Station Names and Positions

Station Name	Lat (N)	Long (W)	Comments
S77			Moore Haven Locks, upstream
S78			Ortona Locks, upstream
S79			Franklin Locks, upstream
Site1	26.6815	81.8340	Marker 27, CES04
Site2	26.6365	81.8887	Marker 54, CES05
Site3	26.5307	81.9657	Marker 83, CES07
Site4	26.4858	82.0238	Marker 5, CES11
GOM01	26.4183	82.0189	since Sep08
GOM02	26.5549	82.2376	since Jun08
GOM03	26.4158	82.0963	since Jun08
GOM04	26.4811	82.2060	since Jun08
GOM05	26.3038	81.9540	since Sep08
GOM06	26.4361	81.9691	since Jun08
GOM07	26.3469	81.8778	since Jun08
GOM08	26.3612	82.1630	since Sep08
GOM10	26.4835	82.2711	since Sep08
GOM11	26.3086	82.0963	since Jun08
GOM12	26.5545	82.2858	since Sep08
GOM16	26.4796	82.0720	Jun08 (old GOM12), since Jan08
GOM09	26.2525	82.2376	Jun08-Nov08 only
GOM13	26.4048	82.0128	Jun08 only (old GOM05)
GOM14	26.3978	81.9304	Jun08 only (old GOM08)
GOM15	26.2216	81.8552	Jun08 only (old GOM10)

Table 1.2. Nutrient Analytical Parameters and Methods.

Parameter	Analytical Method
Dissolved Oxygen	YSI Sonde
Specific Conductance	YSI Sonde
Temperature	YSI Sonde
Dissolved Nitrite	automated colorimetric method (Koroleff, 1983)
Dissolved Nitrate + nitrite	automated colorimetric method (Koroleff, 1983)
Dissolved Ammonia	automated colorimetric method (Koroleff, 1983)
Total Dissolved Nitrogen	persulfate oxidation followed by automated colorimetric method (Koroleff, 1983)
Dissolved Orthophosphate	automated colorimetric method (Koroleff, 1983)
Total Dissolved Phosphorus	persulfate oxidation followed by automated colorimetric method (Koroleff, 1983)
Dissolved Organic Carbon	automated catalytic combustion (Benner and Strom, 1993)
Particulate Organic Carbon	high temperature combustion and/or isotope-ratio mass spectrometry (Loh et al., 2006)
Particulate Nitrogen	high temperature combustion and/or isotope-ratio mass spectrometry (Loh et al., 2006)
Particulate Phosphorus	high temperature ashing followed by colorimetric method (Aspila et al., 1976)
Sedimentary Organic Carbon	high temperature combustion and/or isotope-ratio mass spectrometry (Loh et al., 2006)
Sedimentary Nitrogen	high temperature combustion and/or isotope-ratio mass spectrometry (Loh et al., 2006)
Sedimentary Phosphorus	high temperature ashing followed by colorimetric method (Aspila et al., 1976)

Table 1.3: Hydrographic Data for Caloosahatchee River Estuary and Gulf of Mexico

Station	Salinity Surface	Salinity Bottom	Temp Surface	Temp Bottom	DO (mg/L) Surface	DO (mg/L) Bottom
May 2008						
Site 1	23.23	23.51	26.90	27.91	5.05	3.86
Site 2	27.65	30.43	27.06	27.18	5.26	4.70
Site 3	39.68	39.75	28.26	28.00	3.92	3.93
Site 4	41.97	42.49	28.01	27.56	4.65	4.92
June 2008						
Site 1	23.97	26.93	28.72	29.30	4.04	2.31
Site 2	28.95	29.89	29.31	29.20	3.44	2.77
Site 3	37.29	37.43	29.80	29.74	2.84	2.35
Site 4	42.55	42.64	29.86	29.74	3.34	3.40
GOM01	42.63	42.95	31.50	29.80	3.08	3.85
GOM02	42.69	42.71	30.37	29.85	3.14	3.23
GOM03	42.86	42.84	29.64	29.74	3.03	3.10
GOM04	42.99	42.94	30.03	30.00	3.04	2.98
GOM06	43.49	43.94	29.98	29.80	7.87	2.76
GOM07	41.98	42.08	29.50	29.43	2.80	3.05
GOM09	41.77	41.73	29.25	29.32	4.28	3.70
GOM13	42.78	42.81	29.93	29.73	4.24	3.52
GOM14	42.62	42.91	29.95	29.88	2.96	3.02
GOM15	42.10	42.11	29.24	29.15	2.94	2.98
GOM16	41.65	42.01	28.95	29.06	3.21	3.18
July 2008						
Site 1	3.59	4.02	28.70	28.82	2.63	2.14
Site 2	8.78	11.24	28.47	28.67	1.21	0.80
Site 3	20.12	24.05	27.70	28.54	0.85	0.52
Site 4	35.72	35.98	27.67	28.99	0.35	0.29
August 2008						
Site 1	0.30	0.30	29.76	29.83	4.30	4.13
Site 2	2.15	5.57	29.97	30.46	6.35	2.46
Site 3	16.80	21.66	31.68	30.61	7.29	6.13
Site 4	31.37	31.59	30.37	30.12	6.53	6.07
September 2008						
Site 1	0.20	0.21	28.46	28.04	3.89	2.09
Site 2	0.21	0.21	27.32	27.13	6.90	6.90
Site 3	5.58	18.56	28.61	27.98	6.72	5.82
Site 4	19.67	32.06	29.25	27.94	6.62	5.73
GOM01	34.04	35.52	29.20	28.90	6.30	5.51
GOM02	35.59	37.55	30.57	29.18	6.22	4.22
GOM03	35.80	35.97	30.00	28.98	5.71	5.16
GOM04	38.47	38.45	29.75	29.35	6.07	5.91

Table 1.3 continued

Station	Salinity Surface	Salinity Bottom	Temp Surface	Temp Bottom	DO (mg/L) Surface	DO (mg/L) Bottom
GOM05	39.51	39.52	28.74	28.75	6.82	7.15
GOM06	44.23	46.46	29.05	29.16	5.77	5.16
GOM07	34.70	36.03	29.06	28.71	6.21	4.90
GOM08	39.79	40.08	29.49	29.11	6.83	6.40
GOM09	40.65	40.64	29.20	29.10	5.41	5.42
GOM10	37.86	38.34	29.41	28.92	6.14	5.04
GOM11	39.51	39.74	28.97	28.98	4.44	4.40
GOM12	37.22	38.15	28.82	28.72	5.16	4.29
October 2008						
Site 1	2.09	9.10	25.38	25.23	5.03	4.13
Site 2	6.14	13.55	24.56	25.04	4.85	4.17
Site 3	13.86	16.45	23.74	24.06	4.83	4.78
Site 4	26.18	26.30	22.83	22.85	4.87	5.02
November 2008						
Site 1	7.35	7.35	26.70	26.56	4.31	4.36
Site 2	10.99	13.76	24.32	23.21	4.09	3.86
Site 3	17.86	19.85	23.28	22.84	3.79	3.47
Site 4	29.82	30.37	23.17	22.83	3.50	3.44
GOM01	32.92	39.94	21.76	21.84	8.18	7.20
GOM02	36.39	36.32	20.20	20.72	9.10	9.16
GOM03	36.66	36.66	21.49	21.39	8.13	7.76
GOM04	36.55	36.55	20.87	20.86	9.85	9.28
GOM05	36.73	37.03	21.45	21.46	8.23	7.14
GOM06	32.84	35.02	21.61	21.46	7.98	8.33
GOM07	35.85	36.45	21.93	21.31	7.80	7.83
GOM08	36.67	36.66	21.56	21.50	8.85	7.57
GOM09	47.70	47.66	22.80	22.88	0.91	0.54
GOM10	31.80	36.81	21.43	21.43	8.74	8.17
GOM11	36.07	36.87	21.58	22.42	8.65	7.49
GOM12	36.65	36.65	21.31	21.31	9.03	8.10
December 2008						
Site 1	6.74	11.67	22.59	19.71	7.05	6.85
Site 2	10.77	19.36	21.72	19.72	10.40	8.47
Site 3	23.35	30.86	19.43	19.28	8.96	5.45
Site 4	32.05	32.23	19.92	19.64	8.54	8.36
January 2009						
Site 1	5.86	8.71	24.83	23.21	7.60	6.66
Site 2	14.91	16.84	22.30	22.16	8.42	7.60
Site 3	26.54	28.16	21.77	21.77	7.74	7.58
Site 4	37.28	37.29	21.16	21.18	6.79	6.70
GOM01	36.54	36.52	20.08	20.46	6.43	6.21
GOM02			15.95	15.66	8.10	7.99

Table 1.3 continued

Station	Salinity Surface	Salinity Bottom	Temp Surface	Temp Bottom	DO (mg/L) Surface	DO (mg/L) Bottom
GOM03	36.58	36.65	20.26	20.02	6.64	6.38
GOM04	36.27	36.27	15.58	15.58	7.84	7.81
GOM05	40.10	40.17	20.90	20.89	7.42	7.30
GOM06	37.20	37.18	19.27	19.58	7.27	7.05
GOM07	39.85	39.88	20.93	20.93	7.46	6.48
GOM08	36.58	36.65	20.16	20.05	6.62	6.30
GOM10	40.06	40.04	21.05	20.68	8.06	7.31
GOM11	36.73	36.72	20.24	20.11	6.68	6.39
GOM12	40.02	40.11	21.31	20.77	7.37	7.29
GOM16	35.05	35.47	15.78	15.47	8.44	8.37
February 2009						
Site 1	5.97	8.12	21.38	19.53	10.15	9.65
Site 2	15.28	19.07	17.70	16.83	9.92	9.33
Site 3	23.48	30.34	17.83	16.40	9.25	8.48
Site 4	33.65	34.31	16.27	16.04	8.50	8.47
March 2009						
Site 1	10.83		23.29		7.40	
Site 2	16.62		21.33		7.98	
Site 3	39.49		22.54		7.41	
Site 4	35.86		22.15		6.95	
GOM01	40.10	39.97	20.02	19.25	7.16	7.42
GOM02	40.01	40.02	21.21	21.18	6.16	6.71
GOM03	39.95	40.05	18.90	18.24	7.24	7.24
GOM04		40.05		16.39		6.83
GOM05	40.72	40.67	18.03	17.81	8.67	8.94
GOM06	40.11	40.11	19.90	19.82	7.42	7.47
GOM07	40.55	40.49	18.50	18.57	7.88	7.84
GOM08	39.95	40.02	18.62	18.41	7.24	7.36
GOM10	40.18	39.94	21.66	19.57	3.87	4.30
GOM11	39.82	39.86	22.16	21.32	6.56	7.01
GOM12	40.17	39.96	21.22	19.64	6.85	
GOM16	38.67	38.58	20.18	20.59	7.42	7.39
April 2009						
Site 1	10.54		27.89		8.88	
Site 2	21.13		26.13		6.07	
Site 3	33.45		25.59		5.37	
Site 4	39.78		24.53		5.98	
May 2009						
Site 1	15.45		31.73		7.56	
Site 2	23.14		30.23		6.33	
Site 3	35.53		28.85		5.96	
Site 4	41.21		28.24		6.62	

Table 1.3 continued

Station	Salinity Surface	Salinity Bottom	Temp Surface	Temp Bottom	DO (mg/L) Surface	DO (mg/L) Bottom
GOM01	41.52	41.32	28.38	28.44	6.26	6.15
GOM02	42.09	42.02	28.83	28.45	5.98	6.08
GOM03	41.90	41.94	27.82	27.75	6.25	6.23
GOM04	42.26	41.91	29.18		5.94	6.10
GOM05	41.56	41.53	25.75	25.82	7.34	7.10
GOM06	42.18	42.30	27.57	27.40	5.92	5.86
GOM07	41.81	41.76	26.42	26.50	5.81	5.94
GOM08	41.76	41.82	27.36	27.27	6.58	6.39
GOM10	41.62	41.60	27.33	27.22	6.16	5.96
GOM11	41.73	41.64	26.85	26.99	7.70	7.59
GOM12	41.95	41.94	27.92	27.91	6.03	6.08
GOM16	38.07	37.99	26.21	26.10	6.00	5.79
June 2009						
Site 1	0.74	3.47	31.54	29.87	5.85	1.18
Site 2	4.01	12.24	30.98	29.78	8.95	1.97
Site 3	16.01	22.73	30.06	29.82	5.15	3.72
Site 4	32.52	36.51	28.95	29.58	3.33	3.80
July 2009						
Site 1	0.21	0.21	33.98	31.32	4.17	3.75
Site 2	0.25	0.25	32.86	30.70	9.21	7.42
Site 3	7.58	16.89	31.56	31.17	8.34	5.40
Site 4	25.51	29.31	31.21	31.15	5.61	5.71
GOM01	41.52	41.47	31.20	31.31	7.46	7.44
GOM02	41.15	41.24	31.34	30.95	6.55	6.13
GOM03						
GOM04	40.50	40.73	31.88	31.78	6.56	6.49
GOM05	41.20	39.43	30.89	30.50	8.34	7.67
GOM06	36.89	37.83	32.07	31.81	7.31	7.44
GOM07	38.88	41.13	31.47	30.64	7.94	6.12
GOM08	41.57	41.46	31.03	31.30	6.74	7.20
GOM10	41.13	41.25	31.08	30.63	7.13	7.16
GOM11	41.30	41.30	30.84	30.84	7.89	7.89
GOM12	41.24	41.20	30.50	30.54	4.94	92.20
GOM16		36.61		31.58		4.72
August 2009						
Site 1	0.23	0.23	31.83	31.15	5.60	5.18
Site 2	0.24	0.23	32.10	30.74	5.50	5.92
Site 3	7.68	12.32	30.08	30.56	6.28	4.64
Site 4	21.83	31.43	30.32	30.49	5.00	5.16

Table 1.3 continued

Station	Salinity Surface	Salinity Bottom	Temp Surface	Temp Bottom	DO (mg/L) Surface	DO (mg/L) Bottom
September 2009						
Site 1	0.24	0.25	30.87	29.88	3.98	3.96
Site 2	0.51	0.36	30.33	29.66	5.67	5.02
Site 3	5.81	15.40	29.87	29.96	6.00	4.80
Site 4	23.48	25.65	29.36	29.30	4.88	4.31
GOM01	37.96	38.62	30.43	30.18	6.31	5.36
GOM02	39.69	40.64	30.08	30.05	1.31	0.83
GOM03	40.08	40.12	29.98	29.89	6.37	6.27
GOM04	39.52	40.26	31.87	30.79	1.57	1.26
GOM05	40.70	40.63	29.85	29.97	6.51	6.31
GOM06	37.07	38.07	30.12	30.24	6.54	5.99
GOM07	39.84	40.19	30.25	30.23	6.11	2.91
GOM08	40.53	40.58	29.98	29.92	6.59	6.58
GOM10	38.50	40.67	32.50	31.08	1.18	1.10
GOM11	40.75	40.80	29.88	29.79	6.31	6.40
GOM12	40.12	41.13	29.51	29.96	0.81	0.53
GOM16	30.02	30.07	30.44	30.33	1.25	1.09
October 2009						
Site 1	8.56	12.65	28.00	24.38	7.49	7.18
Site 2	8.55	18.63	25.78	24.23	9.04	8.00
Site 3	23.82	31.09	24.19	24.08	7.74	6.83
Site 4	32.16	33.18	24.03	24.25	6.13	5.87
November 2009						
Site 1	12.89	21.90	22.49	23.08	8.68	5.46
Site 2	17.07	19.30	22.04	21.97	5.52	5.68
Site 3	27.97	27.91	21.73	21.86	7.76	7.39
Site 4	36.06	36.14	20.83	21.24	7.40	6.89
GOM01	39.12	40.26	22.28	22.43	7.37	7.96
GOM02	40.15	40.14	22.66	22.51	6.78	6.67
GOM03	40.90	40.89	22.88	22.81	7.28	7.98
GOM04	40.72	40.87	22.20	22.07	7.61	7.98
GOM05	39.99	41.06	22.34	22.63	7.76	7.82
GOM06	36.70	36.69	21.41	21.45	7.45	7.61
GOM07	39.28	40.44	22.46	22.63	7.42	7.69
GOM08	40.40	40.34	23.40	23.42	7.07	7.13
GOM10	40.39	40.29	22.90	22.94	6.89	6.98
GOM11	41.24	41.30	22.78	22.71	7.43	7.88
GOM12	40.17	40.14	22.65	22.65	6.98	6.98
GOM16	37.55	37.84	21.61	21.66	7.53	8.38

Table 1.3 continued

Station	Salinity Surface	Salinity Bottom	Temp Surface	Temp Bottom	DO (mg/L) Surface	DO (mg/L) Bottom
December 2009						
Site 1	8.57	15.35	26.66	24.34	7.66	5.66
Site 2	13.55	19.42	25.23	24.18	9.19	7.30
Site 3	20.13	24.42	23.84	24.02	8.13	7.65
Site 4	33.17	33.14	23.74	23.75	7.14	7.05
January 2010						
Site 1	7.85	16.16	17.86	13.66	10.05	9.71
Site 2	14.90	20.75	14.16	12.30	10.63	10.62
Site 3	22.63	24.00	12.21	11.72	10.77	11.28
Site 4	32.82	32.77	11.80	11.93	9.96	10.06
GOM01	39.18	39.02	16.97	17.20	39.18	39.02
GOM02	35.21	35.41	16.02	15.69	7.85	7.71
GOM03	39.46	39.40	10.50	16.67	8.97	8.30
GOM04	34.97	35.00	16.42	16.08	8.74	7.97
GOM05	40.05	39.97	16.74	16.87	8.10	7.66
GOM06	38.06	38.06	17.80	17.80	7.39	7.03
GOM07	39.39	39.31	17.31	17.38	8.03	7.50
GOM08	35.43	35.50	16.02	15.93	7.77	7.75
GOM10	35.58	35.65	16.05	16.03	7.95	7.91
GOM11	35.58		16.03		7.92	
GOM12	35.69	35.69	15.57	15.58	8.06	7.86
GOM16			12.54	12.65	8.10	8.01
February 2010						
Site 1	6.15	7.05	17.90	17.13	9.80	9.34
Site 2	11.18	15.52	16.80	17.00	10.08	8.67
Site 3	20.36	20.39	16.24	16.40	9.57	9.60
Site 4	30.26	30.80	14.48	14.30	8.51	8.30
March 2010						
Site 1	0.36	0.38	21.43	20.36	8.88	8.19
Site 2	0.42	0.43	19.47	18.97	9.23	8.83
Site 3	7.31	17.41	18.29	18.94	9.47	9.51
Site 4	28.08	32.44	16.45	16.95	7.81	7.71
GOM01	40.29	40.55	14.80	14.33	8.95	8.82
GOM02			15.93	15.87	7.85	7.87
GOM03	40.64	40.52	13.99	13.97	8.72	8.79
GOM04			16.82	16.37	7.75	7.87
GOM05			14.64	14.52	8.80	8.77
GOM06	39.84	39.91	15.87	16.05	8.76	8.84
GOM07	40.30	40.71	15.31	14.43	8.79	8.34
GOM08	41.09	41.10	14.05	13.85	8.81	8.88
GOM10			16.00	15.93	8.08	8.16
GOM11	41.15	41.17	13.88	13.82	8.65	8.67

Table 1.3 continued

Station	Salinity Surface	Salinity Bottom	Temp Surface	Temp Bottom	DO (mg/L) Surface	DO (mg/L) Bottom
GOM12			15.47	15.45	8.17	8.04
GOM16	33.92	33.92	15.20	15.20	7.75	7.78
April 2010						
Site 1	0.33	0.33	25.10	25.03	9.04	9.19
Site 2	1.09	1.08	23.57	23.79	10.04	10.40
Site 3	10.56	15.99	22.29	22.28	7.75	7.32
Site 4	22.96	27.82	21.63	21.99	7.64	7.86
May 2010						
Site 1	0.27	0.27	29.60	29.17	5.56	1.19
Site 2	0.28	0.28	28.16	27.93	5.75	5.70
Site 3	5.02	10.20	27.35	27.44	4.53	3.87
Site 4	17.10	30.87	26.24	27.34	5.11	3.74
May 2010						
Site 1.5	0.25		29.05		9.03	
Site 3	10.39	19.40	31.07	29.67	3.18	2.26
Site 4	30.03	31.72	30.28	29.86	3.42	3.59

**Site 1.5 is the half-way point between Sites 1 and 2 at Centennial Park.*

Station	Salinity Surface	Salinity Bottom	Temp Surface	Temp Bottom	DO (mg/L) Surface	DO (mg/L) Bottom
June 2010						
Site 1	0.25	0.25	30.20	29.68	5.22	4.93
Site 2	0.26	0.26	30.32	29.98	6.54	6.34
Site 3	11.00	23.14	30.92	30.81	5.84	4.70
Site 4	33.43	35.53	31.77	31.58	4.98	4.51
GOM01	38.71	39.66	30.93	29.97	3.11	2.82
GOM02	34.45	35.17	30.59	30.12	5.25	5.41
GOM03	59.84	59.20	31.59	30.96	6.42	5.99
GOM04	39.96	40.35	27.54	26.95	3.21	2.59
GOM05	40.60	40.62	29.17	29.02	2.63	2.53
GOM06	38.25	38.47	28.29	28.21	2.41	2.17
GOM07	39.87	40.20	30.07	29.67	3.11	2.83
GOM08	35.15	35.17	30.72	30.30	5.99	6.00
GOM10	34.82	35.10	30.82	29.95	5.47	6.12
GOM11	40.48	40.51	28.73	28.33	4.56	4.04
GOM12	34.39	35.15	30.69	29.71	5.61	5.70
GOM16	28.33	28.39	29.82	29.24	2.83	2.80
June 2010						
Site 1	0.23	0.23	31.11	30.85	6.47	6.22
Site 2	0.25	0.25	29.88	29.76	7.27	7.23
Site 3	8.51	10.48	30.50	30.32	5.96	5.53
Site 4	27.45	28.57	30.92	30.63	5.61	4.98

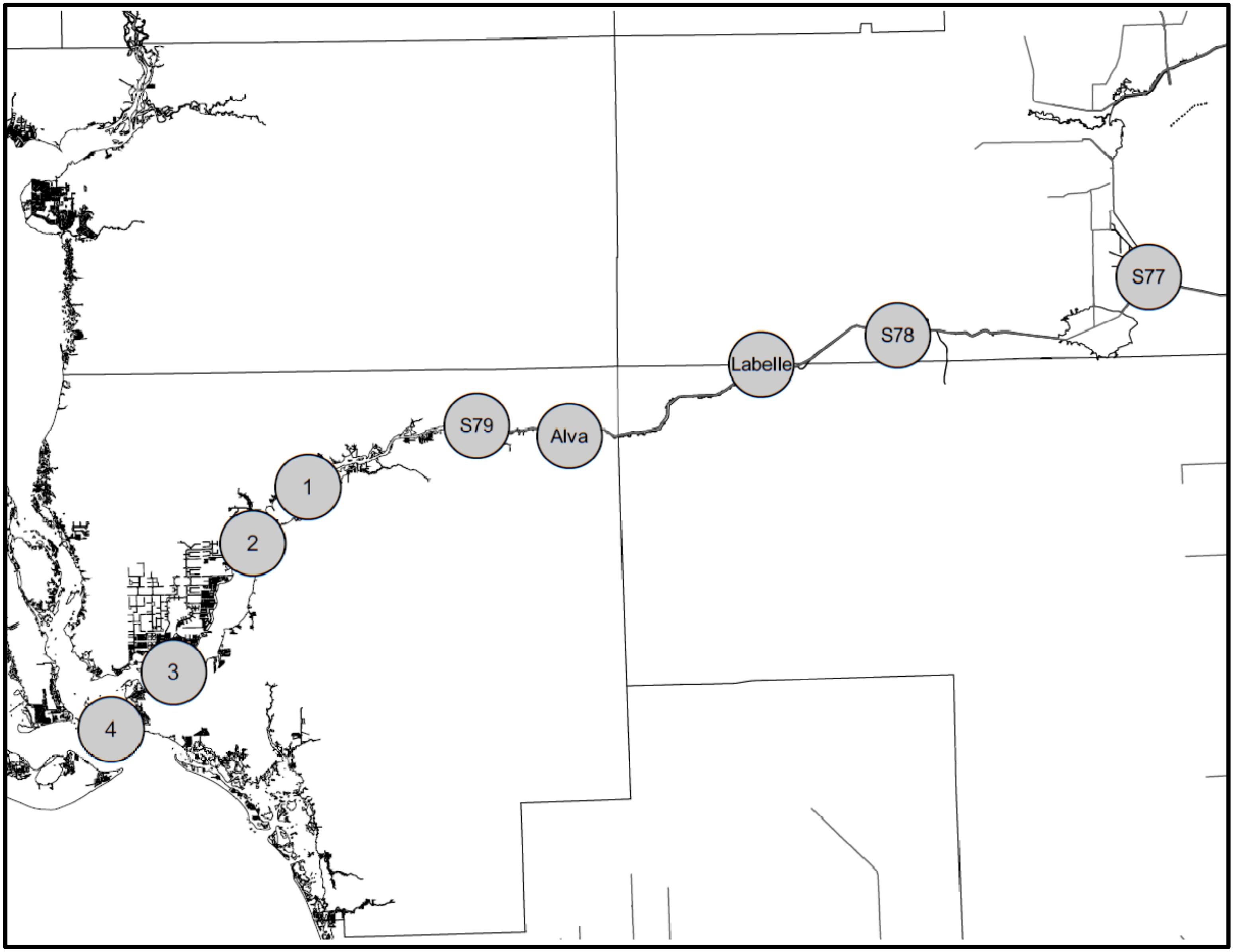


Figure 1.1a. Stations along the C-43 canal and the Caloosahatchee River Estuary (for Figures 1.7 and 1.8).

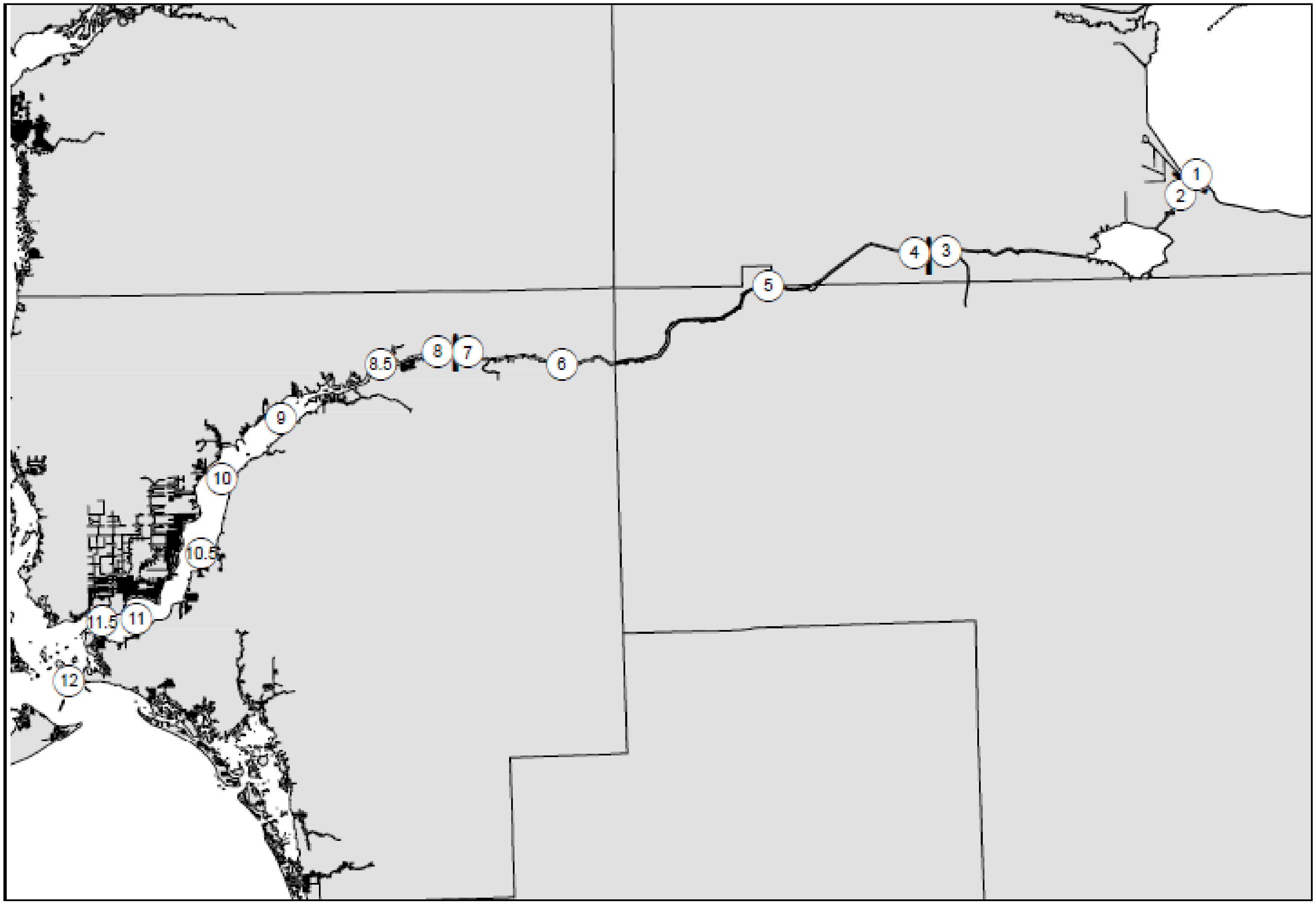


Figure 1.1b. Stations along the C-43 canal and the Caloosahatchee River Estuary (for Figures 1.11 to 1.19).

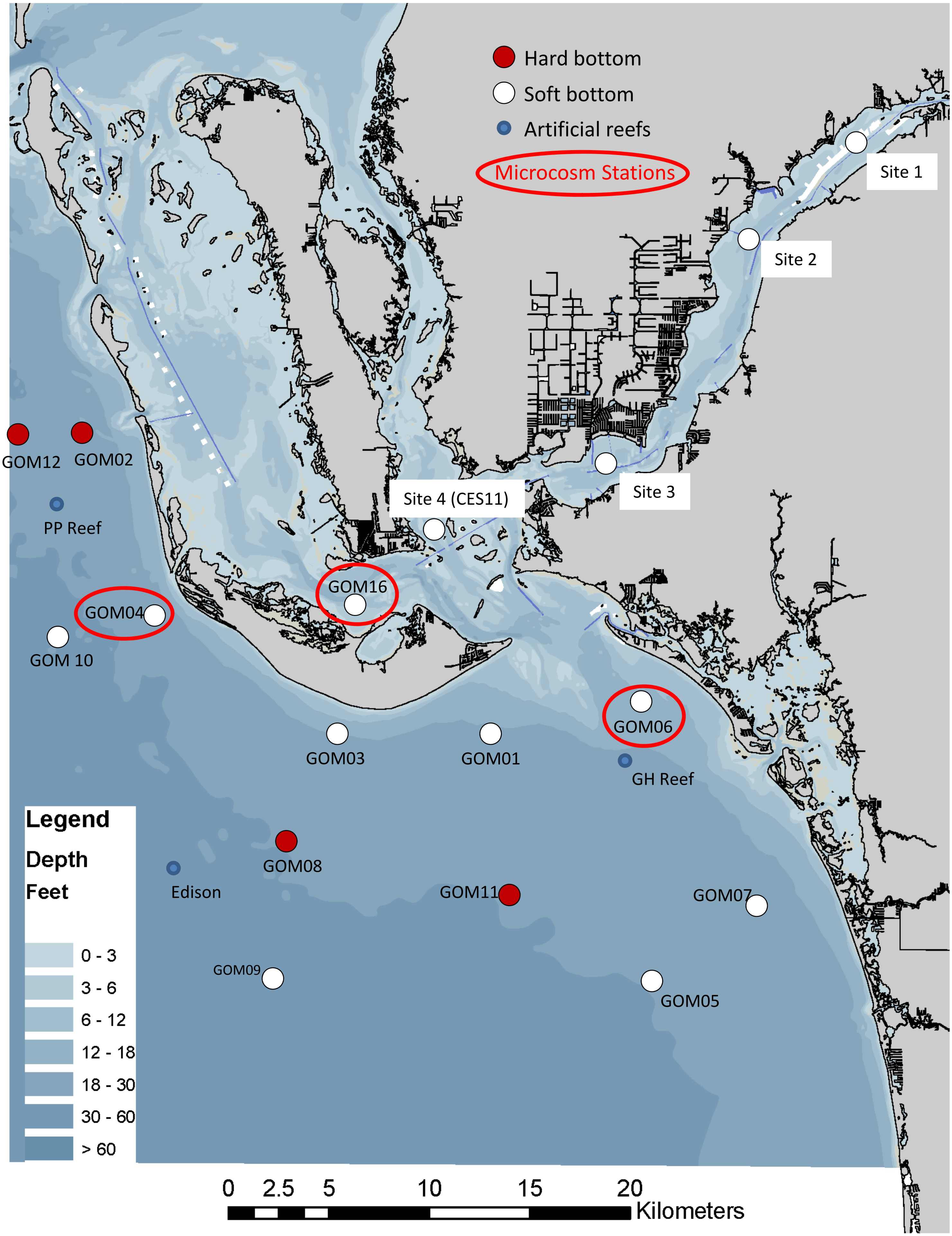


Figure 1.2. Map of sampling stations in the Caloosahatchee River Estuary and Gulf of Mexico.

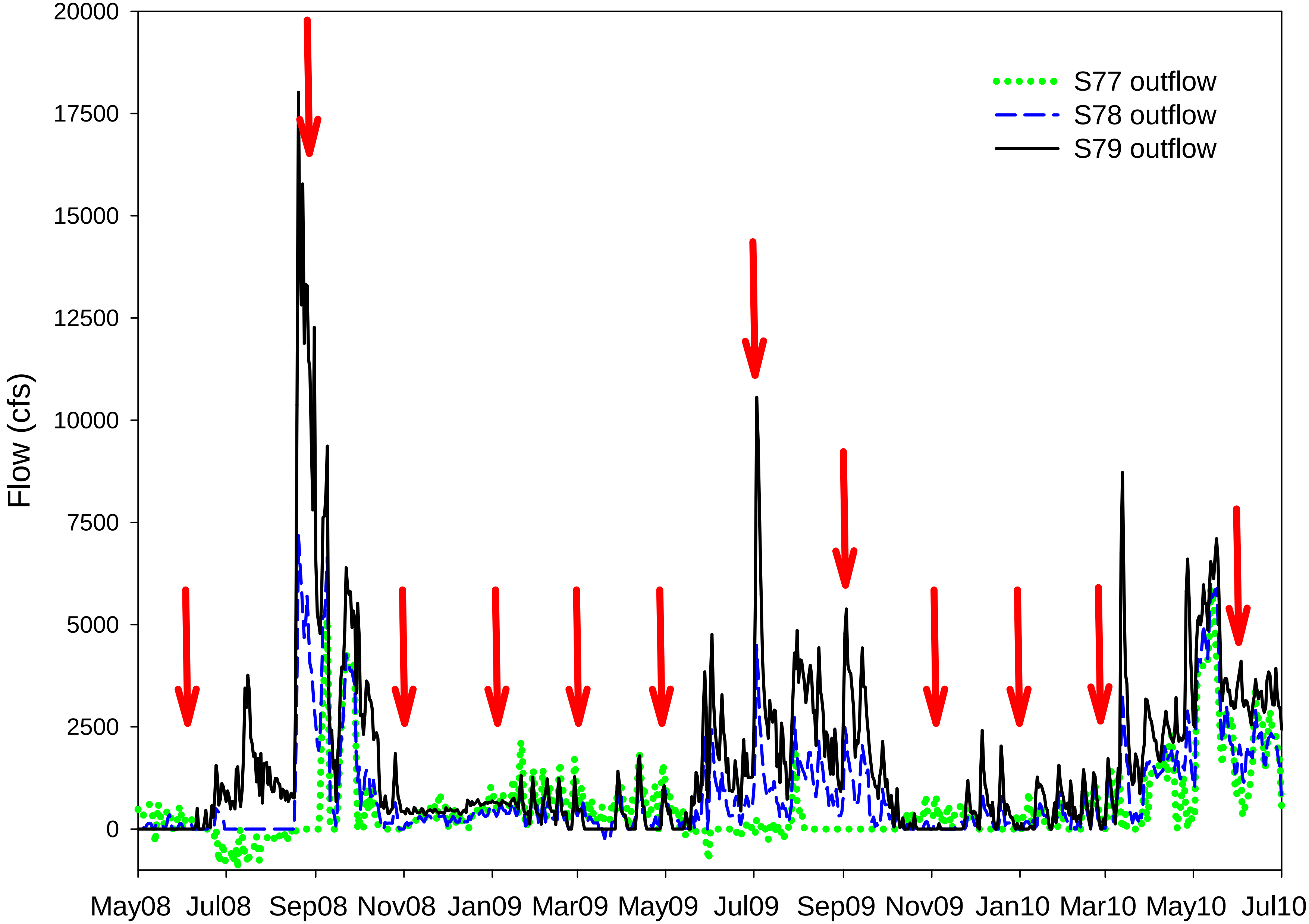


Figure 1.3. Caloosahatchee River flows through S77, S78 and S79 control structures from May 2008 – June 2009. Red arrows indicate actual bi-monthly Gulf of Mexico synoptic surveys for Objectives 1, 2 and 5.

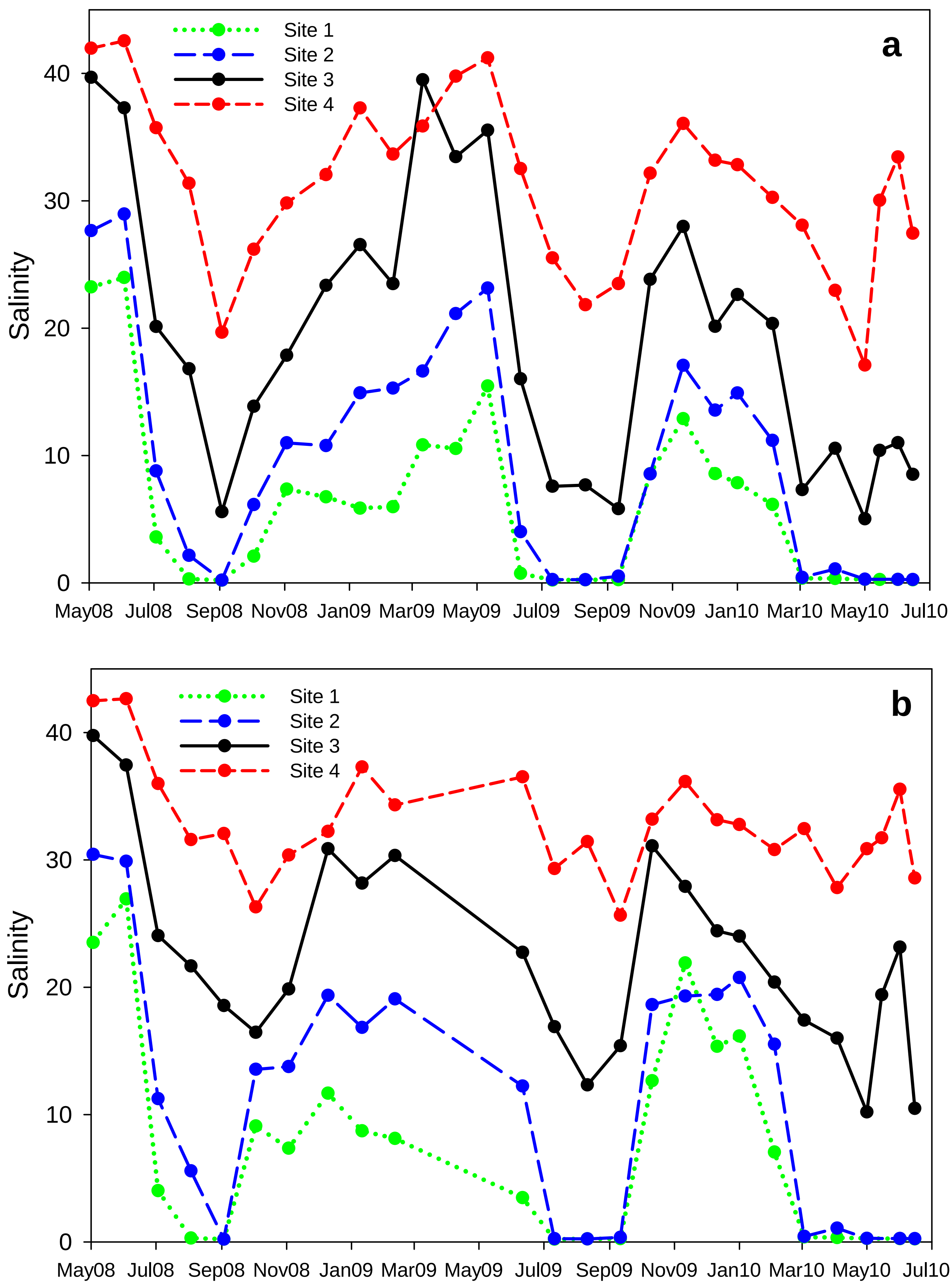


Figure 1.4. (a) Surface and (b) bottom salinity in the Caloosahatchee River Estuary from May 2008 – June 2010.

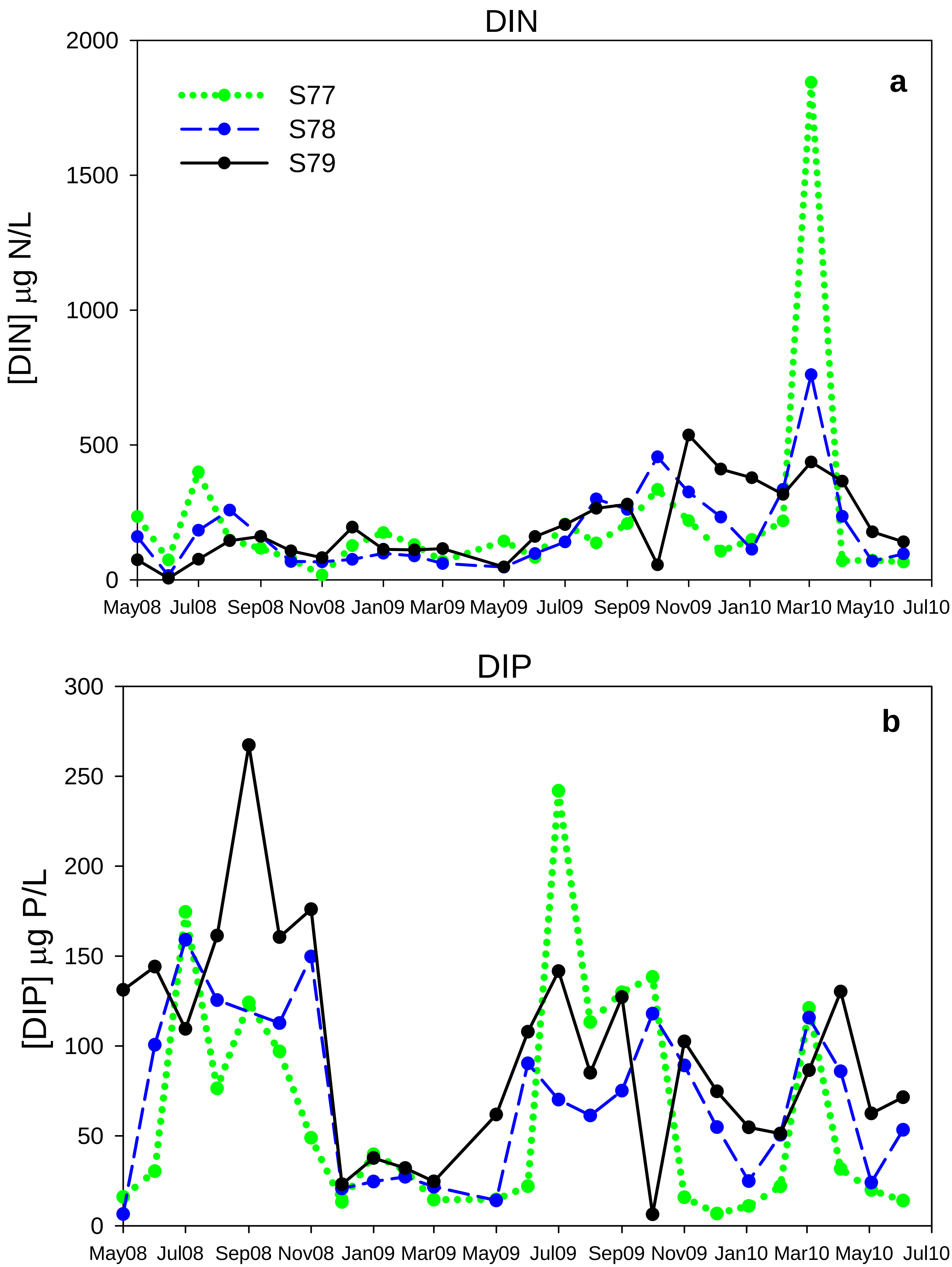


Figure 1.5. Concentrations of dissolved inorganic nitrogen and phosphorus at the S77, S78 and S79 control structures from May 2008 – June 2010.

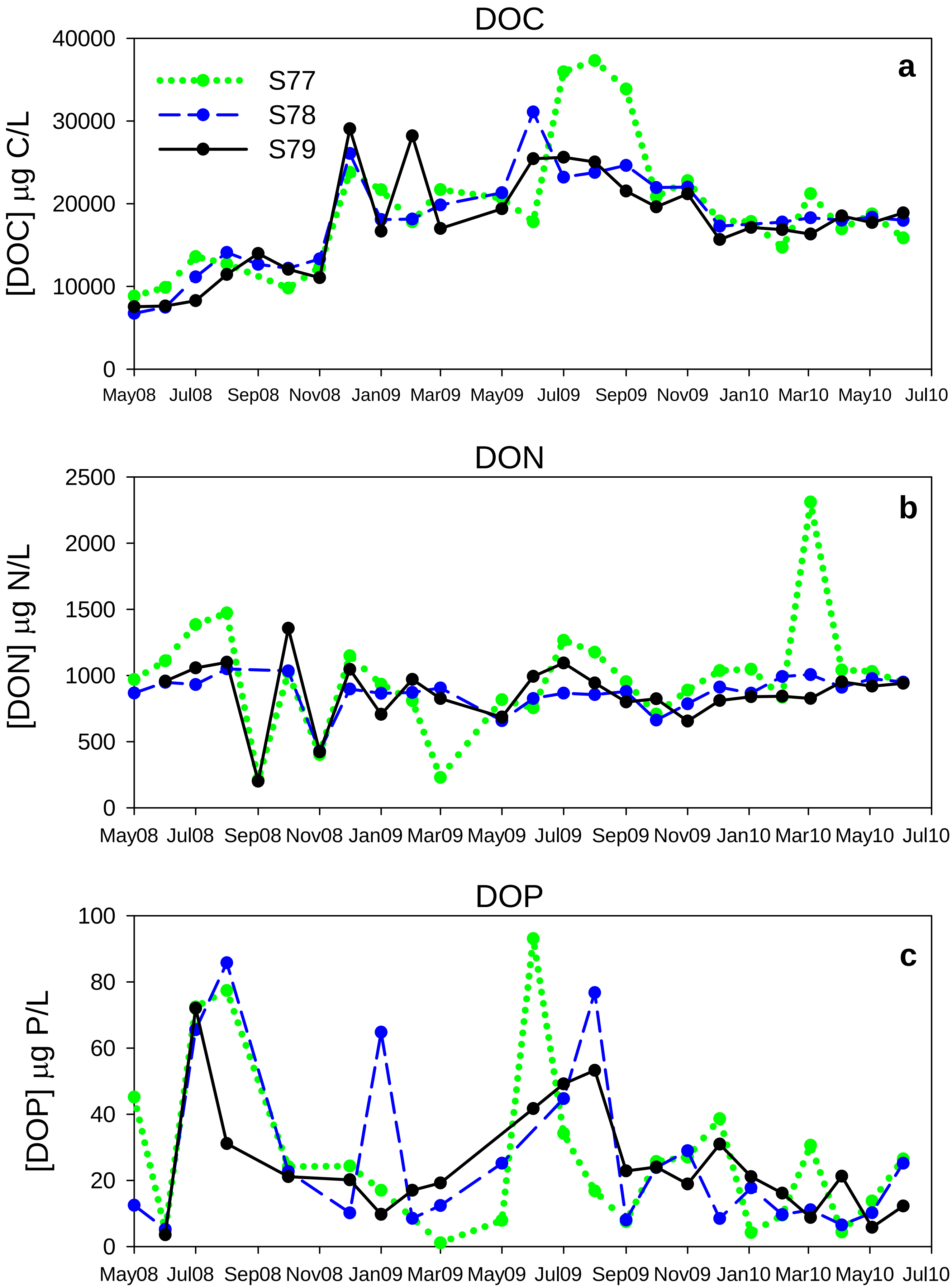


Figure 1.6. Concentrations of dissolved organic carbon, nitrogen and phosphorus at the S77, S78 and S79 control structures from May 2008 – June 2010.

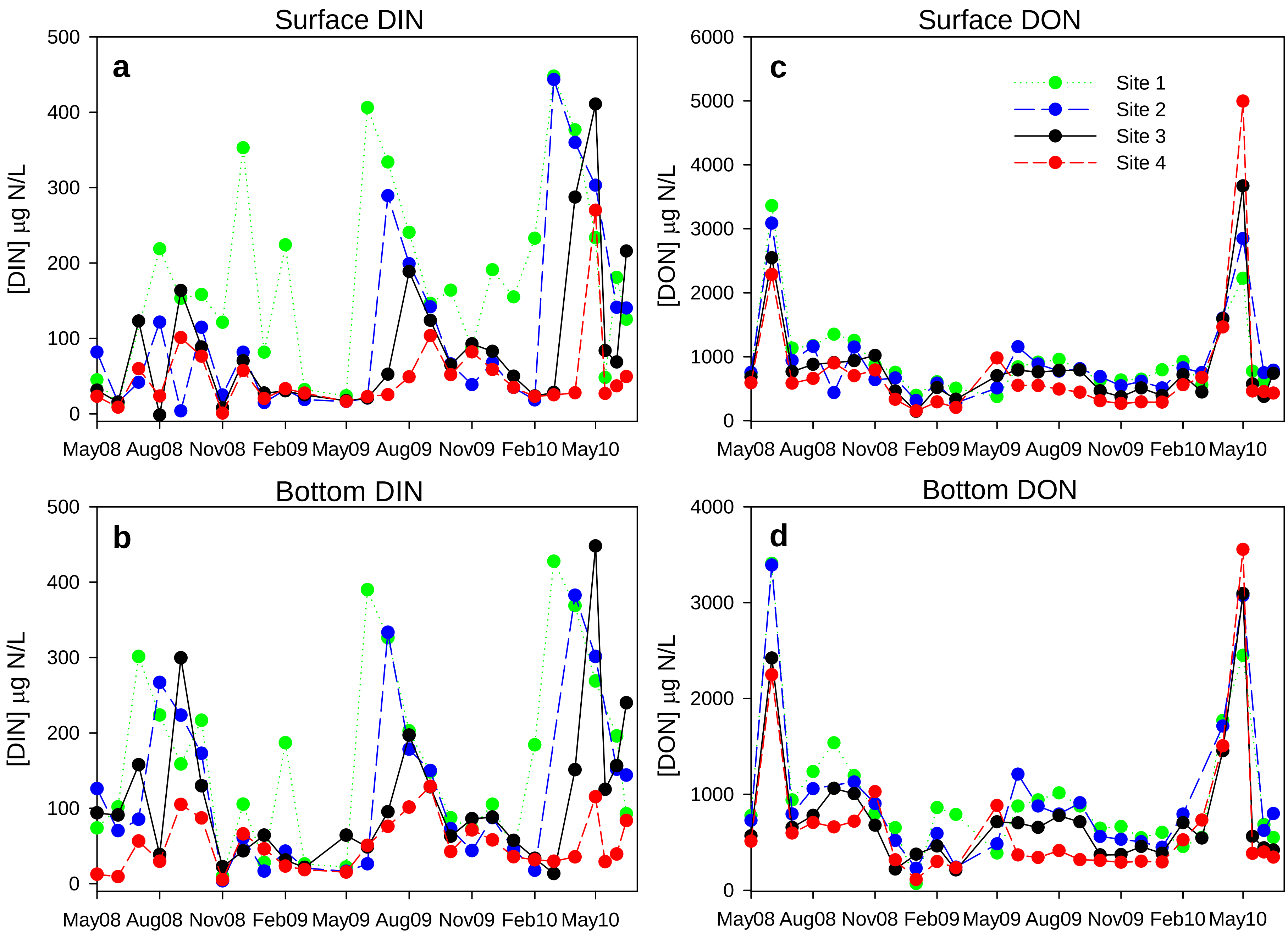


Figure 1.7. Concentrations of a) surface and b) bottom dissolved inorganic nitrogen and, c) surface and d) bottom dissolved organic nitrogen along the Caloosahatchee River Estuary from May 2008 – June 2010.

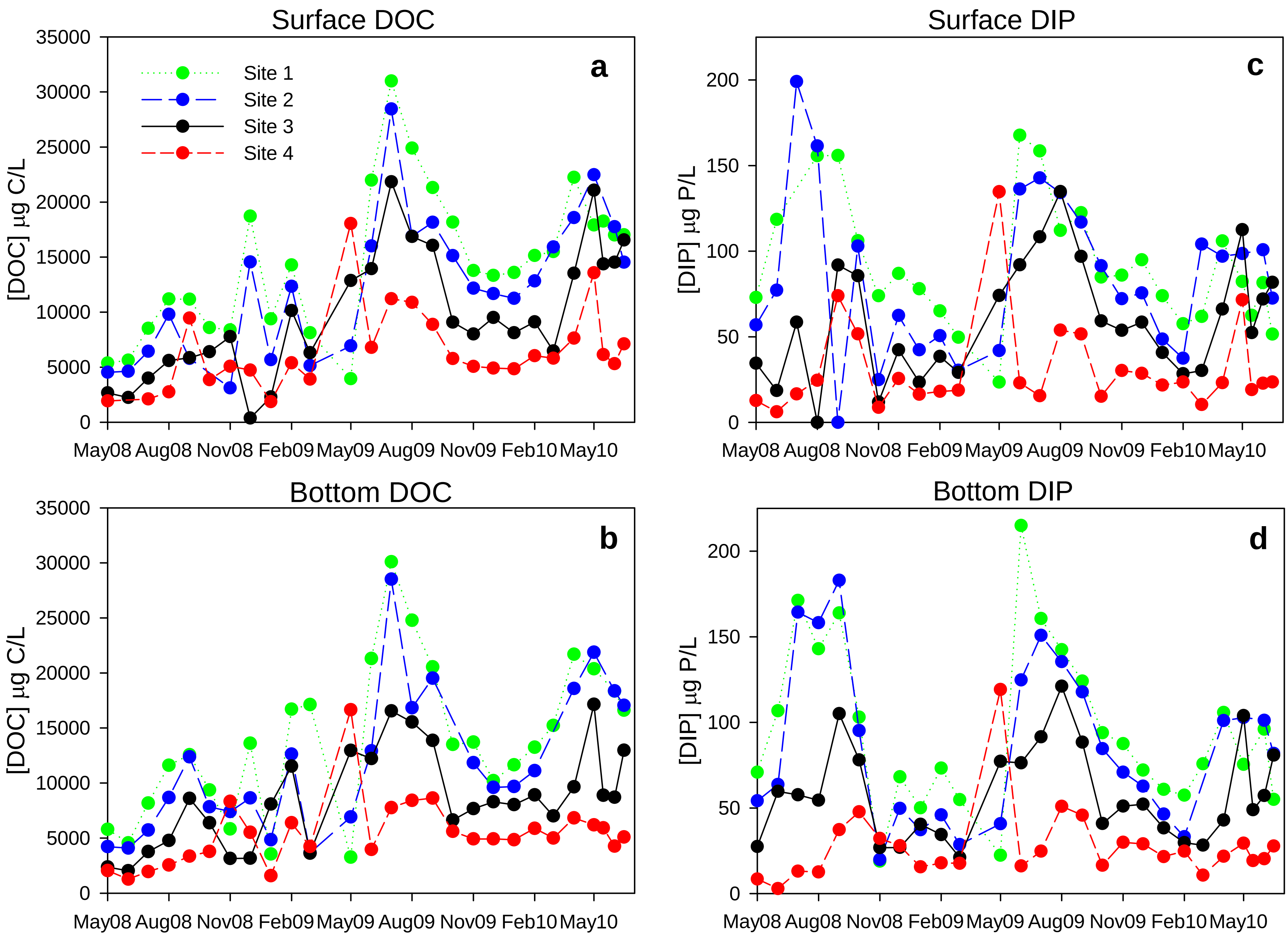


Figure 1.8. Concentrations of a) surface and b) bottom dissolved organic carbon and, c) surface and d) bottom dissolved inorganic phosphorus along the Caloosahatchee River Estuary from May 2008 – June 2010.

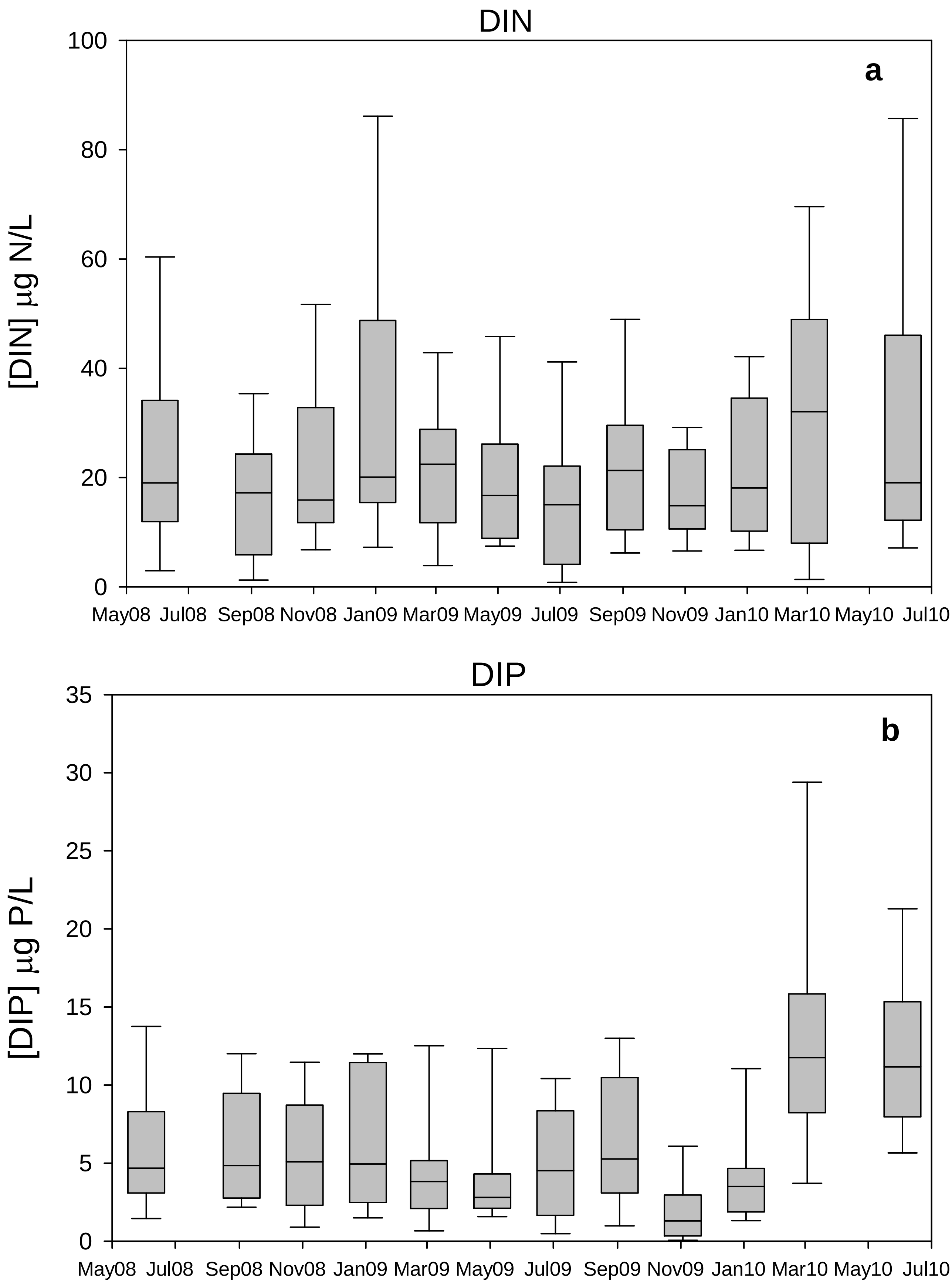


Figure 1.9. Concentrations of dissolved inorganic nitrogen and phosphorus for coastal Gulf of Mexico from May 2008 – June 2010. Boxes represents 25th to 75th percentile of the concentrations from all GOM sites with the line within the box marking the median value. Error bars indicate the 10th and 90th percentiles of the data.

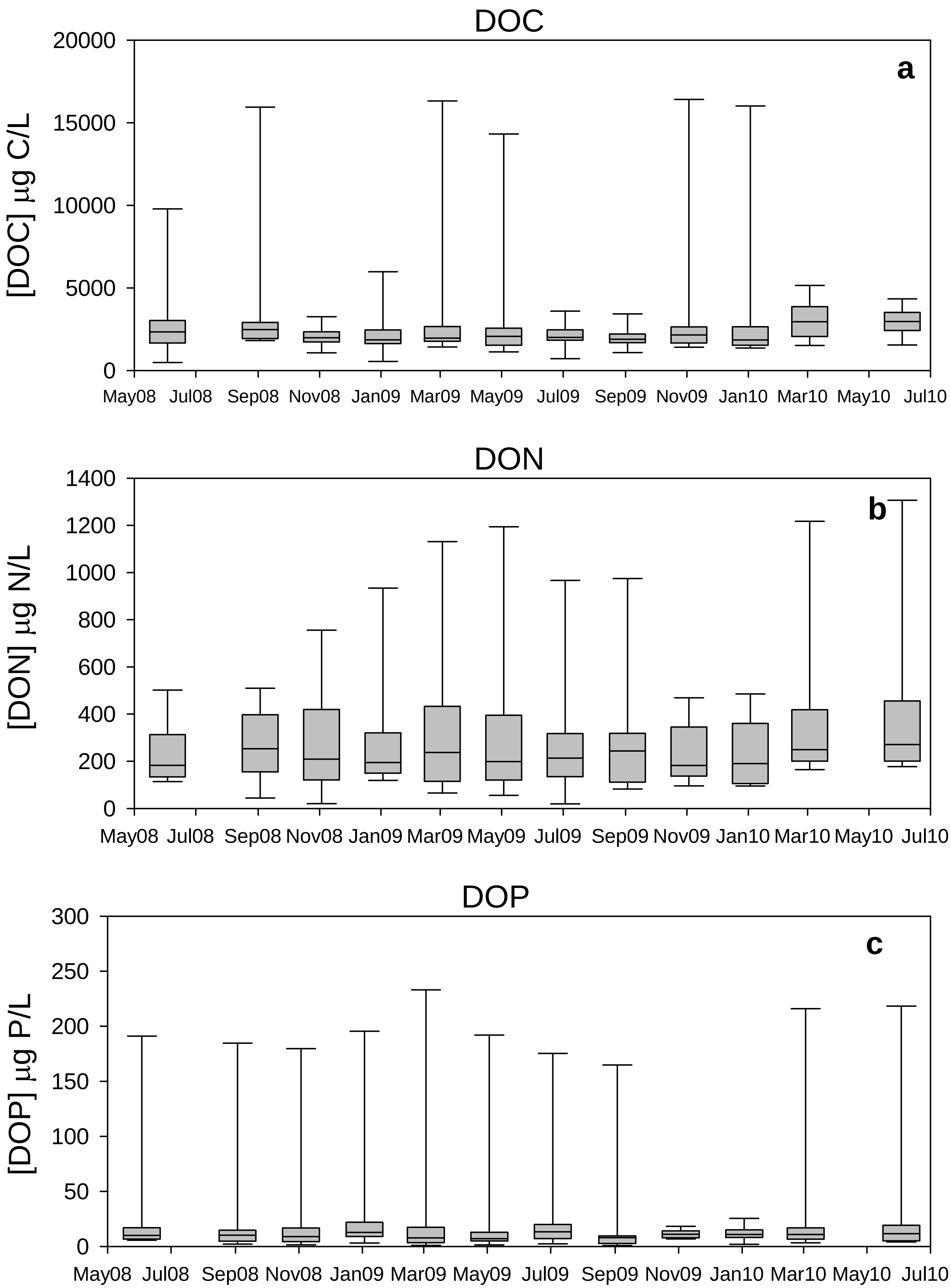


Figure 1.10. Concentrations of dissolved organic carbon, nitrogen and phosphorus for coastal Gulf of Mexico from May 2008 – June 2010. Boxes represents 25th to 75th percentile of the concentrations from all GOM sites with the line within the box marking the median value. Error bars indicate the 10th and 90th percentiles of the data.

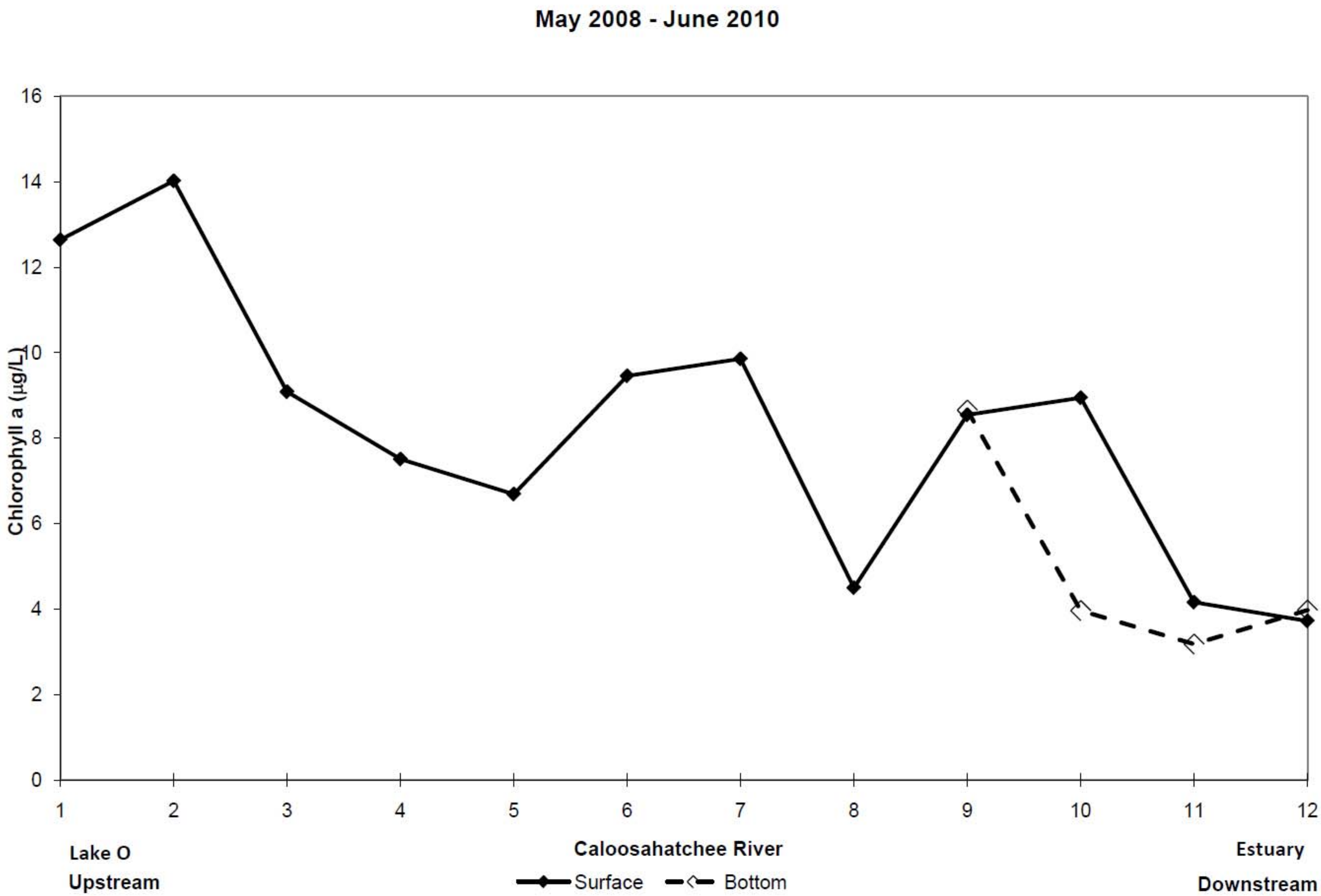


Figure 1.11. Average concentrations of chlorophyll a as an indication of algal abundance along the Caloosahatchee River and estuary. Average of 2 years of monthly data. Solid line is surface samples and dashed line is bottom samples.

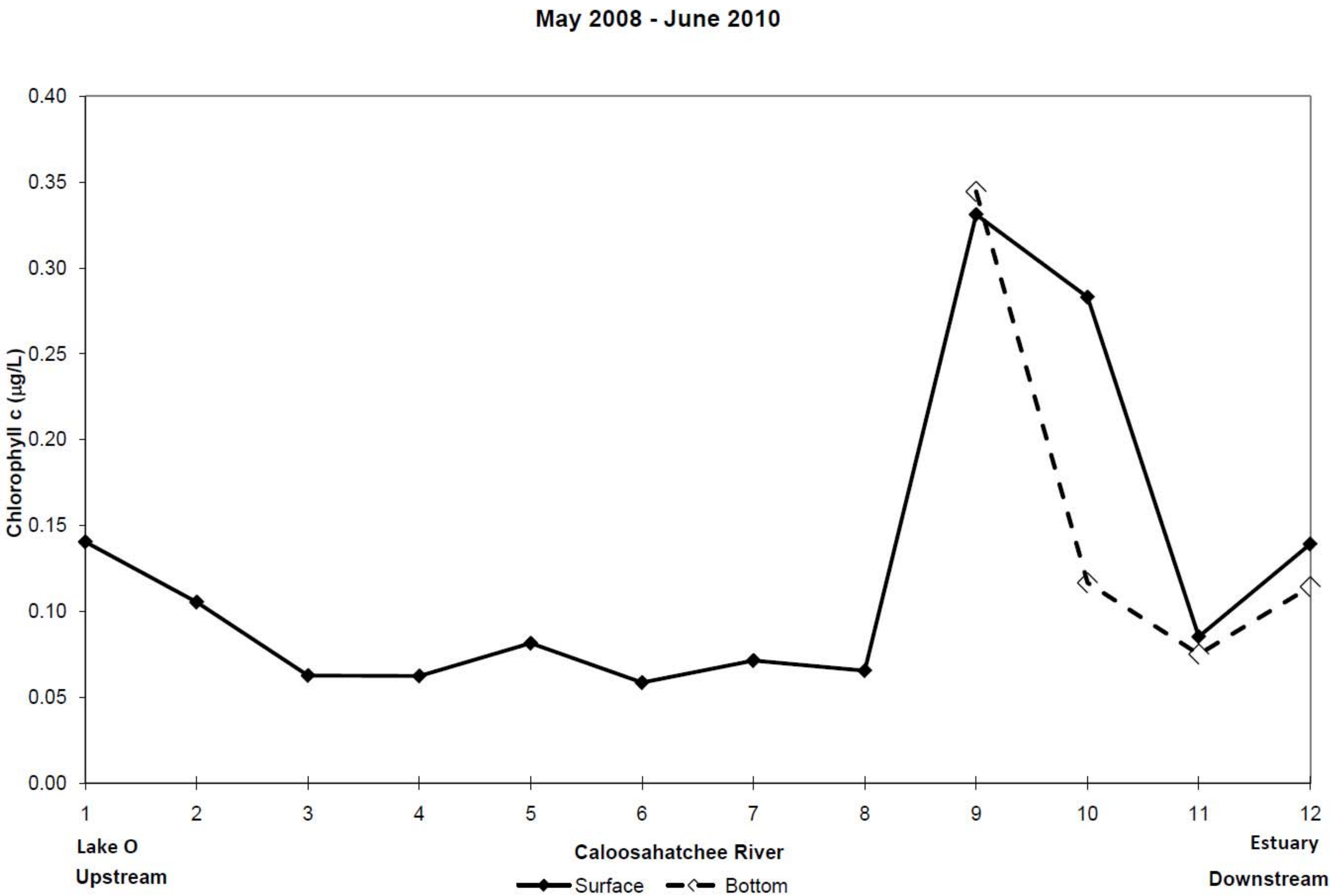


Figure 1.12. Average concentrations of chlorophyll c as an indication of chromoophyte algal abundance along the Caloosahatchee River and estuary. Average of 2 years of monthly data. Solid line is surface samples and dashed line is bottom samples.

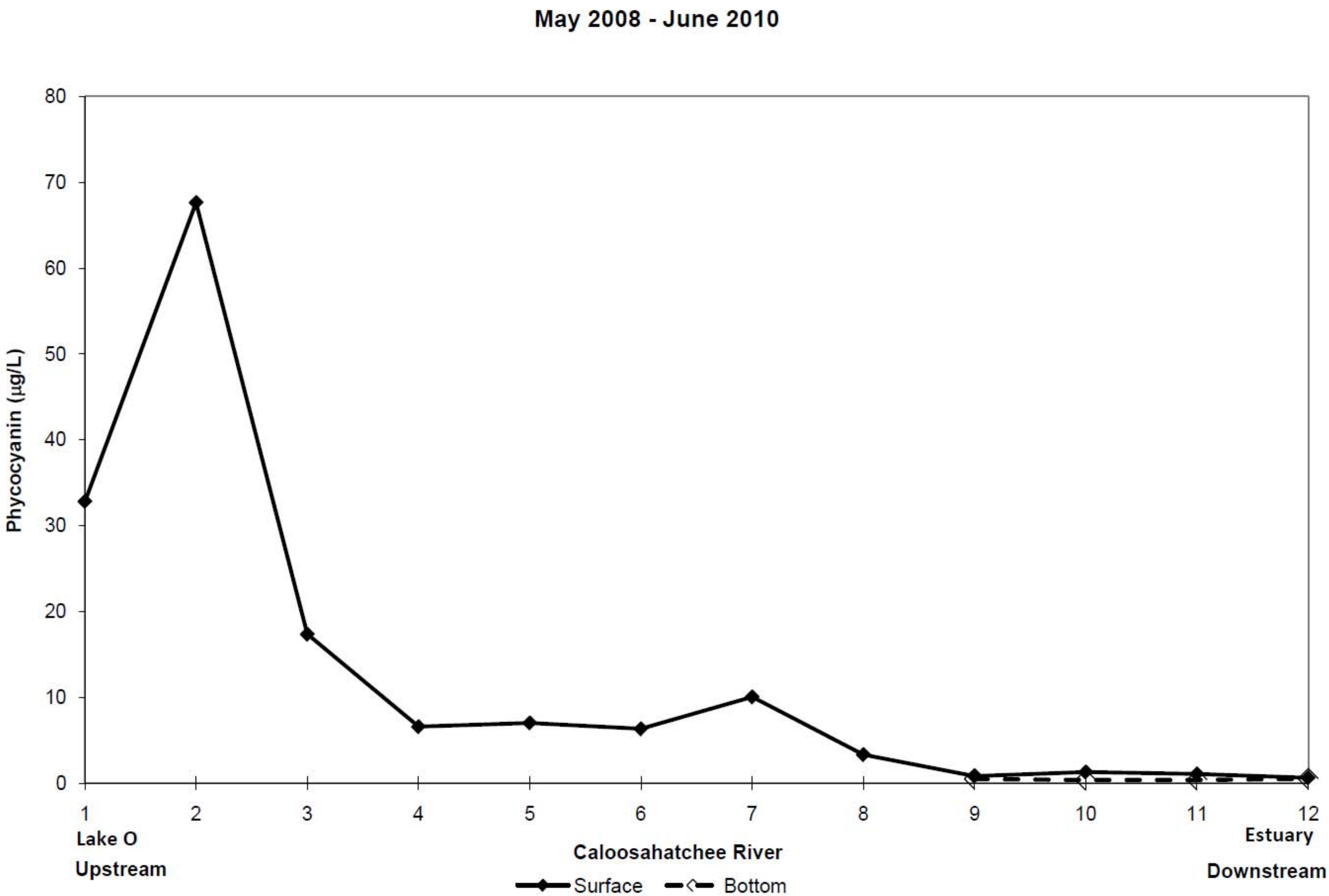


Figure 1.13. Average concentrations of phycocyanin as an indication of cyanobacterial abundance along the Caloosahatchee River and estuary. Average of 2 years of monthly data. Solid line is surface samples and dashed line is bottom samples.

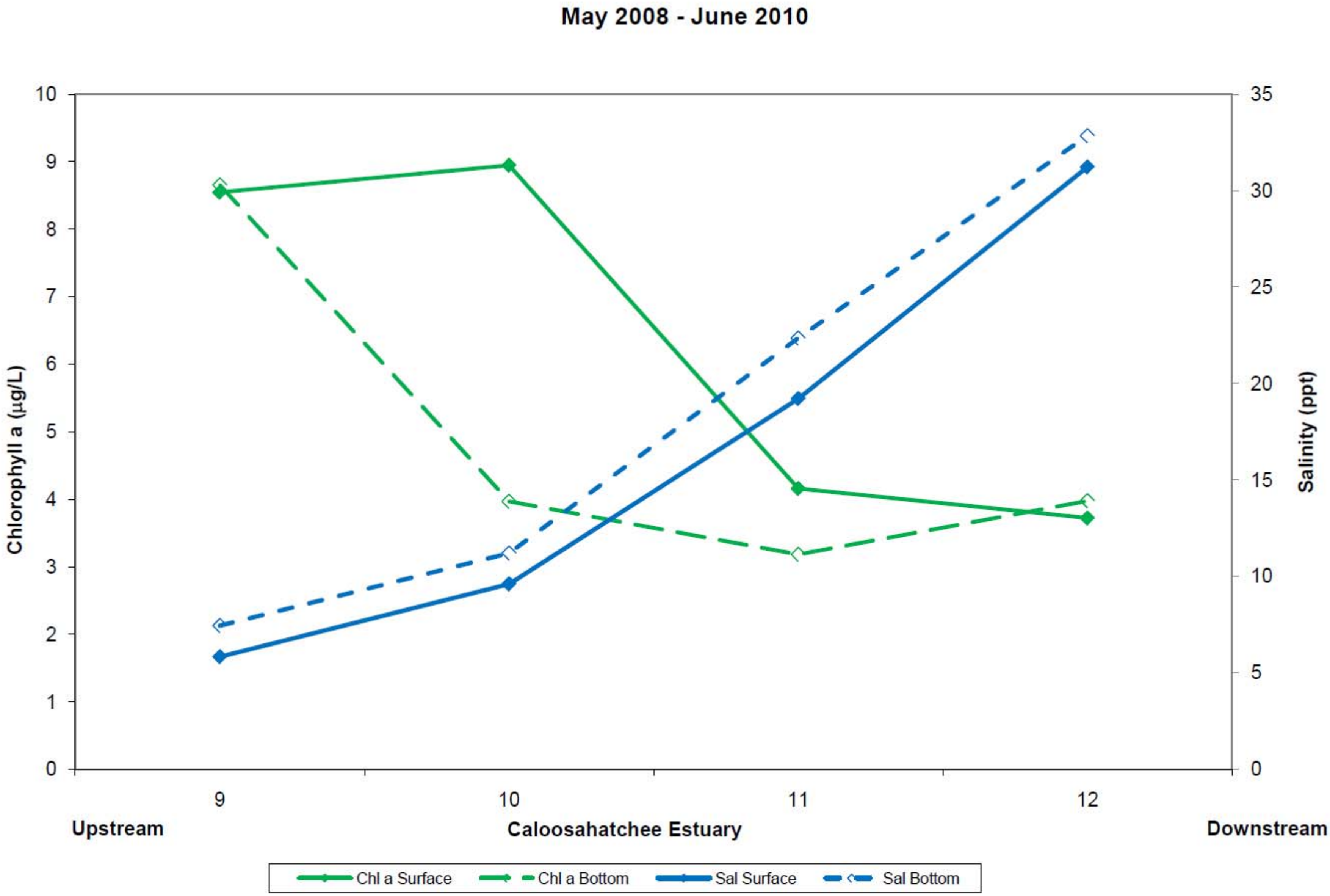


Figure 1.14. Plot of chlorophyll a and salinity along the Caloosahatchee estuary.

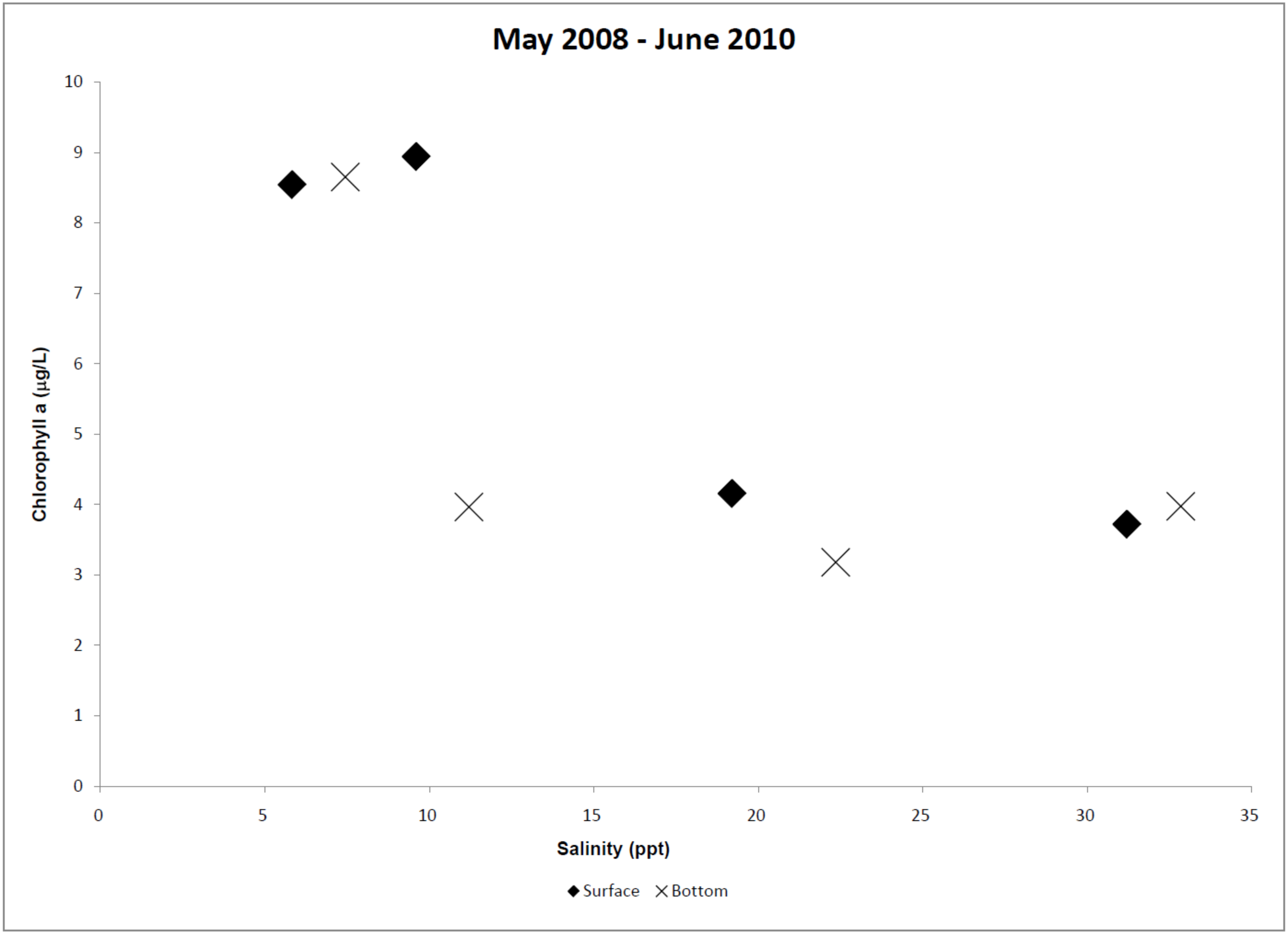


Figure 1.15. Correlation between chlorophyll a and salinity in the Caloosahatchee estuary.

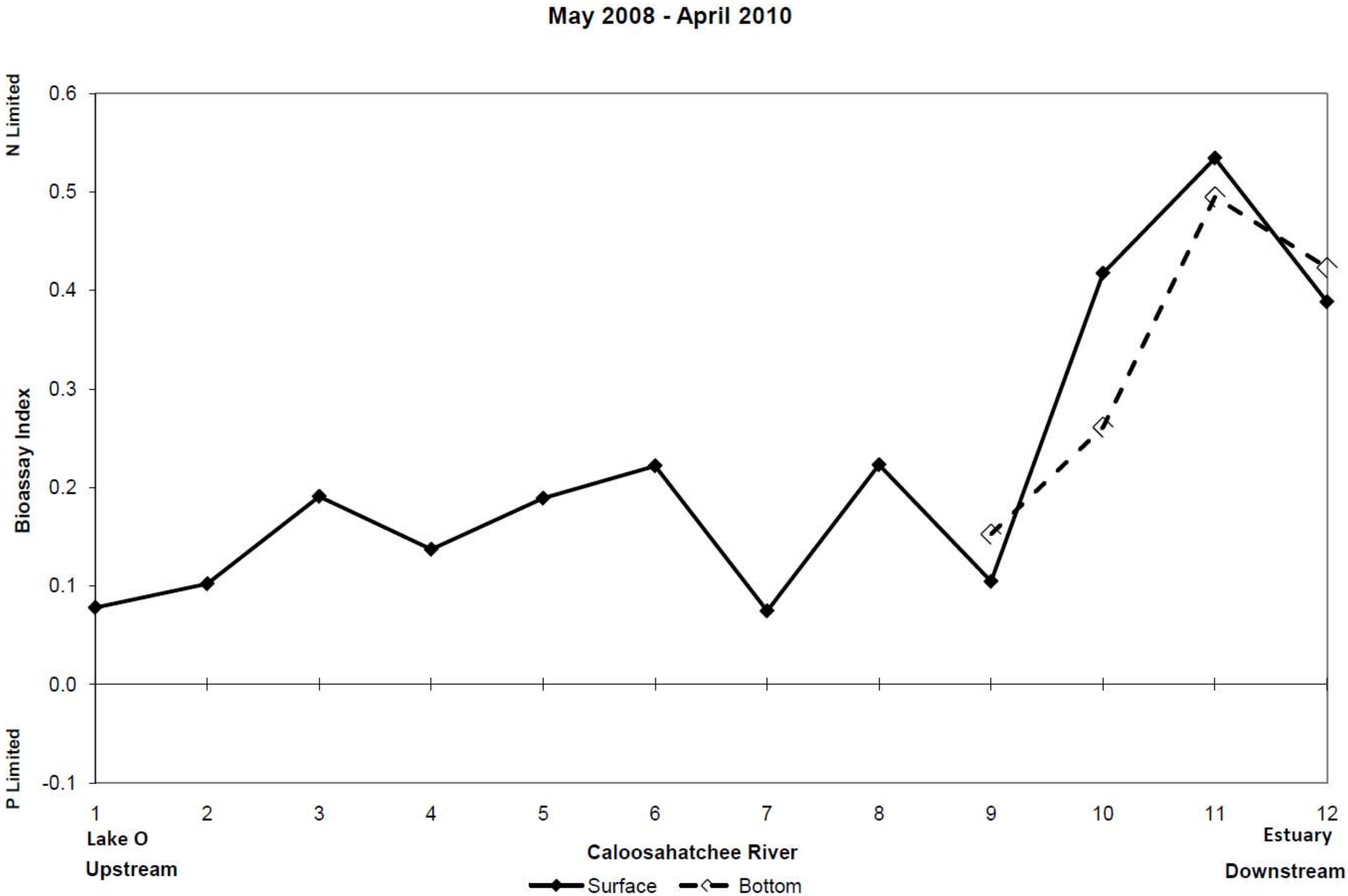


Figure 1.16. Average nutrient bioassay index along the Caloosahatchee River and estuary. Positive numbers indicate nitrogen limitation and negative numbers indicate phosphorus limitation.

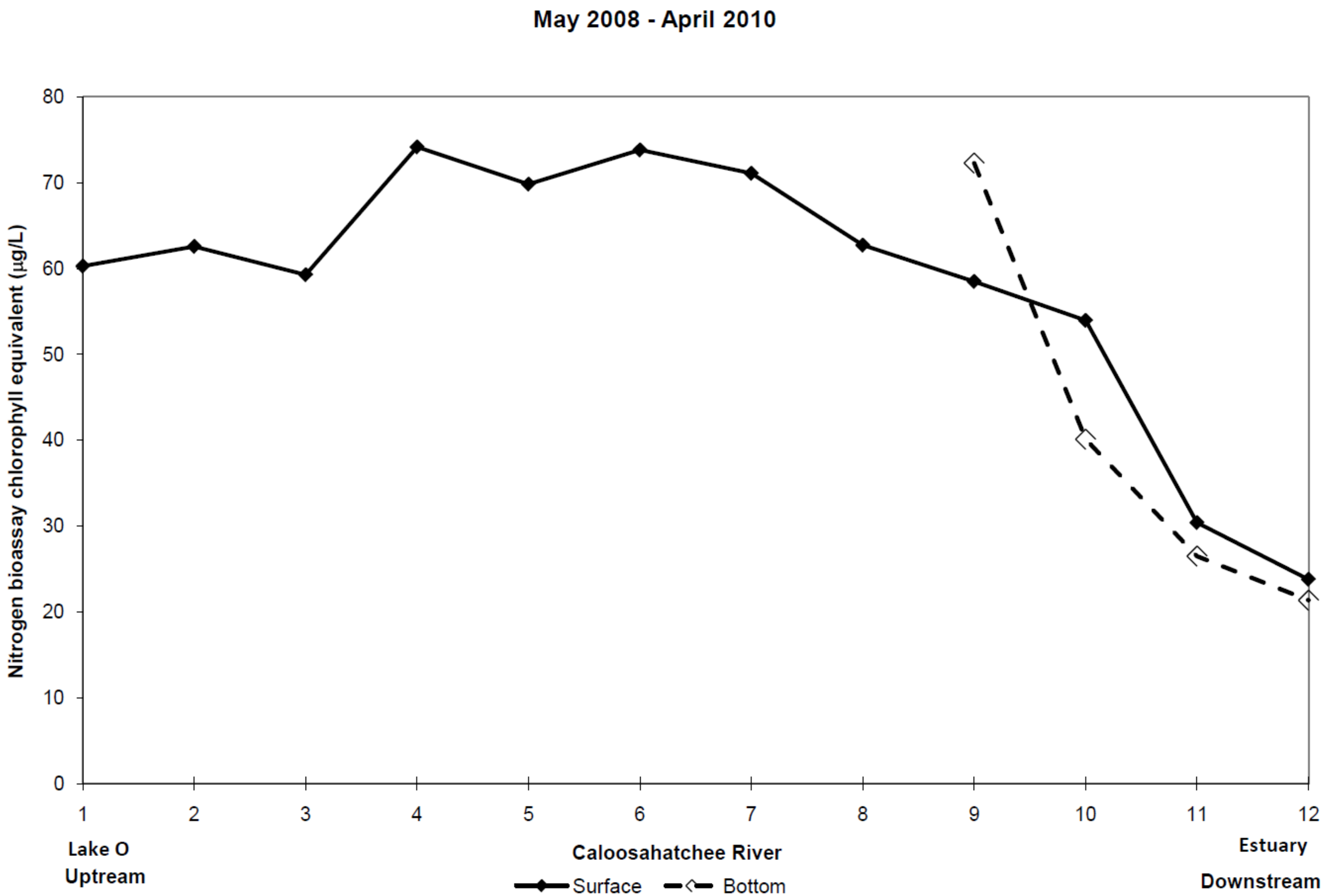


Figure 1.17. Average potential algal abundance produced from bioavailable nitrogen along the Caloosahatchee River and estuary.

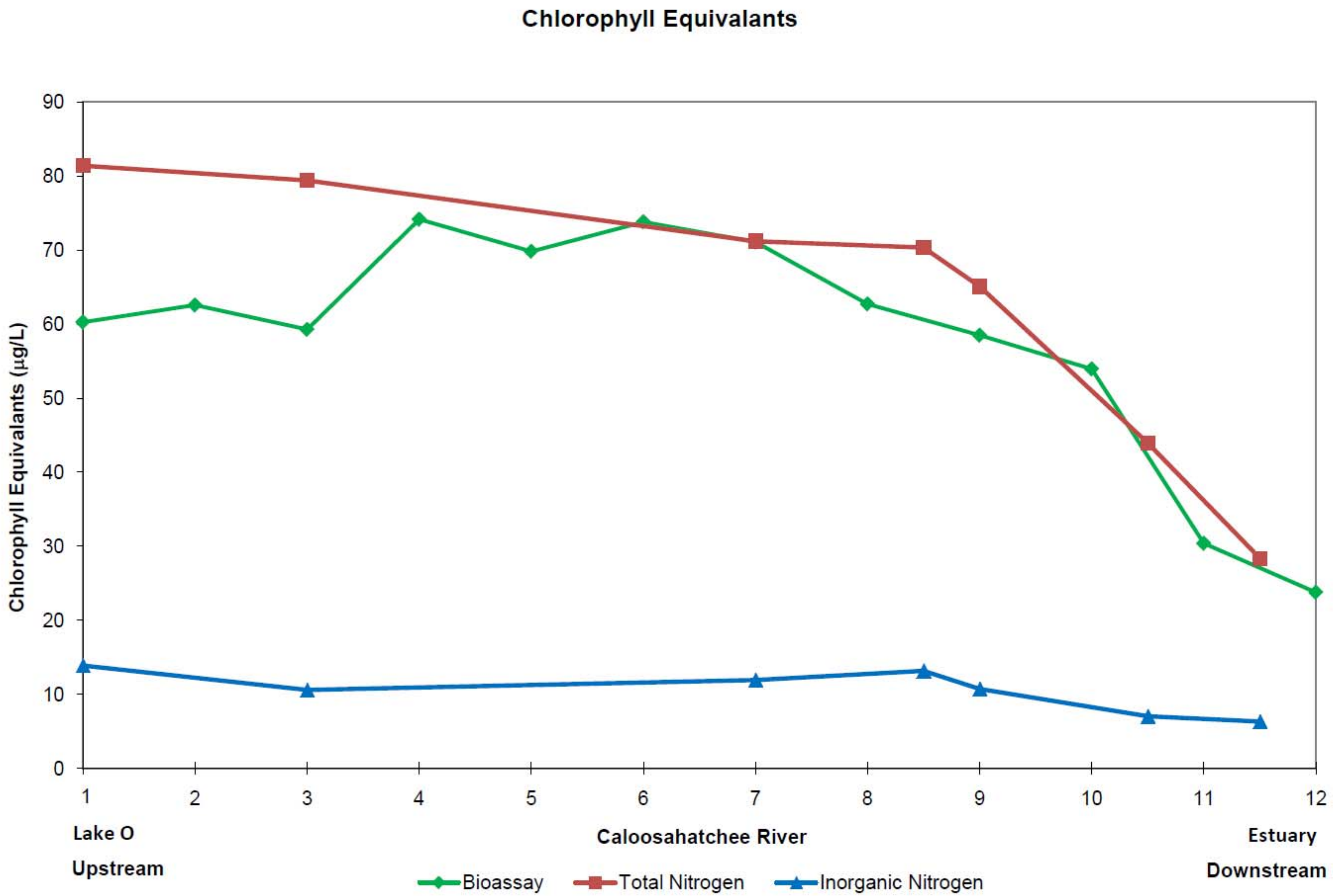


Figure 1.18. Average potential algal abundance produced from bioavailable nitrogen along the Caloosahatchee River and estuary in comparison to potential algal abundance produced from inorganic and total nitrogen as measured by the South Florida Water Management District.

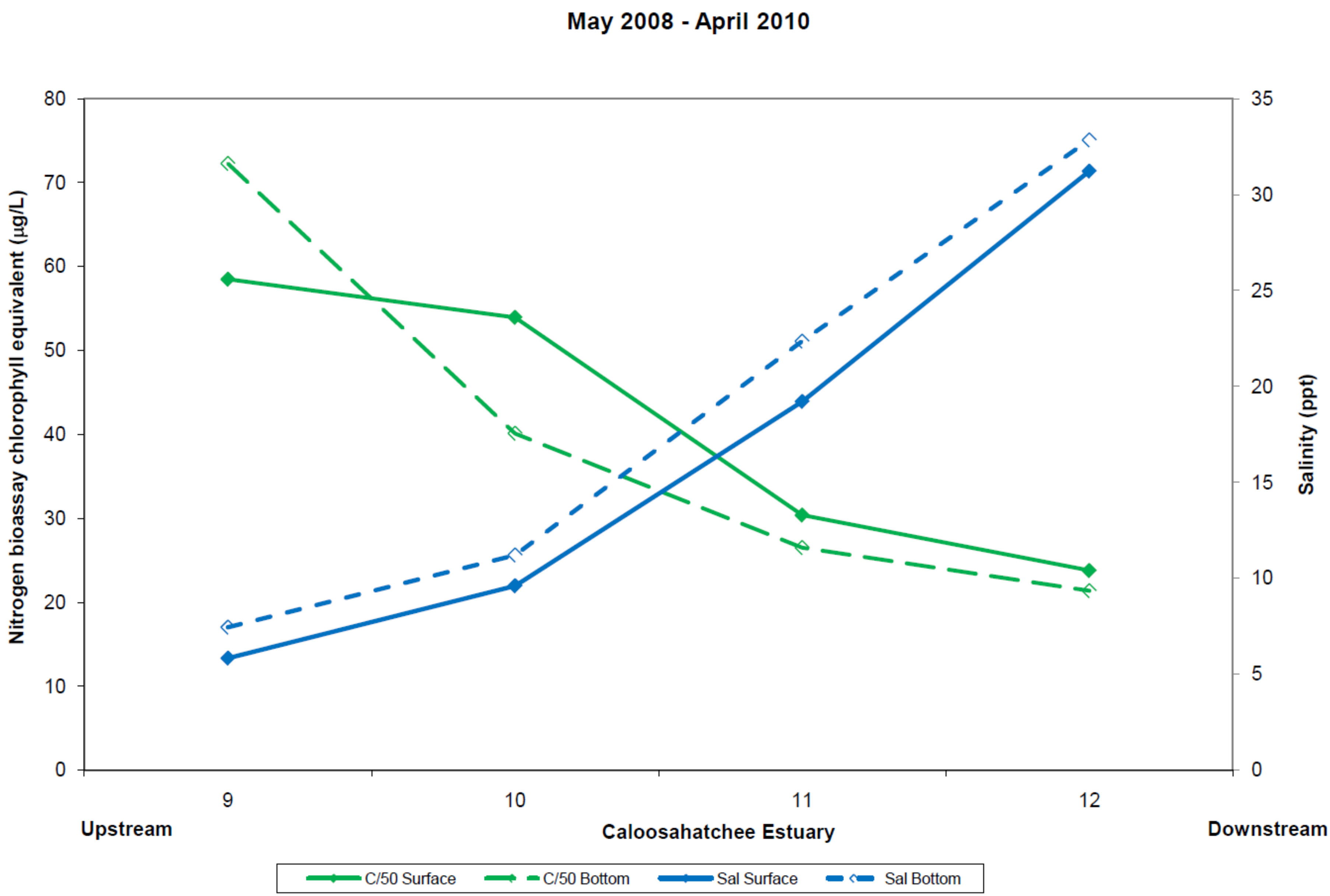


Figure 1.19. Plot of potential algal abundance produced from bioavailable nitrogen and salinity along the Caloosahatchee estuary.

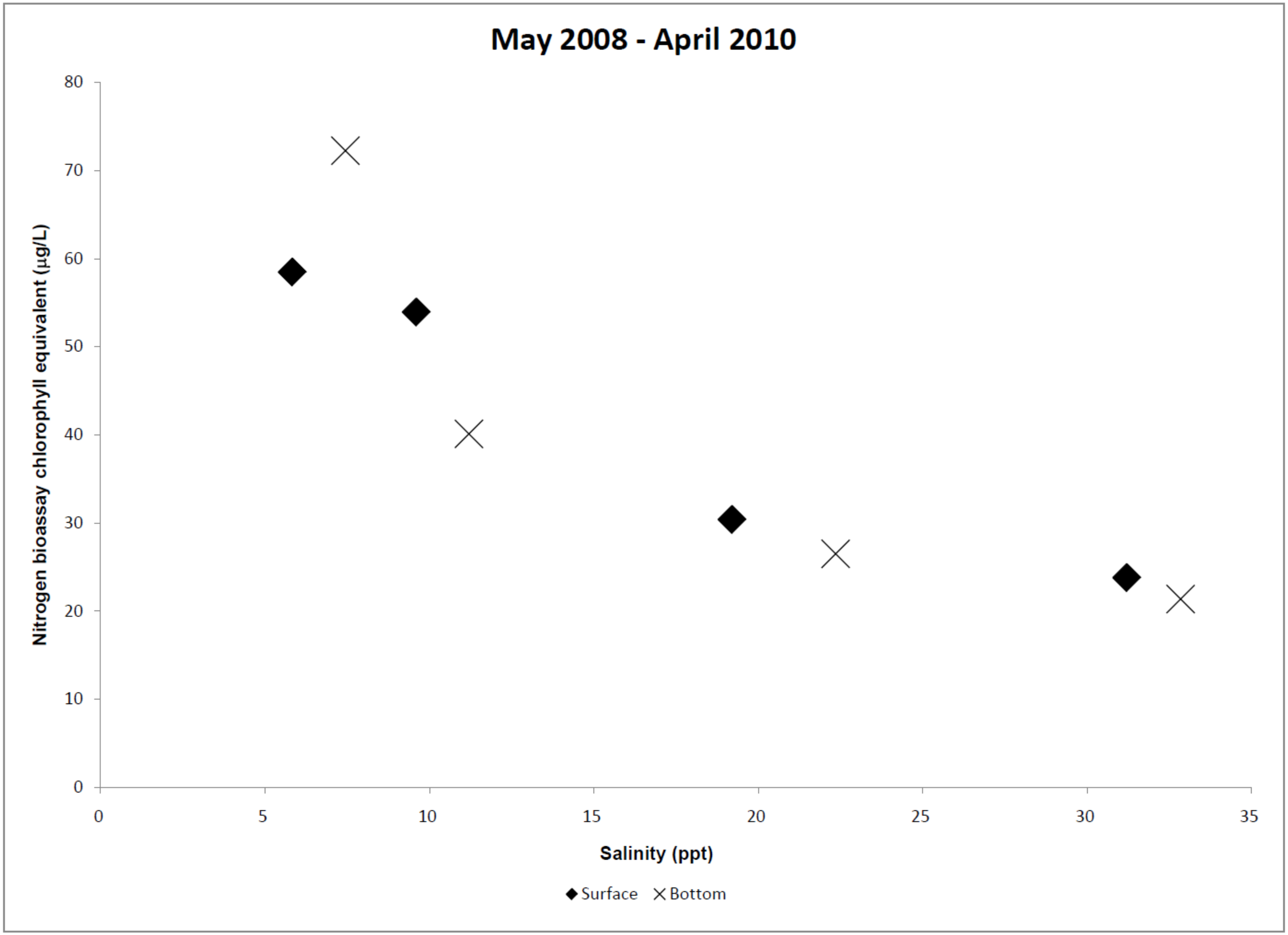


Figure 1.20. Correlation between potential algal abundance produced from bioavailable nitrogen and salinity in the Caloosahatchee estuary.

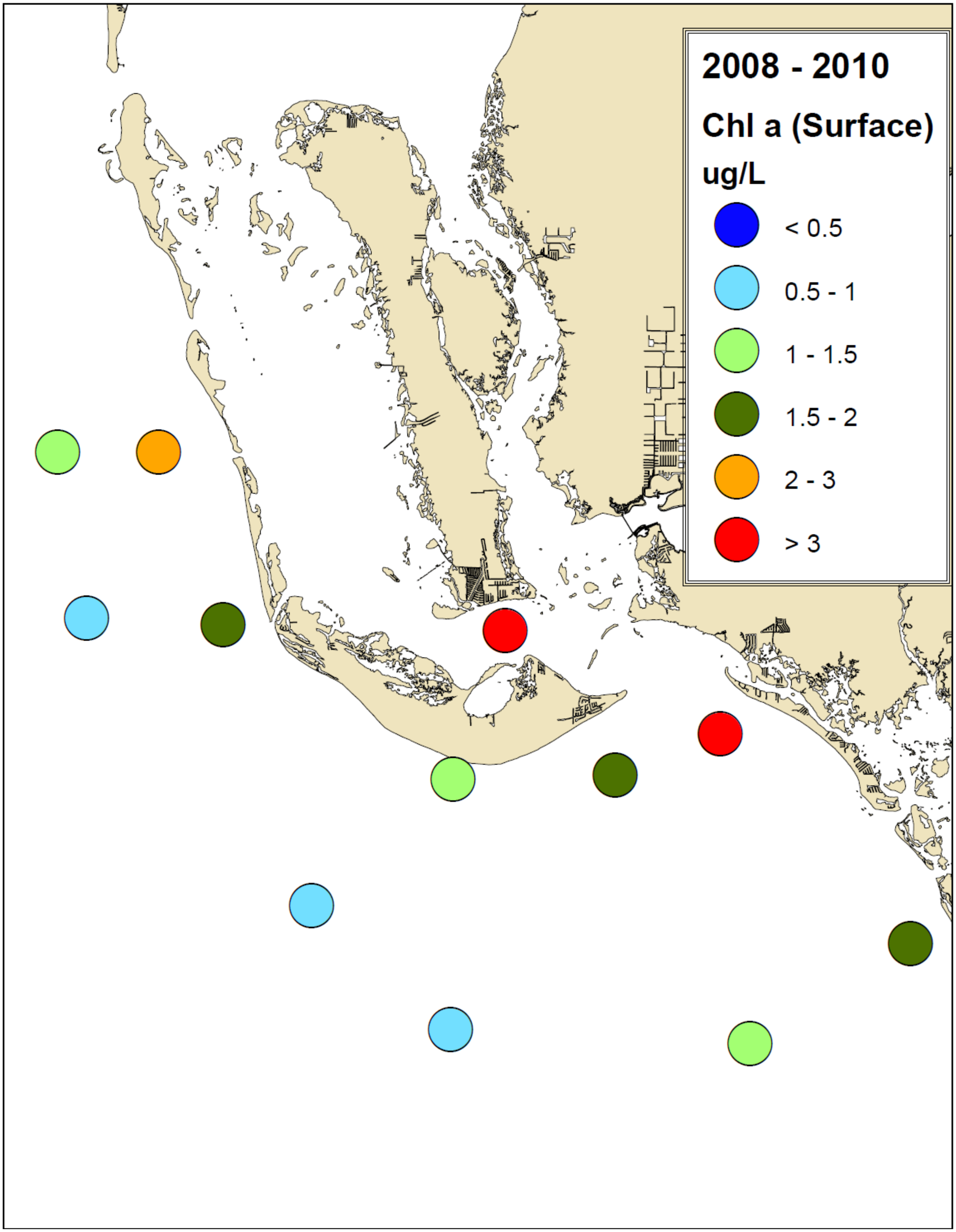


Figure 1.21. Map of average chlorophyll a concentrations in the Gulf of Mexico off Sanibel Island in surface waters.

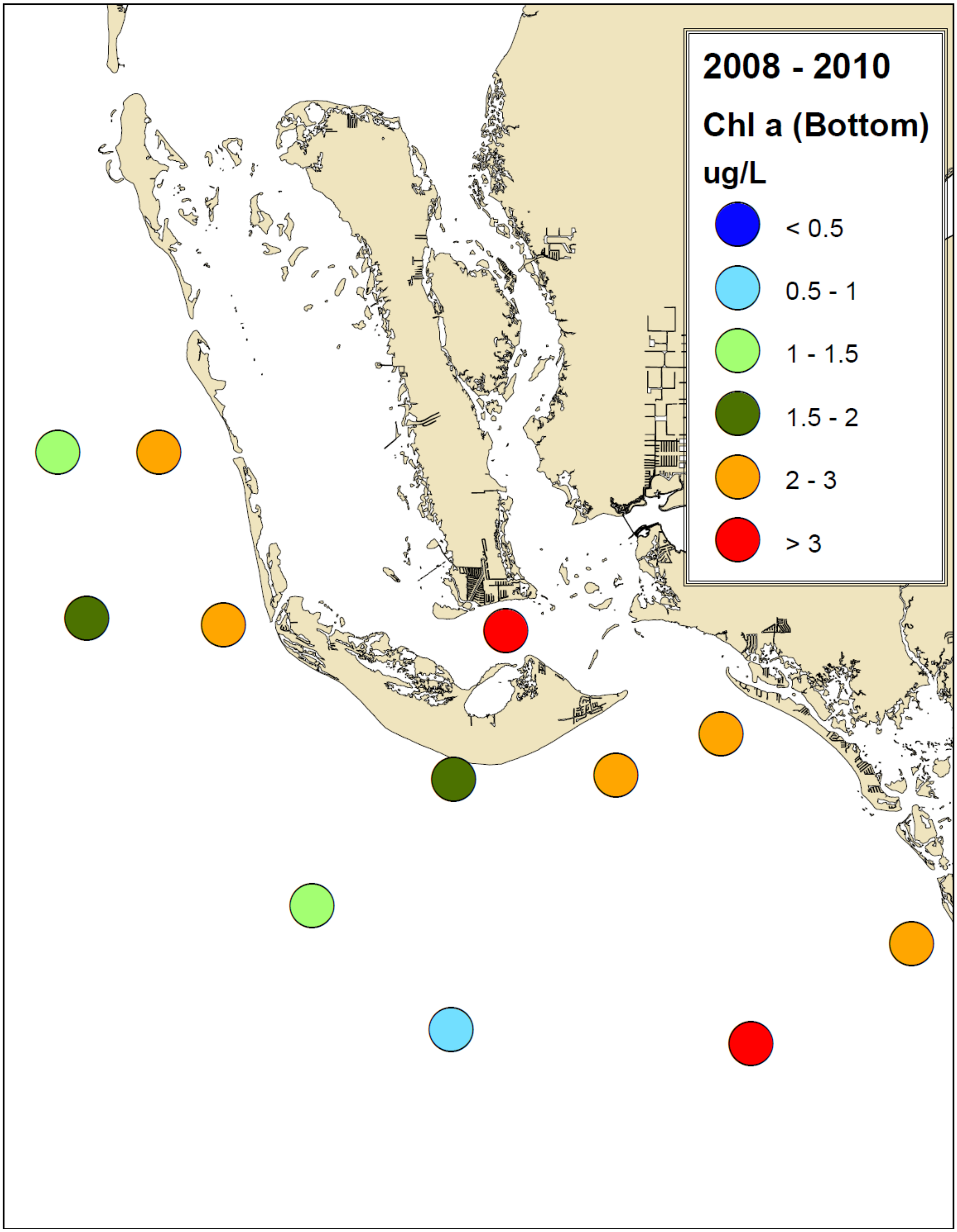


Figure 1.22. Map of average chlorophyll a concentrations in the Gulf of Mexico off Sanibel Island in bottom waters.

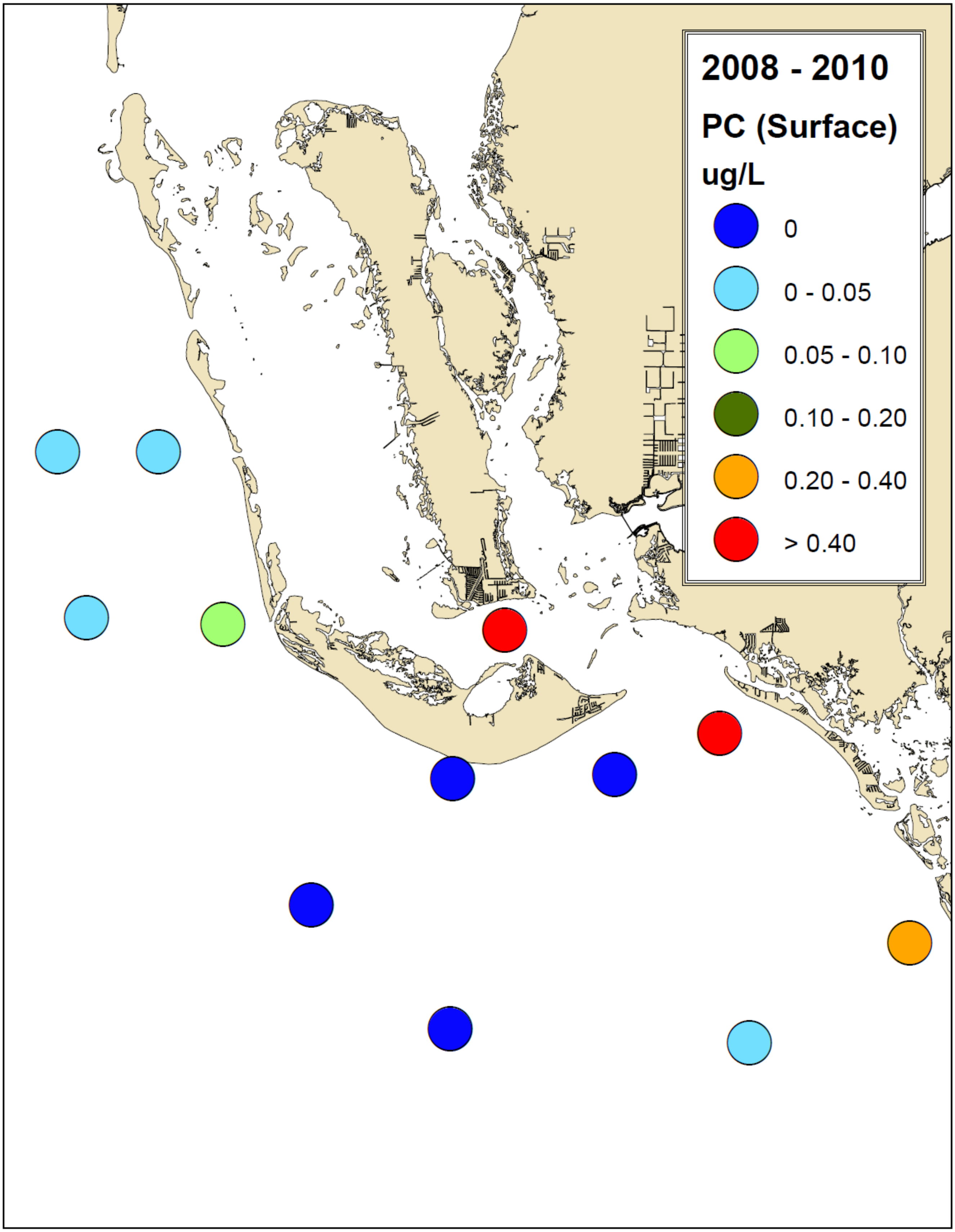


Figure 1.23. Map of average phycocyanin concentrations in the Gulf of Mexico off Sanibel Island in surface waters.

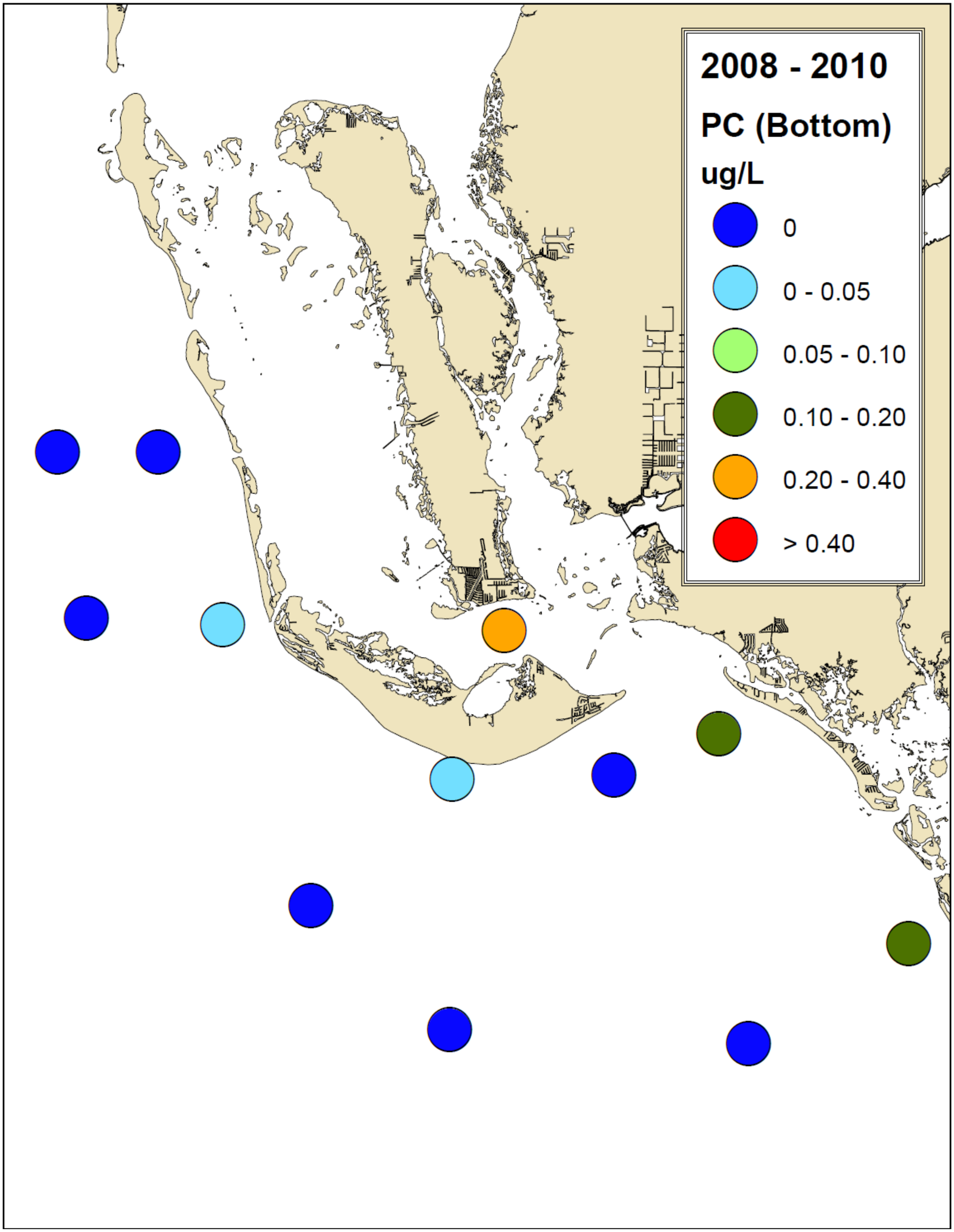


Figure 1.24. Map of average phycocyanin concentrations in the Gulf of Mexico off Sanibel Island in bottom waters.

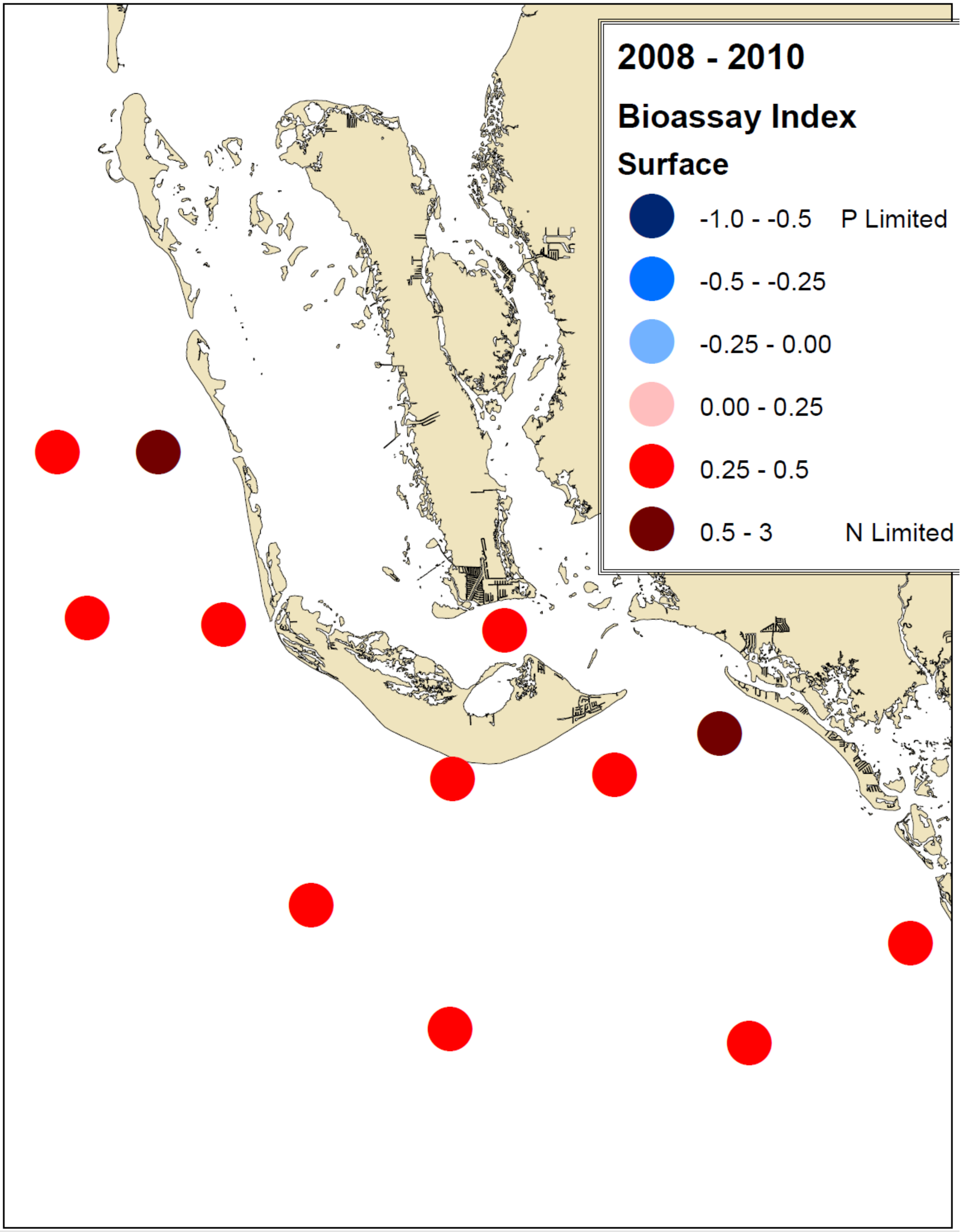


Figure 1.25. Map of average nutrient bioassay index in the Gulf of Mexico off Sanibel Island in surface waters. Positive numbers indicate nitrogen limitation and negative numbers indicate phosphorus limitation.

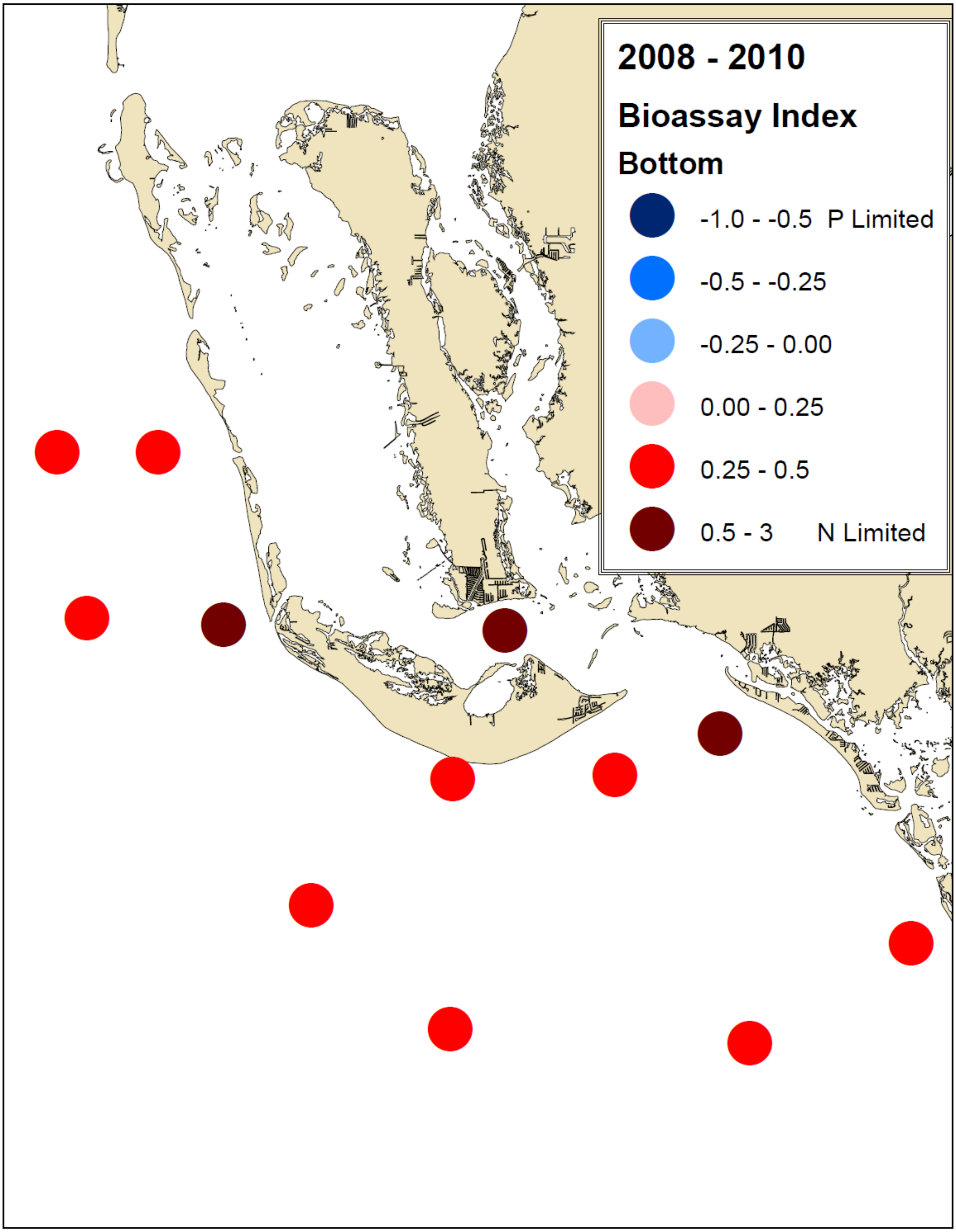


Figure 1.26. Map of average nutrient bioassay index in the Gulf of Mexico off Sanibel Island in bottom waters. Positive numbers indicate nitrogen limitation and negative numbers indicate phosphorus limitation.

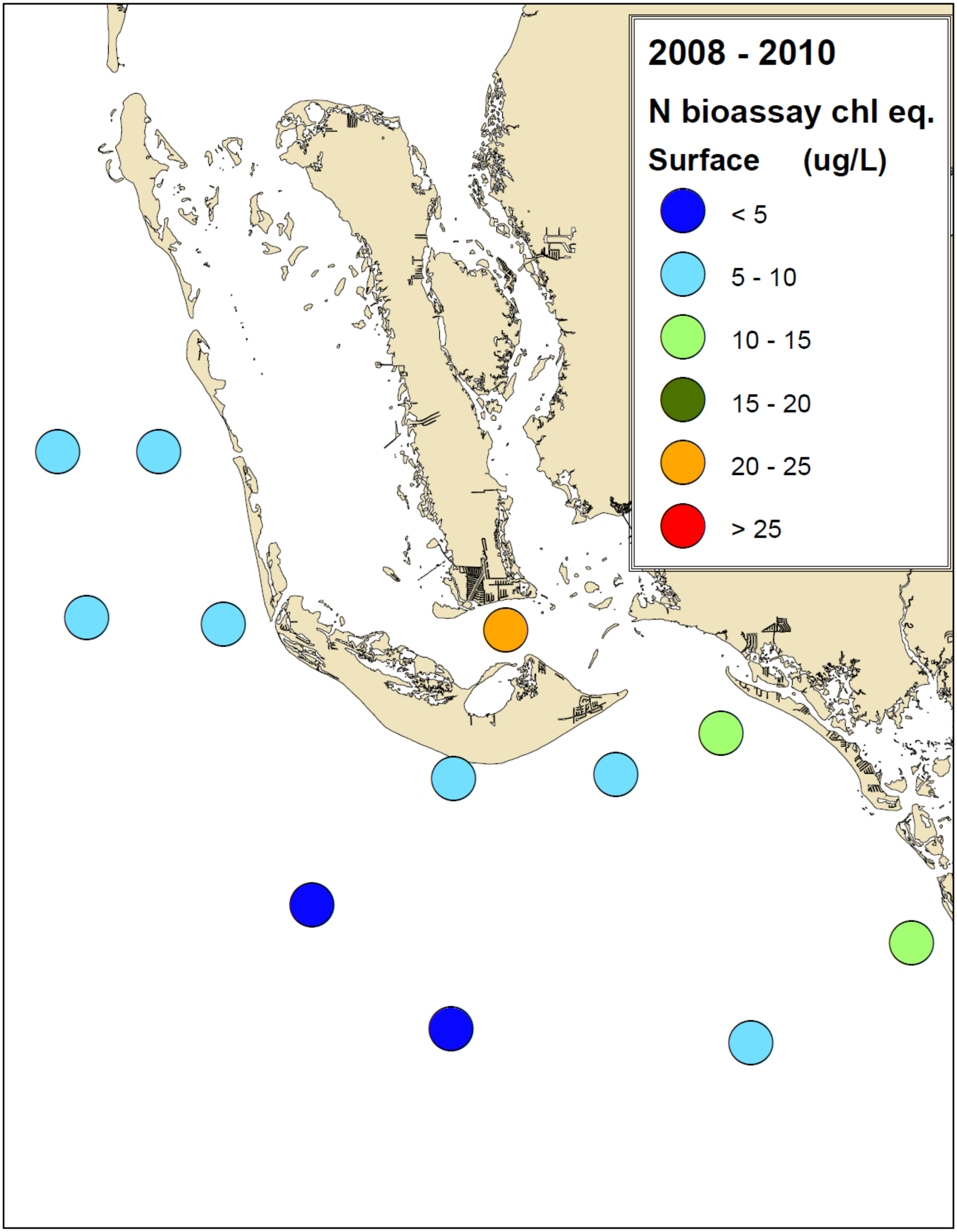


Figure 1.27. Map of average potential algal abundance produced from bioavailable nitrogen in the Gulf of Mexico off Sanibel Island in surface waters.

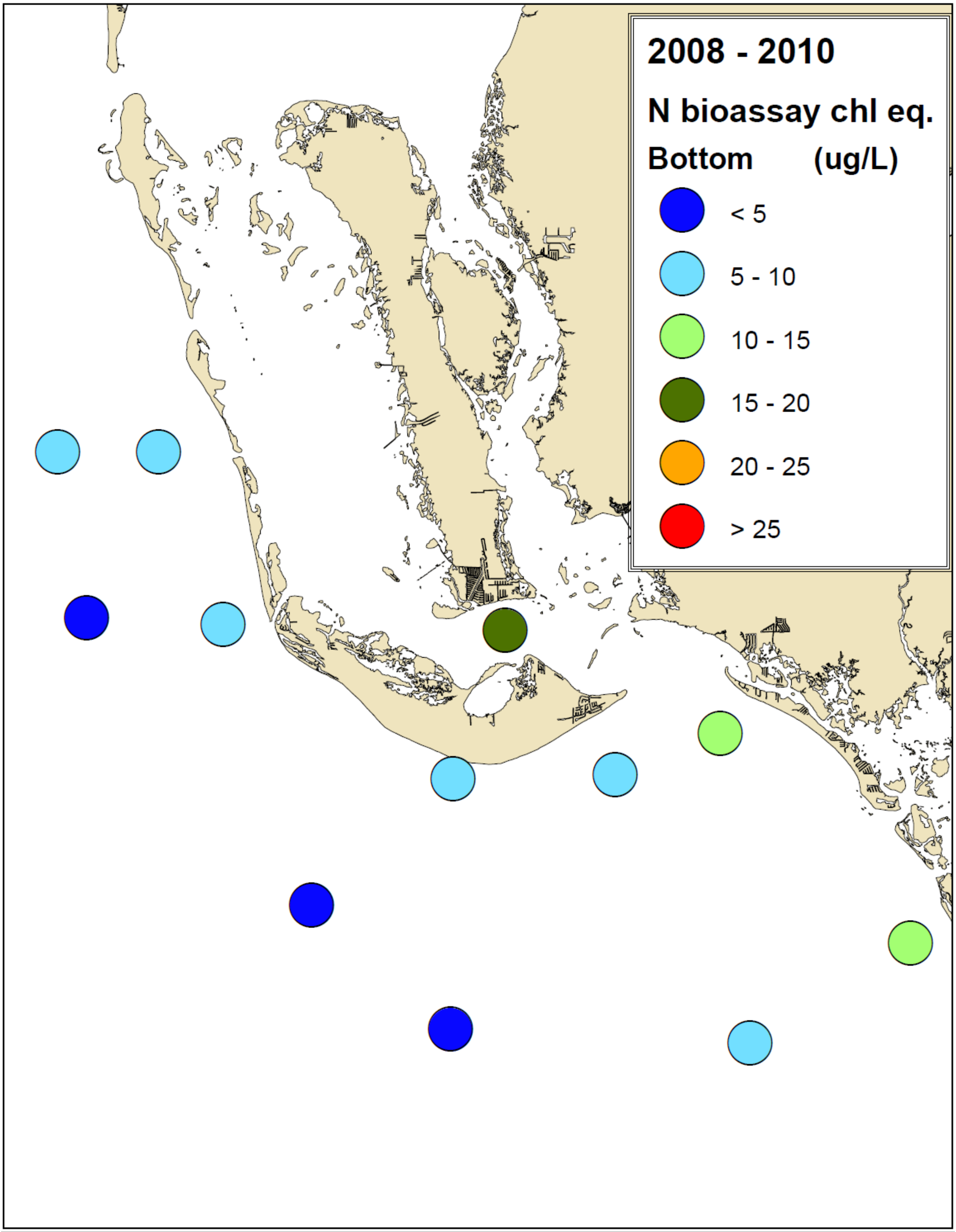


Figure 1.28. Map of average potential algal abundance produced from bioavailable nitrogen in the Gulf of Mexico off Sanibel Island in bottom waters.

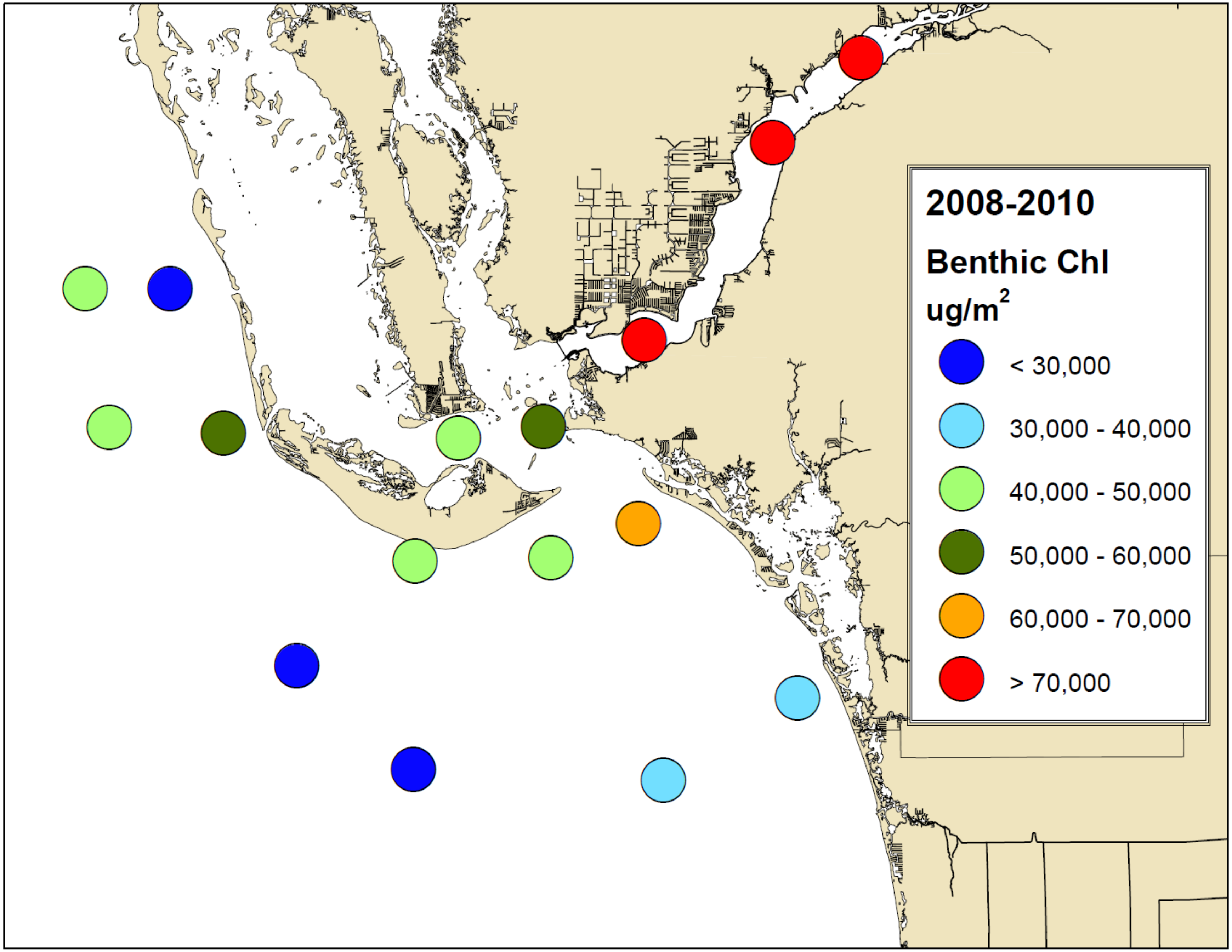


Figure 1.29. Map of average benthic chlorophyll a concentrations as an indication of benthic microalgae in the Gulf of Mexico off Sanibel Island.

Table 2.1. Grain Size and Sedimentary Organic Matter Content

Stations	Grain Size (< 1mm)	Sed OC (mg C/gdw)	Sed N (mg N/gdw)	C:N	$\delta^{13}C$	$\delta^{15}N$
GOM04	39%	-	-	-	-	-
GOM06	55%	8.59	1.09	9.0	-19.6	3.4
GOM16	90%	2.33	0.309	8.8	-18.6	1.5

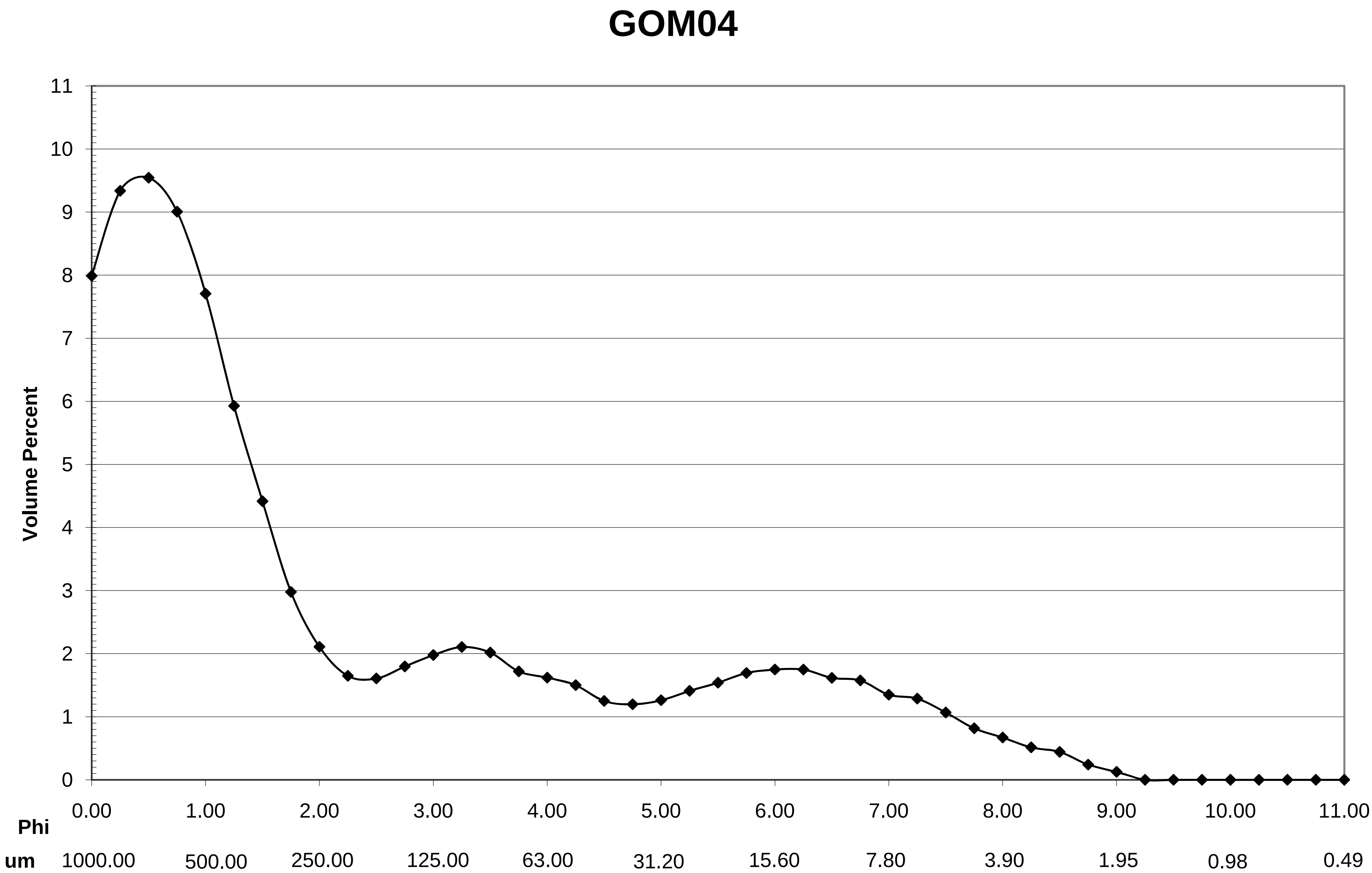


Figure 2.1. Sediment grain size histogram for GOM04 for the fraction of sediment smaller than 1mm.

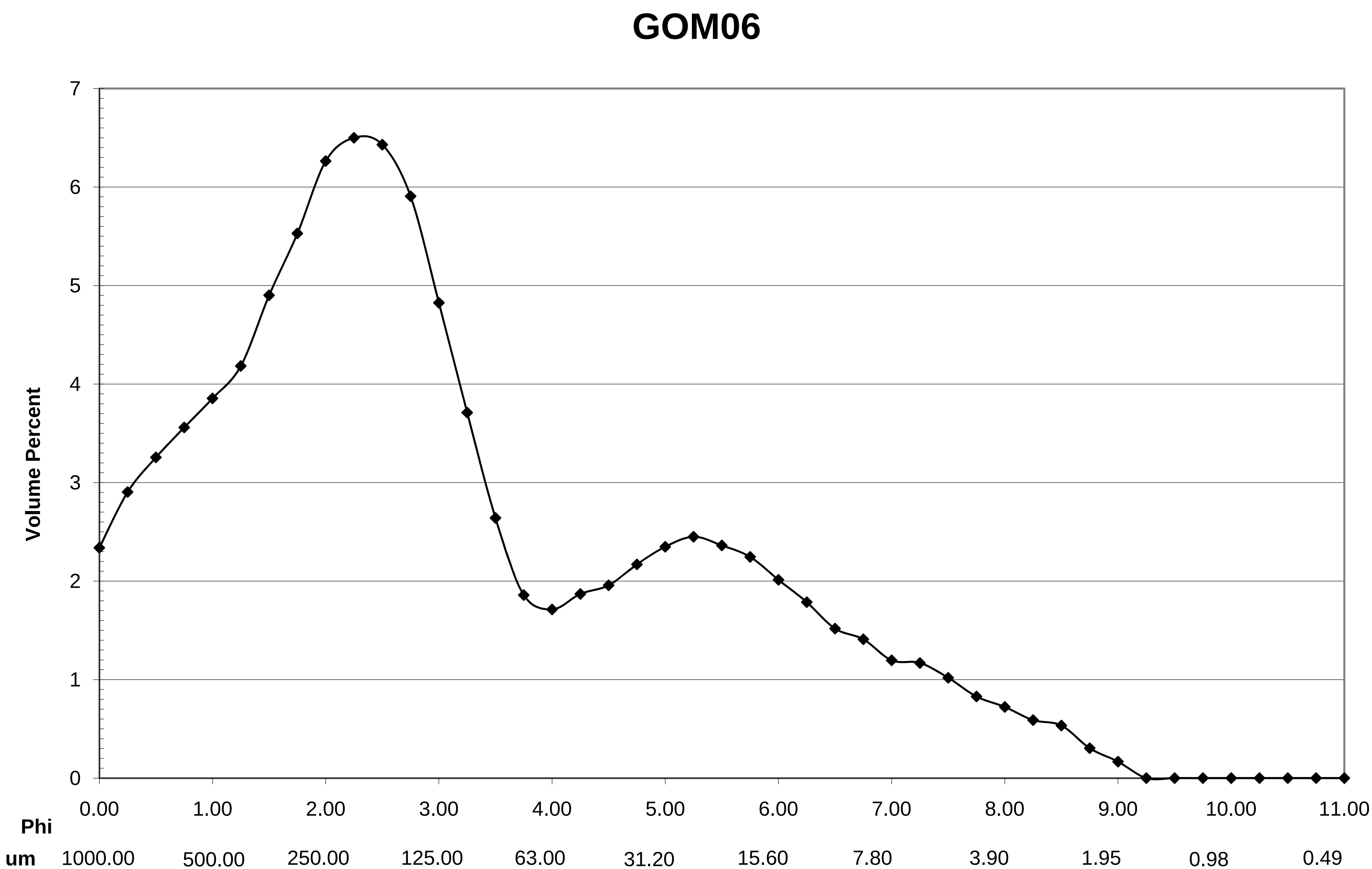


Figure 2.2. Sediment grain size histogram for GOM04 for the fraction of sediment smaller than 1mm.

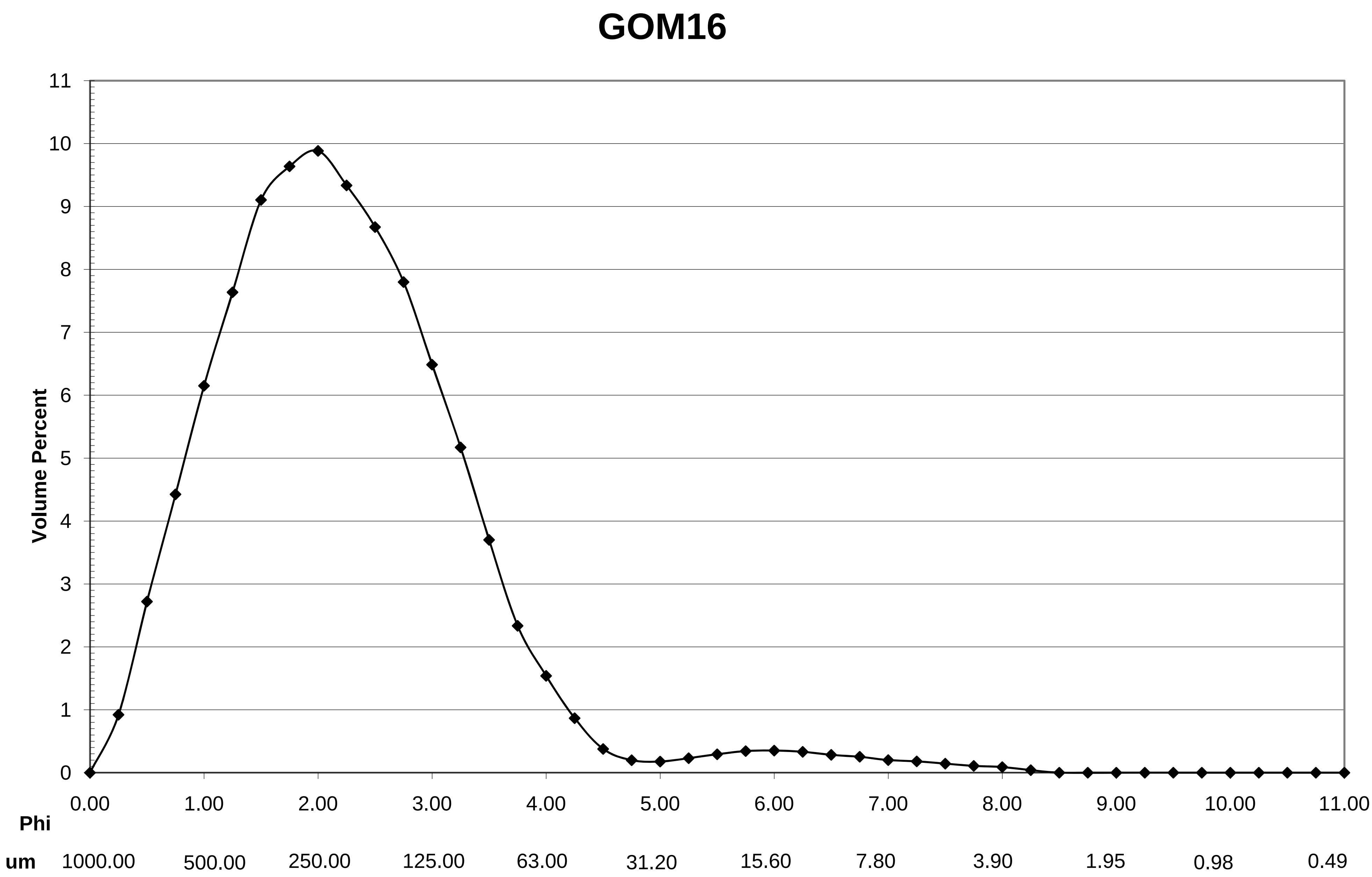


Figure 2.3. Sediment grain size histogram for GOM04 for the fraction of sediment smaller than 1mm.

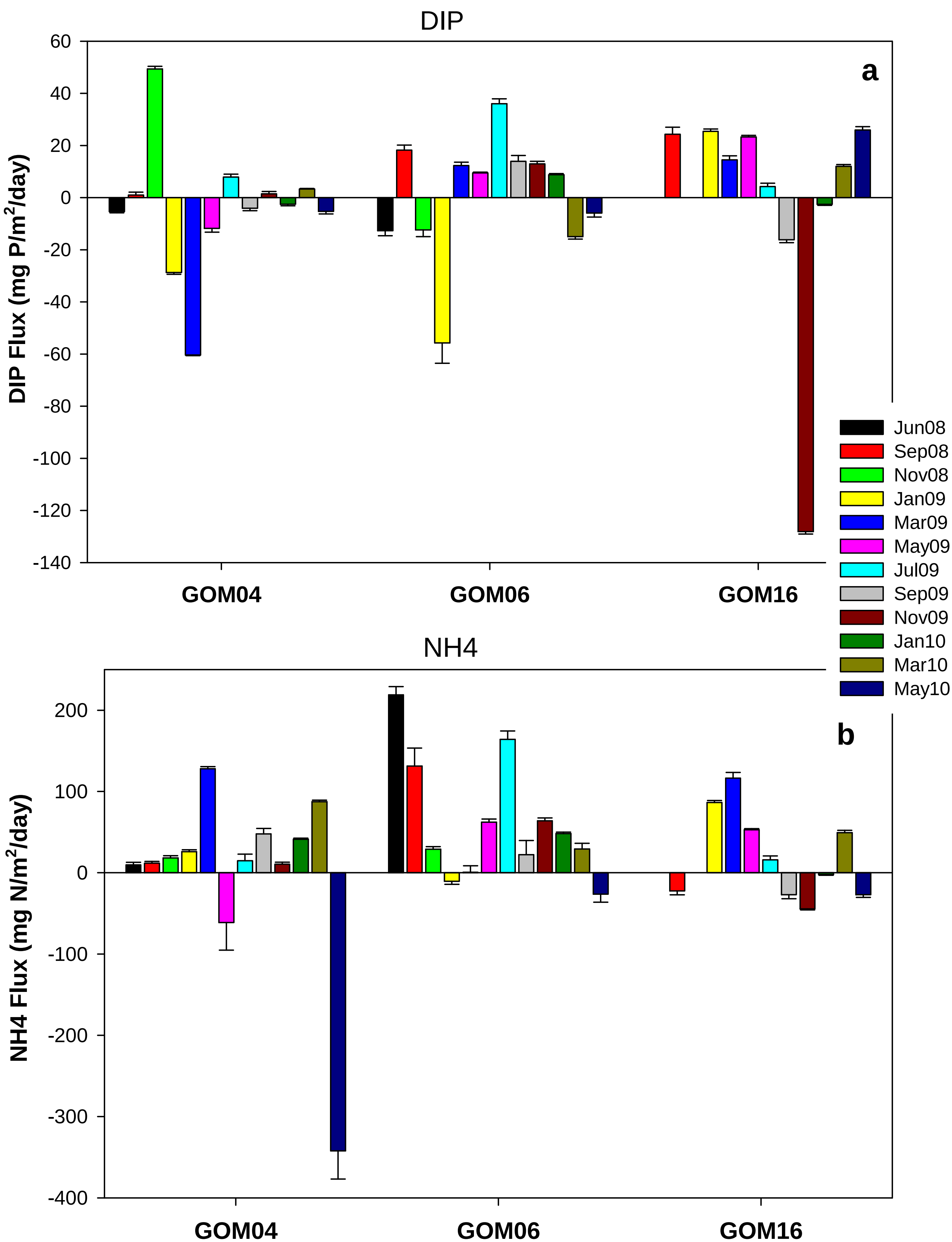


Figure 2.4. (a) Dissolved inorganic phosphorus and (b) ammonium fluxes from sediments collected from GOM04, GOM06 and GOM16 for June 2008 - 2010. Error bars represent 1 standard error for each set of cores.

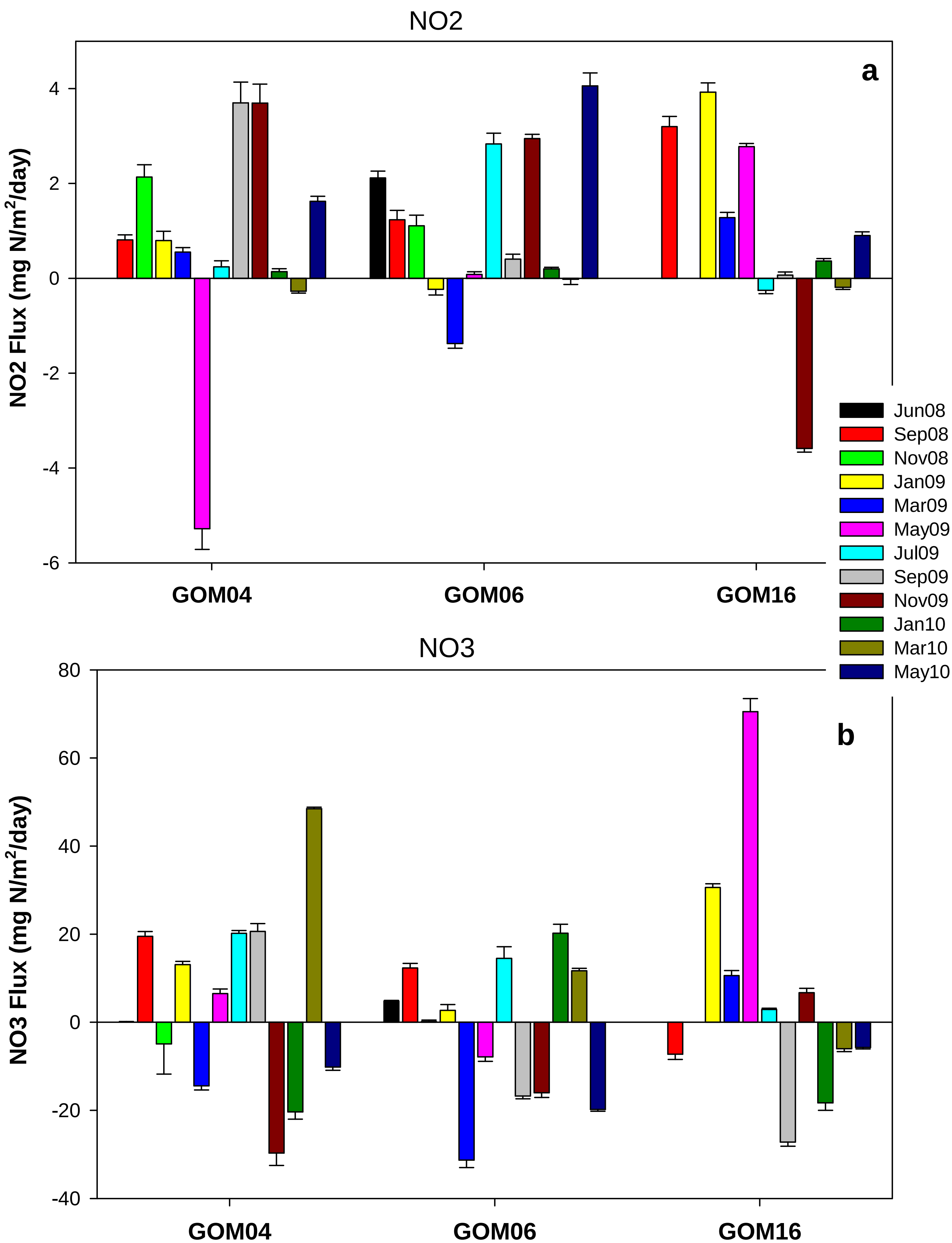


Figure 2.5. (a) Nitrite and (b) nitrate fluxes from sediments collected from GOM04, GOM06 and GOM16 for June 2008 - 2010. Error bars represent 1 standard error for each set of cores.

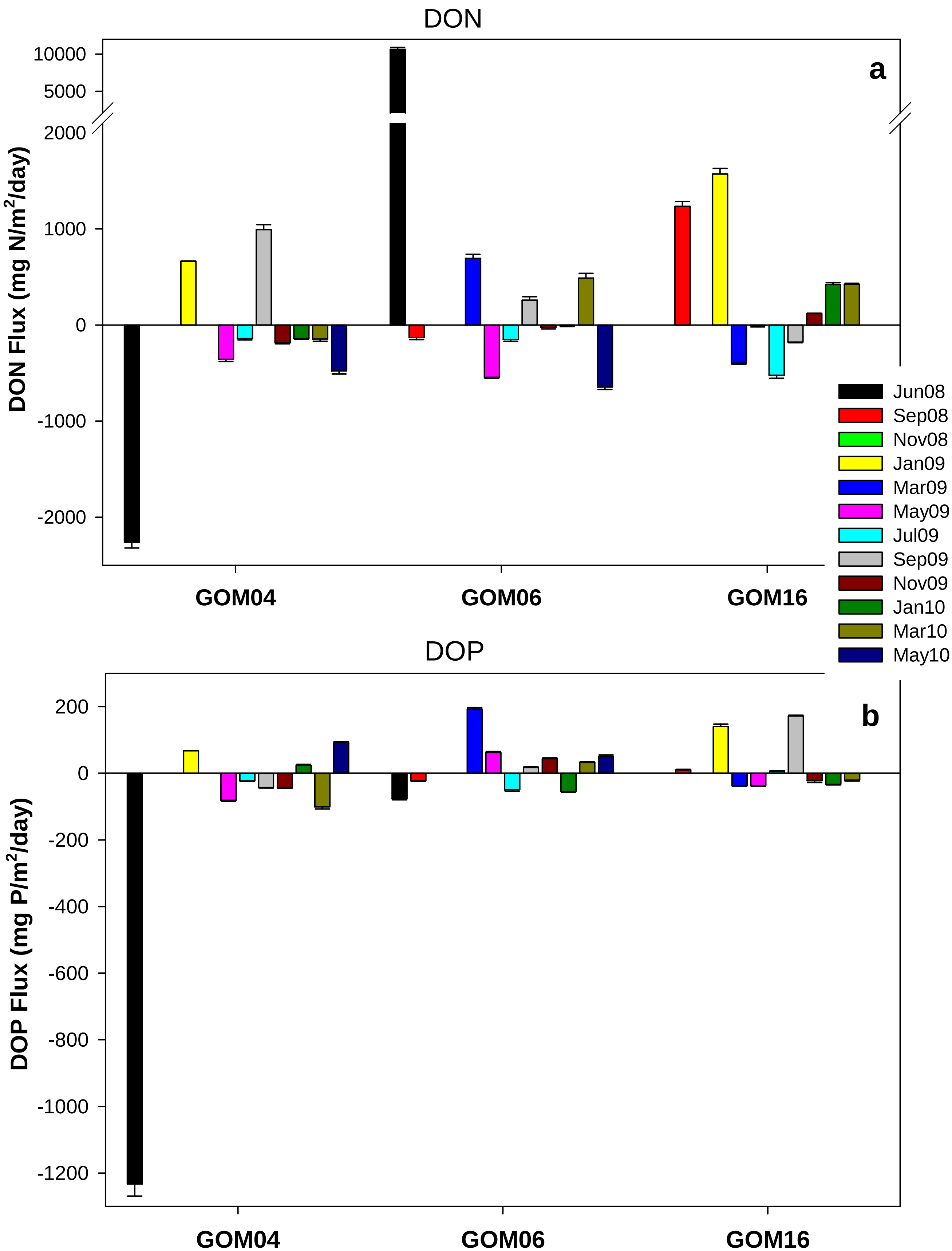


Figure 2.6. Dissolved organic (a) nitrogen and (b) phosphorus fluxes from sediments collected from GOM04, GOM06 and GOM16 for June 2008 - 2010. Error bars represent 1 standard error for each set of cores.

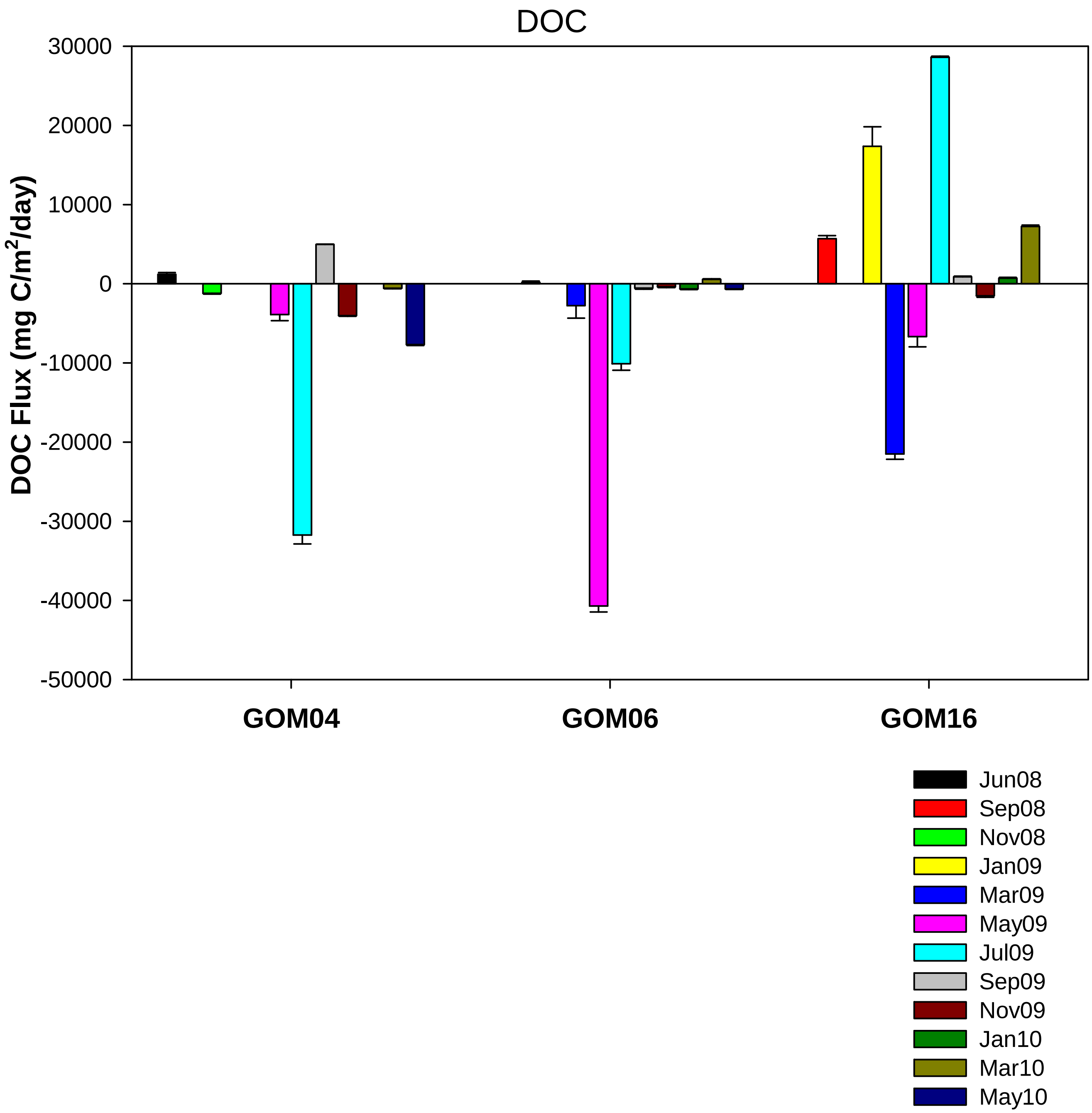


Figure 2.7. Dissolved organic carbon fluxes from sediments collected from GOM04, GOM06 and GOM16 for June 2008 - 2010. Error bars represent 1 standard error for each set of cores.

Table 3.1. April 2009 nutrient concentrations and radium activities from the Caloosahatchee River Estuary groundwater study.

Station ID	Sample Type	Latitude (°N)	Longitude (°W)	Salinity	SiO_4^-	PO_4^{3-}	NO_3^-+NO_2^-	NH_4^+	TDN	^{224}Ra	^{223}Ra	^{226}Ra	^{228}Ra	Water Age
					(µmol L^{-1})					(dpm 100 L^{-1})				(days)
G1	GoM surface	26.4182	-82.0190	36.36	4.5	<0.05	0.00	3.7		5.5	4.0	36.8	19.0	23.9
G3	GoM surface	26.4160	-82.2061	36.28	2.6	<0.05	0.08	3.8	9.3	3.3	1.1	22.1	9.4	18.9
G5	GoM surface	26.3040	-81.9541	36.61	7.8	<0.05	<0.05	4.2		6.7	6.7	61.7	36.9	41.8
G6	GoM surface	26.4353	-81.9631		3.0	<0.05	0.16	5.2	29.1	24.4	13.2	74.1	42.4	9.5
G7	GoM surface	26.3470	-81.8780		4.0	<0.05	<0.05	4.2	20.6	10.5	11.2	68.4	36.1	23.8
G8	GoM surface	26.3612	-82.1631	36.34	10.7	0.10	0.51	5.9	10.6	2.0	1.4	18.8	8.0	28.7
G11	GoM surface	26.3087	-82.0963	36.26	5.6	0.40	<0.05	5.5		5.6	4.6	47.2	21.2	27.0
Mudhole	GoM surface	26.2523	-82.0027	36.45	5.1	0.00	0.54	3.0		4.2	4.5	55.7	29.2	54.0
C1	Cal. Estuary	26.6781	-81.8385	9.54	23.2	1.67	1.07	1.3		19.5	10.7	290.4	36.2	10.5
C2	Cal. Estuary	26.6973	-81.7991	5.46	15.5	1.11	3.69	3.8	34.0	13.1	6.7	280.7	33.9	16.7
C3	Cal. Estuary	26.7215	-81.7339	3.26	23.7	1.64	4.61	3.9	48.4	6.5	17.4	195.1	20.3	21.5
C4	Cal. Estuary	26.7234	-81.7006	2.52	54.6	3.01	7.62	4.2	68.2	7.4	4.7	190.8	20.4	18.1
C5	Cal. Estuary	26.4837	-82.0156	35.82	19.3	0.60	0.54	5.0		38.6	21.0	103.4	47.9	5.2
C6	Cal. Estuary	26.5232	-82.0076	32.87	17.2	0.60	0.71	9.3	27.0	33.9	23.7	200.7	62.5	10.4
C7	Cal. Estuary	26.5312	-81.9597	27.78	19.6	0.99	0.29	5.6		23.9	27.9	287.1	68.6	19.1
C8	Cal. Estuary	26.5573	-81.9301	24.88	10.3	0.92	0.36	5.4	40.4	21.2	18.3	381.8	74.7	24.6
C9	Cal. Estuary	26.6094	-81.8964	19.75	18.6	1.85	0.40	2.1		25.2	14.8	508.0	78.9	21.4
C10	Cal. Estuary	26.6483	-81.8724	17.35	11.7	0.95	0.71	3.3		26.7	17.4	439.8	62.6	14.6
C11	Cal. River	26.7211	-81.6922	0.35	66.3	2.45	8.20	3.2	79.8	3.7	2.5	13.0	14.6	27.9
C12	Cal. River	26.7885	-81.3030	0.26	82.5	0.94	3.39	1.3	89.3	6.0	2.2	71.8	13.8	14.3
C13	Cal. River	26.8394	-81.0809	0.28	113.7	0.93	9.83	5.1	78.3	10.9	1.6	6.6	18.5	9.1
GW1	Monit. Well	26.6711	-81.8799	0.26	144.6	3.08	0.78	24.0	81.7	14.0	8.6	49.0	8.7	
GW2	Monit. Well	26.6711	-81.8799		62.8	3.85	0.32	130.7	169.4	214.2	41.5	485.2	279.9	
GW2B	Monit. Well	26.5100	-82.0846	40.00						709.7	143.4	2443.9	945.4	
GW3	Monit. Well	26.6397	-81.8689	0.40	60.2	0.62	0.58	10.4	29.7	38.3	12.4	428.1	32.2	
GW4	Monit. Well	26.5588	-81.8982	0.43	88.3	0.67	0.76	28.5	122.6	56.1	24.9	308.0	59.3	
GW5	Monit. Well	26.5238	-81.9202	1.53	154.1	0.57	0.65	76.5	92.0	58.3	48.5	735.0	87.6	
GW6	Monit. Well	26.5185	-81.9357	1.16	89.7	2.58	0.38	57.0	100.3	65.4	63.3	2160.8	90.4	
GW7	Monit. Well	26.7114	-81.8382	0.29	108.6	15.37	1.80	53.8	70.8	28.6	-0.4	86.3	15.6	
GW8	Monit. Well	26.7158	-81.8072	0.65	204.6	2.72	0.82	16.8	28.2	32.2	21.7	154.1	9.9	

GW9	Monit. Well	26.7332	-81.7128	0.39	166.7	0.70	0.30	63.3	88.4	32.1	43.9	1527.7	43.4
GW10	Monit. Well	26.7346	-81.7309	0.43	161.1	0.37	7.76	19.5	47.4	49.3	14.5	162.1	30.4
GW11	Monit. Well	26.7046	-81.6797	0.23	167.9	0.34	0.76	24.2	40.1	23.3	29.5	492.6	21.8
GW12	Monit. Well	26.6805	-81.7832	0.22	81.4	0.99	0.52	4.3	38.6	26.3	13.2	128.8	21.2
GW13	Monit. Well	26.5238	-81.9202	0.37	229.5	0.40	0.55	15.5	40.4	11.8	0.1	255.5	24.3
GW14	Monit. Well	26.3339	-81.8046	3.64	239.5	0.38	0.10	26.9	36.1	93.6	272.3	3445.5	47.0
GW15	Monit. Well	26.3339	-81.8046	2.25	283.6	0.53	0.92	29.3	49.9	122.6	129.2	1214.3	79.5
GW16	Monit. Well	26.3339	-81.8046	0.80	99.7	2.09	3.33	97.7	189.0	139.6	28.6	342.6	94.3
GW17	Monit. Well	26.3875	-81.8262	0.37	32.8	3.17	0.68	26.3	48.4	139.4	12.2	141.7	129.6
GW18	Monit. Well	26.4419	-81.8346	0.25	62.5	0.35	0.94	29.9	45.7	52.9	28.9	234.9	20.3

Table 3.2. October 2009 nutrient concentrations and radium activities from the Caloosahatchee River Estuary groundwater study.

Station ID	Sample Type	Latitude (°N)	Longitude (°W)	Salinity	SiO_4^-	PO_4^{3-}	$NO_3^-+NO_2^-$	NH_4^+	TDN	^{224}Ra	^{223}Ra	^{226}Ra	^{228}Ra	Water Age (days)
						(µmol L^{-1})				(dpm 100 L^{-1})				
G1	GoM surface	26.4190	-82.0222	35.03	15.9	<0.05	0.1	0.8	18.2	8.1	5.8	63.6	24.7	20.7
G3	GoM surface	26.4160	-82.2061	35.39	18.3	0.0	0.2	1.0	16.1	8.6	4.8	55.1	22.3	16.8
G5	GoM surface	26.3038	-81.9540	35.89	6.6	<0.05	2.3	1.4	17.0	3.4	2.5	53.3	20.5	46.4
G6	GoM surface	26.4397	-81.9623		26.0	0.1	0.7	2.0	21.6	17.2	9.9	74.5	29.0	9.0
G7	GoM surface	26.3469	-81.8778	35.55	11.6	<0.05	0.5	0.4	22.2	6.7	4.8	71.7	28.2	30.8
G8	GoM surface	26.3612	-82.1630	36.14	5.5	<0.05	0.3	0.6	27.3	3.1	2.3	61.6	21.2	52.7
G11	GoM surface	26.3086	-82.0963	35.80	6.6	<0.05	0.6	1.7	12.8	20.5	2.0	52.0	19.1	2.6
C1	Cal. Estuary	26.6469	-81.8744	6.33	53.7	2.6	1.7	0.2	33.9	10.0	8.9	242.1	27.7	18.2
C2	Cal. Estuary	26.6707	-81.8482	2.20	46.5	2.8	2.8	0.5	28.2	3.3	3.3	144.8	11.7	24.5
C3	Cal. Estuary	26.6905	-81.8182	0.51	37.1	2.4	1.3	0.3	50.2	2.1	2.9	136.3	10.2	36.9
C4	Cal. Estuary	26.7215	-81.7308	0.34	55.3	2.5	7.1	1.9	45.8	2.2	3.3	120.9	10.1	33.6
C5	Cal. Estuary	26.4920	-82.0154	32.51	30.7	0.3	1.5	4.7	31.5	28.6	16.6	105.0	37.9	6.0
C6	Cal. Estuary	26.5242	-82.0055	33.17	64.2	0.6	1.0	0.3	21.8	29.4	16.1	131.6	46.4	8.1
C7	Cal. Estuary	26.5299	-81.9726	23.69	134.3	1.4	1.3	1.5	12.1	8.1	6.2	58.8	12.7	8.0
C8	Cal. Estuary	26.5410	-81.9414	16.50	128.2	2.4	2.4	1.1	31.5	18.3	14.6	164.5	32.9	10.0
C9	Cal. Estuary	26.5684	-81.9239	12.02	53.3	2.3	0.4	1.1	43.4	10.4	8.7	174.5	27.7	17.3
C10	Cal. Estuary	26.5887	-81.9065	8.82	36.5	1.9	1.2	0.3	26.7	9.6	9.8	200.5	24.6	16.5
C10B	Cal. Estuary	26.6270	-81.8924	5.20	28.7	3.2	<0.05	0.3	30.3	8.7	7.8	194.2	19.6	13.8
C10C	Cal. River	26.7228	-81.6960	0.44	137.3	3.2	1.1	5.1	44.3	2.8	3.7	188.6	11.8	
C11	Cal. River	26.7211	-81.6922	0.25	391.7	3.2	1.0	2.2	78.9	4.3	5.0	187.2	10.0	14.4
C12	Cal. River	26.7885	-81.3030	0.24	221.1	1.9	1.9	1.8	50.2	3.9	2.6	163.5	13.3	23.6
C13	Cal. River	26.8394	-81.0809	0.11	46.8	3.4	0.6	1.2	65.7	3.8	0.3	28.5	12.6	22.6
PZ1	Piezometer	26.6905	-81.8182		134.3	0.5	5.7	0.8	56.8					
PZ2	Piezometer	26.5255	-81.9983	30.29	157.5	5.0	1.5	4.8	75.9	121.0	45.5	143.8	142.3	
PZ3	Piezometer	26.5615	-81.9260	21.34	39.4	4.0	0.6	6.5	39.6	59.9	24.8	223.0	41.6	
GW1	Monit. Well	26.6711	-81.8799	0.37	75.2	0.5	0.6	25.6	47.9	29.5	13.3	98.0	13.6	
GW2	Monit. Well	26.6711	-81.8799	32.95	73.6	0.9	<0.05	42.7	152.0	472.6	150.5	890.8	249.7	
GW2b	Monit. Well	26.6397	-81.8689	5.43	34.2	0.1	0.8	21.6	131.7	217.9	30.2	126.8	90.7	
GW4	Monit. Well	26.5588	-81.8982	0.34	54.8	1.1	0.6	41.5	108.8	68.8	31.9	250.6	41.7	

GW5	Monit. Well	26.5238	-81.9202	2.46	136.0	0.6	0.4	76.1	130.3	282.9	131.5	164.0	187.6
GW6	Monit. Well	26.5185	-81.9357	0.82	56.9	0.7	0.3	67.9	124.0	148.4	54.8	1647.9	81.5
GW7	Monit. Well	26.7114	-81.8382	0.32	115.0	5.0	4.6	13.8	45.6	18.1	9.7	150.6	25.7
GW8	Monit. Well	26.7158	-81.8072	0.70	163.3	1.1	0.3	11.8	34.2	68.6	54.3	376.5	46.8
GW9	Monit. Well	26.7332	-81.7128	0.41	160.6	0.2	0.8	80.6	121.7	67.1	110.6	1432.3	36.3
GW10	Monit. Well	26.7346	-81.7309	0.60	187.8	0.3	1.0	24.6	55.4	64.1	49.4	192.3	25.0
GW11	Monit. Well	26.7046	-81.6797	0.28	143.9	0.2	0.2	23.3	43.6	31.0	26.2	398.7	20.2
GW12	Monit. Well	26.6805	-81.7832	0.23	82.2	1.4	0.3	8.4	36.2	40.7	22.4	152.8	27.3
GW13	Monit. Well	26.5238	-81.9202	0.37	183.4	76.2	0.2	5.4	15.1	148.4	4.9	306.2	24.8
GW14	Monit. Well	26.3339	-81.8046	2.13	179.9	0.6	0.9	29.4	57.9	130.6	100.2	903.6	74.5
GW15	Monit. Well	26.3339	-81.8046	3.54	88.6	0.1	0.1	14.3	60.5	-6.3	282.9	2731.4	38.5
GW16	Monit. Well	26.3339	-81.8046	0.93	102.7	2.4	0.9	39.0	149.4	196.8	21.9	255.3	93.0
GW17	Monit. Well	26.3875	-81.8262	0.44	26.8	4.1	0.5	25.0	55.1	175.7	14.4	126.1	122.7
GW18	Monit. Well	26.4419	-81.8346	0.24	67.3	0.3	2.5	25.0	51.6	49.1	33.7	273.2	27.5

Table 3.3. Estimates of groundwater discharge to the Caloosahatchee River Estuary.

Method	Apr-09 (10^6 m^3/day)	Oct-09
SGD (Ra isotopes)[1]	3.33	1.27
SGD (Water Balance)[2]	4.33	2.80
Estuarine Salt Balance	3.85	4.44
Franklin Lock Discharge[3]	1.84	1.93

[1]Franklin Lock to Gulf of Mexico inlet

[2]Does not account for anthropogenic withdrawls and includes input landward of the Franklin Lock

[3]Mean daily flow for 2.5 weeks preceeding the field study

Table 3.4. Estimates of groundwater and Franklin Lock nutrient flux to the Caloosahatchee River Estuary.

	Apr-09		Oct-09		Apr-09	Oct-09
	SGD	Franklin Lock	SGD	Franklin Lock	Groundwater/Franklin Lock Flux	
	(kg/day)					
TDN	3410	2100	1400	2100	162%	67%
DIN	1960	303	582	85	647%	685%
PO4	222	160	209	200	139%	104%

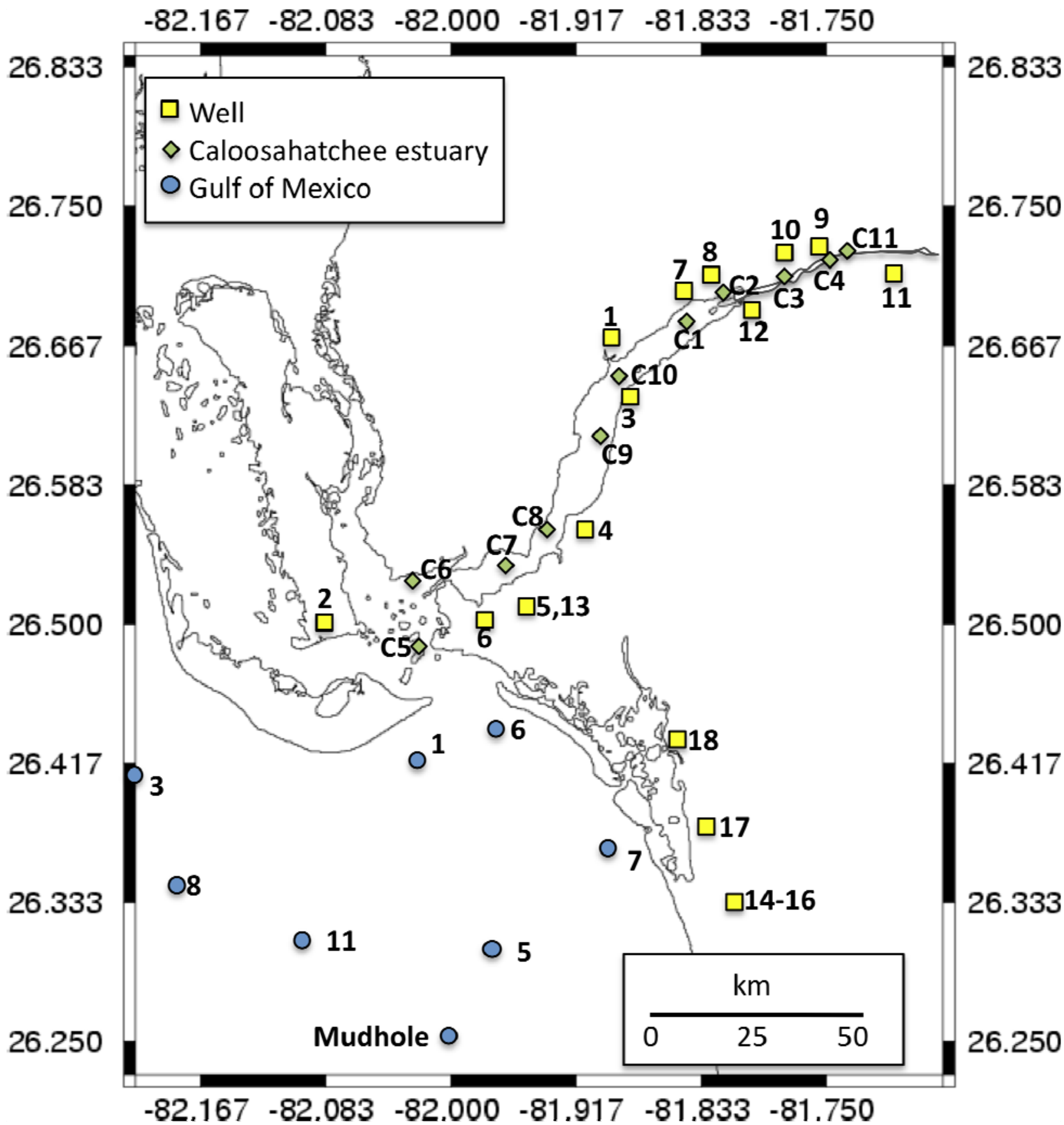


Figure 3.1. Map of the study area including station locations.

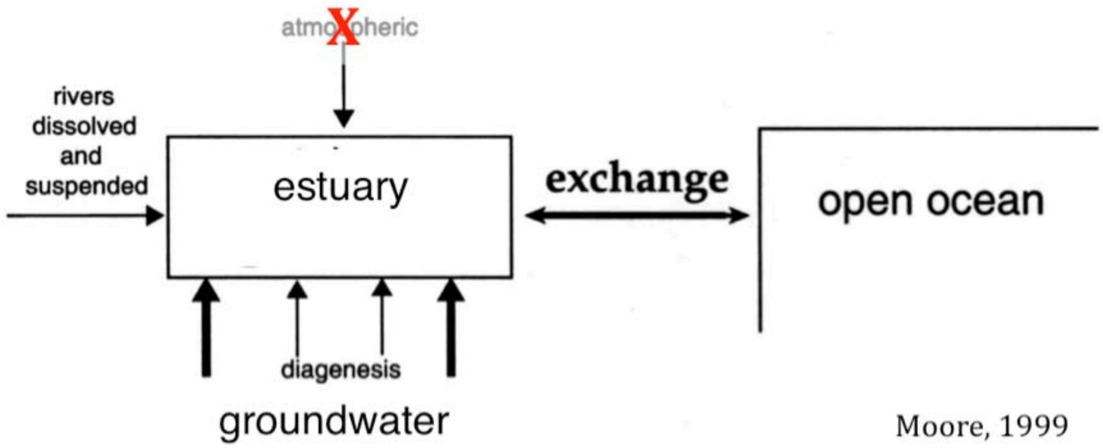


Figure 3.2. Box model illustration for application of radium isotopes for quantifying submarine groundwater discharge.

Table 4.1. Bottom “roughness” final scheme used for classifying hydroacoustic and towed video.

Bottom roughness
Class 1 = low = soft sediments (sand, mud) with no or little bi-valve shell debris, rock, epibenthic organisms; vertical structure < 5 cm in most of area
Class 2 = low = mainly mud/sand mixtures with variable amounts of bi-valve shell debris, rock, epibenthos; vertical structure variable, < 10 cm in most of area
Class 3 = moderate = mainly packed shell debris and scattered rubble/rock with variable amounts of mud/sand mixtures, epibenthos variably abundant, vertical structure < 10 cm in most of area
Class 4 = high = intact bi-valve shells and hard bottom, mostly exposed bedrock, epibenthos typically abundant, vertical structure typically > 10 cm.
Class 5 = high = abundant drift macroalgae, or seagrasses, typically with attached macroalgae and other epibenthos, vertical structure > 10 cm

Table 4.2a-b. a), Comparison matrix of training dataset records classified by DA into 5 bottom roughness classes and by a PCA+K-means into five clusters; and b), the same data standardized to 100 cases per class (to remove bias of unequal sample sizes). Moving across rows note that 4 of the 5 K-Means Clusters were dominated by a single discriminant analysis (DA) Group, while the other was mostly Classes 3 and 4, validating the variance ratio criterion's (VRC) recommendation of 4 (or to a lesser extent 5) optimum classes.

a. Comparison Matrix of Training Dataset

		Exploratory DA					
		1	2	3	4	5	n
K-Means	1	184	0	2	6	45	237
	2	1372	71	102	36	0	1581
	3	0	0	0	0	34	34
	4	506	14	636	243	181	1580
	5	76	1307	30	54	2	1469
	n	2138	1392	770	339	262	4901

b. Standardized to 100 Cases per Class

		Exploratory DA						
		1	2	3	4	5	n	%
K-Means	1	9	0	0	2	17	28	60.7
	2	64	5	13	11	0	93	68.8
	3	0	0	0	0	13	13	100
	4	24	1	83	72	69	249	62.2
	5	4	94	4	16	1	119	79.0
	n	100	100	100	100	100	500	

Table 4.3. Confusion matrix of acoustically-predicted (MAP) versus ground-validated ("TRUTH") classifications of the 89 samples passing QA. Note: Class 5 was omitted as most of its samples were rejected by the minimum depth filter.

	TRUTH						
	Group	**1**	**2**	**3**	**4**	**row**	**User**
MAP	**1**	**28**	2			30	93.3
	2	5	**29**	3	1	38	76.3
	3		1	**5**		6	83.3
	4	1	5	0	**9**	15	60.0
	column	34	37	8	10	**89**	
	Producer	82.4	78.4	62.5	90.0	P_o =	**0.80**
						T_e =	**0.73**

Table 4.4. Video-based bottom classification scheme for estuarine and shallow Gulf of Mexico waters. Seven major classes (numbered 1 – 7 and enclosed by ellipses), each with two or more subclasses (a, b, c, etc.) are described in the here. The subclasses indicate: the dominant benthic organism (either: a, no benthos; b, sand dollars; and c, urchins, etc.).

	Dominant Sediment Type				
Dominant Benthos	**Sand**	**Shell/Sand**	**Low-relief Shell/Rock (=Reef)**	**High-relief Shell/Rock (=Reef)**	**Description by Major Class**
(None)	1a	2a			1 = Sand >90% with no or rare sessile epibenthos
Sand Dollars	1b	2b			2 = Shell/Sand mixtures with no or rare sessile epibenthos
Urchins	1c	2c	5c	6c	3 = Sand >90% with scattered to dense sessile epibenthos
Pen Shells	3d	4d			4 = Shell/Sand mixtures with scattered to dense sessile epibenthos
Soft Corals	3e	4e	5e	6e	5 = Low-relief (<20 cm height) hard bottom with diverse benthos
Hard Corals			5f	6f	6 = High-relief (>20 cm height) hard bottom with diverse benthos
Sponges		4g	5g	6g	7 = Sand >90% with macroalgae and/or seagrasses
Macroalgae	7h	4h	5h	6h	NOTE: All classes except Class 1 (Sand with no or mainly motile benthos) are bottom types with potential for macroalgae attachment
Seagrasses	7i	4i			

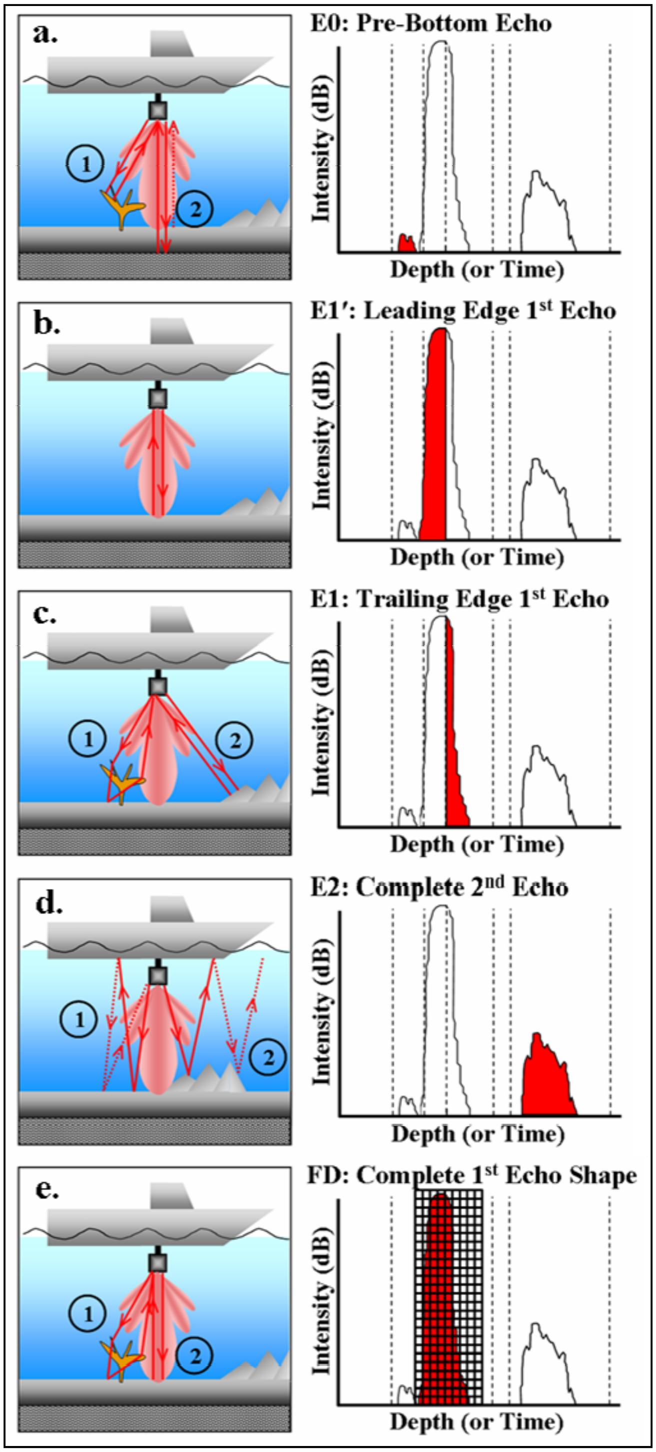


Figure 4.1. Acoustic energy (E0, E1’, E1, E2) and shape (FD) parameters computed from single-beam ASC echo envelopes.

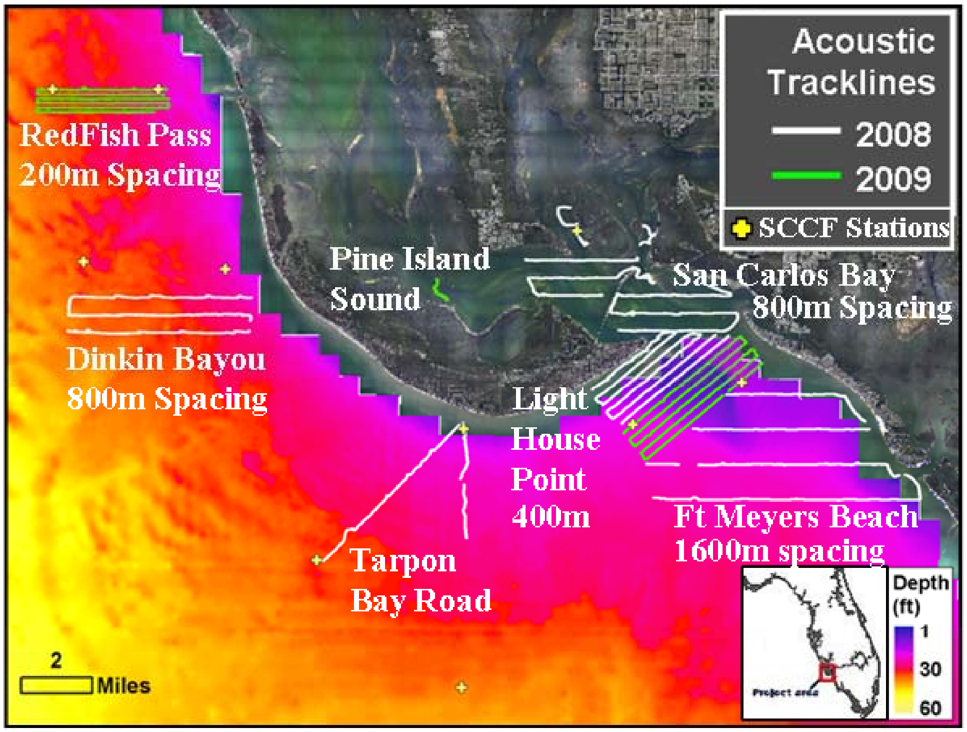


Figure 4.2. GPS trackplots of hydroacoustic surveys, conducted during the periods of October 2008 and May 2009. Yellow crosses (+) denote the location of sampling stations for Objective 5, Sanibel-Captiva Conservation Foundation Marine Laboratory.

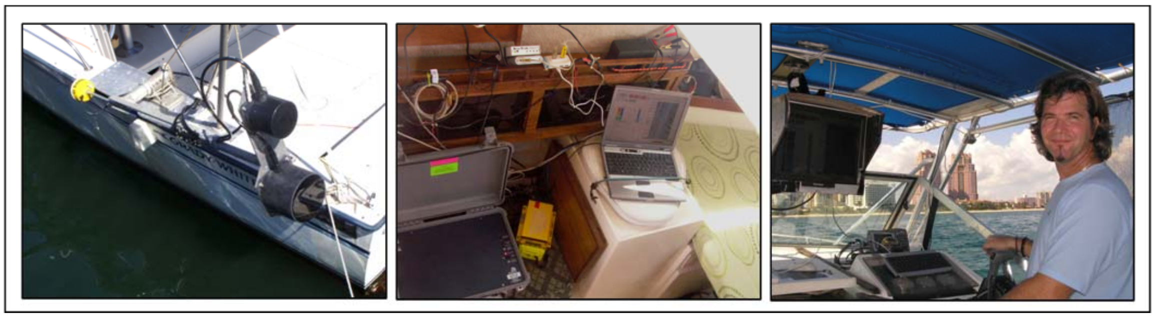


Figure 4.3. Hydroacoustic survey equipment. Left image, swing-arm in horizontal (traveling) position with 420 and 38 kHz transducers and Trimble antenna. Middle image, inside v-berth of survey vessel with BioSonics DT-X echosounder, Trimble receiver, and acquisition PC. Right image, monitor displaying GPS-navigation over pre-planned lines and real-time echo returns.

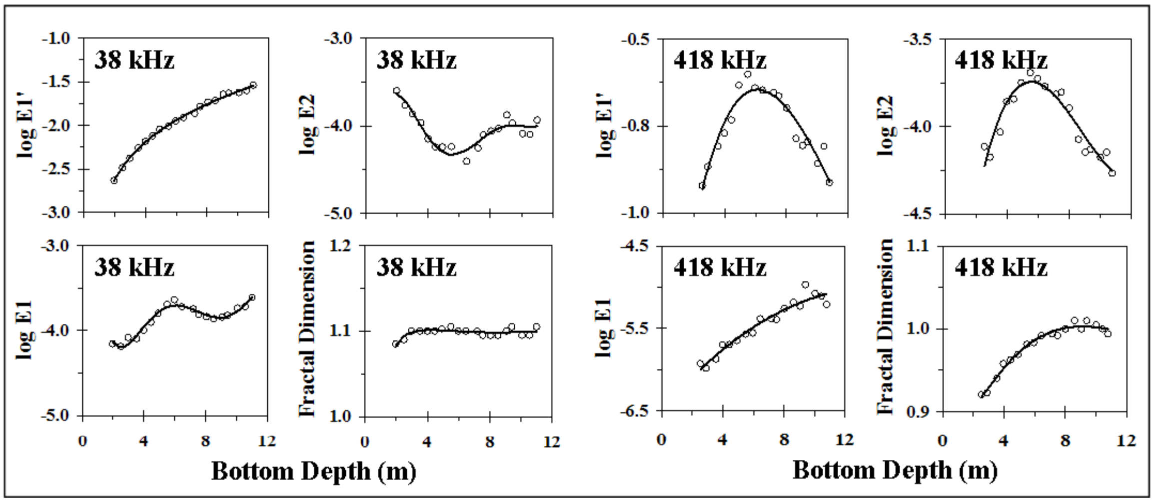


Figure 4.4. High-order logarithmic polynomials (solid lines) were fit to the median values of acoustic parameters at 18 bins of depth (○) used to normalize acoustic parameters to median survey depth.

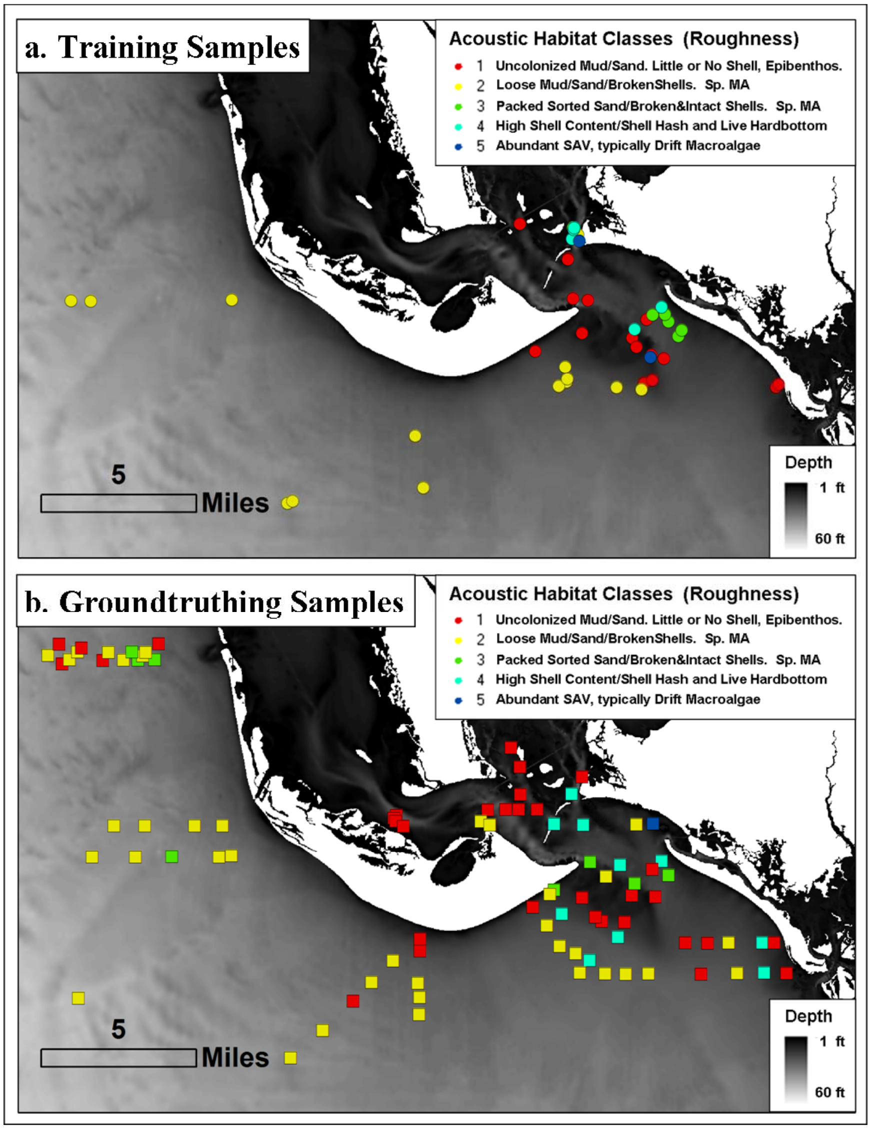


Figure 4.5. Locations of: a), training; and b), accuracy assessment samples. Each sample consisted of a discrete sonar file and a spatially-coincident video file.

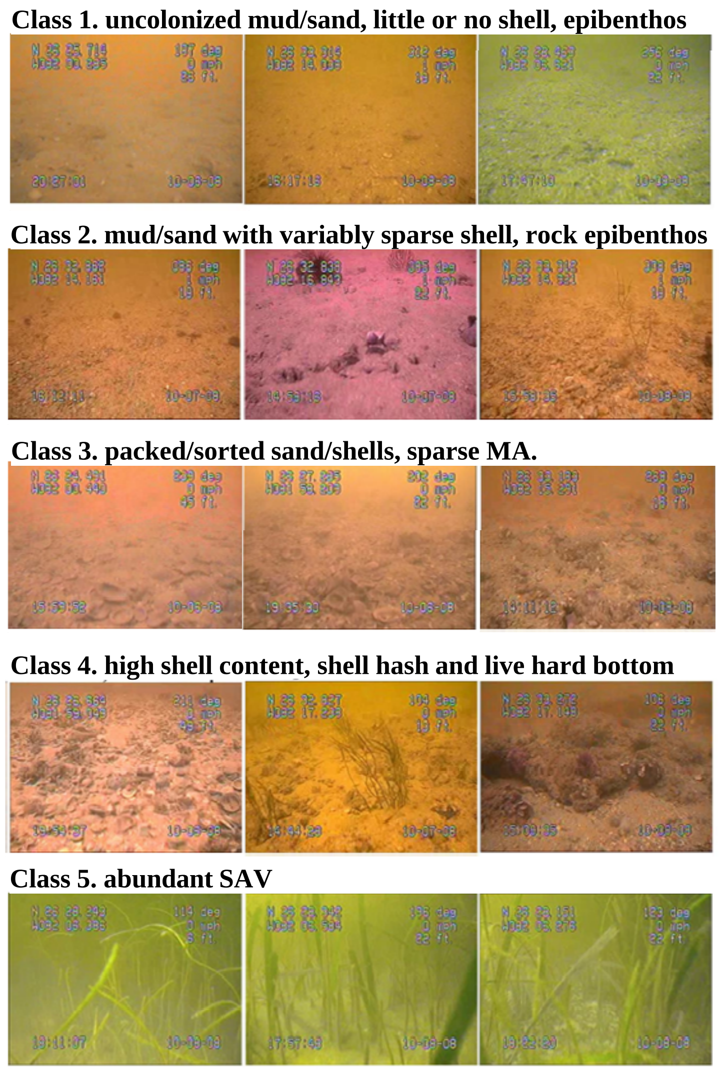
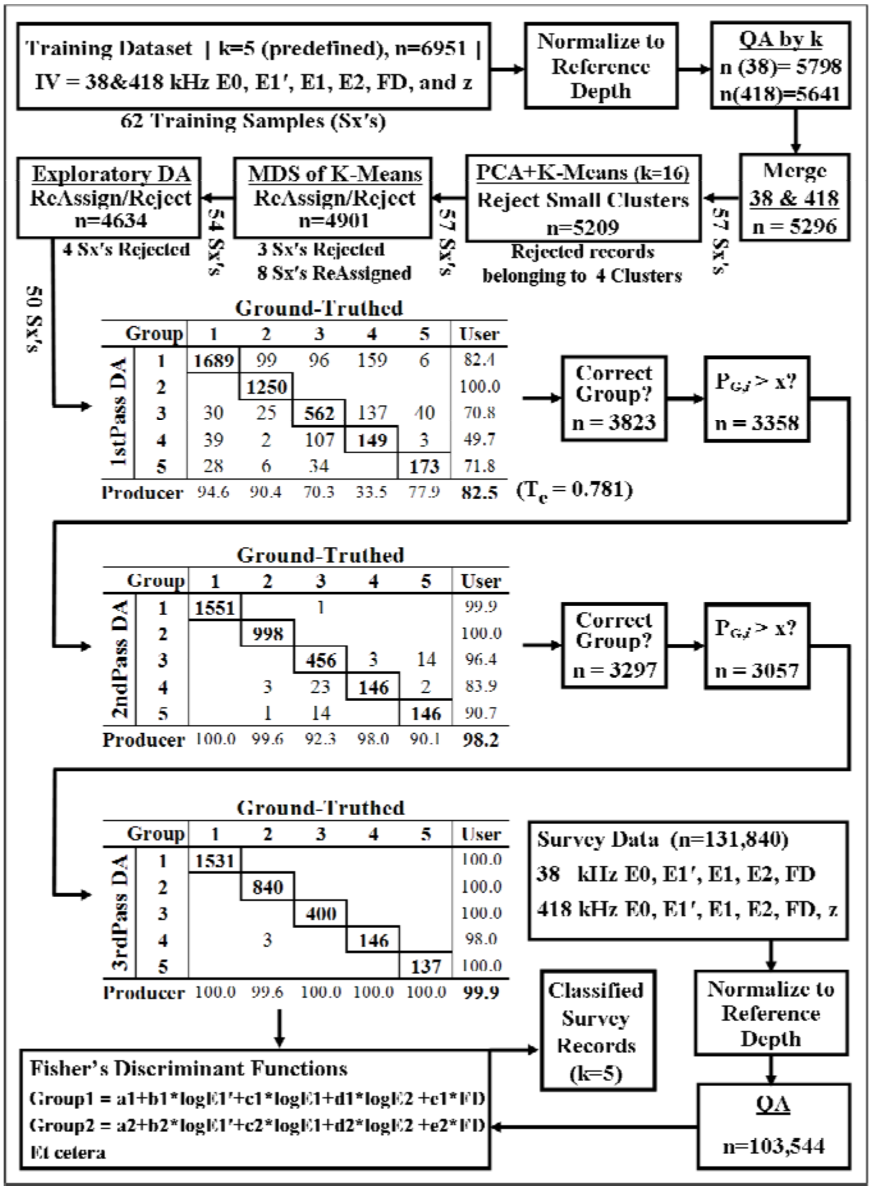


Figure 4.6. Screen captured stills taken from ground-validation videos, representing typical substrate and biota of the five acoustically-derived, Seabed Classes used for supervised classification of Phase I and II mapping.



1stPass DA (Ground-Truthed)

Group	1	2	3	4	5	User
1	**1689**	99	96	159	6	82.4
2		**1250**				100.0
3	30	25	**562**	137	40	70.8
4	39	2	107	**149**	3	49.7
5	28	6	34		**173**	71.8
Producer	94.6	90.4	70.3	33.5	77.9	**82.5**

2ndPass DA (Ground-Truthed)

Group	1	2	3	4	5	User
1	**1551**		1			99.9
2		**998**				100.0
3			**456**	3	14	96.4
4		3	23	**146**	2	83.9
5		1	14		**146**	90.7
Producer	100.0	99.6	92.3	98.0	90.1	**98.2**

3rdPass DA (Ground-Truthed)

Group	1	2	3	4	5	User
1	**1531**					100.0
2		**840**				100.0
3			**400**			100.0
4		3		**146**		98.0
5					**137**	100.0
Producer	100.0	99.6	100.0	100.0	100.0	**99.9**

Figure 4.7. Classification workflow for classification. Hydroacoustic training samples were assigned to one of five *a priori* bottom classes. Acoustic parameters were normalized to average survey depth, using empirical models created from survey and select training data. Quality analysis consisted of a max depth span, min/max depth, and 1 of 99 percentile filters (calculated individually for each training group), followed by PCA/K-means/MDS outlier filtering and class re-assignment. The final membership of training dataset was determined using an exploratory discriminant analysis (DA). The training dataset was refined by passing through three DAs. Only those training records: (1) classifying correctly; and (2) exceeding a minimum probability for group membership passed onto the next DA. The Fisher's Linear Discriminant Functions obtained from the 3rd DA were used to classify survey data into one of five final *a priori* bottom classes.

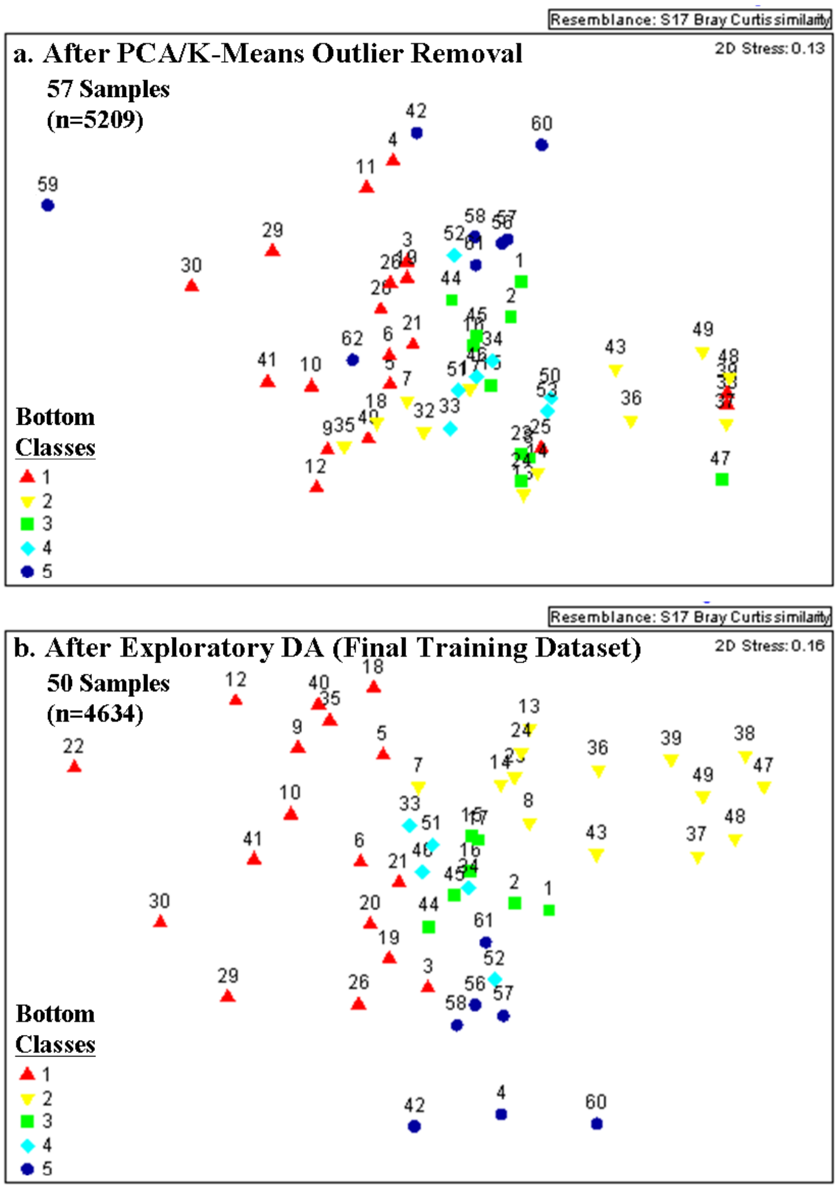


Figure 4.8. 2-D MDS plots of training dataset constructed from Bray-Curtis similarity matrix after: (a) rejecting four disproportionately small PCA+K-means clusters; and after (b) final rejection/reassignment of training records/samples following the exploratory Discriminant Analysis (DA).

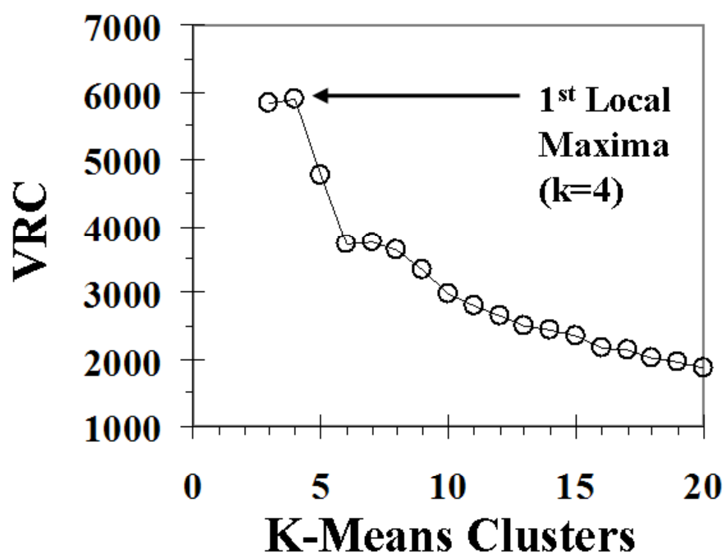


Figure 4.9. Variance ratio criterion (VRC) suggested an “optimal” number at four total bottom classes.

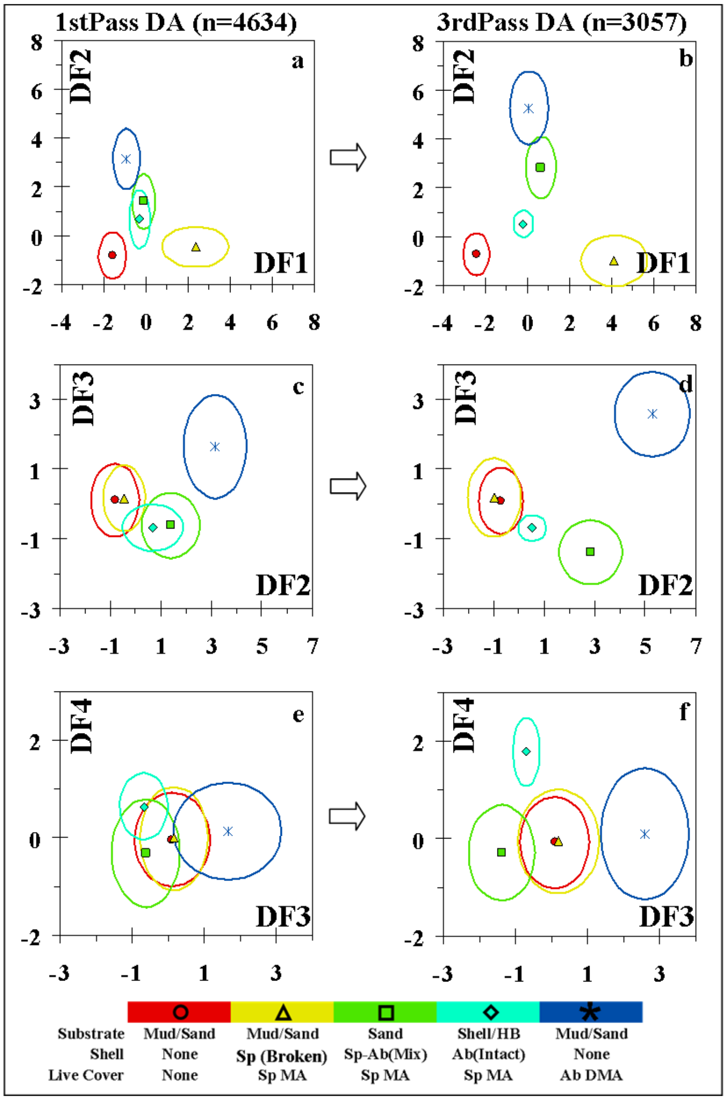


Figure 4.10. Plots of Discriminant Functions from the supervised classification of the training dataset into five discrete bottom classes by multipass Discriminant Analysis (DA). Center points denote cluster averages, ellipses are dispersion (1SD) about an X and Y. Left three graphs are from data submitted to the 1st Descriptive DA. Right three graphs are the results of the 3rd pass descriptive DA. Note the resulting refinement of the training dataset as shown by a greater separation between groupings.

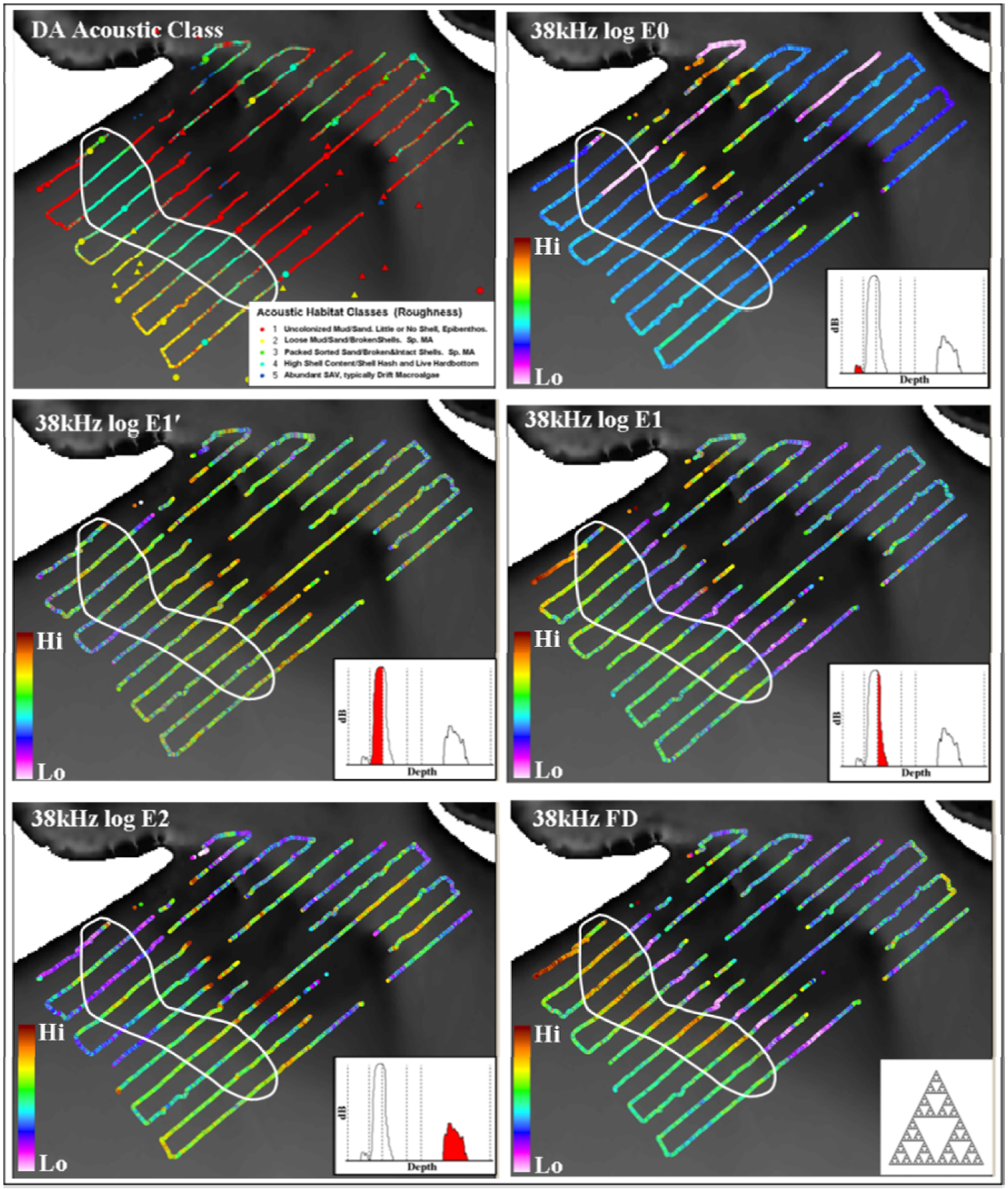


Figure 4.11. Classified acoustic GPS trackplot (see upper left) and trackplots of 38 kHz acoustic energy parameters and fractal dimension (E0, E1, E1', E2, FD) for Lighthouse Point. The boundary of the acoustically-"rough" bottom is indicated for reference.

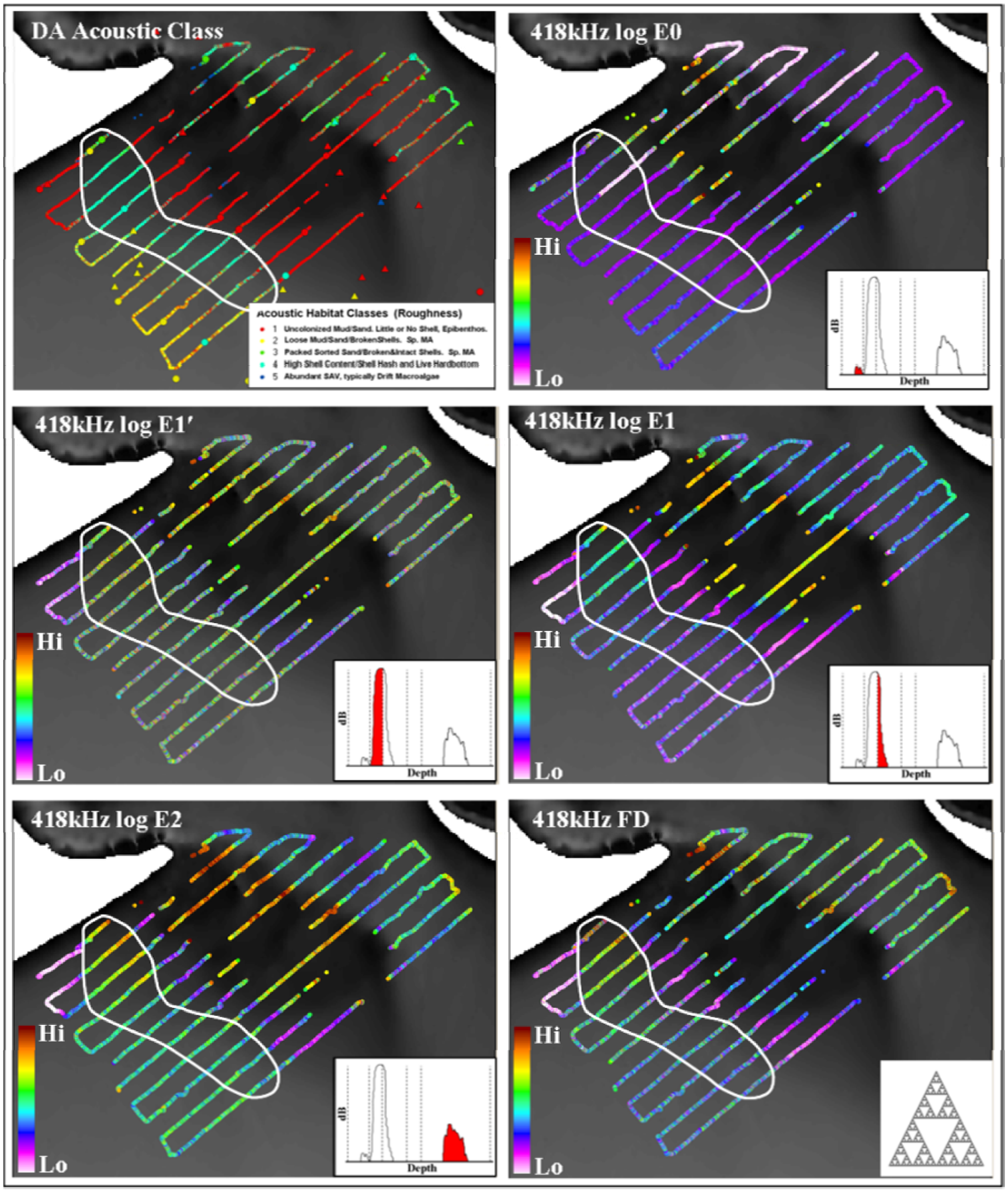


Figure 4.12. Classified acoustic (see upper left) and GPS trackplots of 418 kHz acoustic energy parameters and fractal dimension (E0, E1, E1’, E2, FD) for Lighthouse Point. The boundary of the acoustically-”rough” bottom is indicated for reference.

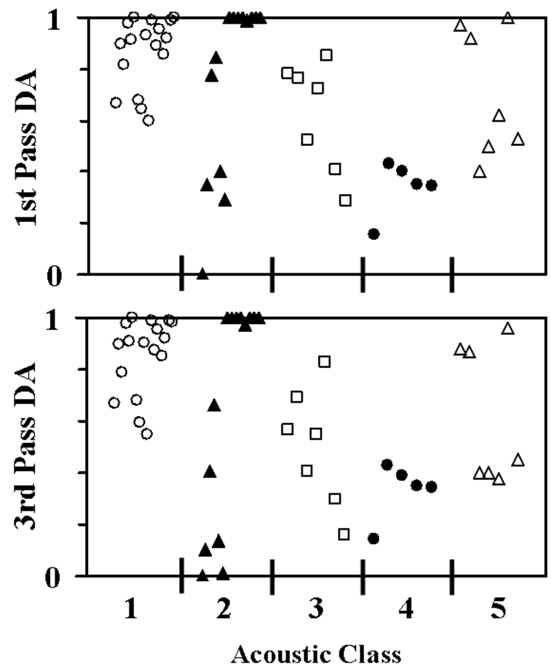


Figure 4.13. Equitable rejection of records among individual training samples suggest suggests the independent variables represented spatially and temporally consistent seabed characteristics of the five acoustic classes (each symbol represents one of the 50 catalog samples comprising the five class training dataset). Proportion of training dataset records that: (1) classified correctly; and (2) exceeded the minimum probability of group membership following the 1st (upper) and 3rd (lower) Descriptive DA.

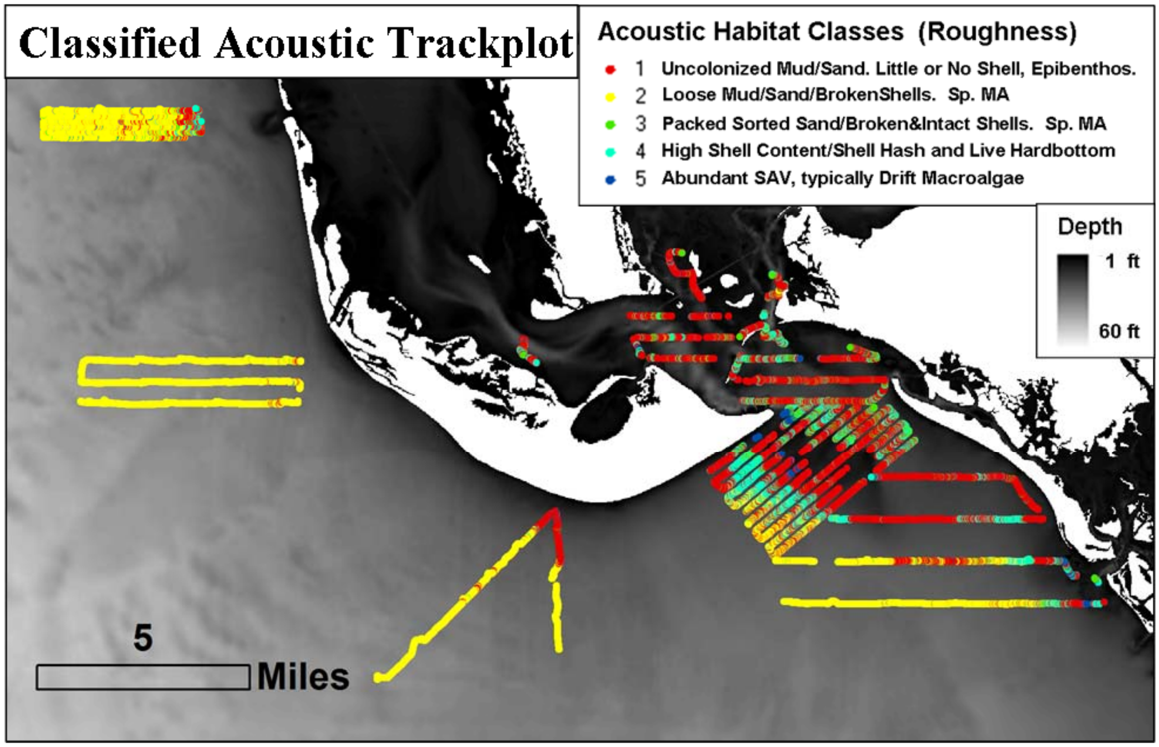


Figure 4.14. Classified GPS trackplot of 2008-09 hydroacoustic surveys, using the Fisher's Linear Discriminant functions obtained from the 3rd Pass Descriptive DA.

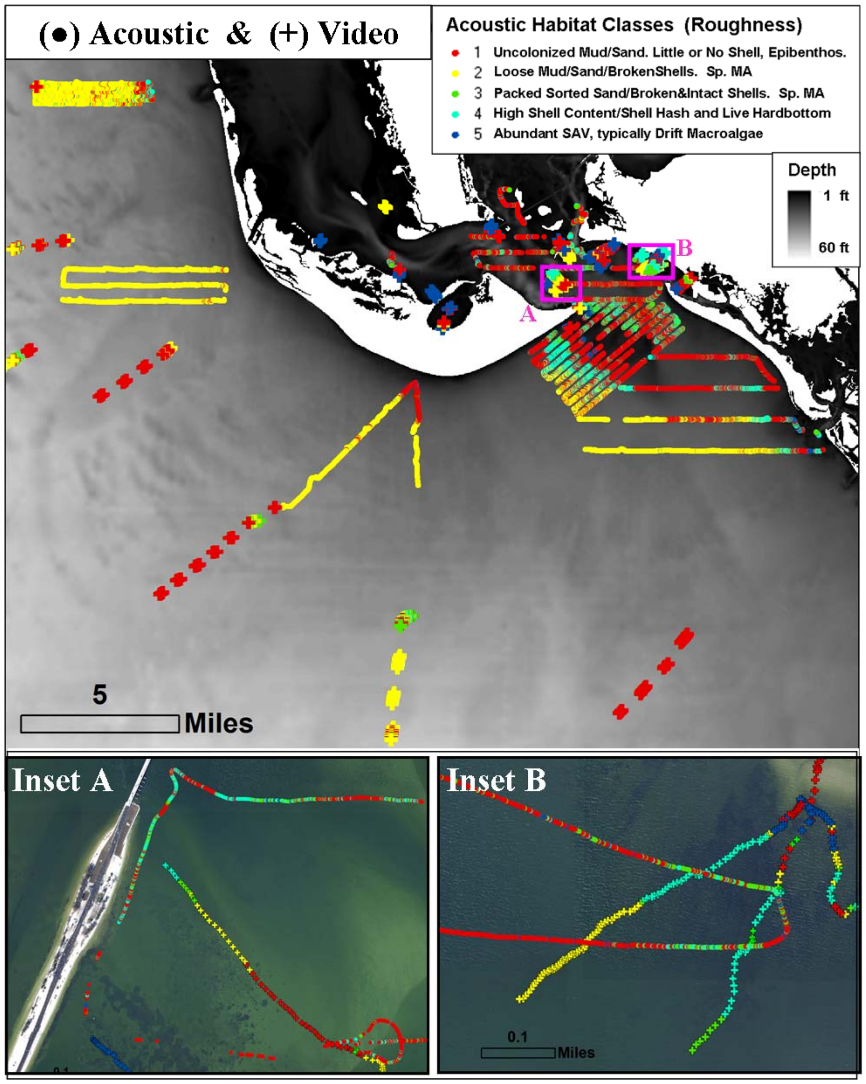


Figure 4.15. Classified hydroacoustic GPS trackplots and classified towed-video transects. Note for Insets A and B (blow-up below), areas where hydroacoustic and towed-video transects intersected the two methods closely agreed on classifications.

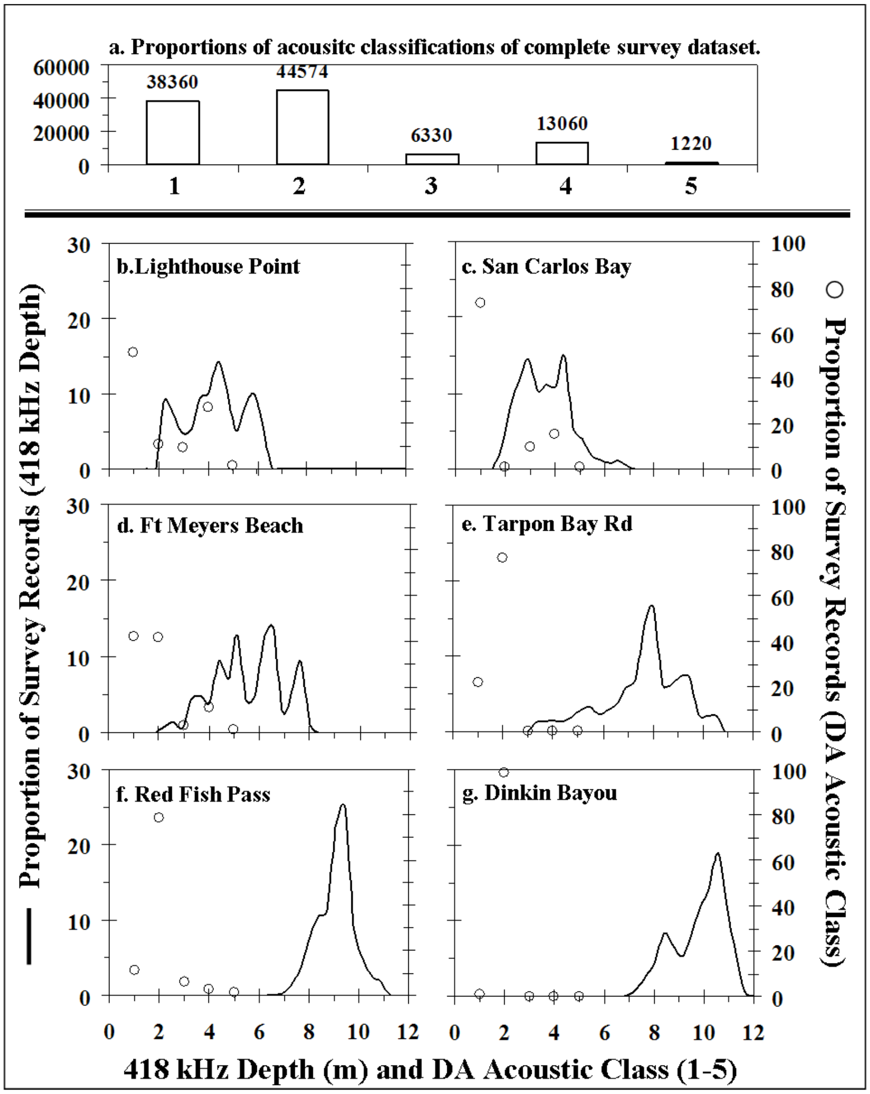


Figure 4.16. Bathymetric and acoustic class profiles of specific survey sites. Top:, a), distribution of hydroacoustic survey records for the five acoustic bottom classes for the complete overall survey; and lower, b-g) histograms for the 418 kHz bottom depth (solid line) and distribution of survey records among the five bottom classes (○) for each survey site.

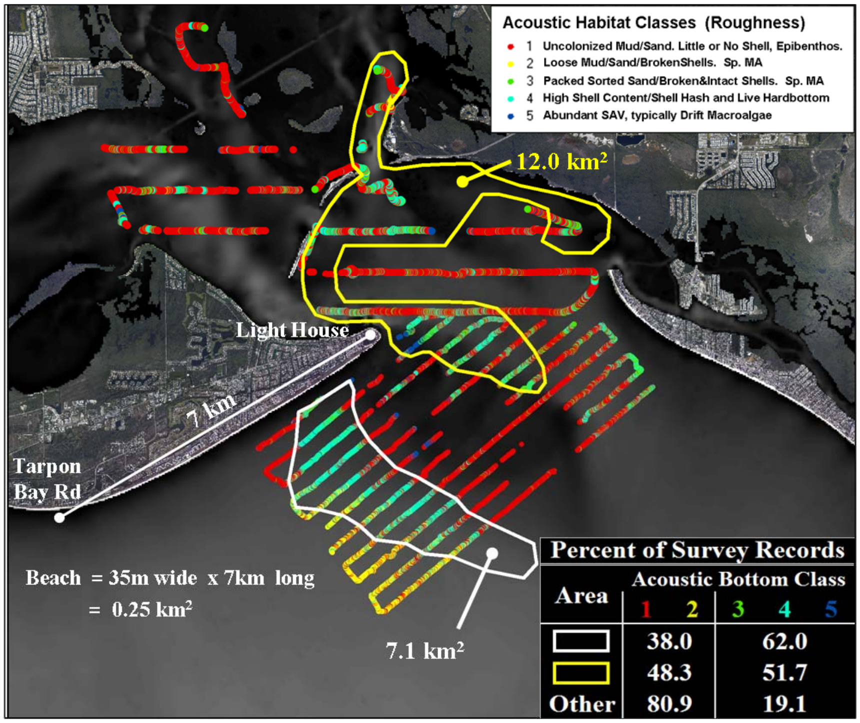


Figure 4.17. Assessment of the potential for Lighthouse and San Carlos Bay sites to generate nuisance macroalgal blooms. Classified hydroacoustic GPS trackplots of the San Carlos Bay and Lighthouse Point surveys. Demarcations denote areas of high acoustic "roughness" (i.e. high proportion of Bottom Classes 3, 4 and 5). Inset (bottom-right) shows the distribution of hydroacoustic survey records among the five Bottom Classes within the two "rough" areas as compared to the other records lying outside of the "rough" demarcations.

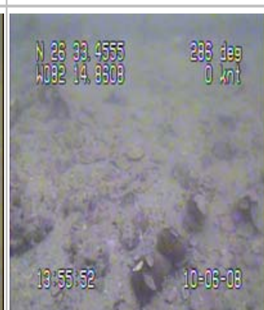
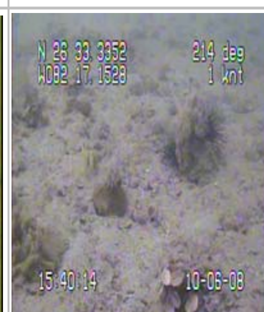
	Dominant Sediment Type			
Dominant Benthos	Sand	Sand/Shell	Low-relief Shell/Rock (=Reef)	High-relief Shell/Rock (=Reef)
(None)				
Sand Dollars				
Urchins				
Pen Shells				

Figure 4.18. Video still (captured) images illustrating the various Classes and Subclasses for the video-derived seabed classification scheme used in Table 4.4.

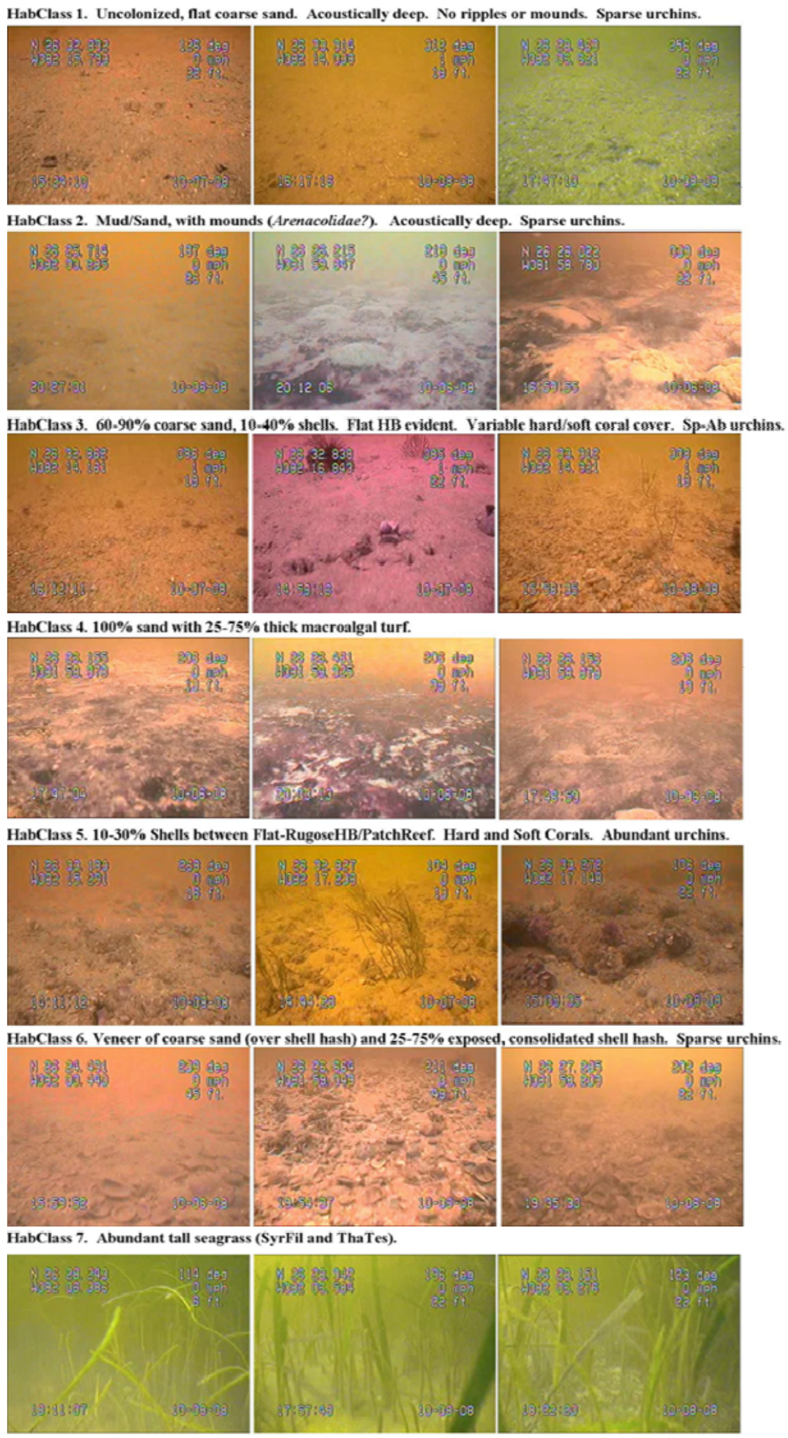


Figure 4.19. Captured stills taken from ground-validation videos, representing typical substrate and biota of the seven acoustically-derived Seabed Classes obtained from the unsupervised classification of the Phase I hydroacoustic data. The seven overall derived-classes were consolidated into five Classes for the final supervised classification of hydroacoustic data from Phases I and II (see Figure 4.6 also).

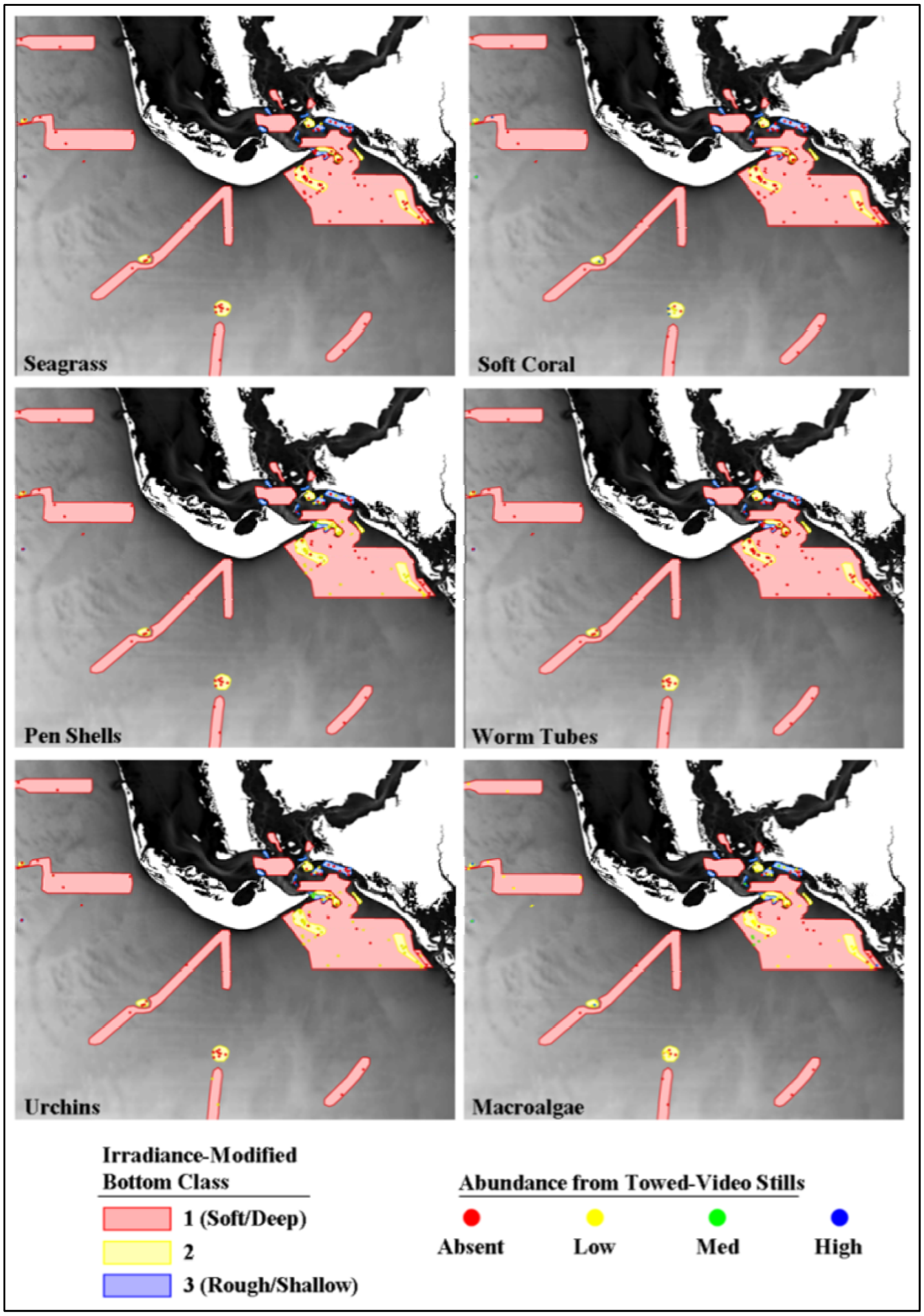


Figure 4.20. 'Expert' classification of biogenic features from stills of Phase III towed-video, displayed over irradiance-modified acoustic bottom class.

Table 5.1. Percent of total video frames containing algae from analysis of entire transect (100 m^{-2} length).

Station	Date Sep-08	Nov -08	Jan-09	Mar-09	May-09	Jul-09	Sep-09	Nov-09	Jan-10	Mar-10	Jun-10
CES11	†	†	†	95	*	†	†	8.6	81.5	93.3	†
GOM16	*	*	*	75.7	†	†	†	0	5.2	34.3	†
GOM01	0	0	0	1.4	0	2.3	†	0	3.7	3.3	2.3
GOM02	2.5	†	5.8	2.3	0	0.7	0	3	0	0	56.8
GOM03	0	64	60.1	0.9	0	†	†	42	5.8	0	0
GOM04	†	†	0	†	0	8.5	2	0	0	†	1.4
GOM05	0	0.7	†	0.8	0	0	†	0	0	0	†
GOM06	†	59.2	90	92.3	†	2.2	0	5	0	50.9	†
GOM07	0	0	†	3.1	0	0.6	†	0	1	1.3	0
GOM08	6.2	0.8	3.5	2.5	1.1	6.7	1	2.4	†	0.7	†
GOM09* (discontinued)	3	*	*	*	*	*	*	*	*	*	*
GOM10	†	†	0	0	0	4.8	0	0.5	0	†	0
GOM11	51.4	†	51.7	34.2	29.4	†	53.6	15.6	77.6	27.1	26.95
GOM12	*	*	94.2	55.3	13.2	100	95.1	88.5	20.8	†	100

* indicates underwater video was unavailable

† indicates poor visibility, therefore video was not interpreted

Table 5.2. Station information; name, whether macroalgae is prominent feature, mean depth (+ SD), depth of sediment overlying live bottom, prominent benthic feature, latitude, and longitude.

Station	Macroalgae	Mean depth (m)	Depth of overlying sediment (cm)	Prominent benthic feature	Latitude (N)	Longitude (W)
CES11	Abundant	3.7 (± 0.9)	>75*	*Diopatra cuprea*	26.4989	82.0456
GOM16	Abundant	2.0 (± 0.8)	>75*	patchy seagrass	26.4660	82.0998
GOM11	Abundant	11.3 (± 1.3)	10 (± 12)	live bottom	26.3091	82.0973
GOM12	Abundant	13.5 (± 1.6)	2 (± 3)	live bottom	26.5545	82.2860
GOM01	Rare	6.0 (± 0.9)	60 (± 33)	pen shells, urchins	26.4187	82.0179
GOM02	Rare	8.0 (± 0.5)	28 (± 17)	pen shells, urchins	26.5546	82.238
GOM03	Rare	5.7 (± 2.3)	67 (± 33)	live bottom	26.4163	82.2067
GOM03A	Not observed	6.2 (± 2.3)	>75*	pen shells, urchins	26.4160	82.1112
GOM04	Not observed	8.0 (± 0.5)	>75*	pen shells, urchins	26.4507	82.2060
GOM05	Not observed	7.6 (± 0.6)	>75*	featureless	26.3046	81.9545
GOM06	Rare	5.5 (± 0.7)	>75*	pen shells, urchins	26.3049	81.9540
GOM07	Rare	5.0 (± 1.0)	>75*	pen shells, urchins	26.3277	81.8832
GOM08	Rare	10.0 (± 0.9)	34 (± 14)	featureless	26.3628	82.1644
GOM09	(discontinued)	13.9	>75*	*Halophila decipiens*	26.2525	82.1463
GOM10	Rare	9.7 (± 0.9)	50 (± 33)	large sand waves	26.4839	82.2710

* Depth of the overlying sediment was deeper than the length of the measuring rod

Table 5.3. List of macroalgal species from this study.

Acanthophora muscoides	*Euchema denudatum*	*Polysiphonia* spp.
Acanthophora spicifera	*Eucheuma isiforme var. denudatum*	*Polysiphonia subtilissima*
Acetabularia polyphysiodes	*Gelidiella sanctarum*	*Sargassum filipendula*
Acetabularia spp.	*Gelidiopsis variabilis*	*Sargassum fluitans*
Agardhiella ramosissima	*Gracilaria armata*	*Sargassum hystrix*
Agardhiella subulata	*Gracilaria blodgettii*	*Sargassum natans*
Botryocladia occidentalis	*Gracilaria bursa-pastoris*	*Sargassum* spp.
Caulerpa ashmeadii	*Gracilaria cervicornis*	*Sargassum vulgare*
Caulerpa brachypus	*Gracilaria cylindrica*	*Schiziothrix calciola*
Caulerpa mexicana	*Gracilaria damaecornis*	*Scinaia halliae*
Caulerpa racemosa	*Gracilaria flabelliformis*	*Sebdenia flabellata*
Caulerpa racemosa var. peltata	*Gracilaria intermedia*	*Solieria filiformis*
Caulerpa sertularioides	*Gracilaria mammillaris*	*Spyridia filamentosa*
Caulerpa sertularioides f. longiseta	*Gracilaria* spp.	*Udotea abbottiorum*
Chaetomorpha linum	*Gracilaria tikvahiae*	*Udotea looensis*
Champia parvula	*Gracilaria venezuelensis*	*Ulva flexuosa*
Chondria capillaris	*Gracilariopsis lemaneiformis*	*Ulva intestinalis*
Chondria collinsiana	*Gymnogongrous griffishsiae*	*Ulva lactuca*
Chondria leptacremon	*Halymenia floresia*	*Ulva* spp.
Chondria littoralis	*Halymenia pseudofloresia*	*Wurdemania miniata*
Chondria sedifolia	*Halymenia* spp.	
Cladosiphon occidentalis	*Heterosiphonia gibbesii*	
Codium isthmocladium	*Hincksia mitchelliae*	
Codium spp.	*Hincksia onslowensis*	
Codium taylorii	*Hydropuntia caudata*	
Dasya antillarum	*Hypnea cornuta*	
Dasya baillouviana	*Hypnea musciformis*	
Dasya collinsiana	*Hypnea spinella*	
Dasya crouaniana	*Hypnea valentiae*	
Dasya ocellata	*Jania rubens*	
Dasya ramosissima	*Laurencia chondrioides*	
Dasya rigidula	*Laurencia filiformis*	
Dasya spp.	*Laurencia intricata*	
Dictyopteris polypodioides	*Lomentaria baileyana*	
Dictyota cervicornis	*Lomentaria occidentalis*	
Dictyota cilidata	*Lyngbya majuscula*	
Dictyota pulchella	*Polysiphonia flaccidissima*	
Ectocarpus spp.	*Polysiphonia ramentacea*	

Table 5.4. List of species, collection date and collection location of macroalgae found on Lee County beaches since 2003.

Genus species	Division	Date	Collection Location	Source
Acanthophora spicifera	Rhodophyta	Jan-08	Tarpon Bay Beach	This study
Agardhiella subulata	Rhodophyta	Jul-04	Lee County Beaches	Lapointe and Bedford (2007)
		Jan-10	Tradewinds Resort	This study
		Mar-10	Lighthouse Beach	This study
		Mar-10	Tarpon Bay Beach	This study
Botryocladia occidentalis	Rhodophyta	Jul-04	Lee County Beaches	Lapointe and Bedford (2007)
Champia parvula	Rhodophyta	Mar-10	Lighthouse Beach	This study
Chondria atropurpurea	Rhodophyta	Feb-04	San Carlos Bay	Dawes (2004)
Chondria collisiana	Rhodophyta	Mar-10	Lighthouse Beach	This study
		Mar-10	Fort Myers Beach	This study
		Mar-10	Tarpon Bay Beach	This study
Ceramium spp.	Rhodophyta	Jun-06	Sanibel Island Beach	Bartleson et al. 2006
Dasya spp.	Rhodophyta	Mar-10	Tarpon Bay Beach	This study
		Mar-10	Fort Myers Beach	This study
Dictyota spp.	Phaeophyta	Feb-08	Tarpon Bay Beach	This study
Eucheuma isiforme	Rhodophyta	Jul-04	Lee County Beaches	Lapointe and Bedford (2007)
Gracilaria spp.†	Rhodophyta	Feb-04	San Carlos Bay	Dawes (2004)
	Rhodophyta	Jul-04	Lee County Beaches	Lapointe and Bedford (2007)
	Rhodophyta	Mar-10	Tarpon Bay Beach	This study
Gracilaria tikvahae	Rhodophyta	Jul-04	Lee County Beaches	Lapointe and Bedford (2007)
		Jan-08	Tarpon Bay Beach	This study
		Jan-10	Bunch Beach	This study
		Jan-10	Tradewinds Resort	This study
		Mar-10	Lighthouse Beach	This study
		Mar-10	Tarpon Bay Beach	This study
		Feb-10	Fort Myers Beach	This study
Gracilaria mammillaris	Rhodophyta	Jun-06	Sanibel Island Beach	Bartleson et al. 2006
Hypnea musciformis	Rhodophyta	Jul-04	Lee County Beaches	Lapointe and Bedford (2007)
Hypnea spinella	Rhodophyta	Dec-03	Sanibel Island Beach	Dawes (2004)
		Jan-08	Tarpon Bay Beach	This study
		Jan-10	Bunch Beach	This study
		Mar-10	Lighthouse Beach	This study
		Jan-10	Tradewinds Resort	This study

Table 5.4. (cont.) List of species, collection date and collection location of macroalgae found on Lee County beaches since 2003.

Genus species	Division	Date	Collection Location	Source
Hypnea spp.	Rhodophyta	Jul-04	Lee County Beaches	Lapointe and Bedford (2007)
Lomentaria baileyana	Rhodophyta	Jan-10	Bunch Beach	This study
Sargassum sp.	Phaeophyta	Jul-04	Lee County Beaches	Lapointe and Bedford (2007)
		Feb-08	Tarpon Bay Beach	This study
		Jan-10	Bunch Beach	This study
Solieria filiformes	Rhodophyta	Dec-03	Sanibel Island Beach	Dawes (2004)
		Jan-08	Tarpon Bay Beach	This study
		Feb-10	Fort Myers Beach	This study
Spyridia filamentosa	Rhodophyta	Mar-10	Tarpon Bay Beach	This study
Ulva spp.	Chlorophyta	Feb-08	Tarpon Bay Beach	This study

† *Gracilaria caudata, Gracilaria cervicornis, Gracilaria bursa-pastoris*

Table 5.5. Total number of attached seaweed species (S) identified during the study period. Zeros indicate dates where no algae was found. GOM04 and GOM05 are not included as they did not have any algae at any date. GOM09 was discontinued in January 2009.

	CES11	GOM01	GOM02	GOM03	GOM06	GOM08	GOM09	GOM10	GOM11	GOM12	GOM16
Jun-08	3	0	1	0	0	0	0	0	14	0	0
Sep-08	0	0	0	0	0	5	2	0	0	10	0
Nov-08	0	0	0	7	0	0	3	0	7	2	0
Jan-09	12	0	0	3	0	0	0	0	0	5	0
Mar-09	16	0	1	0	4	0	0	0	0	8	1
May-09	18	0	0	0	0	0	0	0	14	13	16
Jul-09	9	1	0	0	1	13	0	1	15	38	2
Sep-09	1	0	0	12	0	1	0	11	5	21	1
Nov-09	1	0	0	10	0	0	0	0	3	23	5
Jan-10	14	0	0	0	0	0	0	0	2	0	4
Mar-10	19	0	0	0	4	0	0	0	0	8	15
Jun-10	1	0	14	0	0	0	0	15	8	38	3

Table 5.6. Species diversity as calculated using Shannon-Weiner diversity (H') during the study period. Zeros indicate dates where no algae were found. GOM04 and GOM05 are not included as they did not have any algae at any date.

	CES11	GOM01	GOM02	GOM03	GOM06	GOM08	GOM09	GOM10	GOM11	GOM12	GOM13	GOM16
Jun-08	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.95	0.00	0.00	0.00
Sep-08	0.00	0.00	0.00	0.00	0.00	1.15	0.67	0.00	0.33	1.39	0.00	0.00
Nov-08	0.00	0.00	0.00	1.47	0.00	0.00	0.15	0.00	1.35	0.43	0.00	0.00
Jan-09	1.90	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00
Mar-09	1.53	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	1.55	0.00	0.00
May-09	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.61	1.53	0.00	1.90
Jul-09	0.72	0.00	0.00	0.00	0.00	2.01	0.00	0.00	1.70	2.61	0.00	0.23
Sep-09	0.00	0.00	0.00	1.79	0.00	0.00	0.00	2.01	1.40	2.21	0.00	0.00
Nov-09	0.00	0.00	0.00	2.09	0.00	0.00	0.00	0.00	1.08	2.32	0.00	1.25
Jan-10	1.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	1.74	0.00	0.32
Mar-10	2.17	0.00	0.00	0.00	0.73	0.00	0.00	0.00	0.00	1.36	0.00	2.10
Jun-10	0.00	0.00	0.37	0.00	0.00	0.00	0.00	1.50	1.48	2.63	0.00	0.01

Table 5.7. Most commonly collected seaweed species in this study. Abundant macroalgae was frequently observed at offshore, live bottom habitats (GOM11, GOM12) and inshore soft bottom habitats near the Sanibel Causeway (CES11, GOM16). Algae was rare or absent at the other 9 stations, so the most common species at all other stations may not be indicative of species composition. None of the opportunistic beach samples were included in this analysis.

Offshore, live bottom	Inshore, near Sanibel Causeway	All other stations
Botryocladia occidentalis	*Gracilaria tikvahiae*	*Botryocladia occidentalis*
Solieria filiformis	*Acanthophora spicifera*	*Solieria filiformis*
Hypnea spinella	*Spyridia filamentosa*	*Champia parvula*
Sargassum filipendula	*Lomentaria baileyana*	*Gracilaria blodgettii*
Gracilaria blodgettii	*Sargassum filipendula*	*Caulerpa mexicana*
Gracilaria mammillaris	*Dasya crouaniana*	*Agardhiella subulata*
Gracilaria tikvahiae	*Dictyota cervicornis*	*Sargassum natans*
Agardhiella subulata		*Dictyota cervicornis*
Dictyota cervicornis		*Hypnea spinella*
		Laurencia filiformis

Table 5.8. Correlation matrix of biological and physical variables for all stations, all dates. Pearson correlation coefficients are reported; asterisks denote significance ($p < 0.05$).

	Biomass (g FW m^{-2})	Biomass (g DW m^{-2})	Percent cover	Temp.	D.O.	pH	Sal.	Turbidity	Irr.
Biomass (g FW m-2)	-								
Biomass (g DW m-2)	0.948*	-							
Percent cover	0.852*	0.879*	-						
Temperature	0.113	0.131	0.146	-					
Dissolved Oxygen	-0.062	-0.086	-0.175	-0.759*	-				
pH	0.043	0.043	0.014	0.238*	0.318*	-			
Salinity	-0.089	-0.102	-0.092	0.182*	-0.077	0.059	-		
Turbidity	-0.047	0.052	0.000	-0.143	0.064	0.066	0.066	-	
Irradiance (I_z)	0.037	0.007	0.012	0.251*	-0.183	-0.010	-0.020	-0.124	-

Table 5.9. Pearson correlation coefficient matrix for biological and habitat components; asterisks denote significance ($p < 0.05$).

	Biomass (g FW m^{-2})	Biomass (g DW m^{-2})	Percent cover	*Lytechinus variagatus*	*Arbacia punctulata*	Pinnidae	*Diapatra cuprea*	*Soft coral*	*Hard coral*
Biomass (g FW m^{-2})	-								
Biomass (g DW m^{-2})	0.948*	-							
Percent cover	0.852*	0.879*	-						
Lytechinus variagatus	-0.186*	-0.179*	-0.217*	-					
Arbacia punctulata	-0.088	-0.063	-0.094	0.372*	-				
Pinnidae	-0.154	-0.154	-0.185*	0.380*	0.261*				
Diapatra cuprea	0.069	0.080	0.103	-0.147	-0.086	-0.138	-		
Soft coral	0.122	0.106	0.069	0.033	0.282*	-0.310	-0.063	-	
Hard coral	0.164	0.141	0.126	0.081	0.393*	-0.045	-0.075	0.648*	-

Table 5.10. A list of the algal species analyzed by PAM fluorometry, the number of samples of each species analyzed, and the algal class to which each species belongs.

Algal Species	# of samples analyzed	Class
Botryocladia occidentalis	14	Rhodophyte
Solieria filiformis	12	Rhodophyte
Agardhiella ramosissima	11	Rhodophyte
Agardhiella subulata	9	Rhodophyte
Gracilaria mammillaris	9	Rhodophyte
Gracilaria tikvahiae	9	Rhodophyte
Gracilaria blodgettii	8	Rhodophyte
Gracilaria bursa-pastoris	7	Rhodophyte
Chondria littoralis	5	Rhodophyte
Sargassum filipendula	5	Phaeophyte
Acanthophora musculoides	4	Rhodophyte
Ceramium sp.	4	Rhodophyte
Dictyota divaricata	4	Phaeophyte
Hydropuntia caudata	4	Rhodophyte
Lomentaria baileyana	4	Rhodophyte
Polysiphonia sp.	4	Rhodophyte
Champia parvula	3	Rhodophyte
Gracilaria cervicornis	3	Rhodophyte
Hincksia mitchelliae	3	Phaeophyte
Spyridia filamentosa	3	Rhodophyte
Ulva rigida	3	Chlorophyte
Caulerpa mexicana	2	Chlorophyte

Caulerpa racemosa var. *peltata*	2	Chlorophyte
Cladophora albida	2	Chlorophyte
Cladophora liniformis	2	Chlorophyte
Dasya baillouviana	2	Rhodophyte
Dictyota cervicornis	2	Phaeophyte
Dictyota pulchella	2	Phaeophyte
Eucheuma isiforme	2	Rhodophyte
Gracilaria damaecornis	2	Rhodophyte
Halymenia elongata	2	Rhodophyte
Halymenia floresii	2	Rhodophyte
Hypnea spinella	2	Rhodophyte
Caulerpa sertularioides	1	Chlorophyte
Caulerpa vickersiae	1	Chlorophyte
Champia salicornioides	1	Rhodophyte
Chondria atropurea	1	Rhodophyte
Dasya mollis	1	Rhodophyte
Dasya ocellata	1	Rhodophyte
Dictyota menstrualis	1	Phaeophyte
Gracilaria cylindrica	1	Rhodophyte
Laurencia intricata	1	Rhodophyte
mixed sample	1	na
Sargassum acinarium	1	Phaeophyte
Sargassum histrix	1	Phaeophyte
Scinaia caribaea	1	Rhodophyte
Sebdenia flabellata	1	Rhodophyte

Udotea conglutinata	1	Chlorophyte
Ulva profunda	1	Chlorophyte

Table 5.11. A list of the algal genera analyzed by PAM fluorometry and the number of samples of each genera analyzed.

Genus	# of samples analyzed	Genus	# of samples analyzed
Gracilaria	39	*Lomentaria*	4
Agardhiella	20	*Halymenia*	4
Botryocladia	14	*Polysiphonia*	4
Solieria	12	*Ceramium*	4
Dictyota	9	*Champia*	4
Sargassum	7	*Hincksia*	3
Caulerpa	6	*Spyridia*	3
Chondria	6	*Eucheuma*	2
Dasya	4	*Hypnea*	2
Acanthophora	4	*Laurencia*	1
Cladophora	4	*Scinaia*	1
Ulva	4	*Sebdenia*	1
Hydropuntia	4	*Udotea*	1

Table 5.12. The stations from which samples were collected, and the number of samples analyzed by PAM fluorometry from each station.

Station	# of samples analyzed
CES11	40
GOM12	37
GOM11	32
GOM3	13
GOM16	12
GOM6	7
GOM1	6
GOM2	5
GOM10	4
GOM8	3
GOM9	3
GOM13	1

Table 5.13. The number of samples analyzed each month over the course of the study.

Sampling Month	# of samples analyzed
2008_06	12
2008_09	11
2008_11	10
2009_01	14
2009_03	13
2009_05	16
2009_07	25
2009_09	12
2009_11	15
2010_01	14
2010_03	10
2010_05	12
2010_06	13

Table 5.14. ANOVA results for the six most commonly analyzed species versus location.

Species	location	N	Mean	Std. Error	Sig.
Agardhiella ramosissima	offshore	4	.3367	.04263	.428
	inshore	3	.4018	.06722	
Agardhiella subulata	offshore	4	.3796	.03132	.368
	inshore	5	.4572	.06695	
Botryocladia occidentalis	offshore	9	.4147	.02500	.628
	inshore	2	.4433	.04000	
Gracilaria mammillaris	offshore	6	.3097	.03315	.126
	inshore	3	.4556	.10489	
Gracilaria tikvahiae	offshore	3	.2200	.11082	.459
	inshore	4	.3354	.09289	
Solieria filiformis	offshore	5	.3257	.04216	.028
	inshore	5	.4853	.04218	

Table 5.15. ANOVA results for the six most commonly analyzed species versus season.

Species	season	N	Mean	Std. Error	Sig.
Agardhiella ramosissima	dry	6	.3824	.03778	.267
	wet	1	.2576	.	
Agardhiella subulata	dry	4	.4896	.04447	.143
	wet	5	.3692	.05426	
Botryocladia occidentalis	dry	5	.4362	.03696	.513
	wet	6	.4063	.02569	
Gracilaria mammillaris	dry	3	.3911	.14405	.634
	wet	6	.3419	.02014	
Gracilaria tikvahiae	dry	3	.2272	.17294	.512
	wet	4	.3300	.01447	
Solieria filiformis	dry	2	.5650	.07167	.028
	wet	8	.3656	.03298	

Table 5.16. Results of the two factor ANOVA for the four most common genera analyzed. "nd" stands for "no data", in which a standard deviation (std dev) could not be computed due to the lack of samples (n = 0 or 1). "p location" is the p-value testing for location (inshore vs. offshore) differences in QY values. "p season" is the p-value testing for seasonal (wet vs. dry) differences in QY values.

Genera	Location	Season	N	Mean	std dev	p location	p season
Agardhiella	inshore	dry	1	0.4306	nd	0.125	0.047
		wet	1	0.23	nd		
	offshore	dry	0	nd	nd		
		wet	3	0.3237	0.032		
Botryocladia	inshore	dry	0	nd	nd	0.407	0.354
		wet	2	0.4433	0.057		
	offshore	dry	5	0.4362	0.083		
		wet	4	0.3878	0.065		
Gracilaria	inshore	dry	1	0.47	nd	0.424	0.033
		wet	1	0.315	nd		
	offshore	dry	0	nd	nd		
		wet	3	0.3385	0.02		
Solieria	inshore	dry	1	0.4933	nd	0.367	0.755
		wet	1	0.4625	nd		
	offshore	dry	0	nd	nd		
		wet	3	0.3808	0.06		

Table 5.17. Results of the paired t-tests among the six most common species. Each species was compared to the other five for a total of 15 comparisons. The mean difference (Mean) between the QY values of each species in the pair is given, along with the standard deviation, mean standard error, and lower and upper bounds of the 95% confidence interval. The t statistic is provided with the degrees of freedom (df) and the significance value (two-tailed).

Pair	Comparison	Mean	Std. Dev.	Std. Err.	Lower	Upper	t	df	Sig.
Pair 1	*Agardhiella ramosissima - Agardhiella subulata*	-.176	.055	.028	-.264	-.088	-6.40	3	.008
Pair 2	*Agardhiella ramosissima - Botryocladia occidentalis*	-.084	.105	.053	-.251	.084	-1.59	3	.210
Pair 3	*Agardhiella ramosissima - Gracilaria mammillaris*	-.063	.063	.036	-.220	.093	-1.74	2	.224
Pair 5	*Agardhiella ramosissima - Solieria filiformis*	-.104	.050	.035	-.554	.347	-2.93	1	.210
Pair 6	*Agardhiella subulata - Botryocladia occidentalis*	-.048	.089	.051	-.269	.172	-.940	2	.446
Pair 7	*Agardhiella subulata - Gracilaria mammillaris*	.014	.091	.041	-.100	.128	.342	4	.749
Pair 8	*Agardhiella subulata - Gracilaria tikvahiae*	-.033	.040	.023	-.132	.067	-1.42	2	.292
Pair 9	*Agardhiella subulata - Solieria filiformis*	-.045	.129	.058	-.206	.115	-.784	4	.477
Pair 10	*Botryocladia occidentalis - Gracilaria mammillaris*	.114	.074	.030	.036	.192	3.76	5	.013
Pair 11	*Botryocladia occidentalis - Gracilaria tikvahiae*	.204	.114	.066	-.078	.487	3.11	2	.090
Pair 12	*Botryocladia occidentalis - Solieria filiformis*	.070	.065	.027	.002	.139	2.66	5	.045

Pair 13	*Gracilaria mammillaris* - *Gracilaria tikvahiae*	.073	.070	.035	-.039	.184	2.07	3	.130
Pair 14	*Gracilaria mammillaris* - *Solieria filiformis*	-.038	.064	.026	-.105	.029	-1.46	5	.205
Pair 15	*Gracilaria tikvahiae* - *Solieria filiformis*	-.084	.071	.036	-.198	.029	-2.37	3	.099

Table 5.18. Results of the paired t-tests among the three classes of algae analyzed. Each class was compared to the other two for a total of three comparisons. The mean difference (Mean) between the QY values of each class in the pair is given, along with the standard deviation, mean standard error, and lower and upper bounds of the 95% confidence interval. The t statistic is provided with the degrees of freedom (df) and the significance value (two-tailed).

Pair	Comparison	Mean	Std. Dev.	Std. Err.	Lower	Upper	t	df	Sig.
Pair 1	Chlorophyte - Phaeophyte	-.029	.106	.043	-.140	.082	-.68	5	.526
Pair 2	Chlorophyte - Rhodophyte	.231	.124	.041	.136	.327	5.60	8	.001
Pair 3	Phaeophyte - Rhodophyte	.197	.137	.037	.118	.276	5.37	13	.000

Table 5.19. Results of the three way ANOVA processed through the Generalized Linear Model algorithm in SPSS. The Source refers to each parameter in the model, including interaction effects and error terms. The Type III sum of squares represents the variability in the model caused by the associated variable. Degrees of freedom (df), Mean Square values, and the F statistics are also provided. The significance of each variable (Sig.) is the p-value, and indicates the role of each variable in predicting QY values.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.318	13	.024	1.885	.047
Intercept	7.866	1	7.866	605.303	.000
IO2	.100	1	.100	7.680	.007
Season	.041	1	.041	3.154	.080
Genus	.098	3	.033	2.519	.065
IO2 * Season	.009	1	.009	.672	.415
IO2 * Genus	.008	3	.003	.203	.894
Season * Genus	.018	3	.006	.460	.711
IO2 * Season * Genus	.011	1	.011	.868	.355
Error	.884	68	.013		
Total	13.292	82			
Corrected Total	1.202	81			

Table 5.20. The formulas for the three simulation equations for QY, I_z, and temperature and the pertinent regression data from comparisons with actual, monthly-averaged data.

Parameter	Simulation equation	R^2 value	slope	significance
temperature	24.023*(1-0.27*COS(6.2832/365*(day-5)))	0.88	0.73	<0.0001
I_z	62*(1-0.8375*COS(6.2832/365*(day+70)))	0.81	0.88	0.006
quantum yield	0.4478*(1-0.22*COS(6.2832/365*(day+110)))	0.64	0.82	0.002

Table 5.21. The top five algal species, stations, and sampling events (Date) for which samples were processed for stable isotope analysis.

Species	# analyzed	Station	# analyzed	Date	# analyzed
Solieria filiformis	43	GOM12	86	2009_09	37
Gracilaria mammillaris	32	CES11	37	2010_03	31
Gracilaria tikvahiae	23	GOM3	33	2010_01	29
Botryocladia occidentalis	18	GOM11	21	2009_11	28
Gracilaria intermedia	11	GOM16	12	2010_04	26

Table 5.22. ANOVA results of algal tissue nutrient data including carbon to nitrogen ratios (C:N), $\delta^{15}N$, and total tissue phosphate (TTP) versus location (inshore versus offshore) and season (dry versus wet). The mean values for each parameter are given with the standard errors. The p-values correspond to the location comparison (inshore versus offshore), seasonal differences (dry versus wet), and any interaction between location and season.

Parameter	Group	Location	Season	Mean	Std. Err.	Comparison	p-value
C:N	all algae	inshore	dry	15.61	0.86	Location	0.003
			wet	14.51	0.99	Season	0.741
		offshore	dry	17.43	0.86	Interaction	0.359
			wet	17.94	0.79		
	Gracilaria mammillaris	inshore	dry	23.98	7.81	Location	0.989
			wet	13.23	3.49	Season	0.192
		offshore	dry	19.41	2.09	Interaction	0.32
			wet	17.93	2.47		
	rhodophytes	inshore	dry	18.77	1.26	Location	0.739
			wet	14.12	1.21	Season	0.031
		offshore	dry	17.00	1.08	Interaction	0.063
			wet	16.65	1.02		
	Solieria filiformis	inshore	dry	19.74	2.25	Location	0.996
			wet	13.50	1.59	Season	0.017
		offshore	dry	17.79	1.52	Interaction	0.266
			wet	15.44	1.39		
d15N	all algae	inshore	dry	6.04	0.22	Location	0.108
			wet	4.66	0.26	Season	<0.0001
		offshore	dry	5.14	0.22	Interaction	0.019
			wet	4.83	0.20		
	Gracilaria mammillaris	inshore	dry	4.52	1.19	Location	.516
			wet	5.14	0.53	Season	.805

		offshore	dry	4.51	0.32	Interaction	.521
			wet	4.23	0.38		
	rhodophytes	inshore	dry	6.43	0.27	Location	0.001
			wet	4.87	0.26	Season	<0.0001
		offshore	dry	4.92	0.23	Interaction	0.011
			wet	4.62	0.22		
	Solieria filiformis	inshore	dry	6.92	0.47	Location	.019
			wet	4.38	0.33	Season	.000
		offshore	dry	5.08	0.32	Interaction	.011
			wet	4.46	0.29		
TTP	all algae	inshore	dry	1181.21	396.63	Location	0.87
			wet	851.19	275.22	Season	<0.0001
		offshore	dry	1286.83	384.60	Interaction	0.275
			wet	708.51	314.05		
	all *Gracilaria*	inshore	dry	1285.08	404.56	Location	0.676
			wet	881.45	310.58	Season	<0.0001
		offshore	dry	1691.45	.	Interaction	0.058
			wet	618.09	231.70		

Table 5.23. Regression analysis results of salinity (independent variable) against the algal tissue nutrient (dependent) variables, where C:N refers to the tissue carbon to nitrogen atomic ratio and TTS refers to total tissue phosphate content. The p-value indicates the significance of the regression between the independent and dependent variables, the corresponding slope (when the relationship is significant) and the goodness of fit (r square value).

independent variable	dependent variable	p-value	slope	r square
salinity	$\delta^{13}C$	0.73	0	0.02
salinity	$\delta^{15}N$	0.03	-0.38	0.5
salinity	C:N	0.62	0	0.04
salinity	TTP	0.52	0	0.08
salinity	N:P	0.19	0	0.09

Table 5.24. Attached Macroalgae taxa collected from artificial and natural reefs with species codes used for statistical analysis, plots, and graphs.

Order	Genus	Species	Species Code	Frequency of Occurrence (n=240)	
Rhodophyta	*Agardhiella*	*ramosissima*	AGARAM	1	0.4%
	Agardhiella	*subulata*	AGASUB	35	14.6%
	Botryocladia	*occidentalis*	BOTOCC	105	43.8%
	Champia	*parvula*	CHAPAR	5	2.1%
	Chondria	*floridana*	CHOFLO	3	1.3%
	Chondria	sp.	CHONDRIASP.	31	12.9%
	Ceramium	sp.	CERAMIUMSP.	2	0.8%
	Dasya	*ramosissima*	DASRAM	6	2.5%
	Dasya	sp.	DASYASP.	33	13.8%
	Eucheuma	*isiforme den.*	EUCISI	47	19.6%
	Gracilaria	sp.	GRACILARIASP.	12	5.0%
	Gracilaria	*blodgettii*	GRABLO	38	15.8%
	Gracilaria	*bursa-pastoris*	GRABUR	1	0.4%
	Gracilaria	*caudata*	GRACAU	4	1.7%
	Gracilaria	*cervicornis*	GRACER	11	4.6%
	Gracilaria	*cylindrica*	GRACYL	1	0.4%
	Gracilaria	*damaecornis*	GRADAM	1	0.4%
	Gracilaria	*mammillaris*	GRAMAM	89	37.1%
	Gracilaria	*tikvihiae*	GRATIK	57	23.8%
	Halymenia	*floresii*	HALFLO	13	5.4%
	Halymenia	sp.	HALYMENIASP.	5	2.1%
	Hydropuntia	*caudata*	HYDCAU	1	0.4%
	Hypnea	*spinella*	HYPSPI	1	0.4%
	Laurencia	*chondrioides*	LAUCHO	1	0.4%
	Laurencia	*filiformis*	LAUFIL	6	2.5%
	Laurencia	*intricata*	LAUINT	8	3.3%
	Laurencia	sp. *(poiteaui)*	LAURENCIASP.	41	17.1%
	Sebania	*flabellata*	SEBFLA	5	2.1%
	Solieria	*filiformis*	SOLFIL	25	10.4%
	Wurdemannia	*miniata*	WURMIN	4	1.7%
Phaeophyta	*Dictyota*	*cervicornis*	DICCER	1	0.4%
	Dictyota	*pulchella*	DICPUL	3	1.3%
	Dictyota	sp.	DICTYOTASP.	31	12.9%
	Dictyopteris	*delicatula*	DICDEL	2	0.8%

	Sargassum	*filipendula*	SARFIL	14	5.8%
	Sargassum	*hystrix*	SARHYS	9	3.8%
	Sargassum	*vulgare*	SARVUL	2	0.8%
	Sargassum	sp.	SARGASSUMSP.	53	22.1%
Chlorophyta	*Acetabularia*	sp.	ACETABULARIASP.	1	0.4%
	Caulerpa	*ashmeadii*	CAUASH	1	0.4%
	Caulerpa	*mexicana*	CAUMEX	10	4.2%
	Caulerpa	*racemosa peltata*	CAURAC	34	14.2%
	Caulerpa	*sertularioides*	CAUSER	0	0.0%
	Caulerpa	sp.	CAULERPASP.	12	5.0%
	Codium	*isthmocladum*	CODIST	3	1.3%
	Codium	*decorticatum*	CODDEC	1	0.4%
	Codium	sp.	CODIUMSP.	15	6.3%
	Halimeda	sp.	HALIMEDASP.	4	1.7%
	Halimeda	*incrassata*	HALINC	5	2.1%
	Rhipocephalus	*phoenix group*	RHIPHO	9	3.8%
	Udotea	sp.	UDOTEASP.	86	35.8%
	Ulva	sp.	ULVASP.	2	0.8%

Table 5.25. Univariate Diversity Indices for Wet Season Reef Samples: Based on Frequency of Occurrence (bold indicates highest value for that index where S=species, N=total abundance, d=Margalef richness, J'=Pielous's evenness, H'=Shannon's diversity, and 1- Lambda'= Simpson's index).

Sample	S	N	d	J'	H'(loge)	1-Lambda'
35 ledge 8/8/09	**22**	**71**	**4.926**	0.9168	**2.834**	**0.9445**
Shermans 8/8/09	14	47	3.376	**0.9181**	2.423	0.9214
Edison 8/29/09	15	29	4.158	0.921	2.494	0.931
GH1 8/29/09	9	42	2.14	0.9563	2.101	0.8885
60 ft Ledge 9/19/09	8	31	2.038	0.8931	1.857	0.8538
53 Ledge 9/19/09	19	67	4.281	0.8786	2.587	0.9186
Sherman's 10/10/09	4	6	1.674	0.8962	1.242	0.80
35 Ledge 10/10/09	14	72	3.04	0.9228	2.435	0.9155
60 Ledge 10/24/09	11	36	2.791	0.8762	2.101	0.8698
Ledge 53 10/24/09	16	63	3.62	0.8943	2.479	0.9135
GH Barge 10/31/09	8	14	2.652	0.9475	1.97	0.9121
Edison 10/31/09	8	15	2.585	1.934	0.8952	0.93

Table 5.26. Univariate Diversity Indices for Dry Season Reef Samples: Based on Frequency of Occurrence (bold font indicates highest value for that index where S=species, N=total abundance, d=Margalef richness, J’=Pielous’s evenness, H’=Shannon’s diversity, and 1-Lambda'= Simpson’s index).

Sample	S	N	d	J'	H'(loge)	1-Lambda'
Edison 5/2/09 total	8	22	2.265	0.8857	1.842	0.8485
Sherman's 5/23/09	**19**	51	**4.578**	0.9075	**2.672**	**0.9341**
53 Ledge 5/9/09	14	40	3.524	0.9291	2.452	0.9244
35 Ledge 5/9/09	6	14	1.895	0.8577	1.537	0.7912
60 Ledge 5/23/09	17	45	4.203	0.9134	2.588	0.9303
GH Barge 5/8/10	6	11	2.085	**0.9335**	1.673	0.8727
Sherman's 5/20/10	12	27	3.338	0.9388	2.333	0.9259
60 Ledge 5/20/10	11	33	2.86	0.8755	2.099	0.8788
35 Ledge 5/22/10	17	**58**	3.94	0.9315	2.639	**0.9341**
53 Ledge 5/22/10	12	50	2.812	0.9226	2.293	0.9037
Edison 5/29/10	16	46	3.918	0.9234	2.56	0.9295

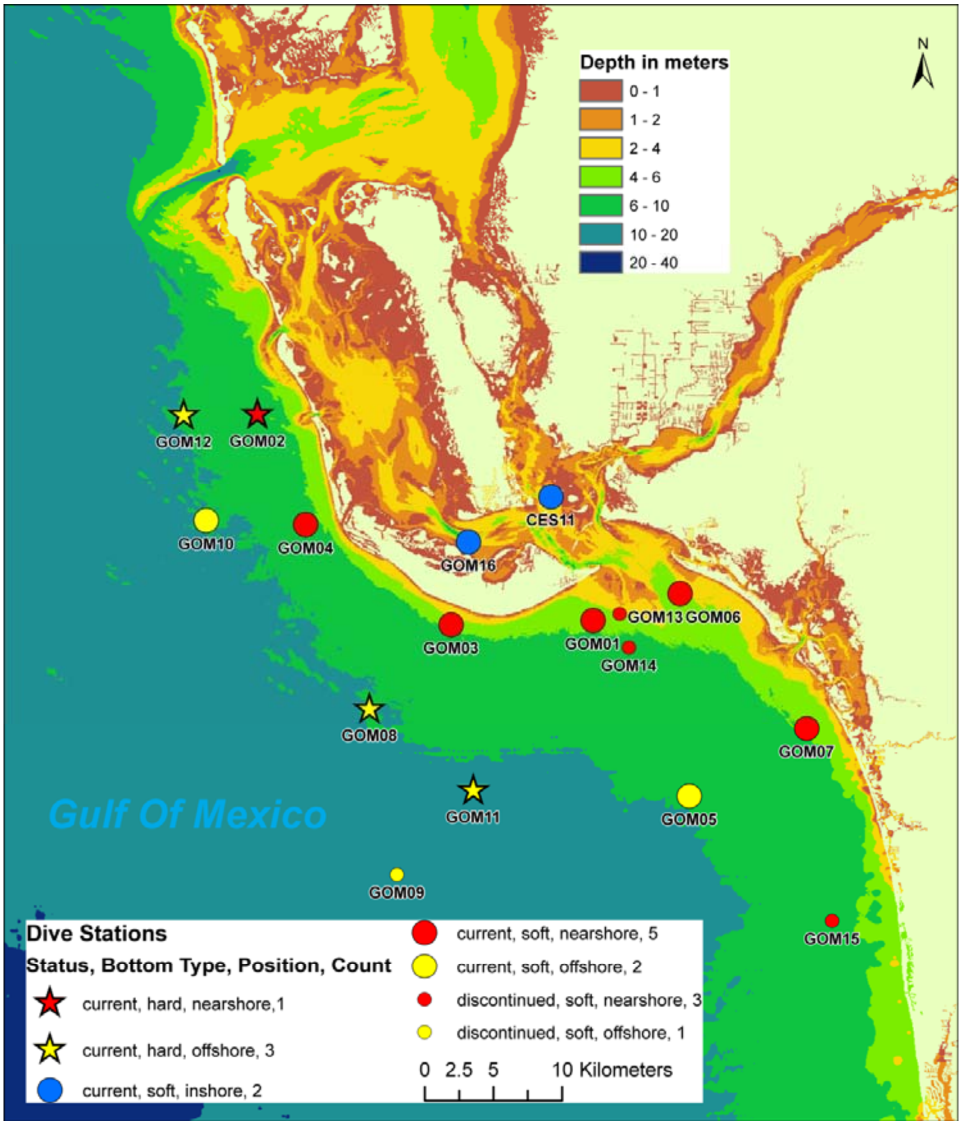


Fig.5.1. Map of the study area, Lee County, FL. The figure legend denotes the current and discontinued stations. Sampling began in June 2008 and continued bimonthly until July 2010. Station GOM09 was discontinued in November 2008. GOM12 was added in September 2008 and GOM16 was added in January 2009.

Fig. 5.2. Macroalgae were collected in quadrats along a belt transect by two SCUBA divers (n =20). Percent cover of macroalgae was estimated, then all of the algae within the 1 sq. meter quadrat was collected. Invertebrates and other epibenthic features were then enumerated. This image was taken by V. Roche, News-Press.

Fig. 5.3. Macroalgae was collected into mesh bags at random locations along a transect. Photo courtesy of V. Roche, News-Press

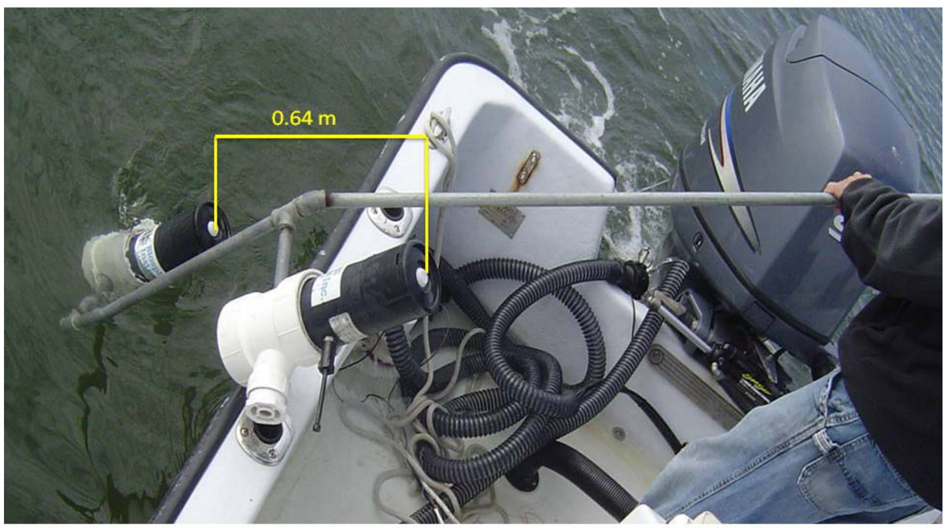


Fig 5.4. Light sensor deployment. Each sensor is mounted at 0.64 m depth intervals. Sensors are deployed underwater for 30 seconds, recording at 1Hz. Data is downloaded via PC upon return to lab, and % light at depth is calculated using raw irradiance values from the top and bottom sensors.

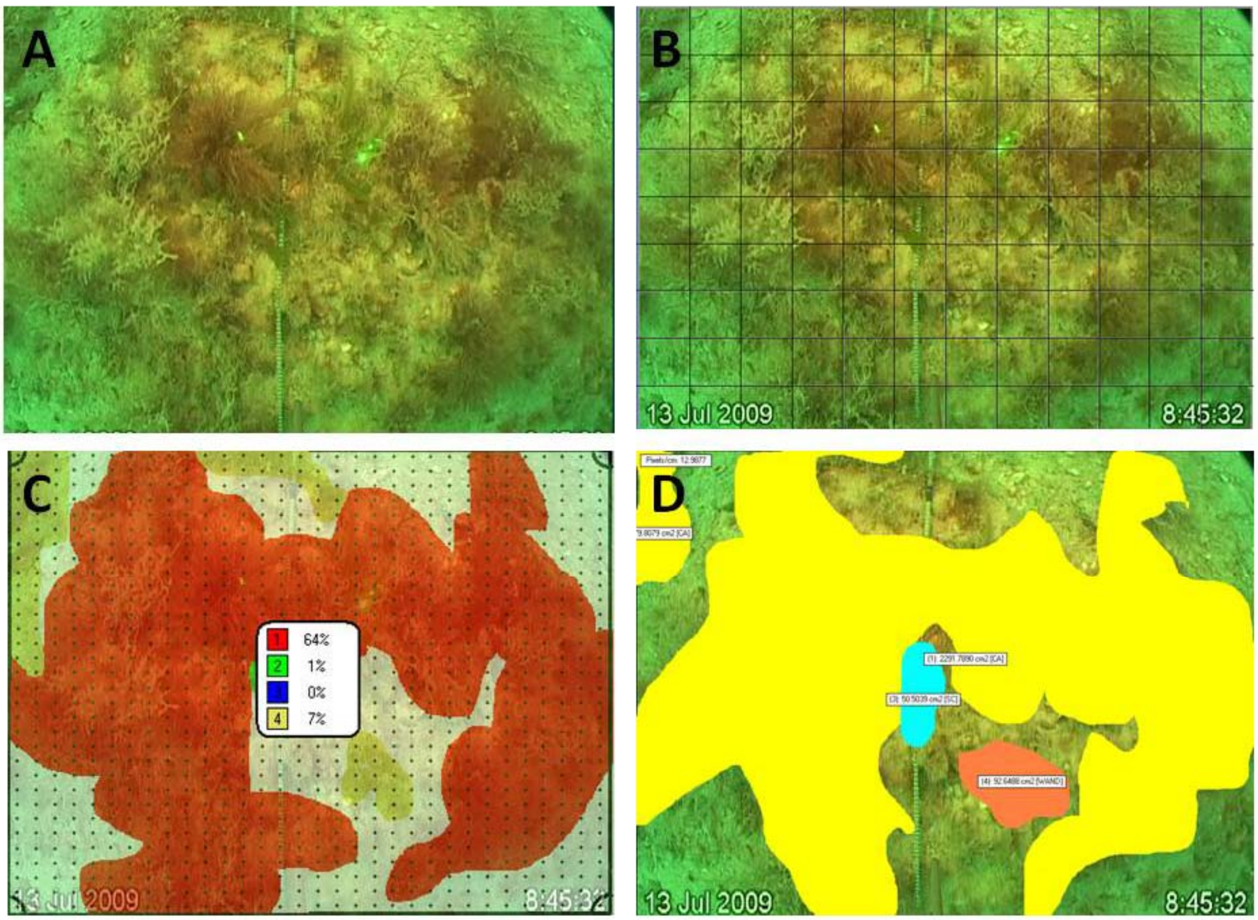


Figure 5.5. Methods for video transect analysis. (A) A raw frame grab from July 2009 using Pinnacle© software. (B) The presence/absence grid using COREL© software. (C) The point count method using Vidana©. Colors are applied by user, and overlay of points are superimposed. (D) The area analysis using laser calibration (15 cm, seen in A) and calculated area using CPCE©. Areas are outlined after calibration to laser scale, and area is calculated based on pixels per cm.

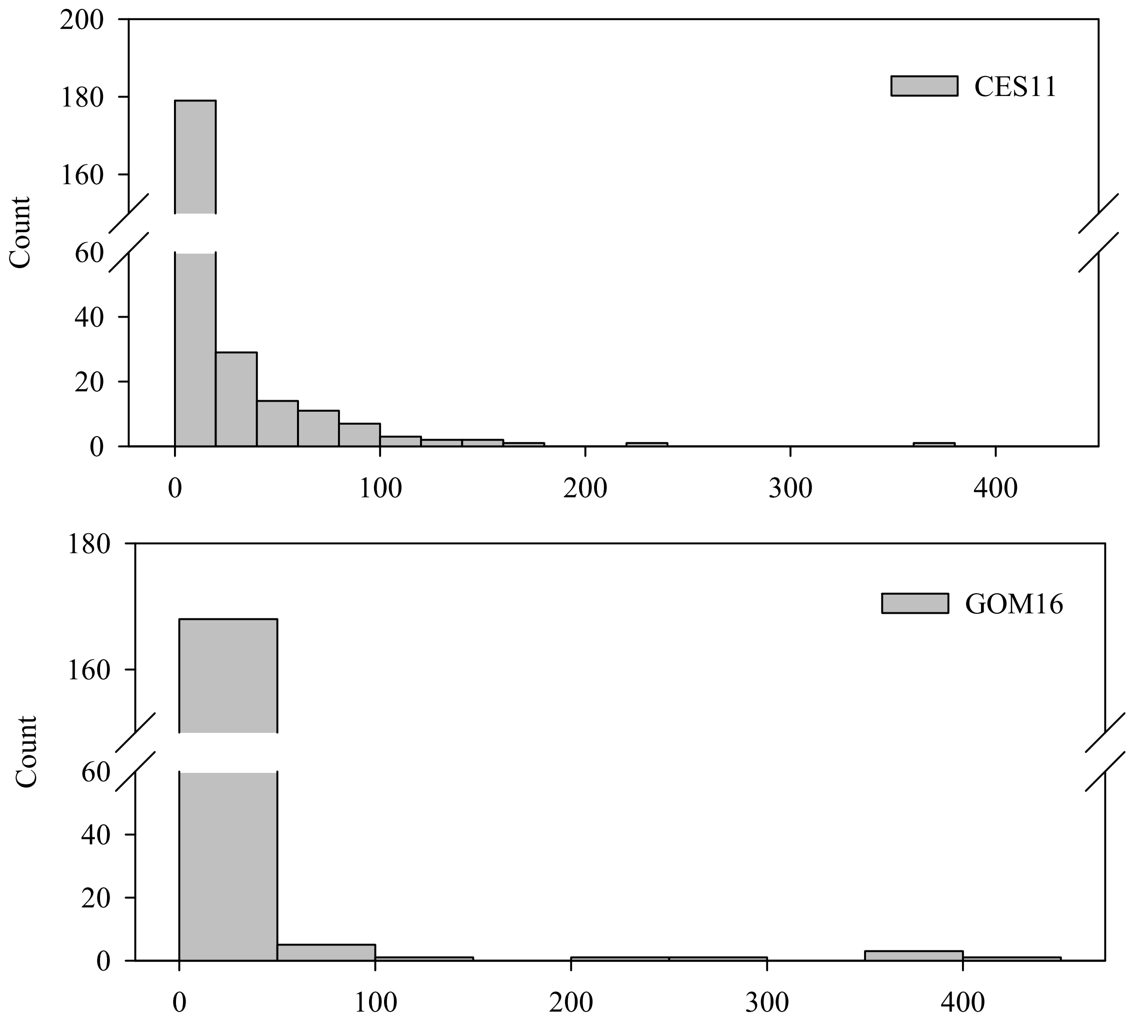


Fig. 5.6. Histogram containing number of quadrats (1 m^2) containing algae binned by the total fresh (wet) weight biomass (g FW m^{-2}). Upper; CES11. Lower; GOM16. These two stations were inshore, near the Sanibel causeway, and typically contained abundant macroalgae.

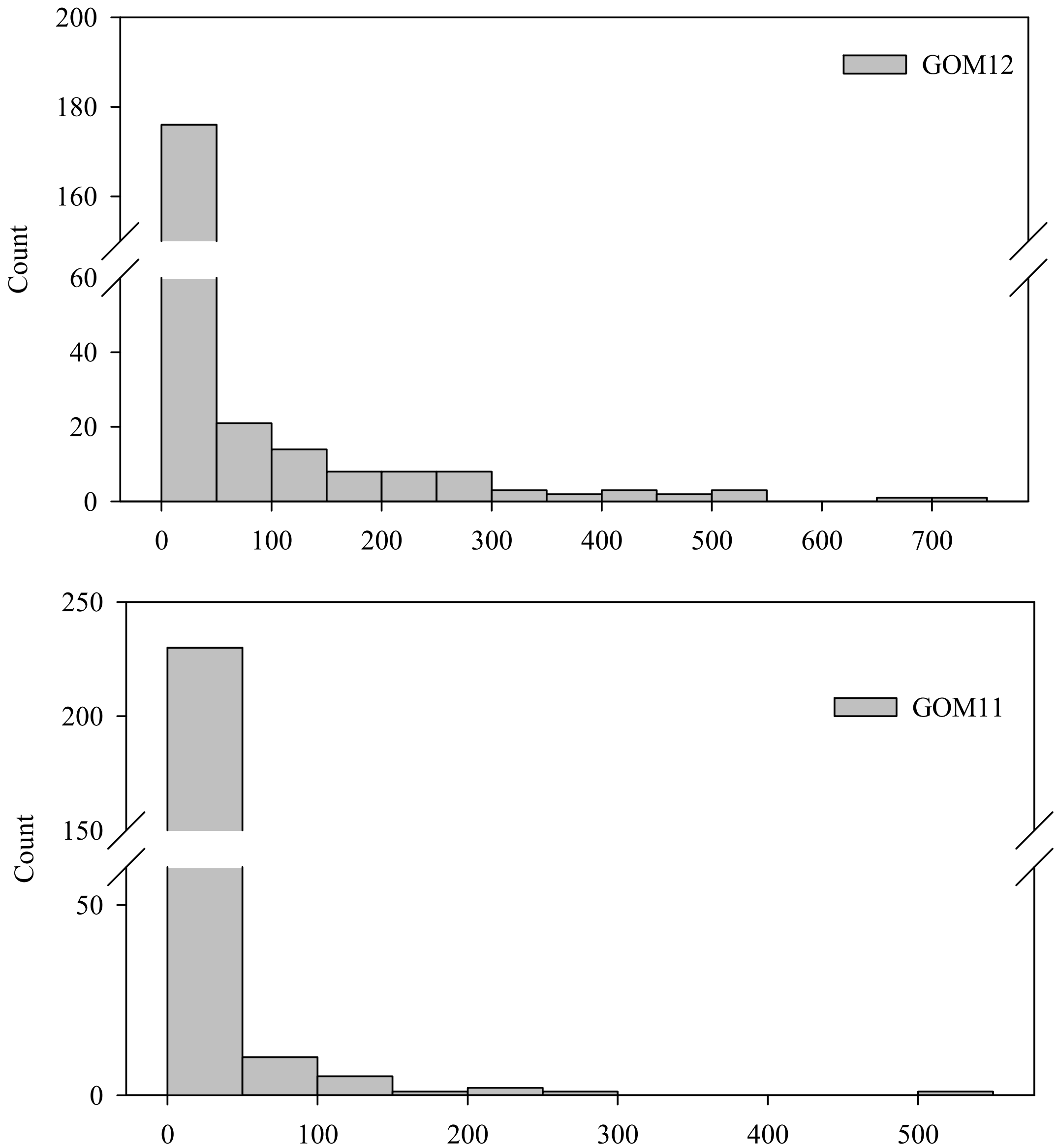


Fig. 5.7. Histograms containing the number of quadrats (1 m2) containing algae binned by the total fresh weight biomass. Upper; GOM12. Lower GOM11. These stations were offshore and contained natural limestone outcroppings with abundant macroalgae, corals and sponges.

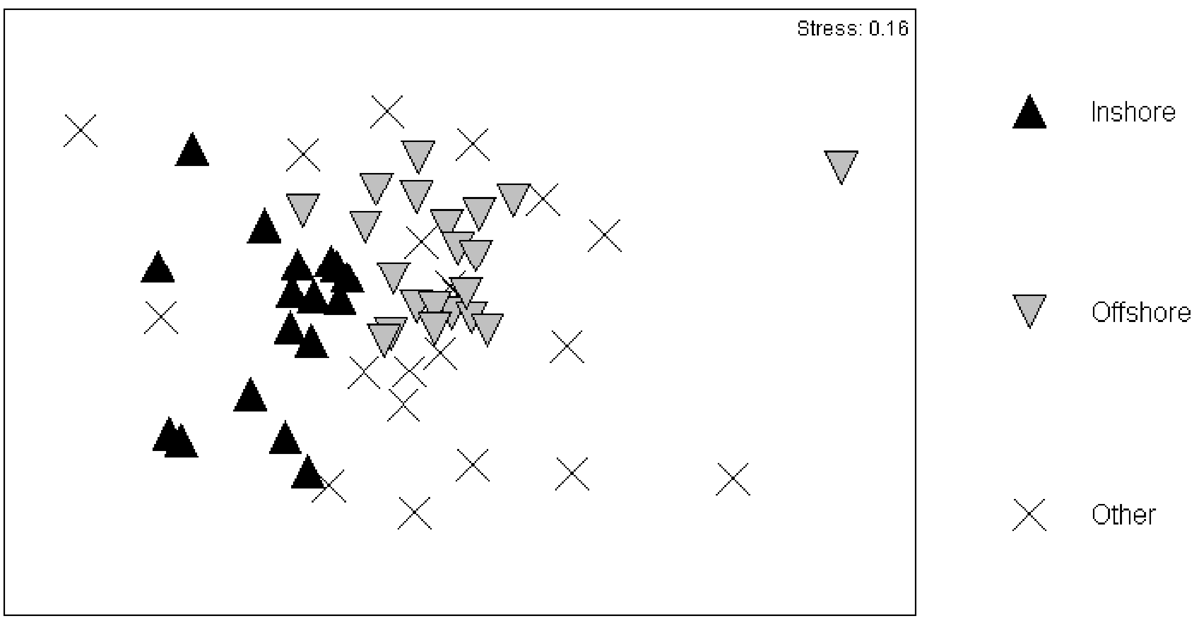


Fig. 5.8. Non-metric multidimensional scaling analysis (MDS) for macroalgal species found most often at offshore (live bottom; GOM11, GOM12), and inshore (Stations CES11 and GOM16) as well as others(Stations GOM01, GOM02, GOM03, GOM04, GOM05, GOM06, and GOM07, GOM10).

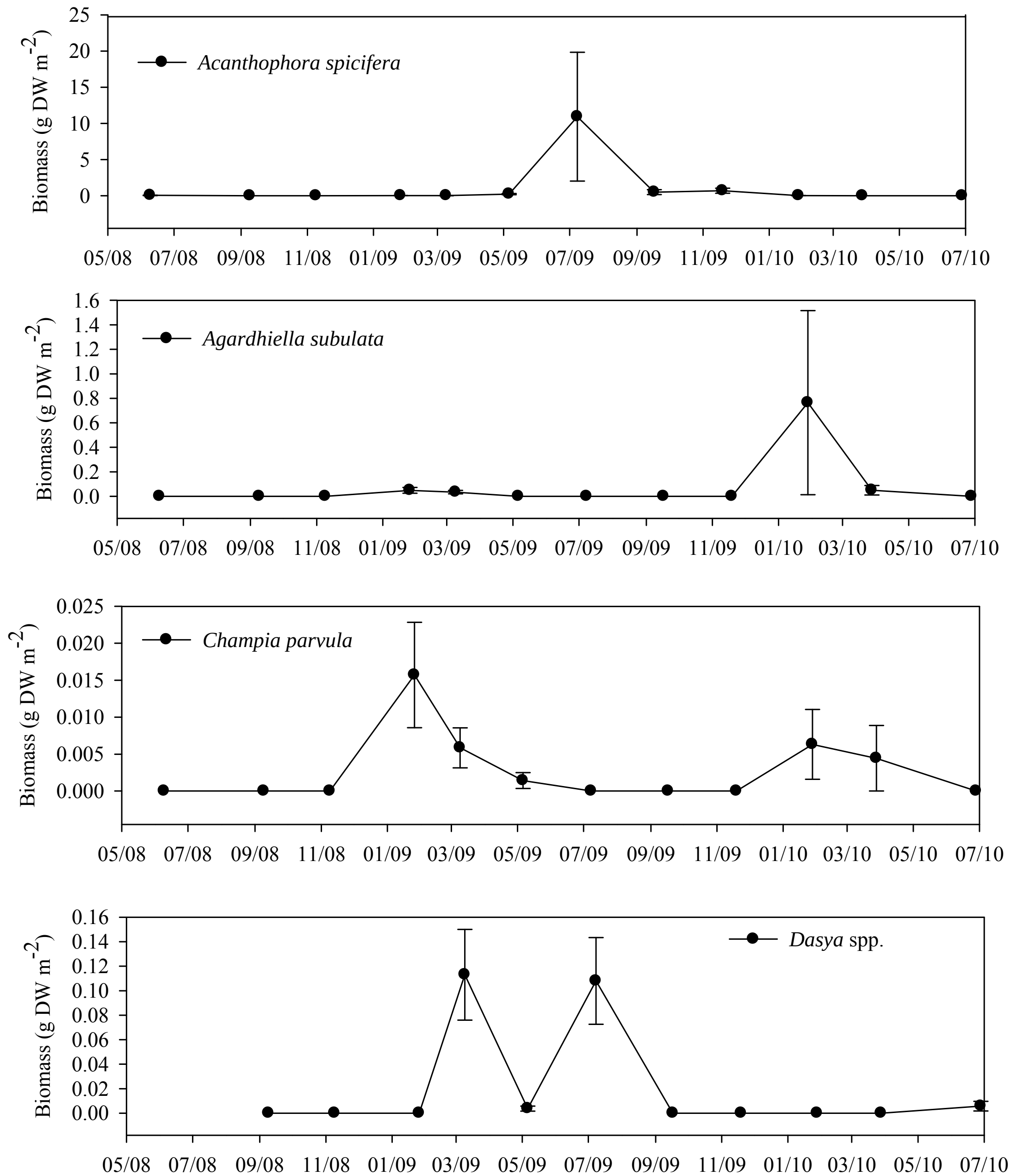


Fig. 5.9 Biomass (g DW m^{-2}) of key macroalgal species at CES11. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

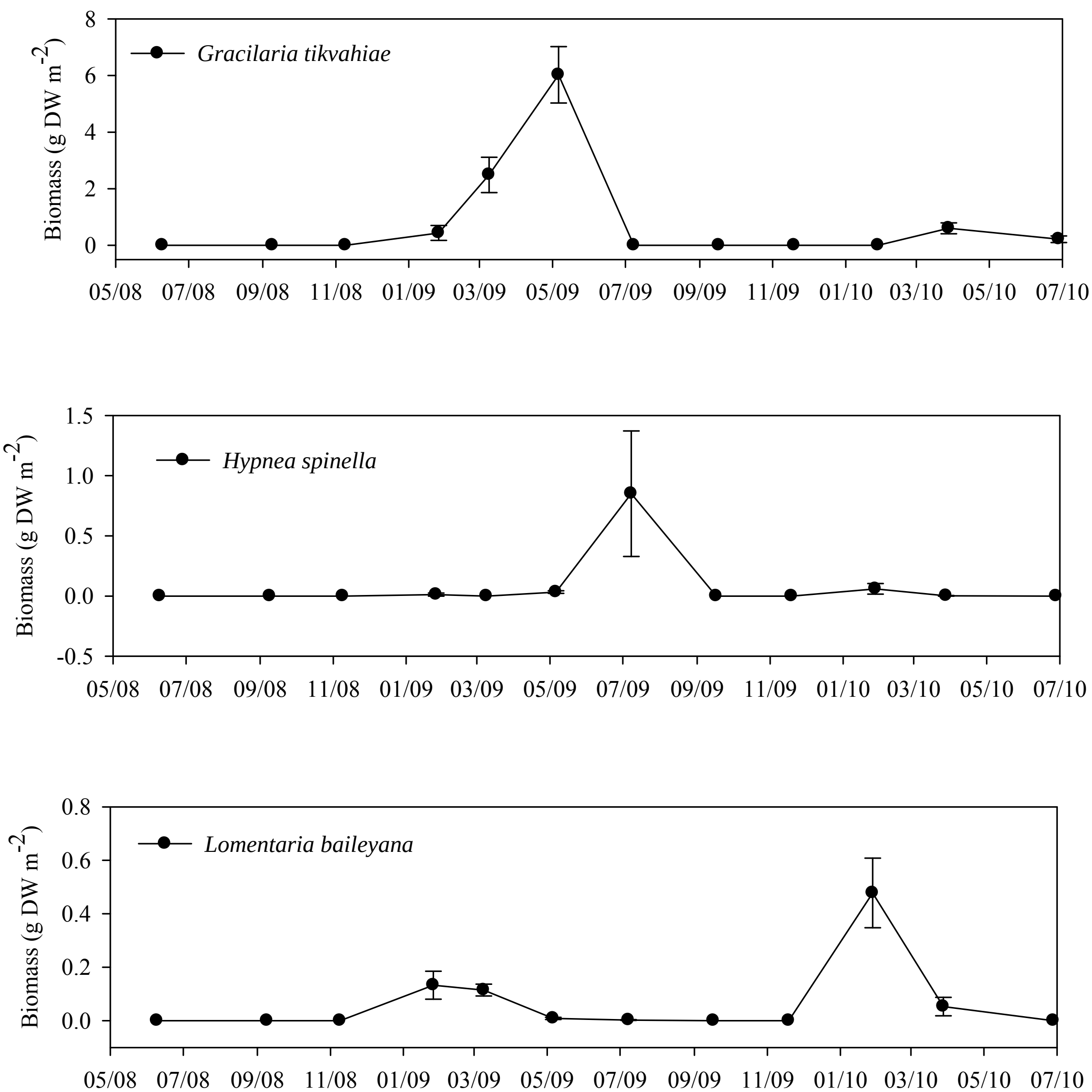


Fig. 5.10. Biomass (g DW m^{-2}) of key macroalgal species at CES11. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

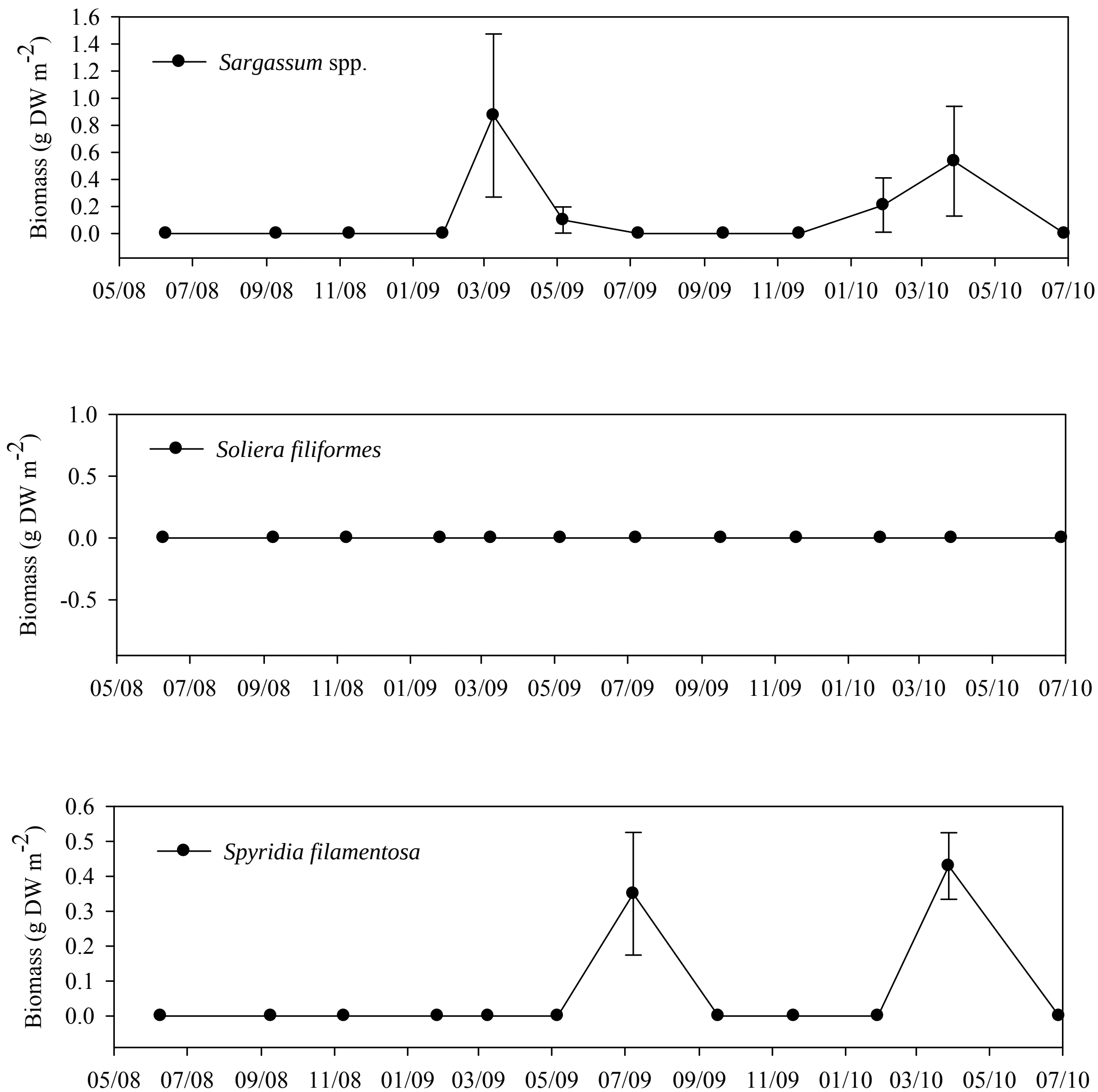


Fig. 5.11. Biomass (g DW m^{-2}) of a subset macroalgal species at CES11. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

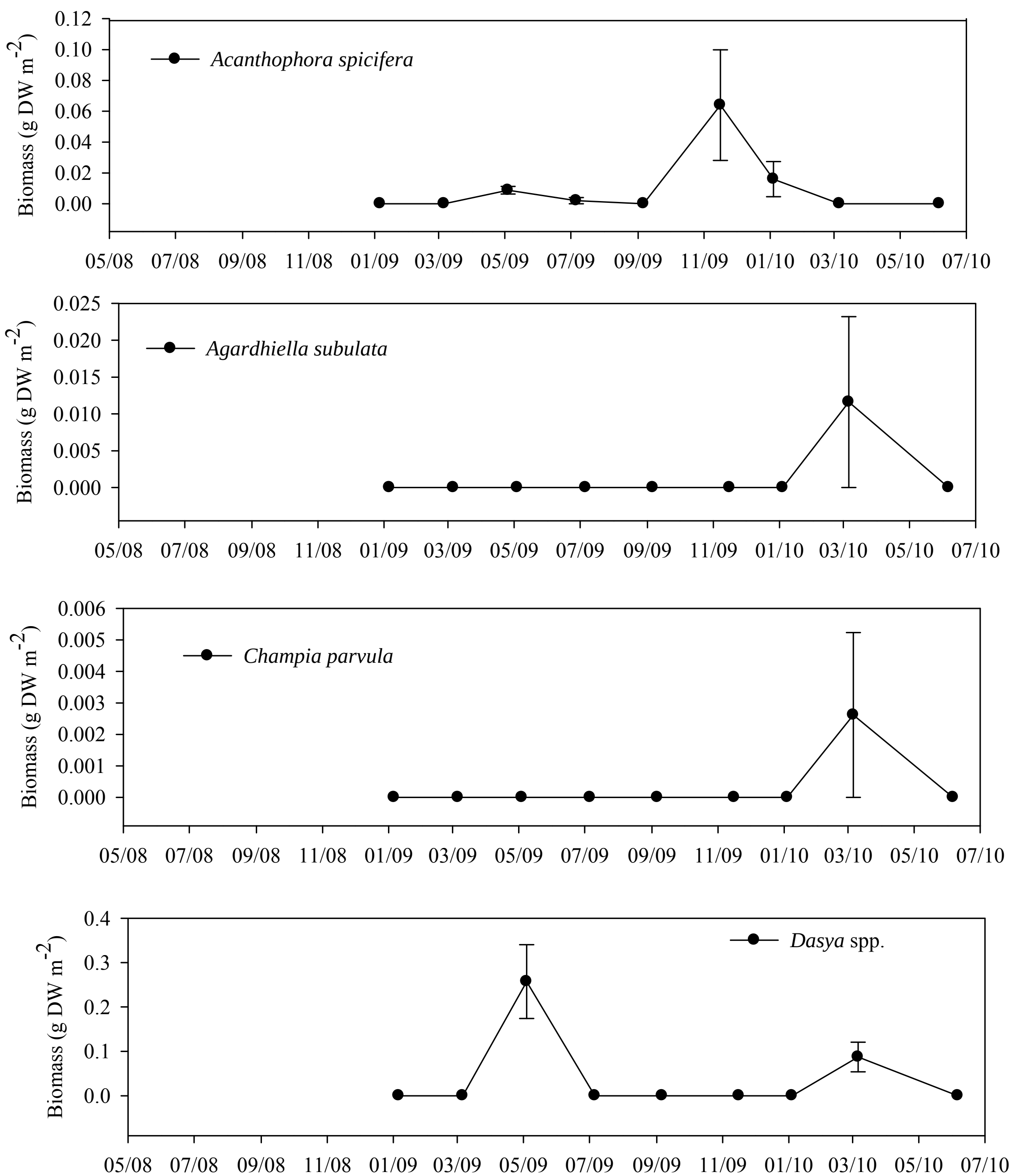


Fig. 5.12. Biomass (g DW m^{-2}) of a subset of macroalgal species at GOM16. GOM16 was added as a permanent station in January 2009 and samples were not collected in June, September, or November 2008. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

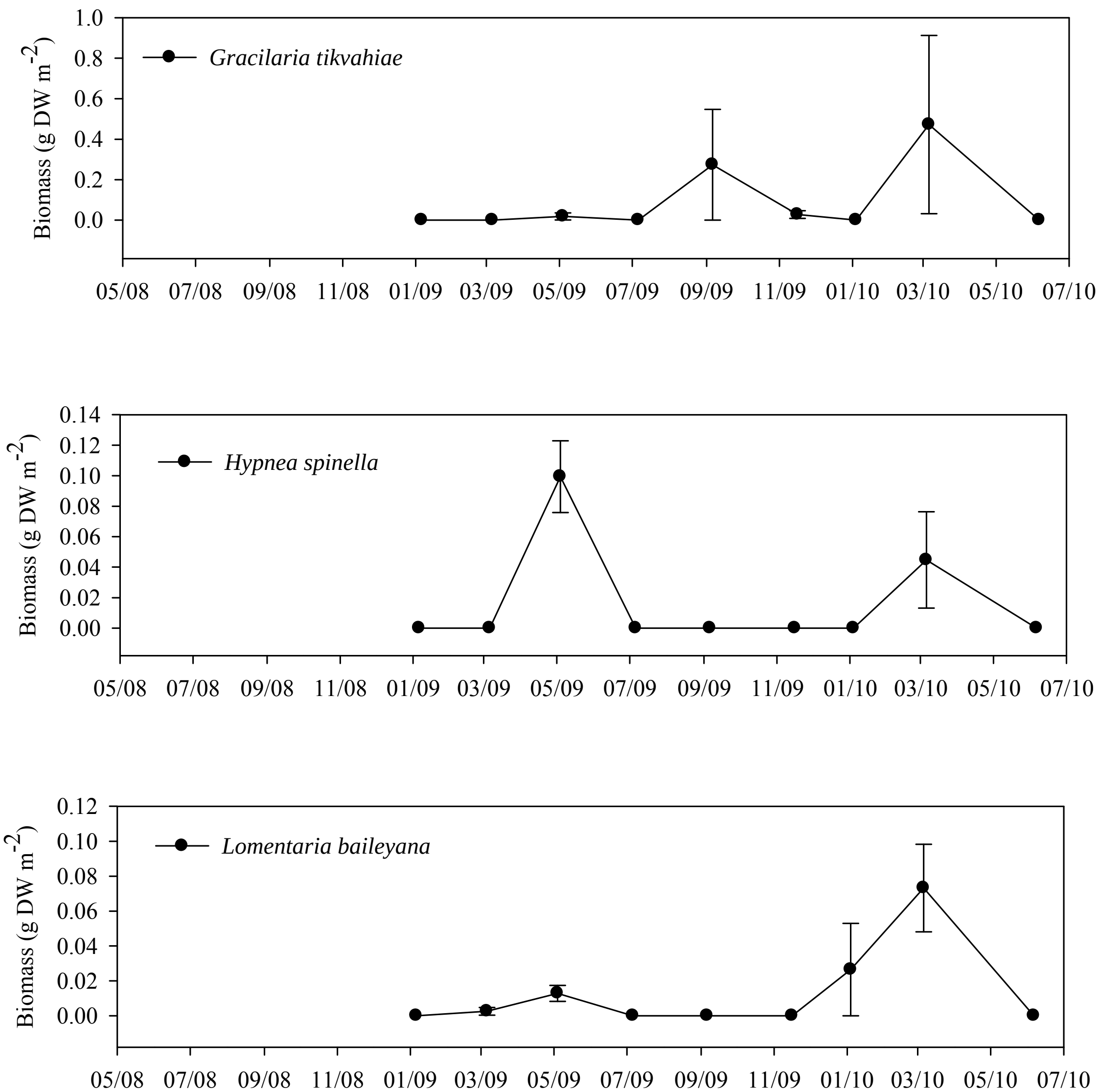


Fig. 5.13. Biomass (g DW m^{-2}) of a subset of macroalgal species at GOM16. GOM16 was added as a permanent station in January 2009 and samples were not collected in June, September, or November 2008. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

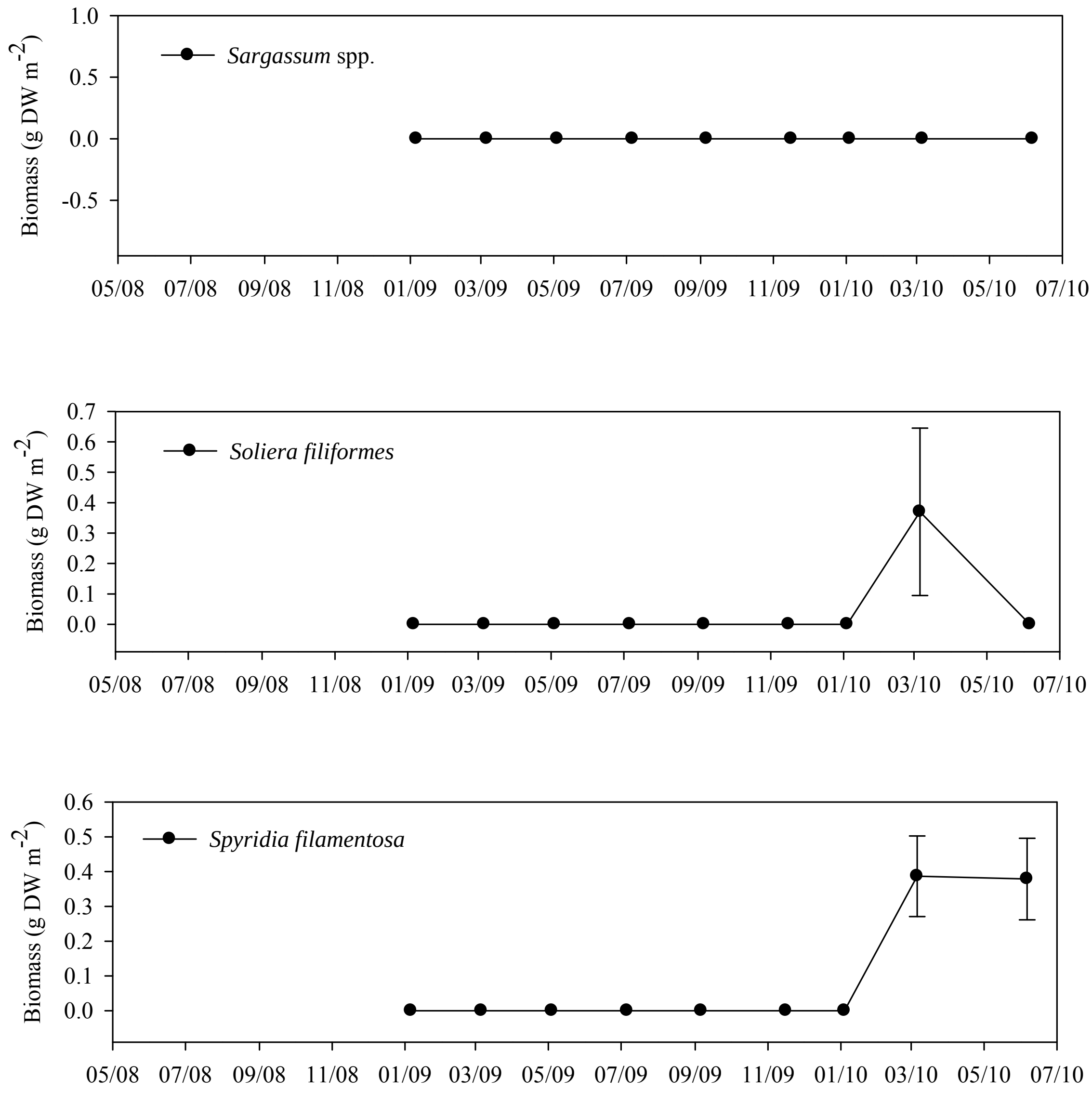


Fig. 5.14. Biomass (g DW m^{-2}) of a subset of macroalgal species at GOM16. GOM16 was added as a permanent station in January 2009 and samples were not collected in June, September, or November 2008. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

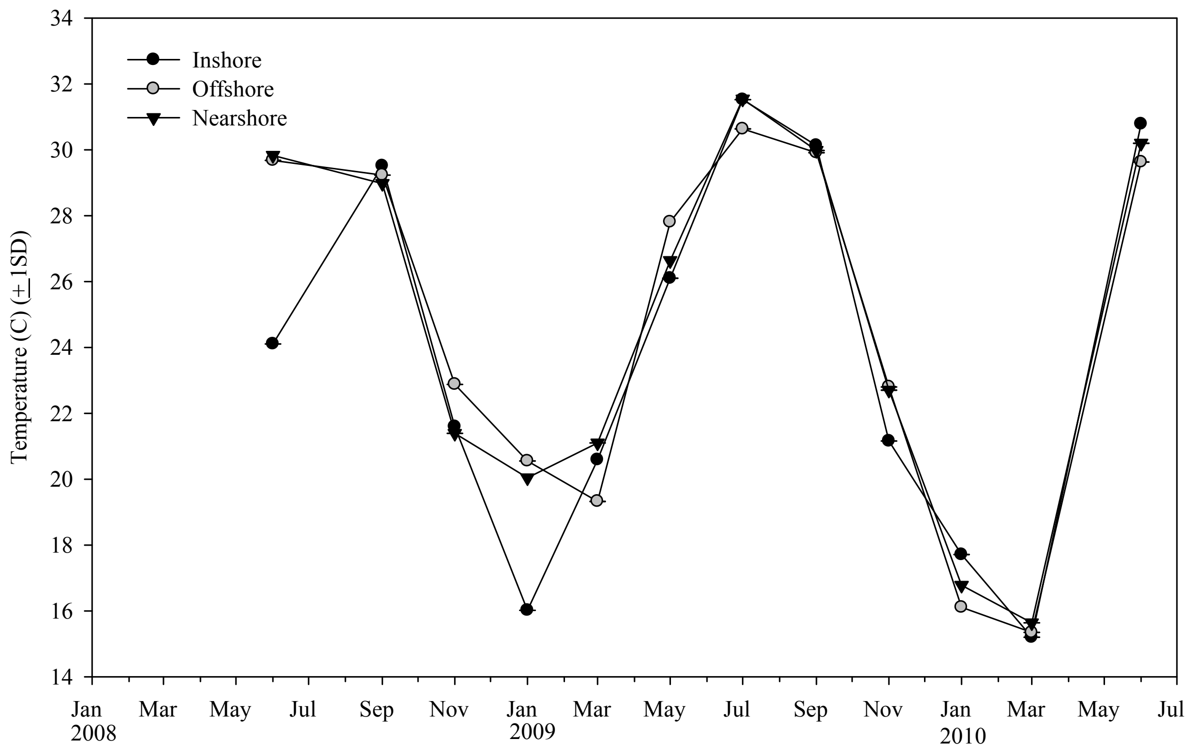


Fig. 5.15. Mean temperature in degrees C ± 1SD. Inshore sites include inshore (GOM16, CES11), nearshore (GOM01, GOM02, GOM03, GOM04, GOM06 and GOM07), and offshore (GOM05, GOM08, GOM10, GOM11, GOM12).

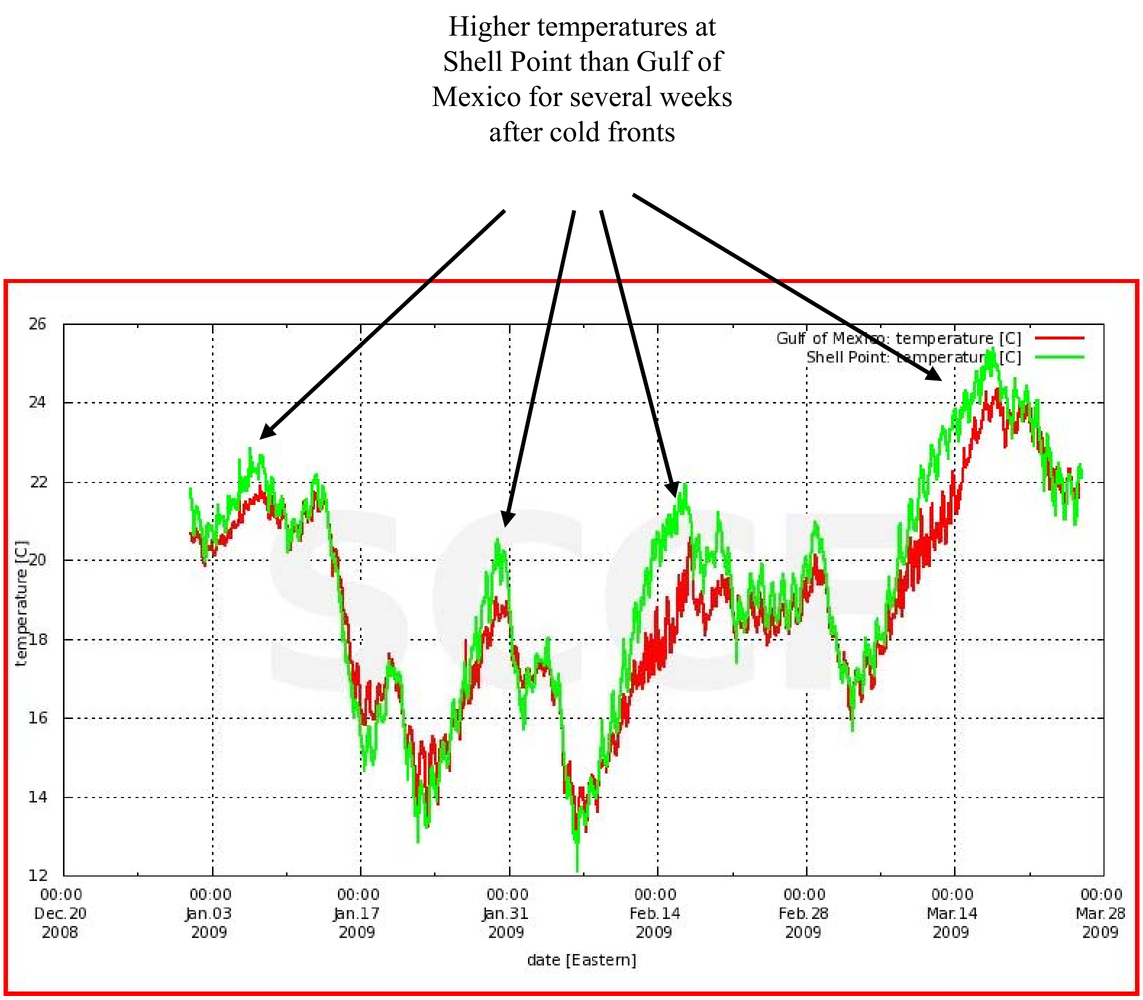


Fig. 5.16. Hourly temperature recordings as recorded by RECON from January 1, 2009 to March 25, 2009.

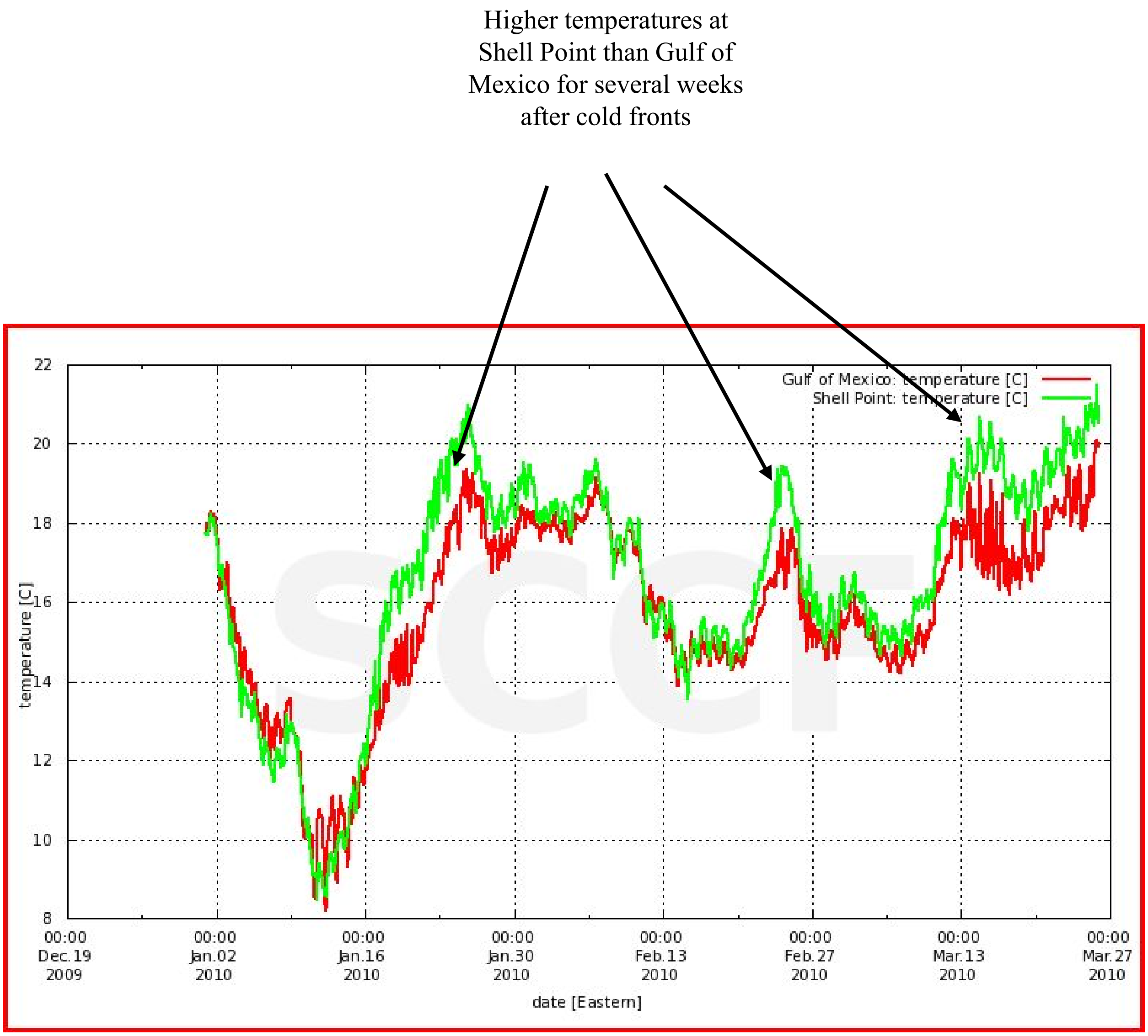


Fig. 5.17. Hourly temperature recordings as recorded by RECON from January 1, 2010 to March 25, 2010.

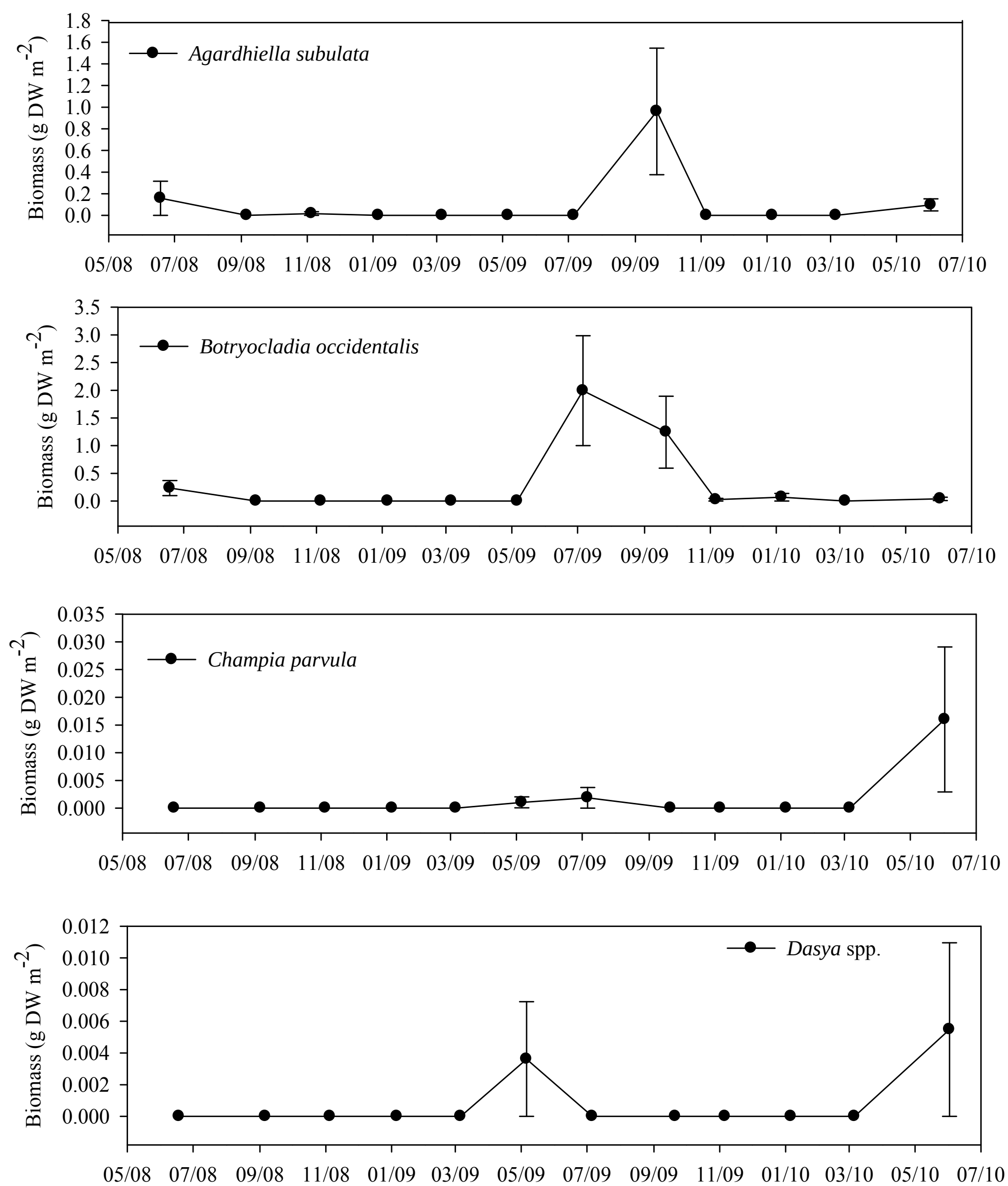


Fig. 5.18. Biomass (g DW m^{-2}) of a subset of macroalgal species at GOM11. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

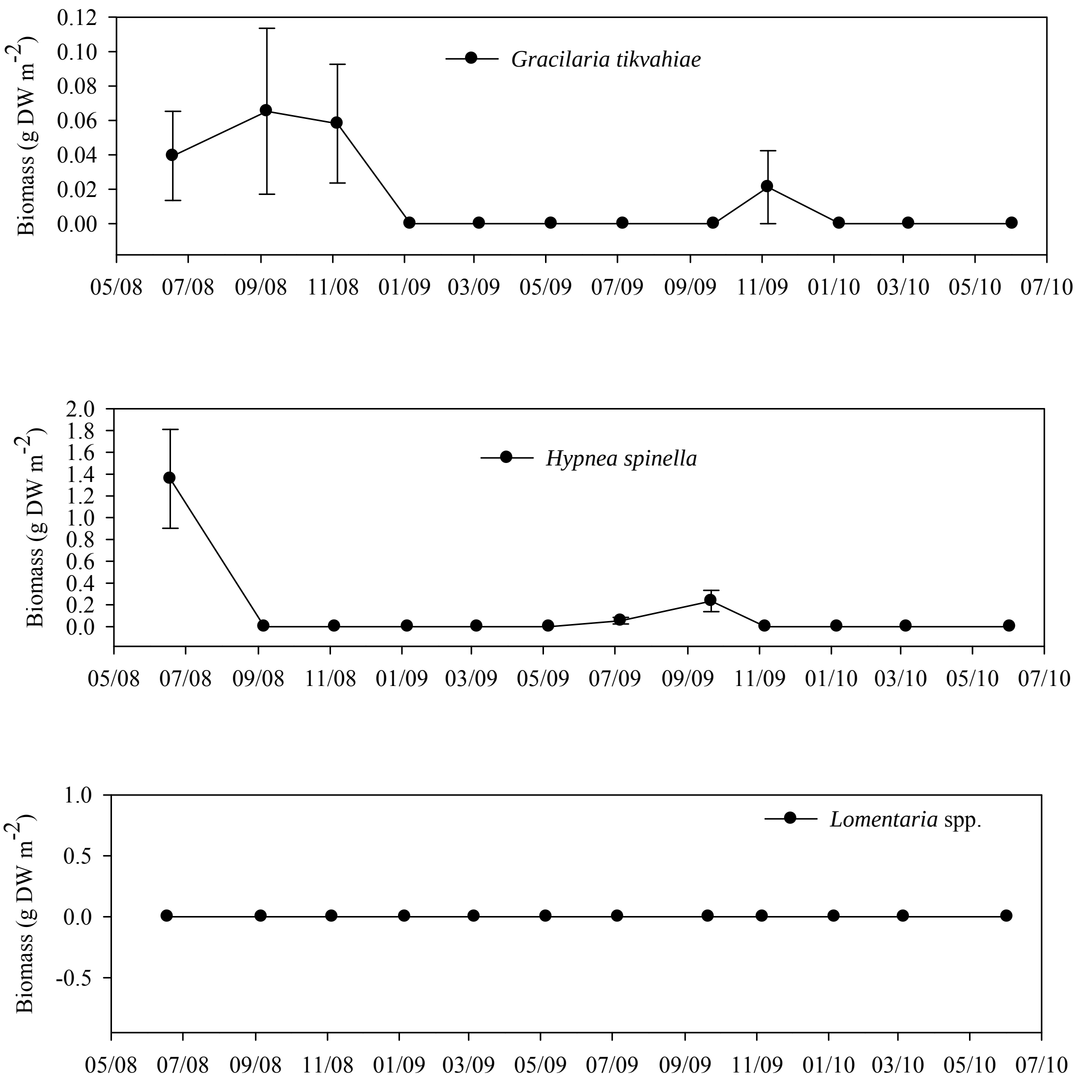


Fig. 5.19. Biomass (g DW m^{-2}) of a subset of macroalgal species at GOM11. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

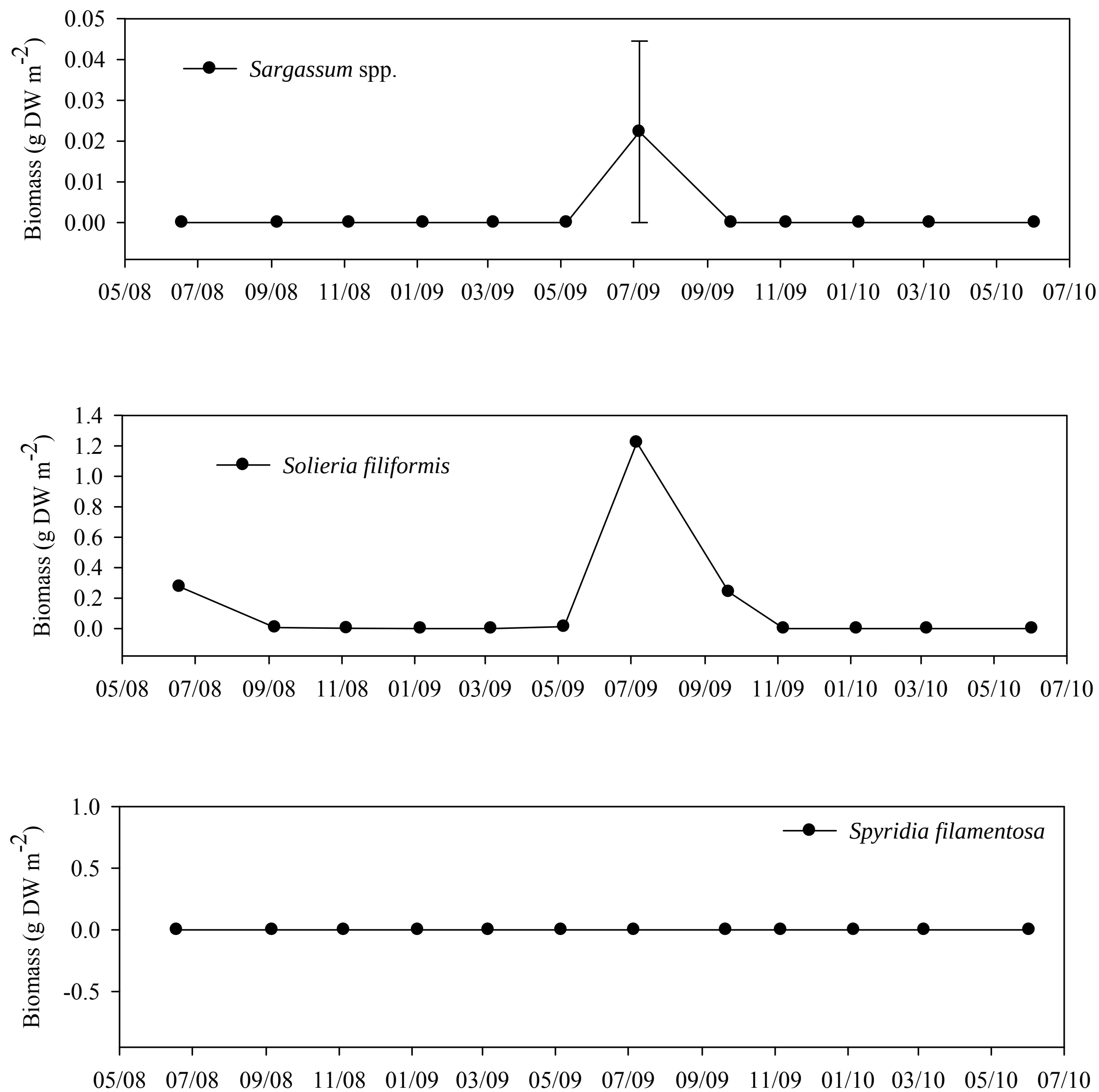


Fig. 5.20 Biomass (g DW m^{-2}) of a subset of macroalgal species at GOM11. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

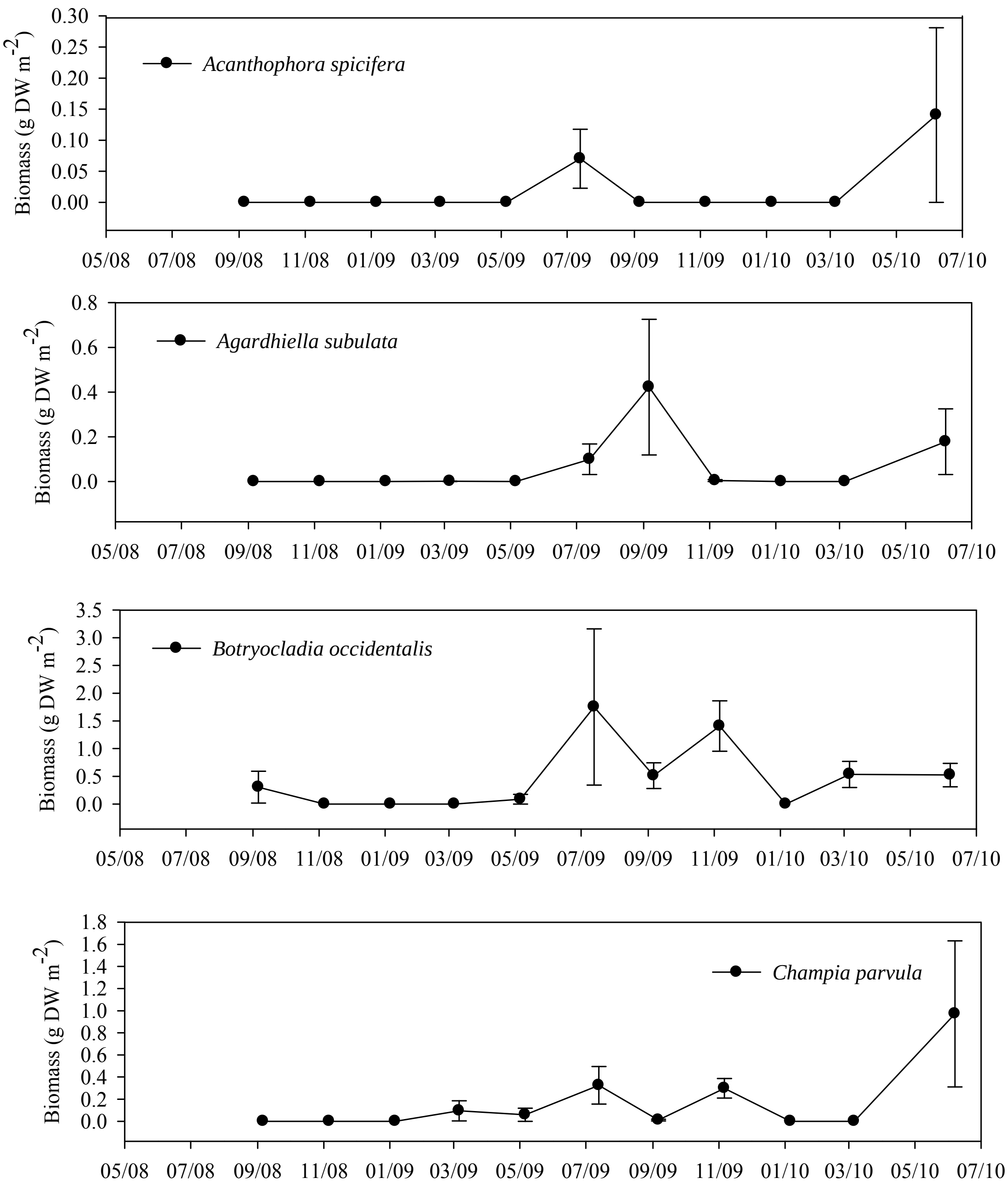


Fig. 5.21. Biomass (g DW m^{-2}) of a subset of macroalgal species at GOM12. GOM12 was not chosen as a permanent station until Sept. 2008 and samples were not collected in June 2008. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

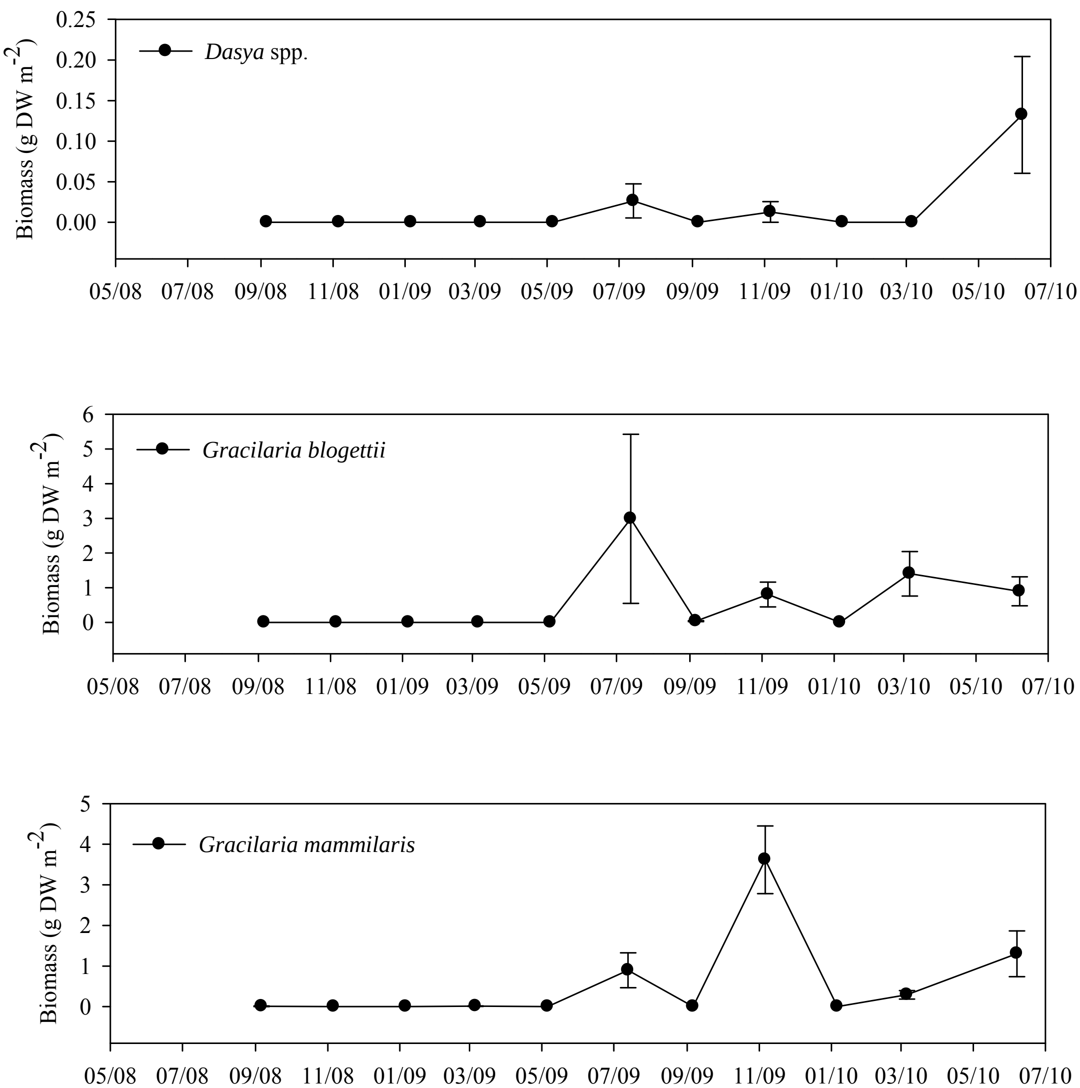


Fig. 5.22. Biomass (g DW m^{-2}) of a subset of macroalgal species at GOM12. GOM12 was not chosen as a permanent station until Sept. 2008 and samples were not collected in June 2008. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

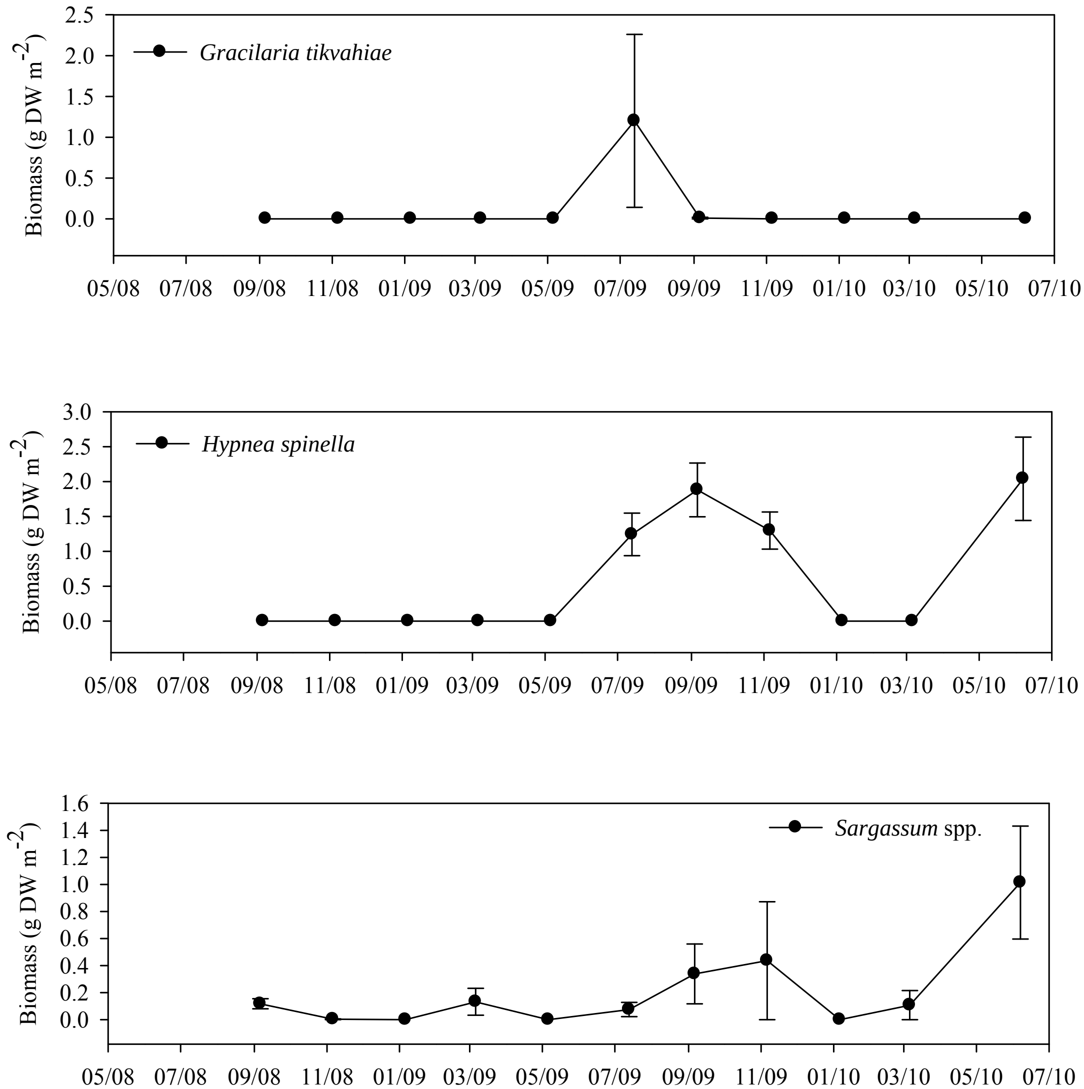


Fig. 5.23. Biomass (g DW m^{-2}) of a subset of macroalgal species at GOM12. GOM12 was not chosen as a permanent station until Sept. 2008 and samples were not collected in June 2008. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

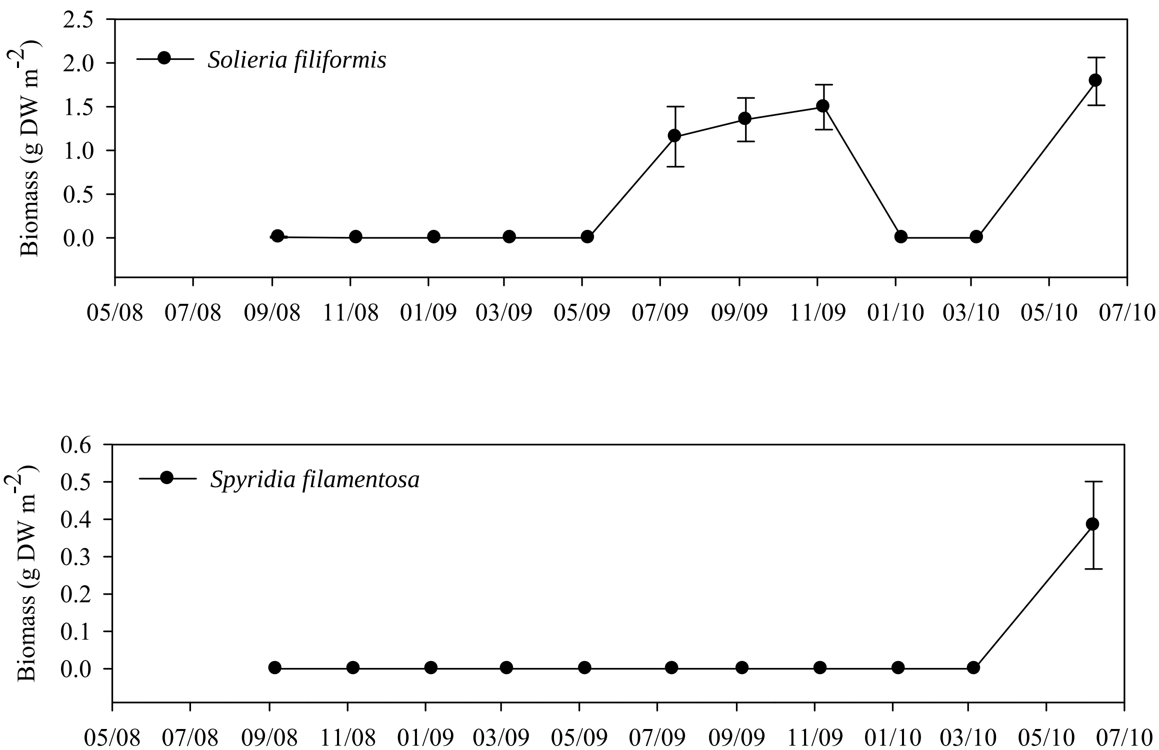


Fig. 5.24. Biomass (g DW m^{-2}) of a subset of macroalgal species at GOM12. GOM12 was not chosen as a permanent station until Sept. 2008 and samples were not collected in June 2008. Note differences in scale on the X-axis. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

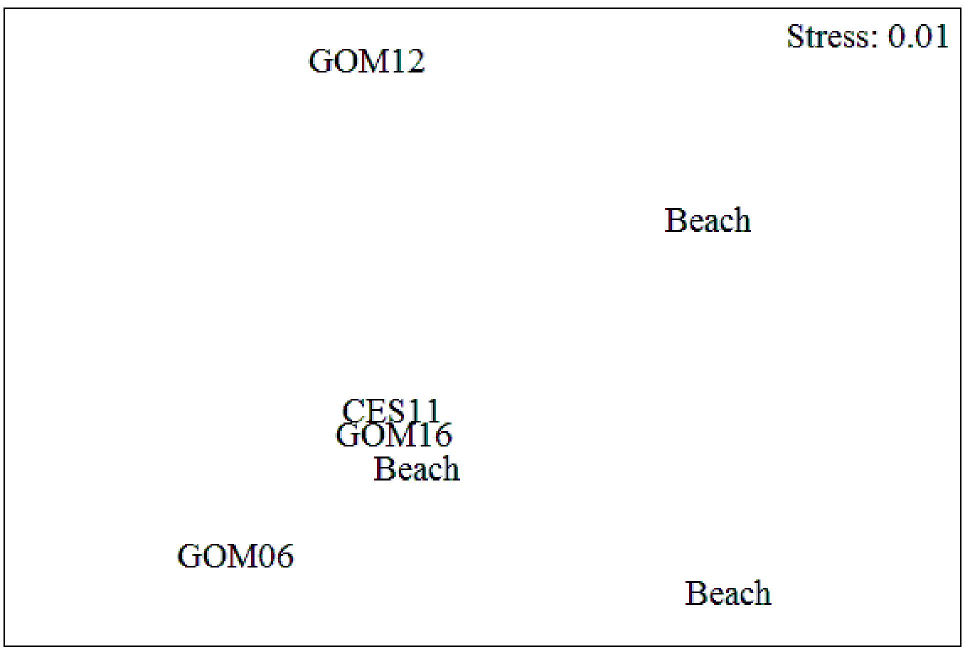


Fig. 5.25. Non-metric multidimensional scaling analysis (MDS) for species found during the March 2010 beach stranding at Fort Myers Beach. Samples collected from the beach, and from sites nearshore-GOM06, inshore-CES11 and GOM16, and offshore GOM12. Analysis used presence/absence indicators by species rather than biomass estimates, as beaches were not quantitatively sampled.

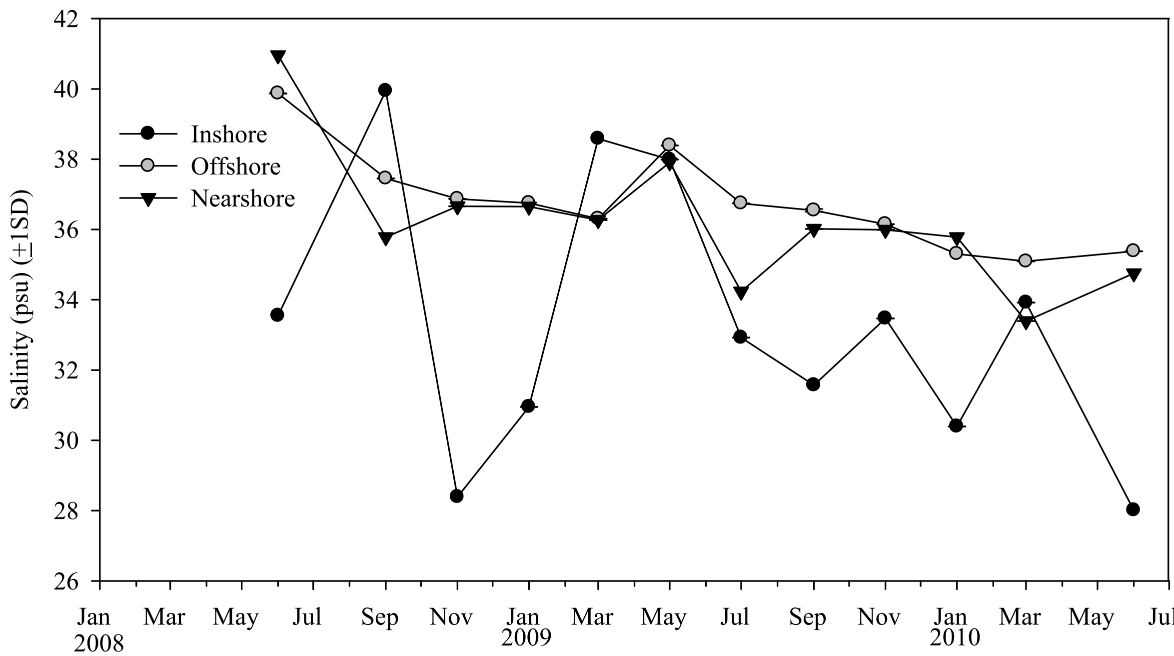


Fig. 5.26. Mean salinity in practical salinity units (psu) ± 1SD. Inshore sites include inshore (GOM16, CES11), nearshore (GOM01, GOM02, GOM03, GOM04, GOM06 and GOM07), and offshore (GOM05, GOM08, GOM10, GOM11, GOM12).

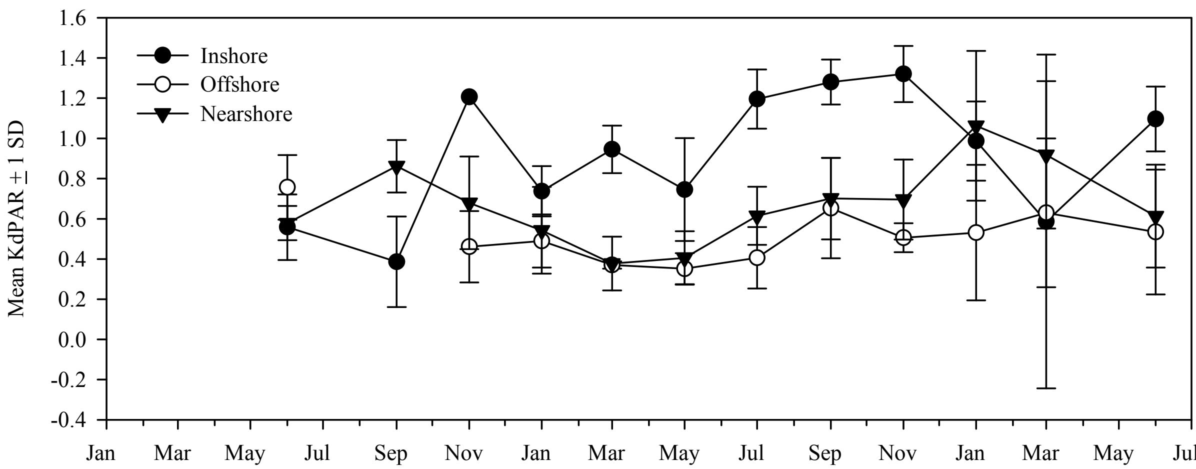


Fig. 5.27. Average KdPAR values as recorded by calibrated 2π light sensors (Biospherical, CA) during the study period. Stations are then grouped into offshore (Stations GOM05, GOM08, GOM09, GOM10, GOM11, GOM12), inshore (Stations CES11 and GOM16) and nearshore (Stations GOM01, GOM02, GOM03, GOM04, GOM06, and GOM07). GOM12 was not added as a permanent station in September 2008 and GOM16 was added in January 2009.

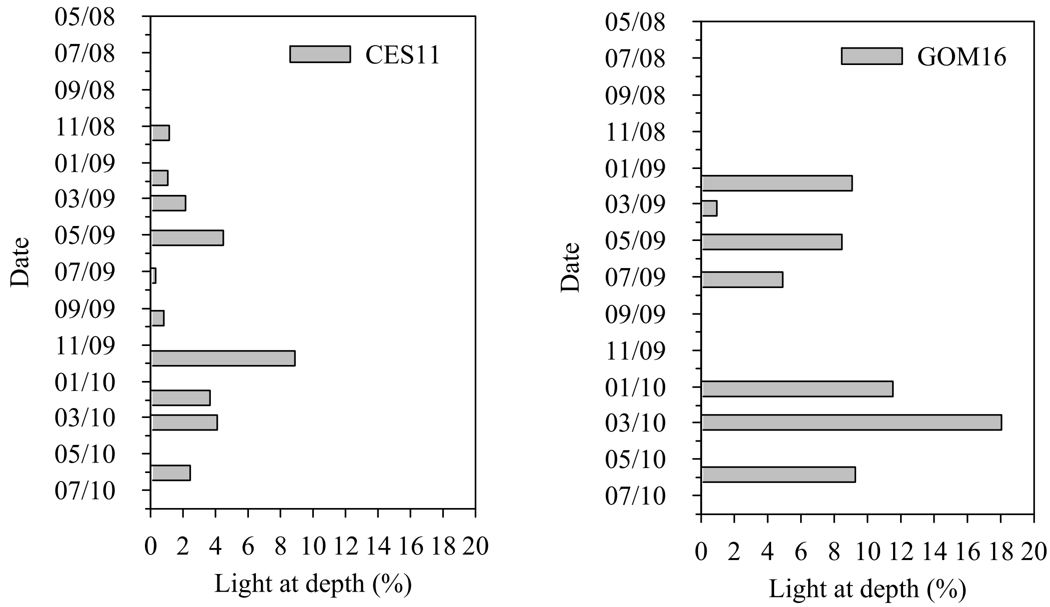


Fig. 5.28. Percent of surface irradiance at CES11 and GOM16. Irradiances were measured at each station during the sampling event to calculate KdPAR, which was used to calculate the percent of surface irradiance at the seafloor.

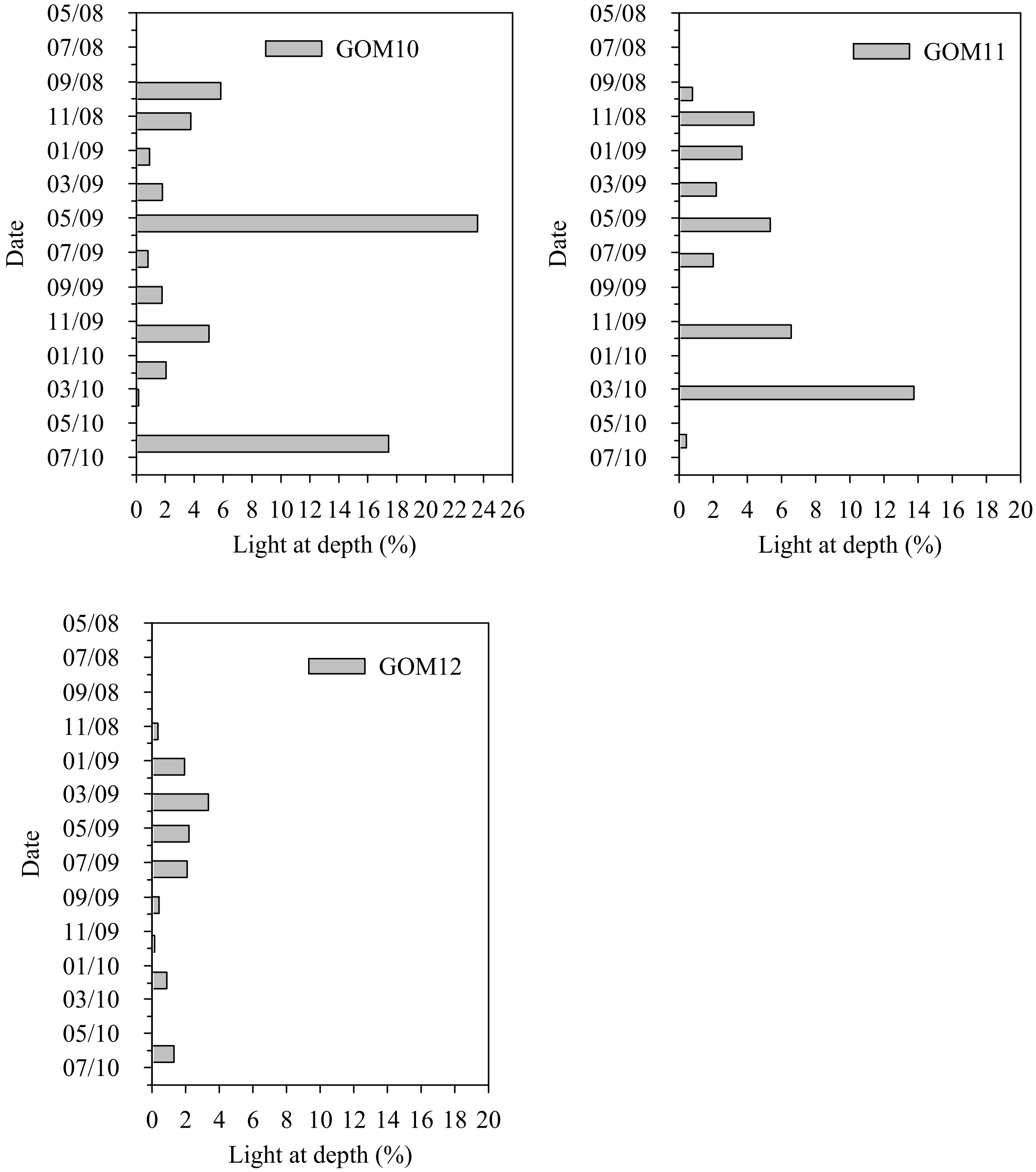


Fig. 5.29. Percent of surface irradiance at GOM10, GOM11, and GOM12. Irradiances were measured at each station during the sampling event to calculate KdPAR, which was used to calculate the percent of surface irradiance at the seafloor.

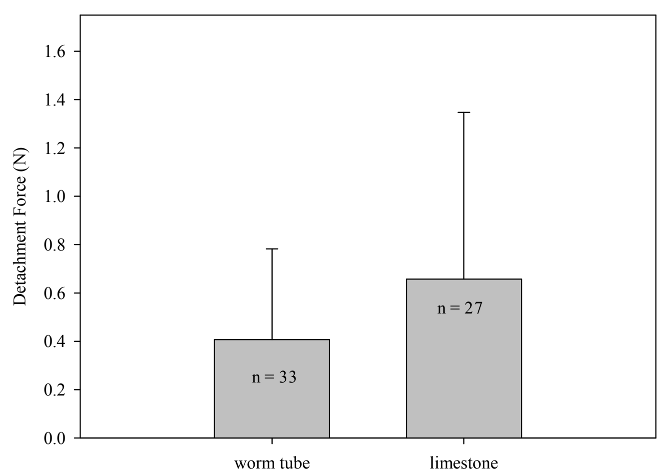


Fig. 5.30. Mean detachment force for dislodging macroalgal holdfasts from worm tubes (*Diapatra cuprea*) and limestone.

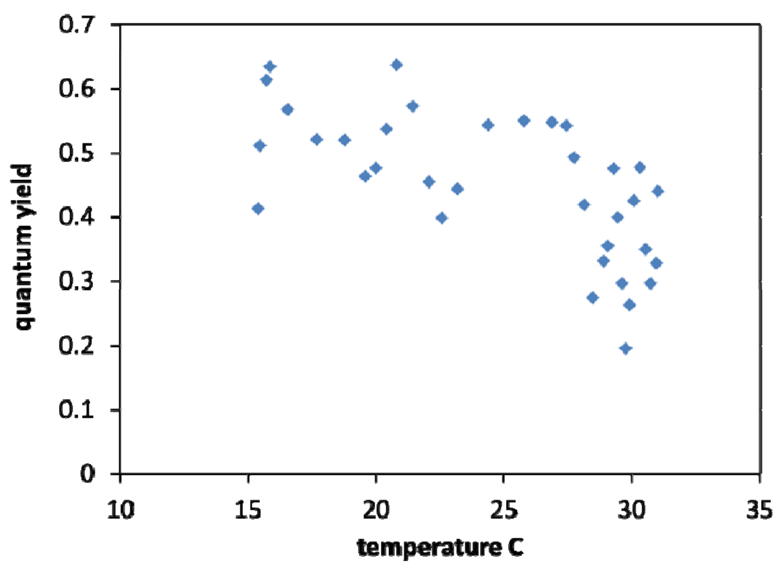


Fig. 5.31. Comparison of bottom temperature values and corresponding quantum yield values of algae present when temperature readings were taken. The regression results were significant, with an intercept of 0.775, a slope of -0.013, an $r^2 = 0.42$, and a $p < 0.0001$.

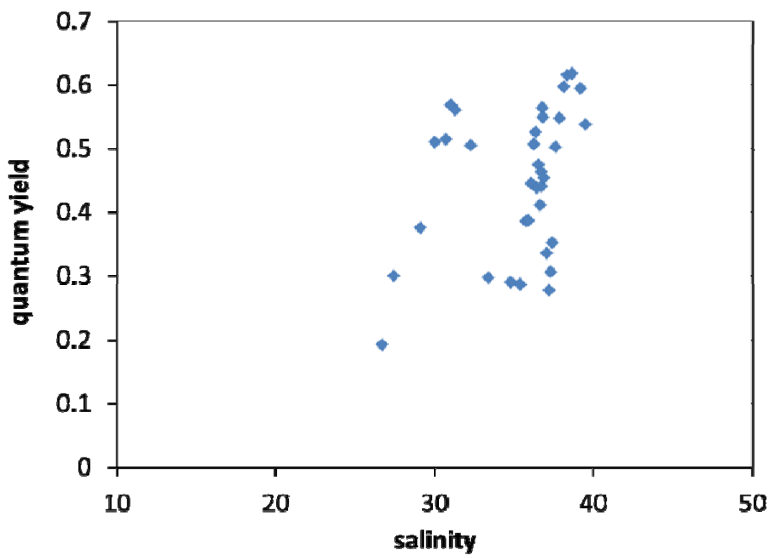


Fig. 5.32. Comparison of bottom salinity values and corresponding quantum yield values of algae present when salinity readings were taken. The regression results were significant, with an intercept of 0.16, a slope of 0.008, an $r^2 = 0.20$, and a $p = 0.03$.

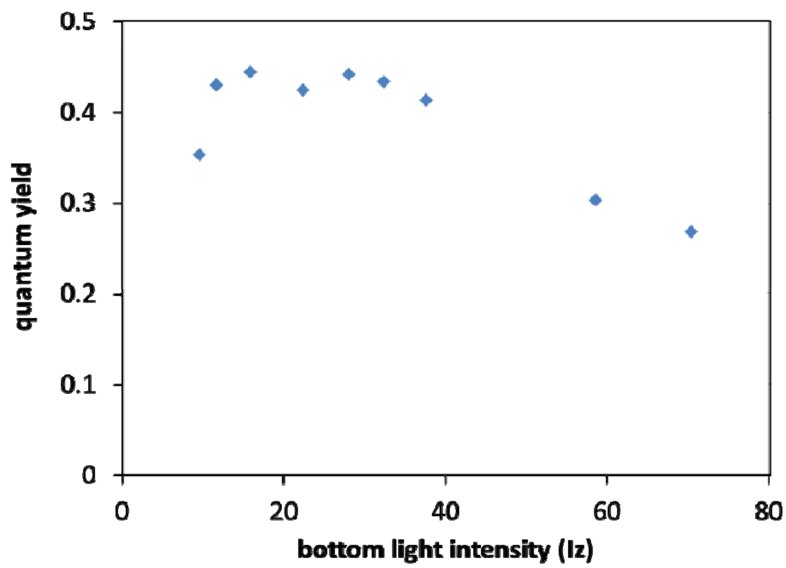


Fig. 5.33. Comparison of monthly-averaged bottom light intensity readings (I_z) and corresponding monthly-averaged quantum yield values. The regression results were significant, with an intercept of 0.465, a slope of -0.002, an r^2 = 0.56, and a p = 0.02.

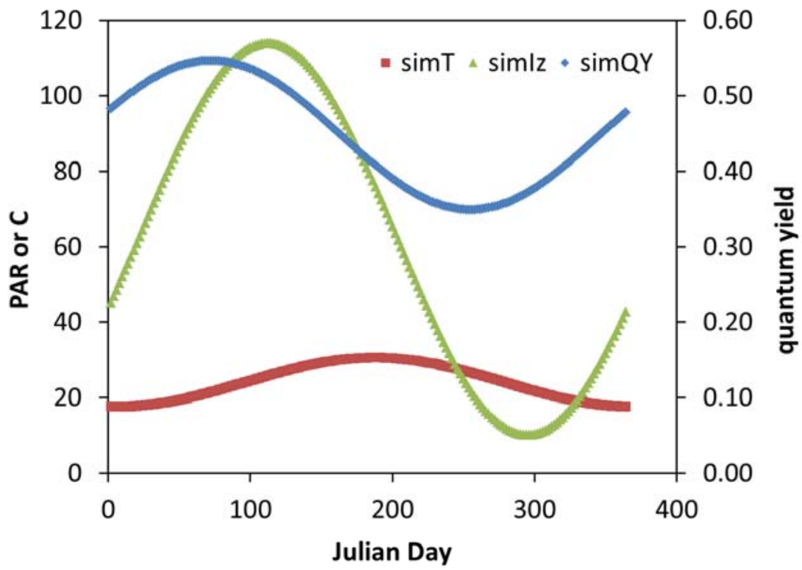


Fig. 5.34. Simulations of seasonal changes in temperature (simT), bottom light intensity (simIz), and quantum yield (simQY) over the course of one year (365 Julian days). PAR refers to photosynthetically active radiation (measured in µE/m^2/s).

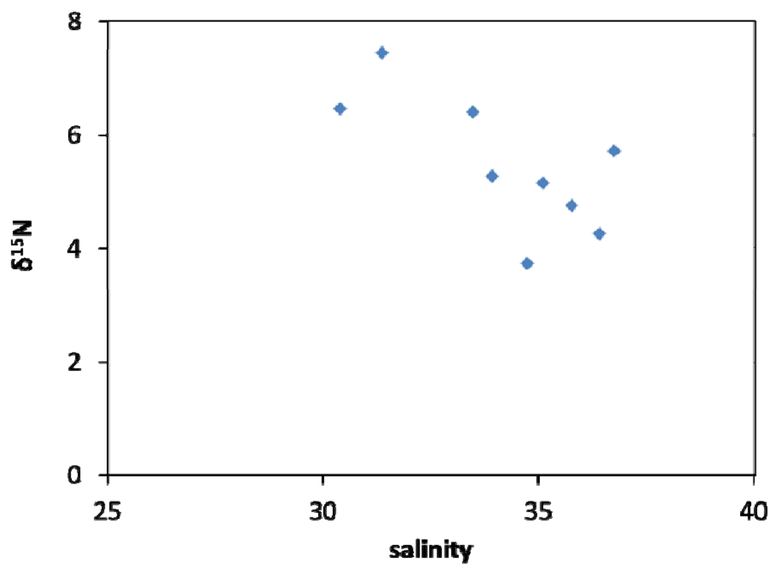
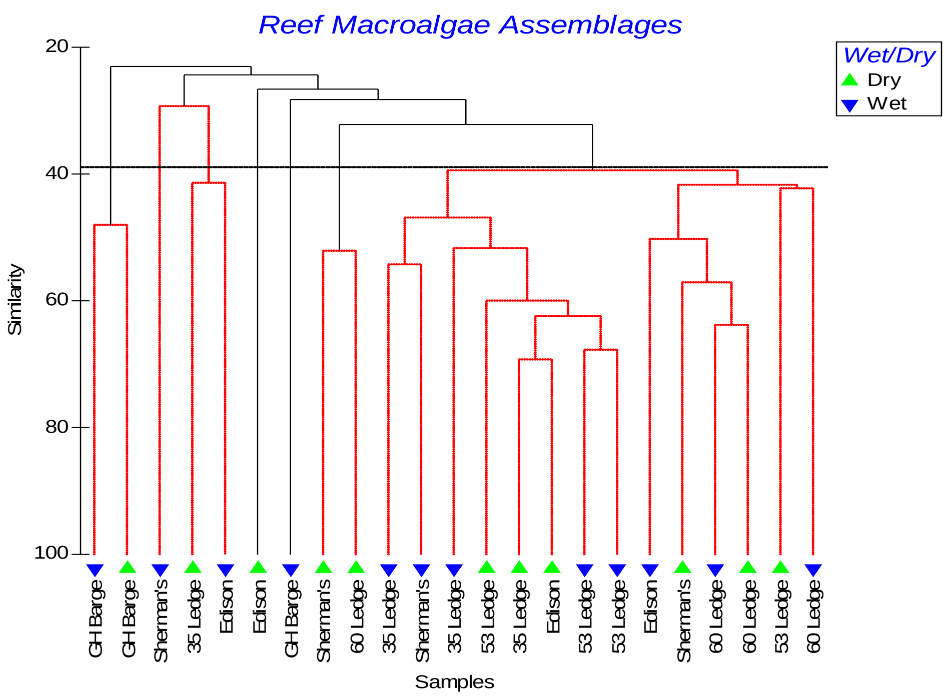


Fig. 5.35. Station salinity versus the average $\delta^{15}N$ for the algae collected at the time salinity was measured. The negative relationship is significant ($p = 0.03$) with a slope of -0.38 and an r^2 value of 0.50.



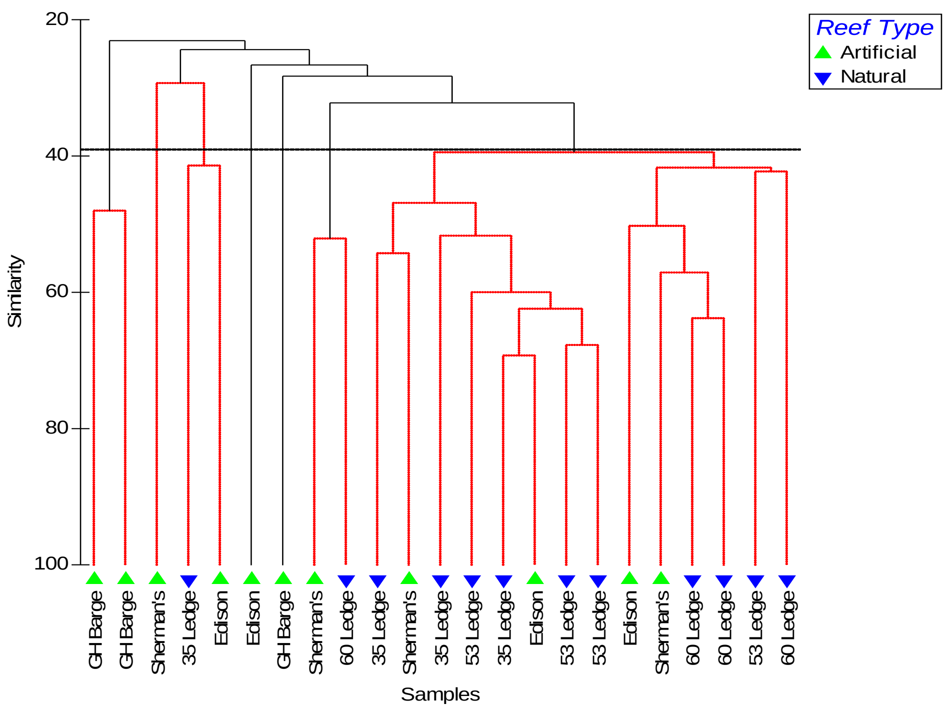


Fig. 5.36. Cluster diagram illustrating significantly different groupings of sites as black lines with those connected by red lines not significantly different. Figure labeled by site and wet or dry season (top) and by reef type (bottom). Note outliers and scattered low-similarity of artificial reef sites and sample events.

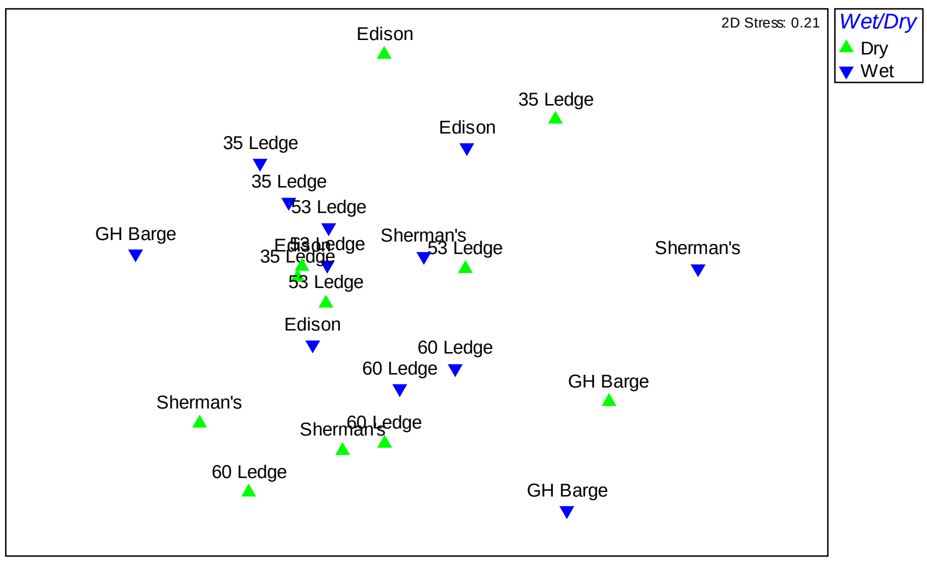


Fig. 5.37. Non-metric multidimensional scaling ordination of all sites and sampling events labeled by site and wet/dry season. The 2D stress value of 0.21 indicates a potentially useful ordination but caution should be used in interpreting results.

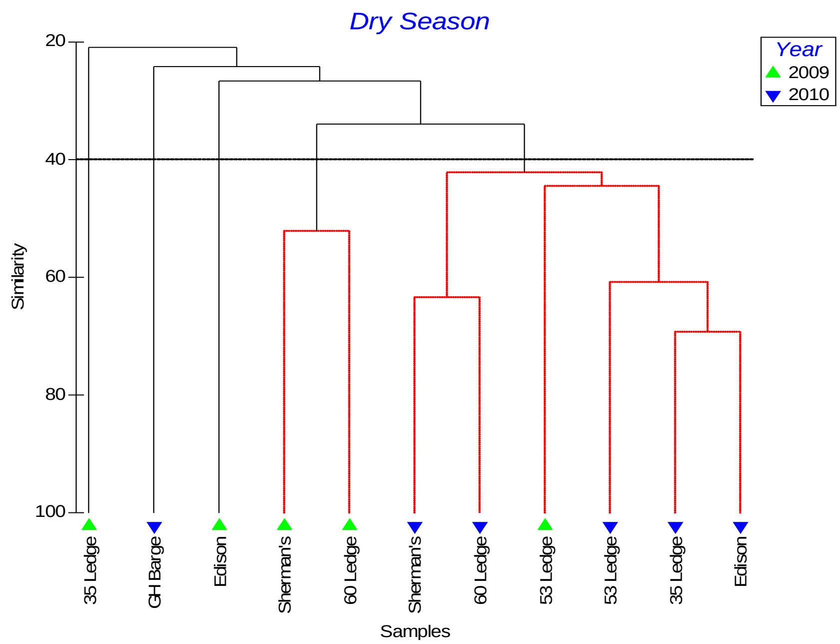


Fig. 5.38. Hierarchical clustering based on Bray-Curtis Similarity of all dry season algae assemblages events. Five significant groups are identified by black lines with those connected in red as not significantly different from each other. Slice added at 40% similarity to illustrate groupings and for overlay on MDS ordination.

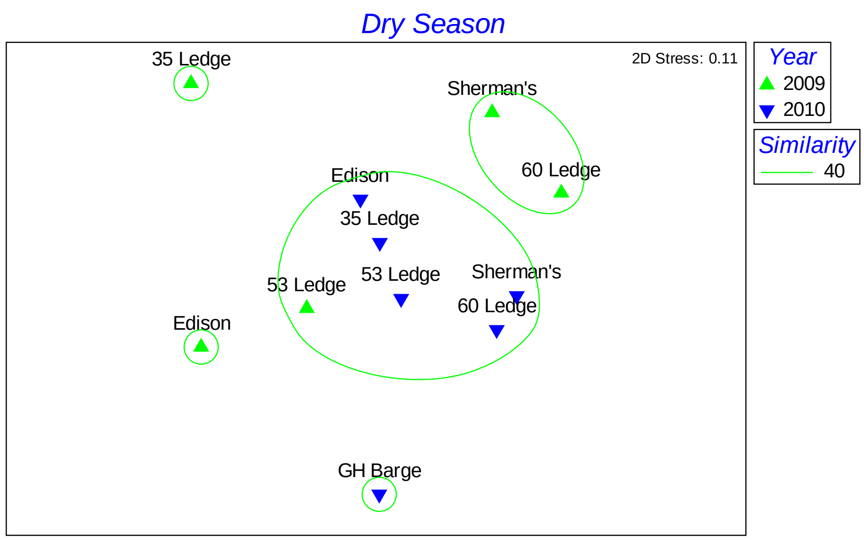


Fig. 5.39. MDS ordination of dry season algae assemblages labeled by site and year. Significant groupings are identified by overlay at 40% similarity. Note outliers consist of artificial reefs with greater dissimilarity expressed as scatter among the 2009 samples. The 2D stress value of 0.11 indicates a good ordination with little prospect of misinterpretation of the results.

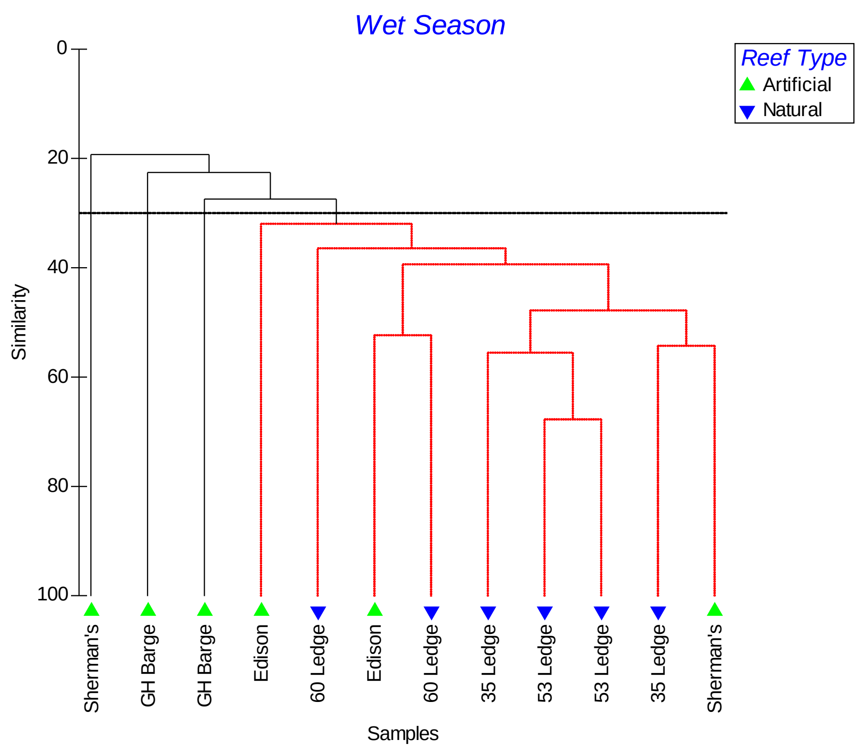


Fig. 5.40. Hierarchical clustering based on Bray-Curtis Similarity of all dry season algae assemblages events. Four significant groups are identified by black lines with those connected in red as not significantly different from each other. Slice added at 30% similarity to illustrate groupings and for overlay on MDS ordination.

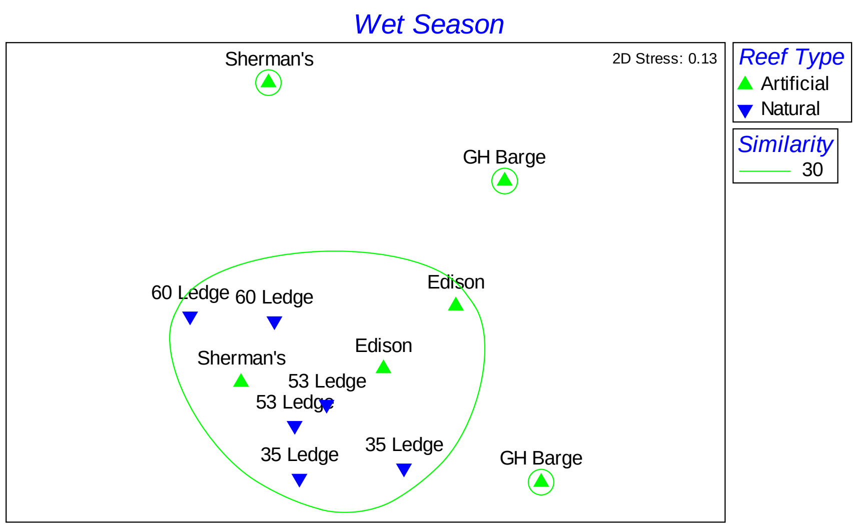


Fig. 5.41. MDS ordination of dry season algae assemblages labeled by site and year. Significant groupings are identified by overlay at 30% similarity. Scatter reflects the dissimilarity between significant groups and influence of wet season influence on algal community structure. The 2D stress value of 0.13 indicates a good ordination with little prospect of misinterpretation of the results.

Appendix 5.1: Literature Review

The benthic offshore habitats on the Southwest Florida continental shelf are poorly understood but are thought to provide habitats for supporting macroalgal growth. Much of the previous research is largely descriptive with few long-term or wide-reaching investigations. The Hourglass expeditionary cruises, initiated by the Florida Board of Conservation Marine Research Lab, occurred from 1965-1967 (Joyce and Williams 1969). The Hourglass program provided the first characterization of the sediments and biology of the offshore benthic habitats. Hourglass cruises (Joyce and Williams 1969) sampled 20, 60, 120, 180, 240 ft. with trynet and otter trawl, naturalist dredge, plankton net, nekton net, van Dorn water sampler, traps, fishing, diving. Exploratory in nature, these occurred from 1965-67. Stations represented only a small area of the total shelf and were positioned offshore of Egmont Key and Sanibel Island. Shallow (20 ft.) stations were described as quartz and crushed shell with living and dead mollusks (*Atrina* sp., *Butrycon* sp.). Mid-depth stations (60 ft) contained abundant limestone outcroppings with up to 3 ft. of relief were colonized by sponges, alcyonarians, stony corals (*Solenastrea hyades* and *Cladocora arbuscula*). The featureless seafloor in between was typically quartz sand colonized by *Halophila decipiens* and *Caulerpa* spp.

A rich macroalgal flora were collected in the Hourglass study were comprised mostly seaweeds of tropical and subtropical genera (Dawes 1969). A large number of perennial, tropical species were collected in the 20-80 ft. depth range. Seasonal patterns indicated a late spring to summer growth period, maturing in late summer and disappearing in the early winter. The live bottom where the algae were found was characterized by the epifaunal assemblages associated with limestone outcroppings. Typically, the "live bottom" was covered by a thin veneer of sand, shell and carbonaceous silt from 1 to 10 cm in thickness.

The natural history and geology of the continental shelf was further elaborated in a recent review by Hine and Locker (in press). Many modern techniques were used to characterize the continental shelf including; hydroacoustic mapping, side-scan sonar, and drop video cameras. The shelf off Southwest Florida is described as a very wide, low energy, sediment-starved shelf seaward the west-central Florida barrier island system. This inner shelf presents a wide variety of sand ridges up to 4 m thick separated by extensive areas of exposed limestone. To the south, the shelf has small reef banks, and a linear shelf edge, and sand shoals and cays.

Several inventories containing species lists and descriptions of potential macroalgal habitats were completed due to benthic sand mining for renourishment of barrier island beaches. Culter (1988) sampled macrofauna from the sea floor for both ‘live bottom’ and soft bottom areas on the continental shelf. Similar to that described previously, the live bottom infaunal habitat consisted of the thin veneer of sediments overlying limestone bottom, marked by conspicuous epifauna, such as sponges, gorgonians, and corals. The soft bottom was adjacent to the live bottom habitat characterized by lack of conspicuous epifauna and a thicker layer of sediments, although similar in sediment. The Minerals Management Service (MMS) also funded a biological inventory and sediment grain size analysis of an area offshore of Tampa Bay (Brooks et al. 2004, Brooks et al. 2006). The continental shelf contained many shoal and ridge features and supported a diversity of polychaetes, bivalves, and amphipods (Posey et al. 1998).

In one of the first published reports from Sanibel Island, pen shells were reported to be stranded on Sanibel beaches (Perry 1936). The abundance of these bivalve communities provided important attachment substrates for seaweeds and other invertebrates. Others have demonstrated that living and dead pen shell populations in St. Joe Bay provides important structure for mobile and sessile invertebrates (Munguia 2004, 2007). However, the role of the epibiotic community in life histories of macroalgae and their ecological role in macroalgal production remains poorly understood.

An often observed habitat supporting the growth macroalgae is within the protected bays and estuaries. Drift macroalgae is often associated with seagrasses and is usually not attached to any substrates or is growing in the surface of the sediment (psammophytic). These mobile habitats made up of *Hypnea cervicornis* (Rhodophyta) are valuable to amphipods and small crustaceans in Tampa Bay (Brooks and Bell 2001) and have been proposed as a mechanism of transport from seagrass areas across sand ecotones. *Digenia simplex*, *Gracilaria verrucosa*, *Gracilaria folifera*, and *Laurencia poitei* (Rhodophyta) were frequently found large clumps or windrows in protected areas throughout Florida (Hooks et al. 1976, Brown 2001). The movement and concentration of these large masses of algae are attributed to wind and tide but are also trapped in areas with seagrass. Brown (2001) found 14 dominant species of drift alga common to Tarpon Springs, Cockroach Bay, and Tarpon Bay on Sanibel Island. The drift algal species for the three distinct sites were similar and stable year around, with peak biomass occurring in late winter and spring. The most common taxa in contain species of the genera *Gracilaria, Hypnea, Chondria, Acanthophora,* and *Laurencia* (Rhodophyta). In addition, the genera *Ulva* (Chlorophyta), *Lyngbya majescula* (Cyanophyta), and *Sargassum filipendula* and *S. pteropleuron* (Phaeophyta) were common. The growth rates of drift seaweeds residing in the bays and estuaries are not well understood, partly because of the transport and accumulation processes. Josselyn (1977) reported a wet weight increase of 2-5% d^{-1} during late fall and spring for the red alga *Laurencia poiteaui* in Card Sound and an annual production of 21 g dry wt m^{-2} y^{-1}. At Tarpon Bay, the daily growth rate for seven drift red algal species averaged 1.1% for *Spyridia filamentosa*, 2.0% for *Hypnea musciformis*, 4.5% for *Acanthophora spicifera*, and 7.7% for *Gracilaria caudata*, which was the highest rate measured. Daily growth rates indicated that at least half of the dominant drift algae could produce a high biomass within a short period.

Shifts in seaweed species composition can be a useful indicator in determining phase shifts (*sensu* Valiela et al. 1997) associated with coastal eutrophication and pollution (Littler 1973). Specifically, *Ulva* spp. and corraline algae became the dominant species in the community when subjected to sewage effluent (Kindig and Littler 1980). In mesocosm experiments macroalgae became the dominant macrophyte after nutrient enrichment (Short et al. 1995). However, a lack of coupling between eutrophication and relative abundance can occur because of light limitation

(Krause-Jensen et al. 2007). Shifts in species composition can also be indicative of other physical or biological processes. Grazer preference for a particular species because of feeding behavior or interactions with other species can change the abundance and distribution of macroalgal communities (Underwood 1980, Lewis 1986, Hauxwell et al. 1998). Invasive species have also negatively impacted native macroalgal communities (Meinesz 2001, Boudouresque and Verlaque 2002) resulting in changes in distribution and abundances. Introduction of non-native species has also led to large free-floating populations (Cecere et al. 2003) capable of washing up on the beach. A cryptic invasive species was found in Cheasapeake Bay (Thomsen et al. 2005) which was mis-identified as *Gracilaria tikvahiae*, a common species reported in this area (Lapointe and Bedford 2007). On the East Coast of Florida, an invasive *Caulerpa* (Chlorophyta) was reported on coral reefs (Lapointe and Bedford 2010), but there have been no reports of invasives on the Gulf Coast, but there is a strong possibility of cryptic invasive species. *Hypnea spinella* (Rhodophyta) is an invasive species on Hawaii's coral reefs (Vermeij et al. 2009), but is native to southwest Florida and is found in a variety of habitats. Physical disturbances, such as scouring (Sousa 1984), wave energy (Kraufvalin et al. 2010), and current velocities can also affect the distribution and abundances of macroalgae.

More recently, stable isotope analysis and nutrient content have been used extensively to determine nutrient sources for primary producers (Heaton 1986, Lapointe et al. 2005, Derse et al. 2007, Teichberg et al. 2010). Previous isotopic studies of algae collected on Sanibel beaches indicated slight enrichment in $\delta^{15}N$ (Lapointe and Bedford 2007), suggesting a human source of nutrients. Other samples of *Ceramium* were collected and had a $\delta^{15}N$ value of 5.84 and indicated that N was neither elevated nor depressed (Bartleson et al. 2006).

Appendix 5.2: Station Descriptions

CES11– Macroalgae was abundant at this inshore station during most months (see Fig. 5.24). There was a mixture of sand, silt and loosely consolidated shell with high densities of *Diopatra cuprea,* low densities of chaetopterid species, and no pen shells at this site. Video analysis also indicated an abundance of macroalgae with greater than 80% of the still frames containing algae. The species composition differed from offshore sites, dominated by *Gracilaria tikvahiae, Acanthophora spicifera*, and *Ulva lactuca*. It was the closest station to the Sanibel causeway and the mouth of the Caloosahatchee estuary (less than 5 km). Strong tidal currents were observed on most visits moving north and south to Matlacha Pass. There was greater seasonal variability in temperature and salinity than at other stations located in the Gulf of Mexico. Light attenuation was also higher as measured due to the suspended and colored dissolved organic matter (CDOM) in the water column.

GOM16 – Macroalgae was abundant at GOM16 (see Fig 5.25), another inshore station located North of the Sanibel Causeway in lower Pine Island Sound. This station had a mixture of silt and sand with no pen shells and patchy seagrass (mostly *Thalassia testudinum, Syringodium filiforme* and *Halodule wrightii*). The station was located at the southwest segment of Pine Island Sound and adjacent to the J.N. "Ding" Darling National Wildlife Refuge. It was positioned 11 km from the mouth of the Caloosahatchee Estuary and 8 km from the Sanibel Causeway on the Pine Island/San Carlos bay side. This station was relocated in January 2009 from the original placement around the lighthouse as a result of large amounts of algae reported by the seafloor mapping group (see Objective 4). Poor visibility was common and resulted in difficult diving conditions. Wind-driven resuspension of particulates is suspected as the primary driver for poor visibility conditions. However, periods of rainfall plus high discharges increased the CDOM, making the water appear yellow-brown. In June 2010, there was an unusually high abundance of *Spyridia filamentosa* which contributed heavily to the pattern of occurrence at this site. During the two-year study, *Acanthophora spicifera, Gracilaria tikvahae* and *Spyridia filamentosa* were the most common species. Mesocosm core samples were collected for Objective 2 (FGCU) at GOM16, GOM04 and GOM06.

GOM11 – This station was located offshore (18 km, bearing 206° from the Sanibel Lighthouse) and had abundant live bottom and macroalgae (see Fig. 5.26). GOM11 was a limestone patch reef with a thin veneer of overlying loose, unconsolidated sand, carbonate silt and shell. There were high densities of hard and soft corals and large barrel sponges providing many attachment sites for macroalgae. *Botryocladia occidentalis*, a reef-associated red algal species, was the dominant macroalga collected. Macroalgae biomass was modest compared to the inshore stations, possibly caused by low light and/or nutrient limitation. Analysis of the underwater video analysis indicated greater than 50% of the frames analyzed contained algae in four of 12 dates, and for 30% of frames for all other dates analyzed. GOM11 was located offshore, 18 km, (bearing 220°) from the Sanibel lighthouse.

GOM12 – This was another offshore station with abundant limestone outcroppings, live bottom, and abundant macroalgae (Fig. 5.27). Located 8 km west (bearing 270°) of Redfish Pass, this station had moderate relief limestone bottom with abundant reef fish, hard and soft corals, and a diversity of mobile invertebrates. Visibility was generally good, with a 1 m ledge where larger fish, such as grouper, sharks and trigger fish, were observed. This site was dominated by rocky outcroppings and frequently abundant algae. Algae were consistently found at this site, and in two of 12 video transects, 100% of the frames analyzed contained algae. Algae were typically attached to the limestone bottom. Two species of greatest biomass (net g DW) were *Dictyota cervicornis* and *Caulerpa racemosa*, both species are commonly found on reefs.

GOM01 – Located near the Sanibel lighthouse beach (less than 2 km, bearing 180) GOM01 was a nearshore location where, in 2006, underwater video indicated abundant attached, branching macroalgae (data provided by J. Evans, City of Sanibel). There were abundant pen shells and shell fragments at this site which are potential attachment substrates for algae (Fig. 5.28). However, in this study, macroalgae was recorded only once (July 2009), despite the availability of substrate for attachment and proximity to the Caloosahatchee River and Sanibel causeway. Given also the initial hypothesis about the discharges from the Caloosahatchee fueling algal growth, it is surprising that algae at this location were comparatively rare. This site was selected for the grazer study as place to exclude grazers with cages and examine the algal response (see Objective 9). The only species recorded at this site was a drift piece of *Sargassum* spp. Additional dates with the presence of algae were recorded in the video analysis (March 2009 and March-June 2010) but in less than 5% of the total frames. Removed space after

GOM02 - This nearshore station was located west of Redfish Pass (bearing 270°) and had a limestone bottom with a thick layer of sand and medium-sized shell hash (Fig. 5.29). There was a mixture of reef epifauna with occasional small limestone rubble and abundant pen shells. There appeared to be frequent disturbance from wave action and scouring. During most of the study period, little to no algae was reported and collected. However, during June 2010, an unusually large amount of a single species, *Halymenia psuedofloresia*, was collected. This species was attached to the rocky outcroppings and covered 60-80% of the area sampled. This species (and only this species) was also found on the beaches of Sanibel (Rabbit Road) during the same month, suggesting that these nearshore patch reef habitats may be a source of algae on the west end of Sanibel. From the video analysis, approximately 56% of the still frames had algae found in a frame in June 2010. Macroalgae was present on several other dates, however, cover estimates were less than 6% for the entire 100 m transect.

GOM03 – There were two general locations visited with the name GOM03. The two stations differed in bottom type and in macroalgal abundance. Therefore, the locations were separated and described here as GOM03 and GOM03A. From November 2008 through January 2010, GOM03 (10 km, bearing 247° from Sanibel Lighthouse) was sampled bimonthly. This station contained packed sand with a rock outcroppings and a patchy live bottom (Fig. 5.30). Video analysis indicated approximately 60% of the still frames contained algae in November 2008 and January 2009. The dominant macroalgal species were typical reef species with well delineated holdfasts and include *Botryocladia occidentalis*, and *Sargassum filipendula*. Several large fish and *Arbacia puntulata* were also observed on the reef along with a diversity of sponges, gorgonians and soft corals.

GOM03A – This station was located nearshore, close to the beaches of Sanibel. While largely featureless, no algae were recorded or collected. The station was moved to GOM03 to capture live bottom and 20 cm of relief and sampled from November 2008 to January 2010. However, during the last two sampling events, GOM03A was visited unintentionally due to problems with the vessel GPS. Typically this station had strong currents and poor visibility with mostly packed fine to medium-sized sand/shell (Fig. 5.31).

GOM04 – This nearshore station was located west of Blind Pass (2.3 km; bearing 267°) and had abundant pen shells (Pinnidae) and urchins (Fig. 5.32). Mesocosm core samples were collected at this station for Objective 2. No macroalgae were collected at this station during the study. There were abundant sea urchins (*Lytechinus variagatus*) present at all times (432 per 100 m transect in January 2009); however, urchin densities were highly variable. This is not surprising given the relatively high mobility of these potential macroalgal grazers. This site was also chosen for the grazer exclusion project because of the consistent densities of pen shells and *Diopatra cuprea* (deemed potential attachment substrates) for macroalgae growth. There was one sampling event (March 2010) where the transect was deployed some distance away from the intended station due to problems with the vessel GPS (see Appendix for map). However, no differences in macroalgal abundance or bottom type were found in the underwater samples or video. Very difficult diving conditions and sampling conditions were common because of strong tidal and longshore currents and poor visibility. Thus, the video analysis was unable to be performed for four of 11 sampling dates. Less than 10% of the total number of frames analyzed contained macroalgae. Mesocosm core samples were collected at GOM04, GOM16, and GOM06 for Objective 2.

GOM05 – This offshore station (17 km, bearing 159° from the Sanibel Lighthouse) had a largely featureless bottom with sand/silt (Fig. 5.33) and numerous fighting conchs (*Strombus alatus*). There were no pen shells or worm tubes at this site. It was located offshore 11 km west of Bonita Beach. No algae were collected at this location and there were rare instances of macroalgae in the analyzed video transects.

GOM06 **–** This nearshore station was located near Estero Island (6 km, bearing 105° from the Sanibel Lighthouse) and at the north end of Estero Island (Fig. 5.34). It was located nearby a real-time water quality monitoring platform, RECON, maintained by SCCF. GOM06 contained packed sand with abundant pen shells. This site, at times, had large amounts of drifting algae, and it was difficult to discern whether the algae was attached and growing. Much of the drift algae was not amendable to quantitative sampling because it was difficult to determine what was in the quadrat as it drifted past. Macroalgae were collected and identified and later quantitated in the video analysis. The close proximity to the Sanibel Causeway and Matanzas Pass created difficult dive conditions with strong currents and very poor visibility as demonstrated in the frame image (Fig. 5.34). In March of 2009 and 2010, this station had large amounts of algae found by the video (92% and 50% of transect contained algae), but underwater observations by divers recorded only 1% cover. This descrepancy was caused by the difficulty in sampling the large drifting macroalgae and is further elaborated below. The most common species collected at this site were highly branched reds, and were similar in species composition to those found on the beaches of Sanibel and Fort Myers and at stations inshore of the Sanibel causeway in March 2010. The most abundant species were *Chondria collinsiana* and *Hincksia onslowensis*. This site also had abundant sea urchins.

GOM07 – This nearshore station was south of Estero Island, near Wiggans Pass (Fig. 5.35). It was 18 km from the Sanibel Lighthouse (bearing 130°) and was similar in character to GOM06. High densities of pen shells and occassionally high densities of the sea urchin *Lytechinus variagatus*. The sediment was packed sand/shell with abundant large shell fragments. There was very little algae collected at this station but the video analysis indicated several occurrances of drifting macroalgae. However, it was present in a very low percentage of the total frames analyzed for the entire transect contained algae (<2% of the total transect). The only genus collected was *Ectocarpus,* a filamentous brown alga, collected in June 2010. This alga was seen at other sites in June 2010, suggesting a short-lived, but widespread occurrance. It was observed growing on and around other macroalgal species.

GOM08 – This offshore station had little to no algae and was largely featureless (Fig. 5.36). GOM08 (18 km, bearing 236° from the Sanibel Lighthouse) contained packed sand and was devoid of suitable macroalgal attachment sites. However, GOM08 did have evidence of sand overlying a limestone outcropping or limestone rubble. Video analysis found less than 10% of the frames contained algae for all dates sampled. Those few specimens collected were drift species such as *Sargassum vulgare* (June 2008). A red algal species common to live bottom reefs, *Botryocladia occidentalis,* was collected in July 2009 and may have been transported from a nearby live bottom area.

GOM09 – Station GOM09 was only visited twice (June 2008, September 2008) before discontinuation due to the difficulty in sampling it regularly (25 km, bearing 210° from the Sanibel Lighthouse). However, a dense population of *Halophila decipiens* (Div. Anthophyta) was observed at this site in June 2008 at a depth of 18 m. Others have reported ephemeral *H. decipiens* in deeper waters of Florida Bay (e.g. Fourqueran et al. 2002) and inshore in Pine Island Sound.

GOM10 – This offshore station (9 km, bearing 270 from Blind Pass) occasionally contained high densities of heart urchins (*Moira atropos*), sand dollars (*Mellita quinquiesperforata*) and bivalve shells (Fig. 5.37). The bottom consisted of loosely consolidated medium to large coarse shell (hash) and sand with large (greater than 20 cm wide) sand waves. Very little algae was collected overall, consisting of species typically found on live bottom reefs. The most abundant macroalgae collected was *Dictyota cervicornis*, a brown alga. Jawfish and calico crabs were frequently observed at this station, as were stomatopods (mantis shrimp). This site was chosen for the grazer exclusion cages because it had high numbers of *Lytechinus variagatus* and little algal growth (see Objective 9).

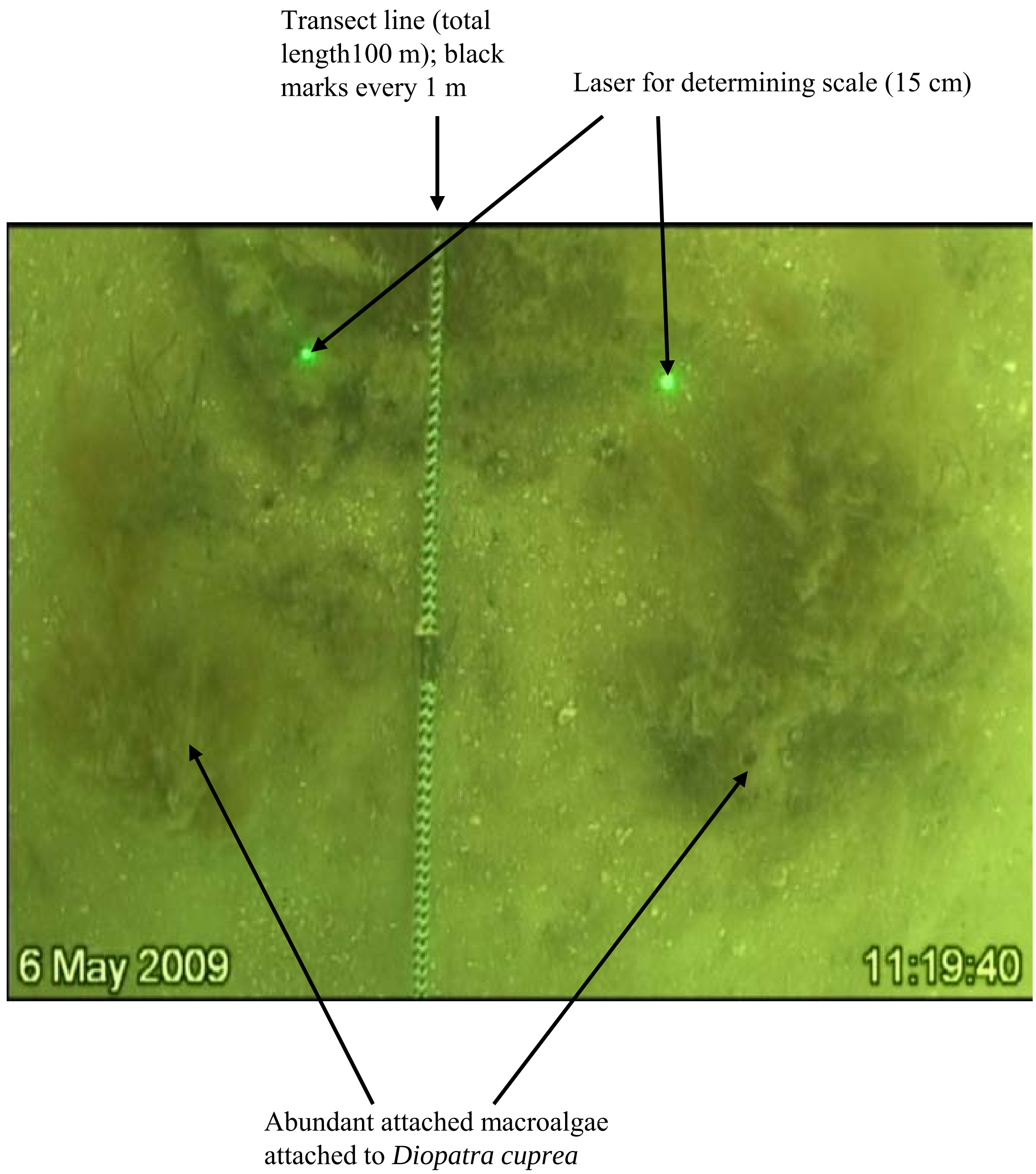


Fig. 5.2.1. Representative still frame of the video transect at CES11 highlighting features typical of the station.

Fig. 5.2.2. Representative still frame of the video transect at GOM16 highlighting features typical of the station. Mapping efforts in Objective 4 identified seagrass areas as high likelihood for trapping macroalgae. GOM16 was added in January 2009 based on initial surveys conducted for Objective 4.

Fig. 5.2.3. Representative still frame of the video transect at GOM11 highlighting features typical of the station. Live bottom, as shown above, was provided habitat for the proliferation of macroalgae.

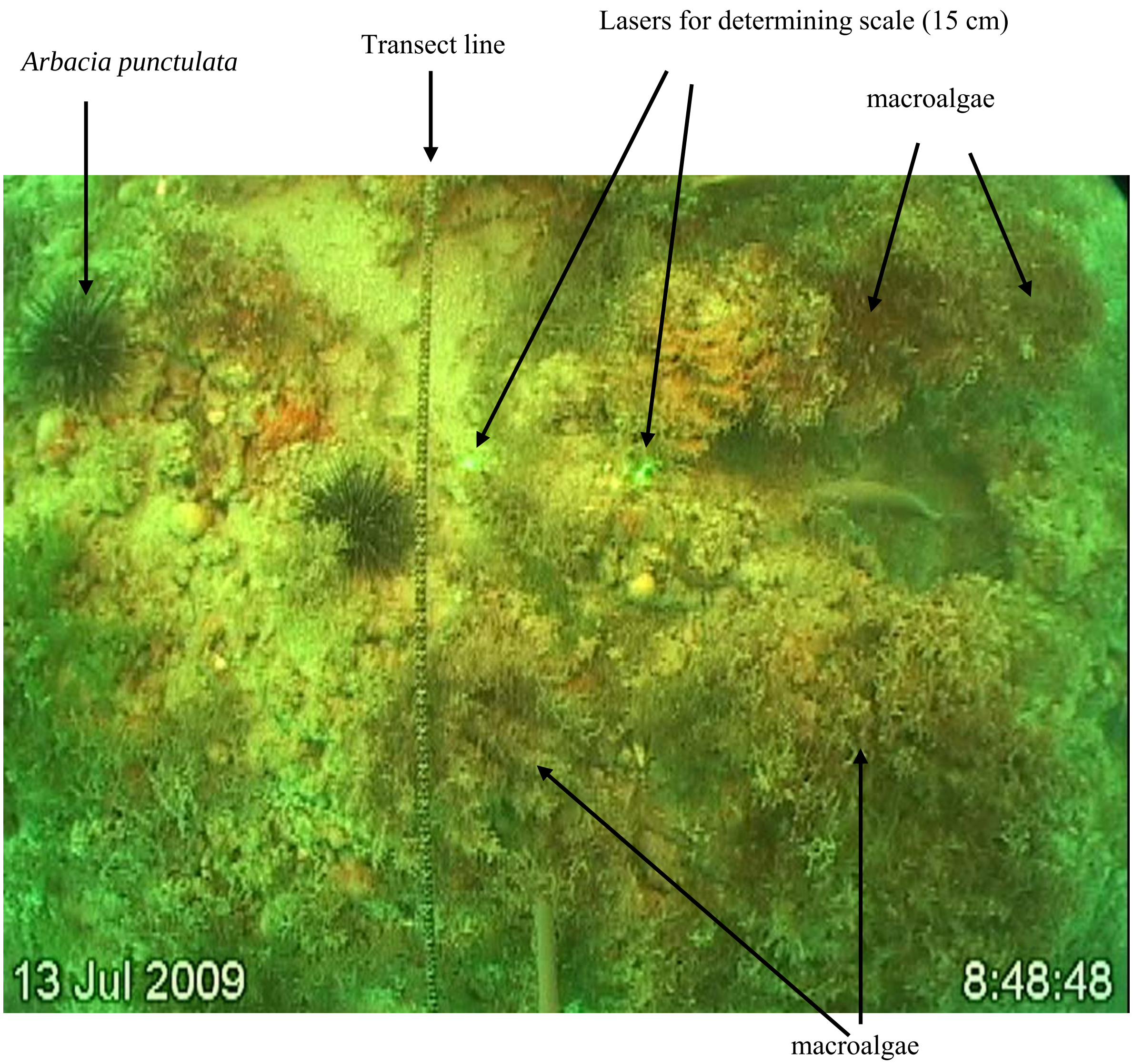


Fig. 5.2.4. Representative still frame of the video transect at GOM12 highlighting features typical of the station. Live bottom, as shown above, was typically productive habitat for macroalgae.

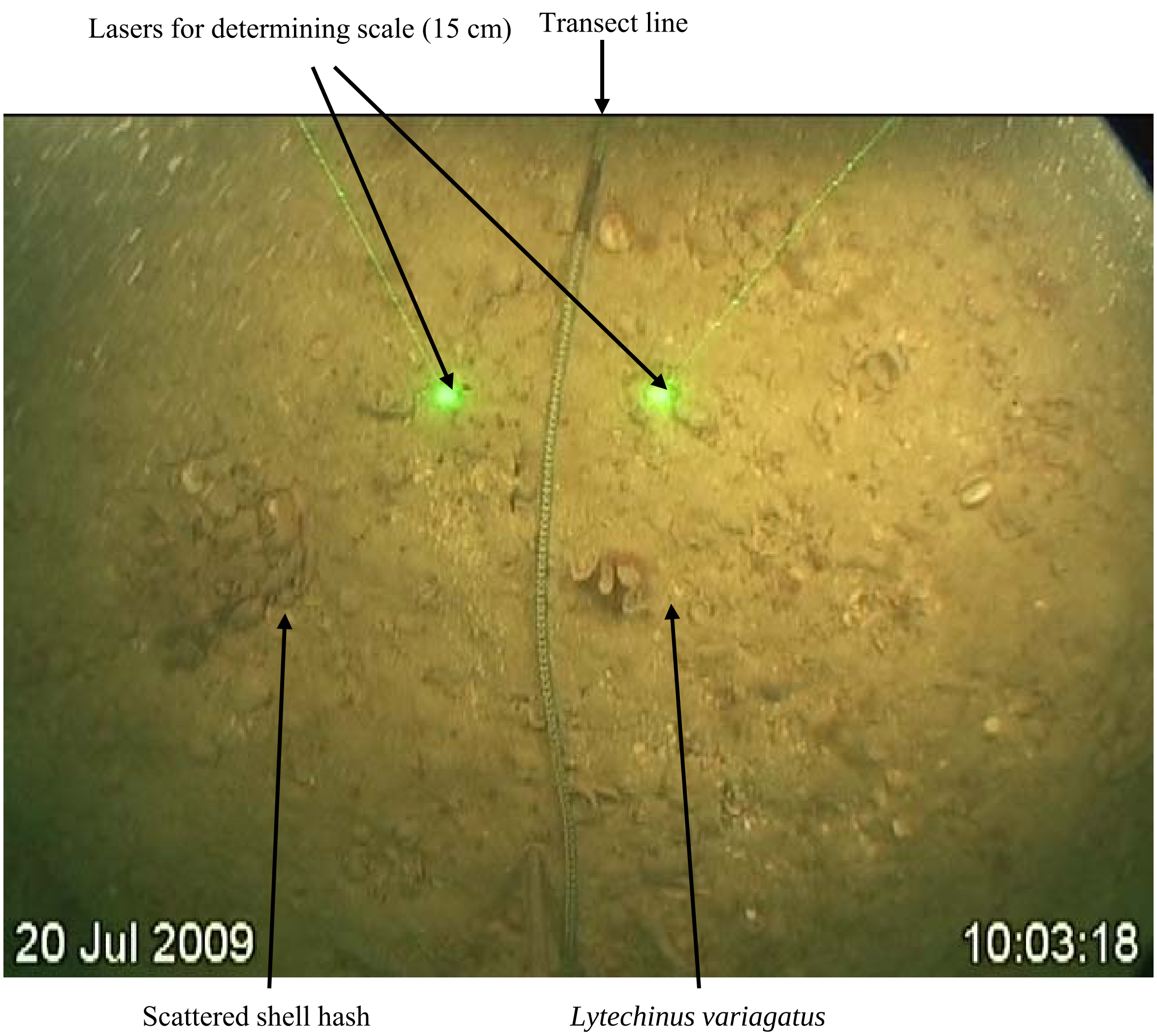


Fig. 5.2.5. Representative still frame of the video transect at GOM01 highlighting features typical of the station. Macroalgae was rare, the sediment was typified by scattered shell hash over siliclistic and carbonate muds with abundant *Lytechinus variagatus*.

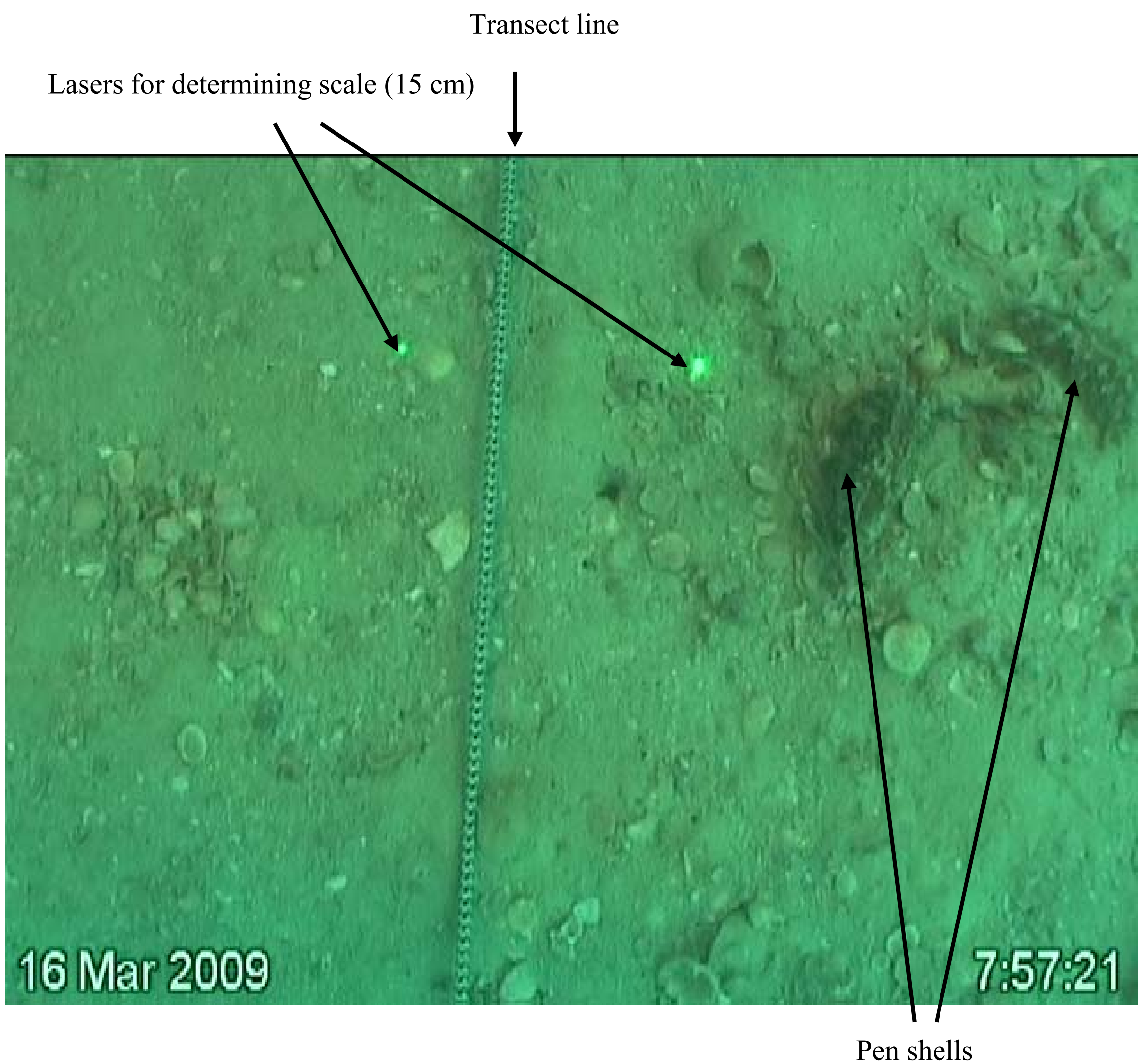


Fig. 5.2.6. Representative still frame of the video transect at GOM02 highlighting features typical of the station. Pen shells were present in addition to *Lytechinus variagatus;* macroalgae was rare.

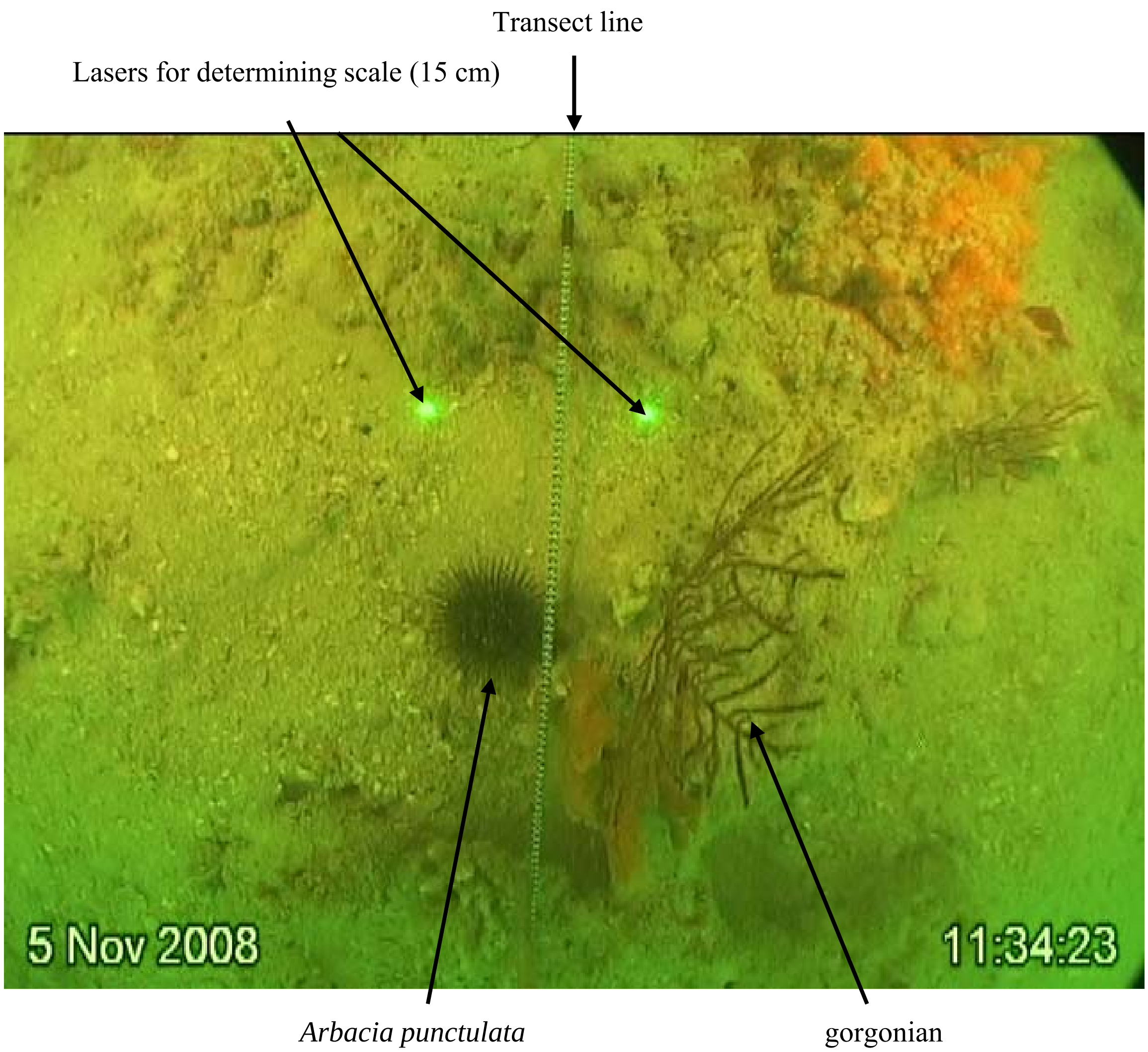


Fig. 5.2.7. Representative still frame of the video transect at GOM03 highlighting features typical of the station. Live bottom only comprised a small fraction of the entire transect. In areas away from the live bottom, there was typically sand and shell with little to no epibiota.

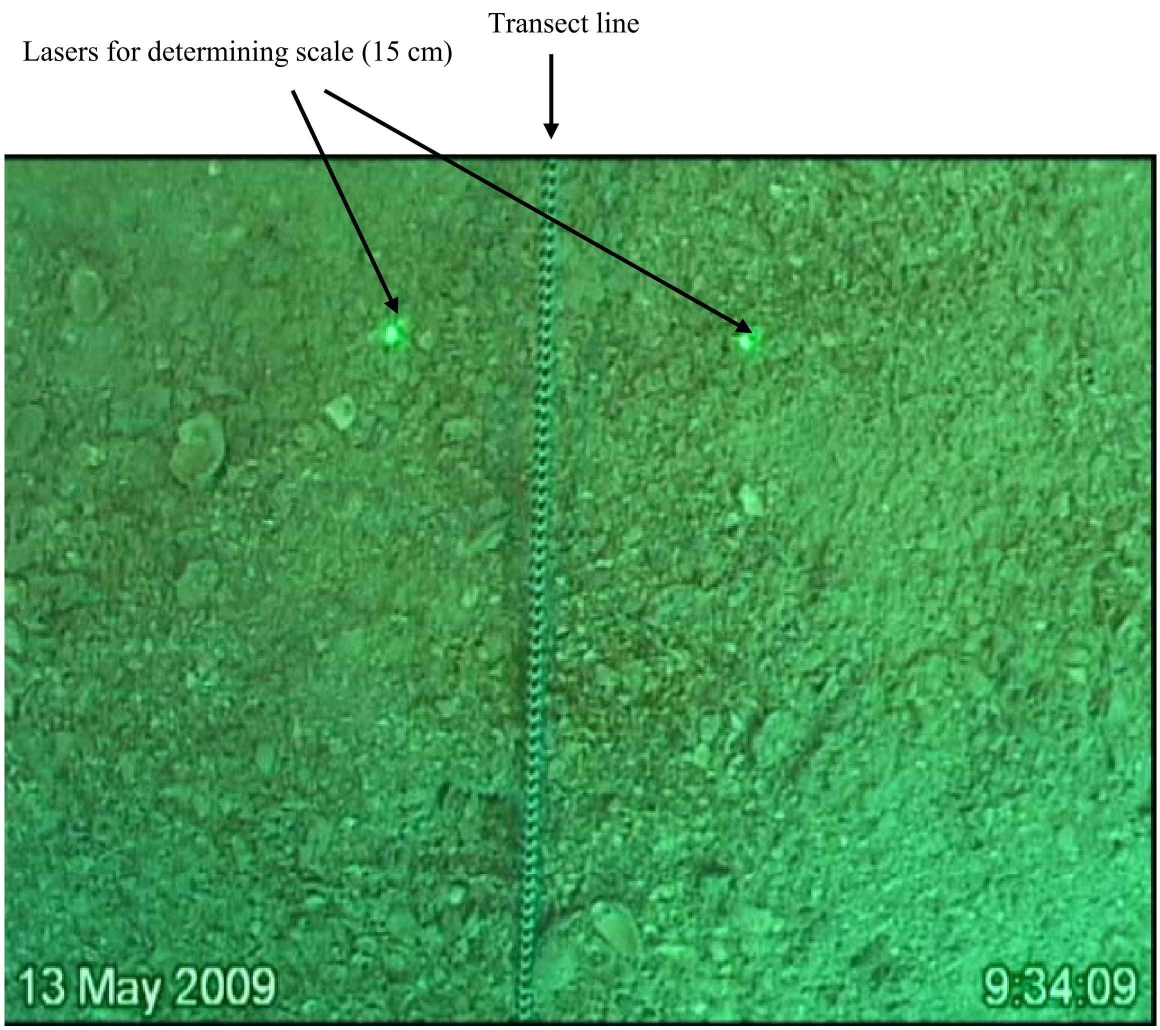


Fig. 5.2.8. Representative still frame of the video transect at GOM03A highlighting features typical of the station. GOM3A was largely featureless with scattered shell hash.

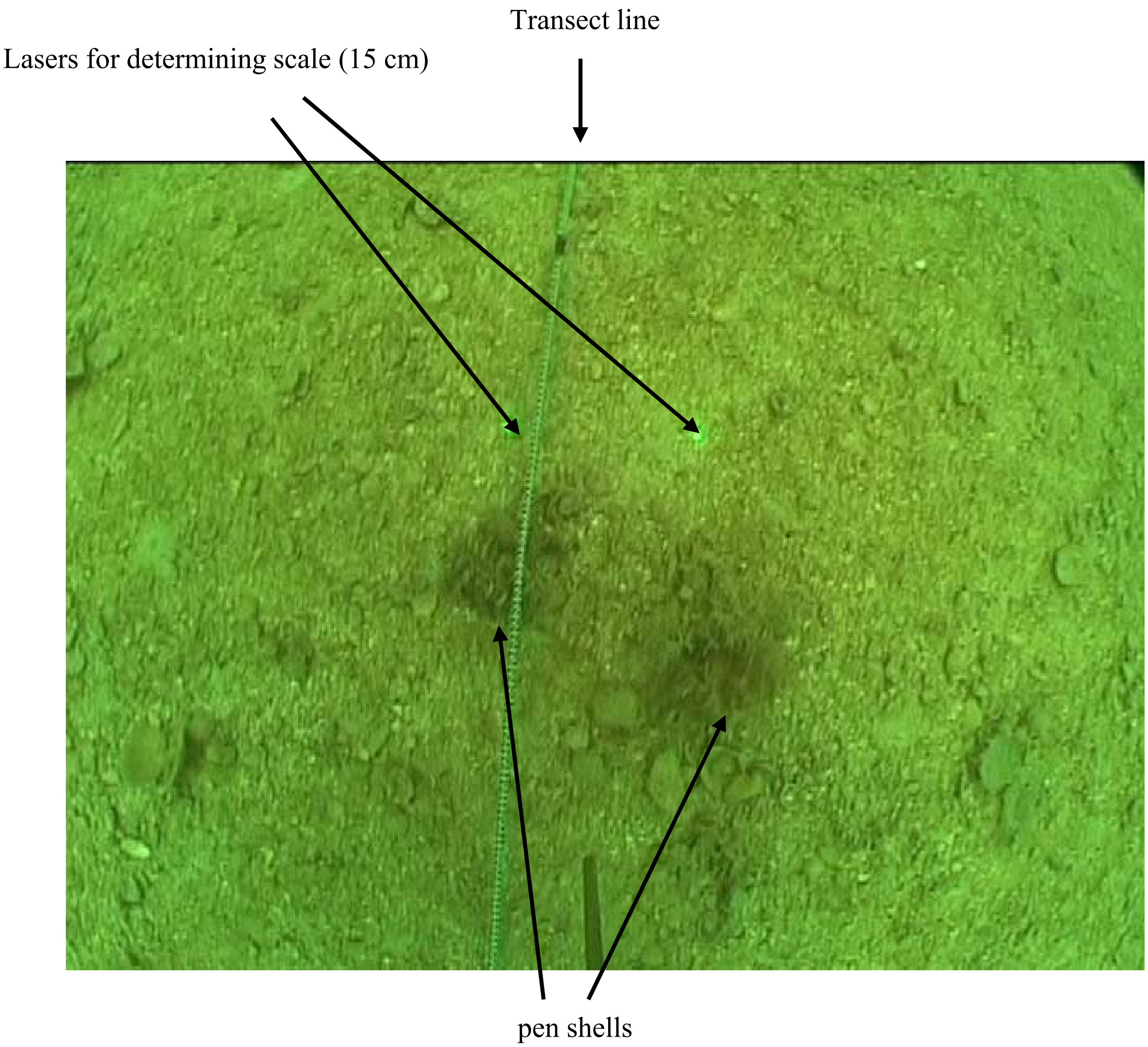


Fig. 5.2.9. Representative still frame of the video transect at GOM04 highlighting features typical of the station.

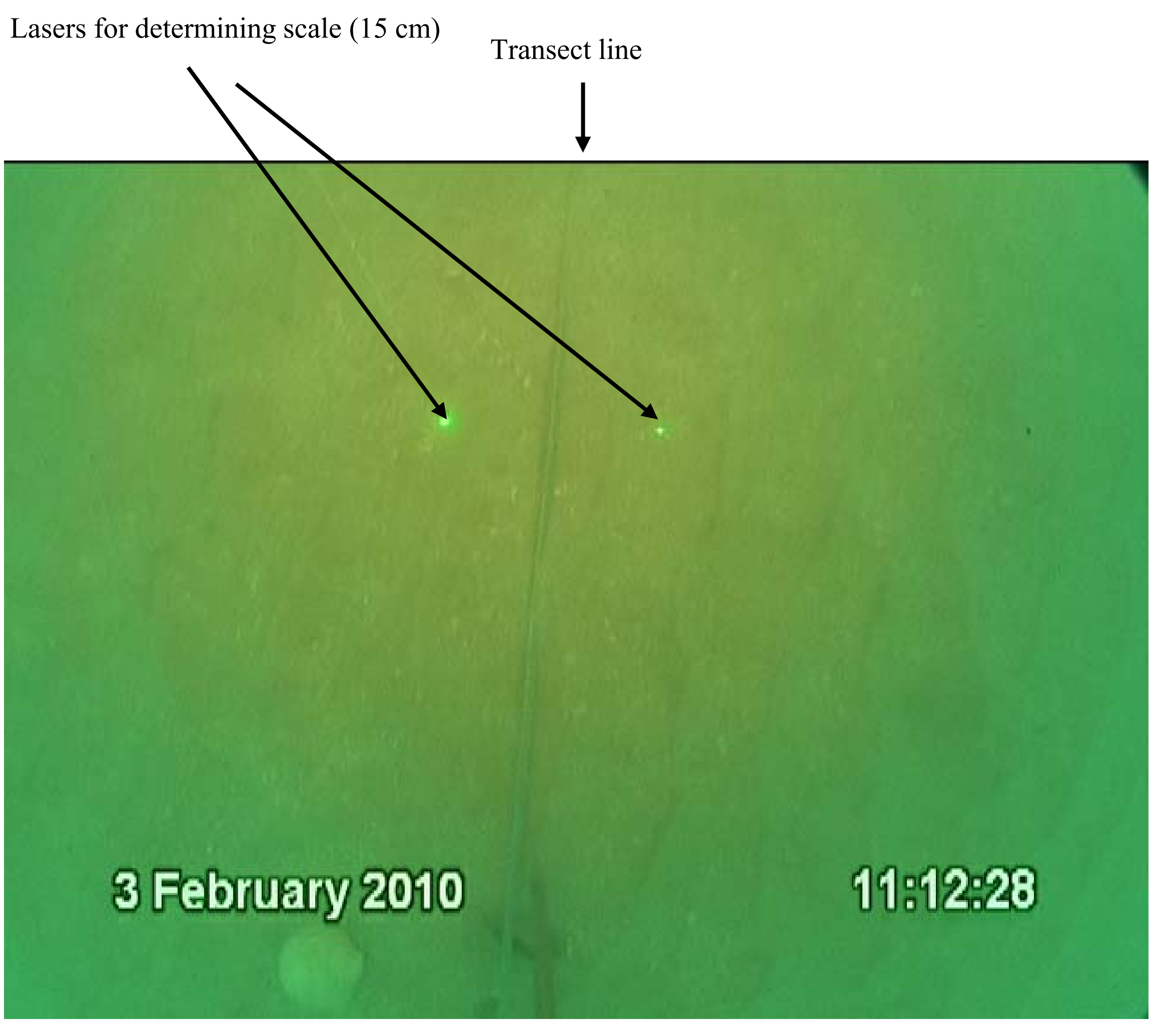


Fig. 5.2.10. Representative still frame of the video transect at GOM05 highlighting features typical of the station. GOM05 was mostly carbonate muds with little to no epibiota with the exception of the Florida fighting conch, *Strombus alatus*.

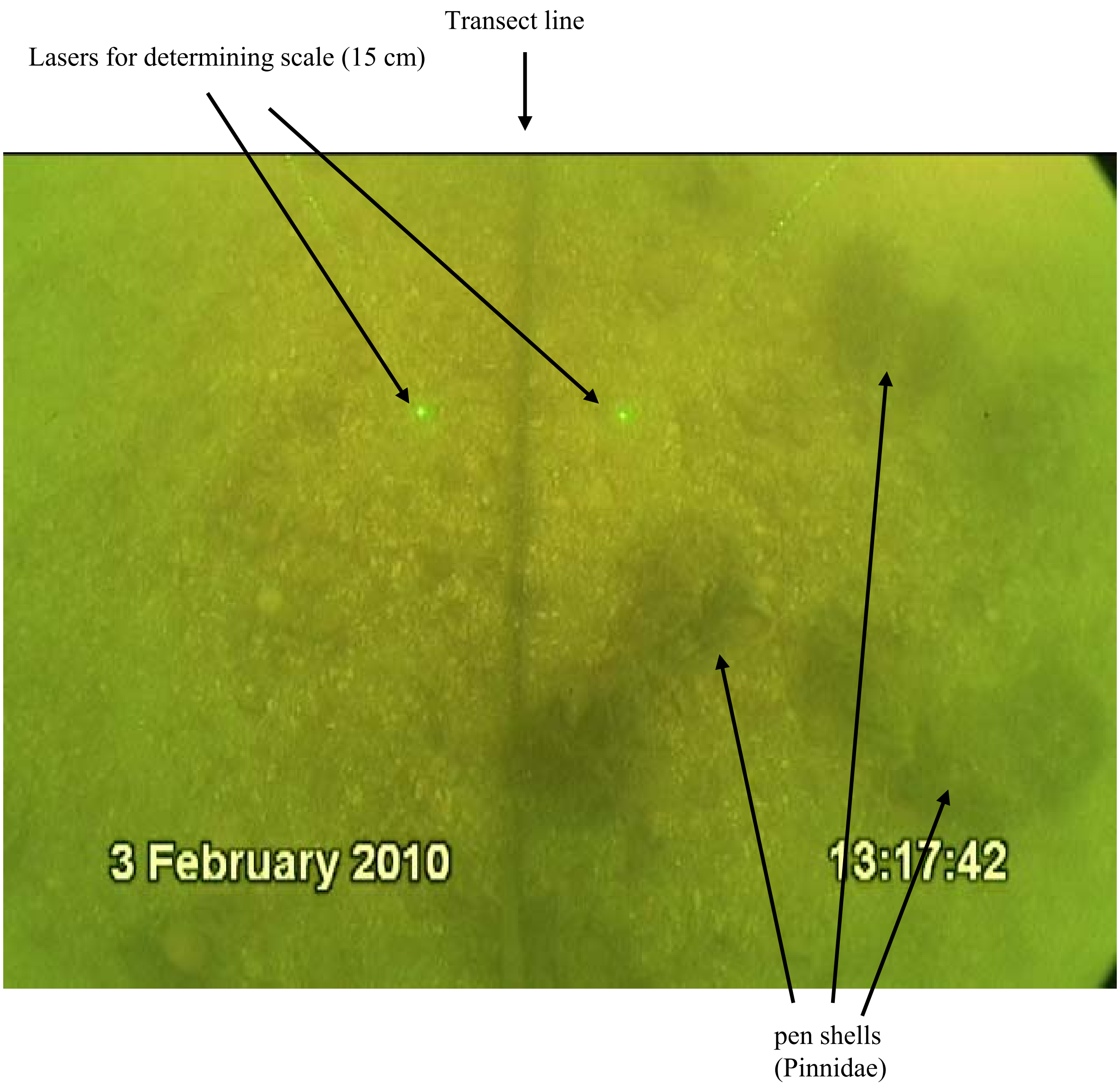


Fig. 5.2.11. Representative still frame of the video transect at GOM06 highlighting features typical of the station. There were large amounts of unattached, drift algae observed at this site which was quantified by the analysis of underwater video. There were abundant pen shells (Pinnidae) and urchins (*Lytechinus variegates*).

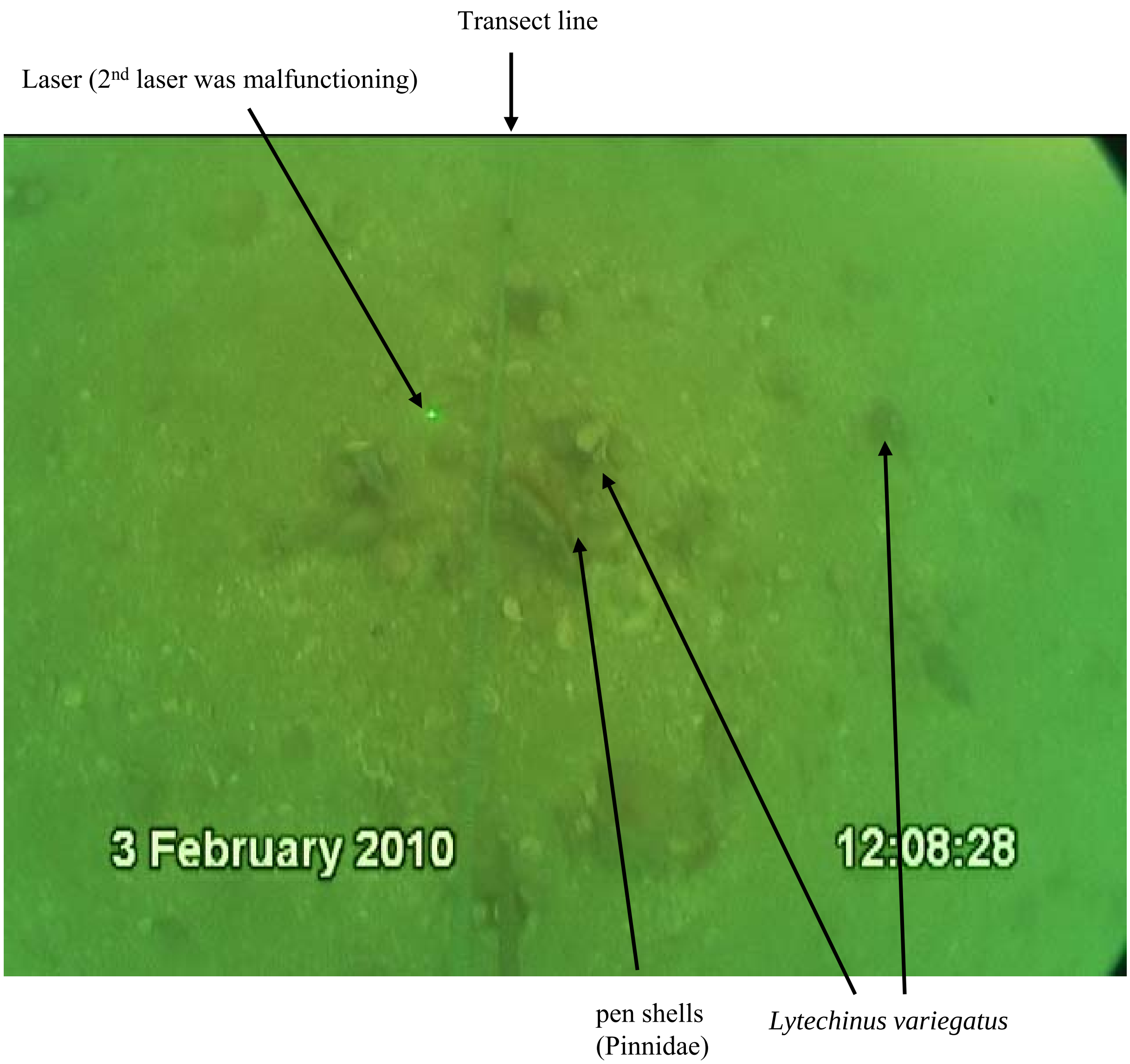


Fig. 5.2.12. Representative still frame of the video transect at GOM07 highlighting features typical of the station. GOM07 was very similar to GOM06 with occasional abundant drifting macroalgae.

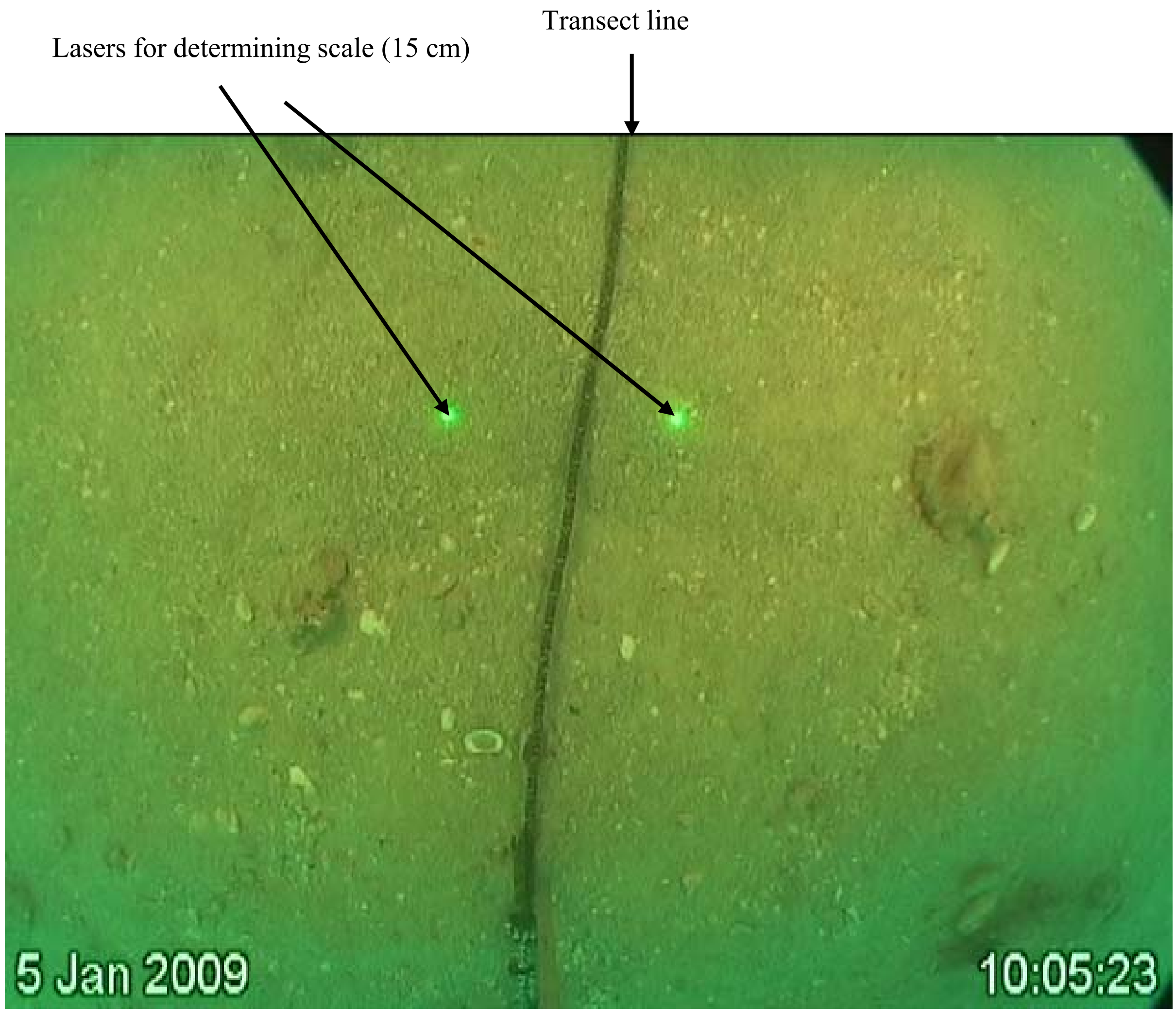


Fig. 5.2.13. Representative still frame of the video transect at GOM08 highlighting features typical of the station. GOM08 was similar to GOM05, a largely featureless seafloor with mostly and carbonate mud with little to no epibiota.

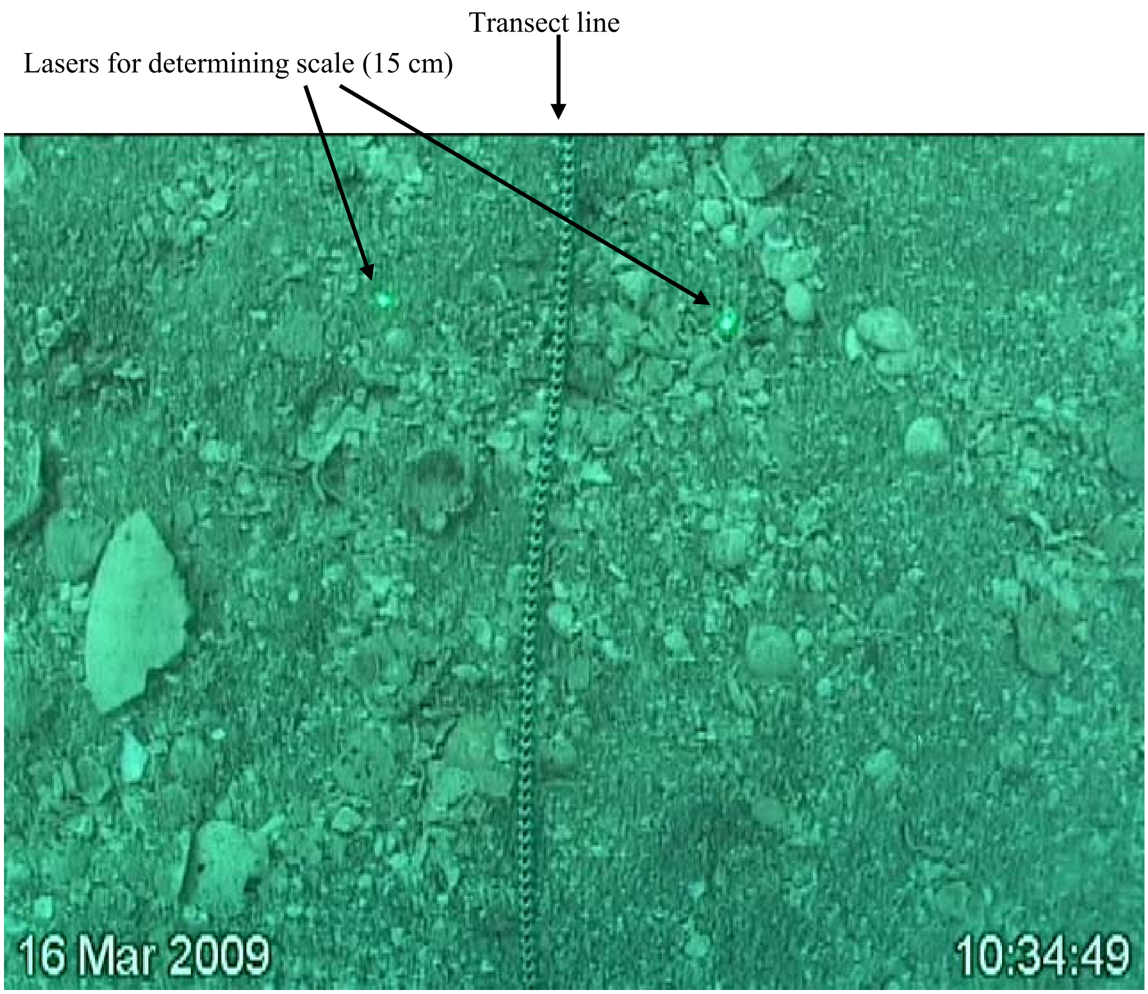


Fig. 5.2.14. Representative still frame of the video transect at GOM10 highlighting features typical of the station. There were large (> 20 cm) sand waves and larger shell hash.

Appendix 5.3: Color plates of the common macroalgae found during the study

Fig. 5.3.1. *Acanthophora spicifera* (Rhodophyta). This species is abundant in seagrass beds and inshore stations and was frequently collected at stations GOM16 and CES11.

Fig. 5.3.2. *Agardhiella subulata* (Rhodophyta). This species is associated with live bottom and typically has a large well-developed discoid holdfast. It was collected frequently at live bottom stations, such as GOM11 and GOM12.

Fig. 5.3.3. *Botryocladia occidentalis* (Rhodophyta). This species is associated with live bottom habitats and was collected frequently at GOM11 and GOM12. It typically has a discoid holdfast.

Fig. 5.3.4. *Champia parvula* (Rhodophyta) is a species found commonly throughout the study area. It was found in great abundance inshore at stations GOM16, CES 11 and stranded on Fort Myers Beach in March 2010.

Fig. 5.3.5. *Chondria collisiana* (Rhodophyta) was very abundant in March 2010 on Fort Myers Beach and CES11.

Fig. 5.3.6 *Gracilaria mammilaris* (Rhodophyta) is a species associated with live bottom and frequently collected at GOM11 and GOM12. It typically has a small discoid holdfast.

Fig. 5.3.7. *Dasya* spp. (Rhodophyta) are macroalgae with small branchlets called 'ramelli' which give the thallus the appearance of being blurry or fuzzy. *Dasya* spp. was found at both inshore and offshore stations.

Fig. 5.3.8. *Dictyota cervicornis* (Phaeophyta) is a brown alga that is found at both inshore and offshore stations

Fig. 5.3.9. *Solieria filiformes* (Rhodophyta) was found offshore (GOM11, GOM12) and is associated with live bottom habitats.

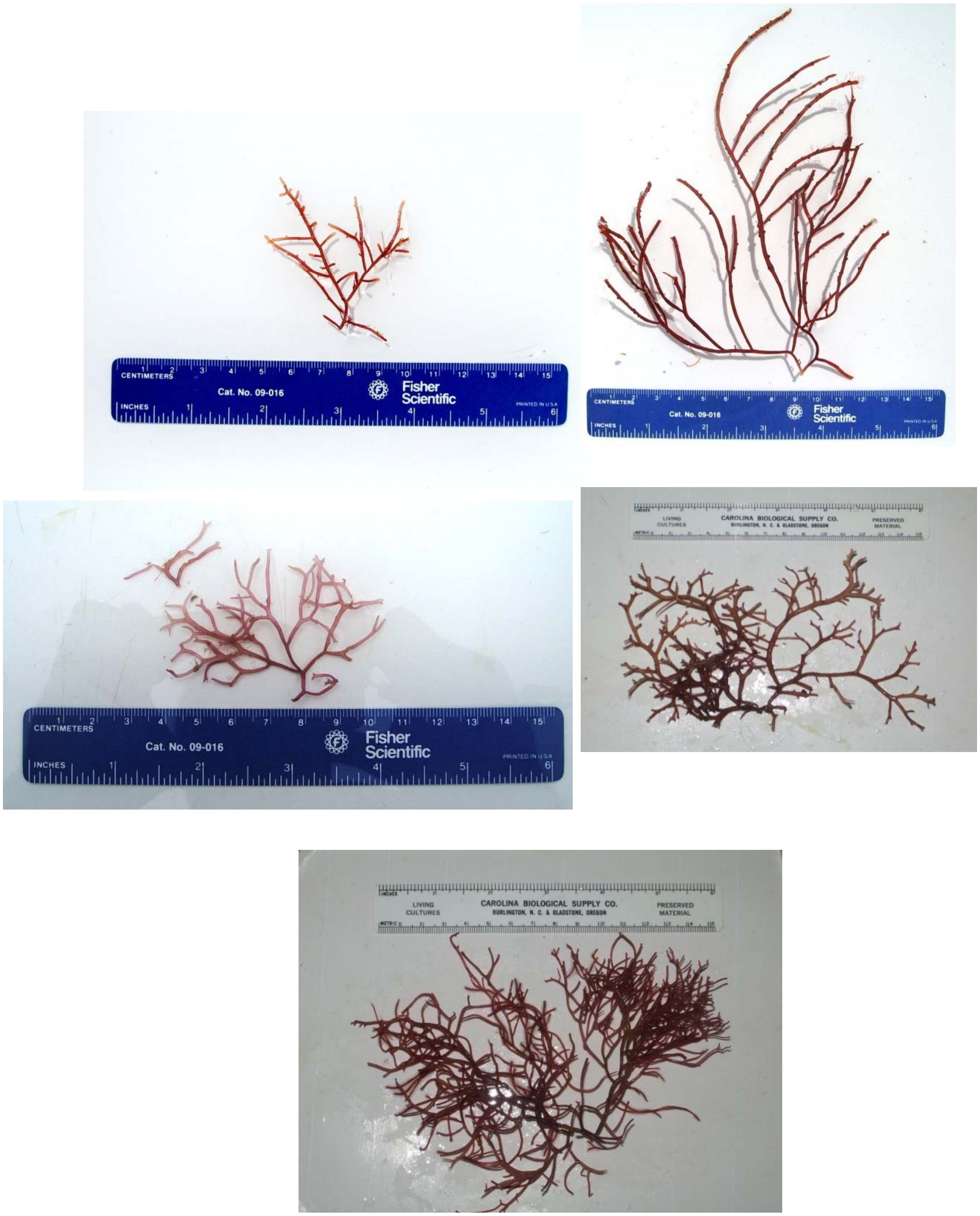


Fig 5.3.10. *Gracilaria* spp. (Rhodophyta) was found throughout the study area. There are 19 species of Gracilaria found in Florida (Dawes and Matheisson 2008) and may appear alike. Several species are shown above with distinctions depending on the degree of compression of the main axis and the branching patterns.

Fig. 5.3.11. *Eucheuma isiforme* (Rhodophyta) was collected at live bottom stations (GOM11, GOM12). It has a well-developed discoid holdfast and is associated with live bottom habitats.

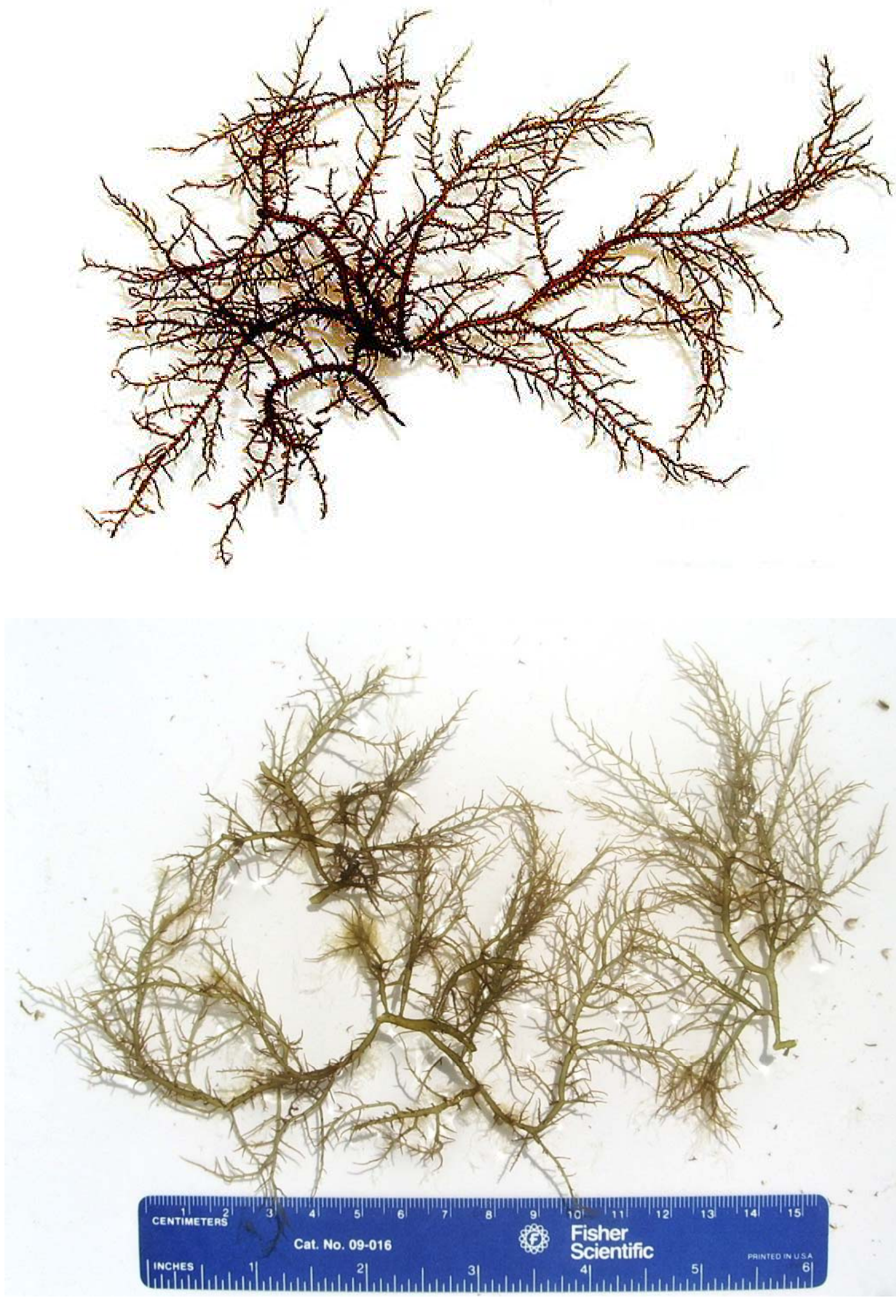


Fig 5.3.12. *Hypnea spinella* (Rhodophyta) was found throughout the study area including inshore and offshore stations. This species was reported to be in great abundances on area beaches during events from 2003-2007.

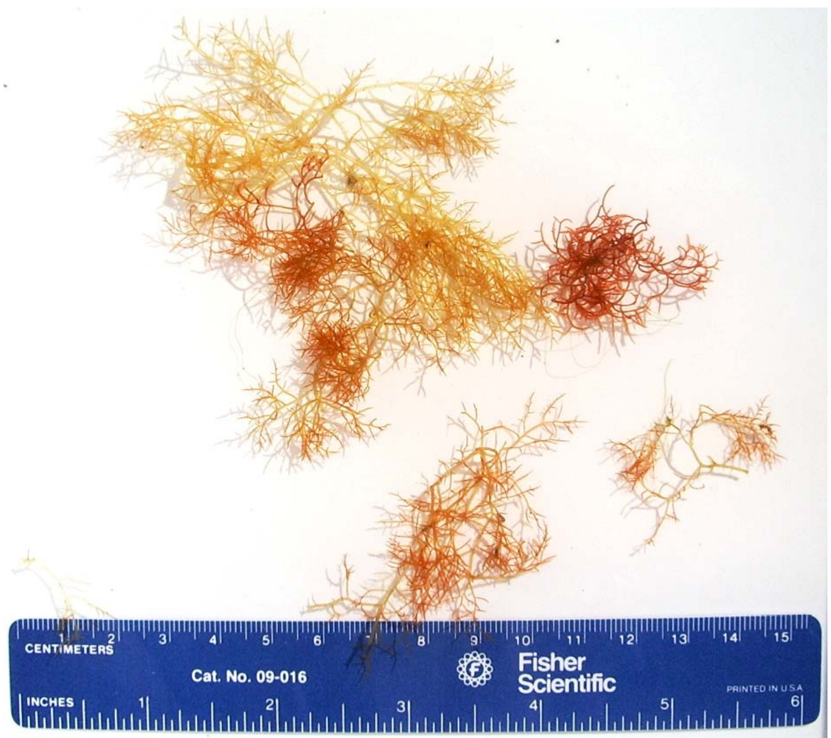


Fig. 5.3.13. *Lomentaria baileyana* (Rhodophyta) was abundant at inshore stations, GOM16 and CES11.

Fig. 5.3.14. *Sargassum* spp. (Phaeophyta) was found at CES11 and GOM12 and was associated with both inshore and live bottom habitats.

Fig. 5.3.15. *Spyridia filamentosa* (Rhodophyta) was abundant at inshore stations, such as CES11 and GOM16.

Fig. 5.3.16. *Ulva lactuca* (Chlorophyta) was found at CES11 and other inshore locations. It is an indicator of nitrogen pollution.

Appendix 5.4

The total biomass from the individual stations (all macroalgal species combined) is presented as dry weight biomass per quadrat (Figs. 5.4.1-5.4.5), wet weight biomass per quadrat (Figs. 5.4.6-5.4.10) and by percent cover (Figs. 5.4.11-5.4.12).

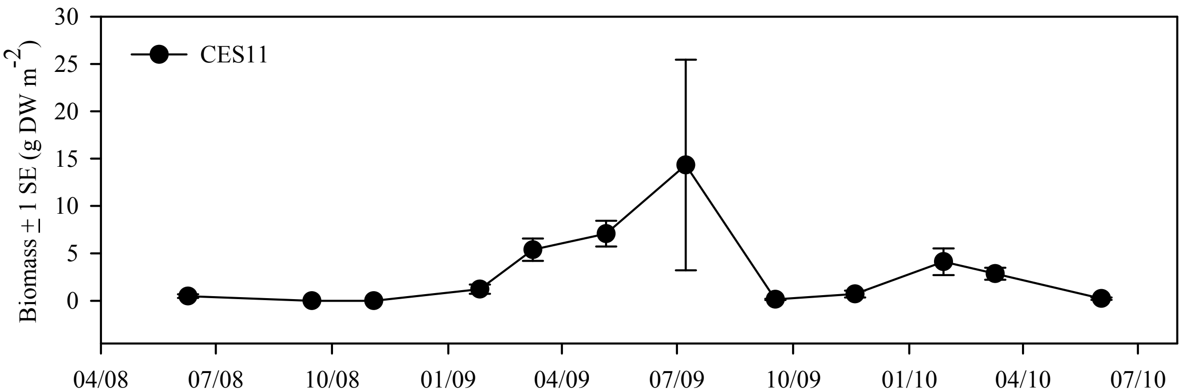
A series of pie charts by station and month depict the species composition by proportion (%) of the species biomass over the total biomass for the transect. Similarly, an emphasis was placed on those species found on area beaches in this study or previously. Species composition pie charts are also useful for demonstrating a spatial patterns of organization over the large target area sampled in this study.

The community composition at CES11 (Figs. 5.4.16-5.4.18) had three dominant red macroalgal species; *Acanthophora spicifera, Gracilaria tikvahae,* and *Spyridia filamentosa*. Similarly, the species composition at GOM16 (Figs. 5.4.19-5.4.20), also located near the Sanibel Causeway, had several of the same dominant three species including; *A. spicifera*, *G. tikvahae*, and *Soliera filiformis.* However, there was a sampling event when the rhodophyte *Lomentaria baileyana* was the only species found.

At the offshore, live bottom stations, there was greater diversity and evenness with the dominant species comprising a lower proportion of biomass to the total for the transect. At GOM11 (Figs. 5.4.21-5.4.23), several *Gracilaria* spp., *Botryocladia occidentalis, Soliera filiformis, Aghardhiella subulata,* and *Eucheuma isofirme* were typically found. A similar pattern was found at station GOM12 (Figs. 5.4.24-5.4.26), and when several other species with low contributions (e.g., *Dictyota cervicornis, Hypnea spinella*), those same species contributing to GOM11 comprised the majority of the total biomass of GOM12.

Pie charts of species composition at the 9 other stations were included for completeness (Figs 5.4.27-5.4.31), but given the diminutive amount of biomass collected over the study period, the results are not comparable to the four stations where the majority of macroalgae were collected.

Underwater video analysis was used as an independent check on the seafloor surveys. The results are listed here. CES11 had 32% mean percent cover (n = 139) of macroalgae in March 2009 per video analysis (Fig. 5.4.32) whereas mean percent cover was 15% (n = 20) when recorded in quadrats. GOM16 had a maximum mean percent cover in March 2010 of 26% (n = 137; Fig. 5.4.32). The percent cover was generally lower at offshore than at inshore stations where the maximum mean macroalgae cover at GOM11 in September 2009 was 13% (n = 211; Fig. 5.4.33). Maximum mean cover at GOM12 occurred in June 2010 (Fig. 5.4.33) and was 27% (n = 158), using the underwater video analysis. The percent cover observed in June 2010 at GOM12 was 26% (n = 20) as estimated by underwater observers (Fig. 5.4.33). A Kruskal-Wallis One-Way ANOVA comparing video transects to underwater observations indicated no significant differences in ranked cover at these stations.



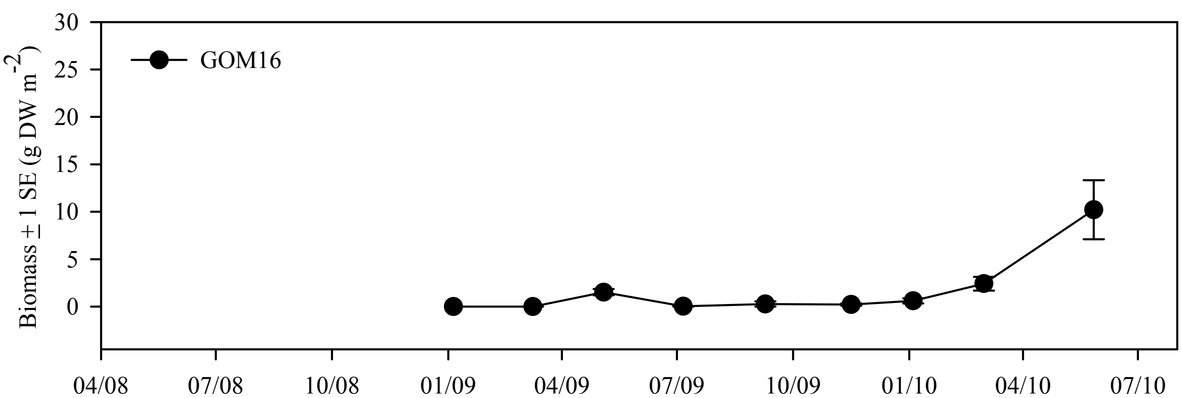


Fig. 5.4.1. Mean monthly biomass (g DW m^{-2}) by station with error estimates (±1 SE) for sites CES11 and GOM16. Note that the scale for CES11 is different than the others. Sampling size was 20 random quadrats per station except June 2008, where n = 30. These two stations routinely had an abundant macroalgal community, GOM16 also contained patchy seagrass. GOM16 was not added as a permanent station until January 2009. Detailed descriptions of the stations are provided in the text.

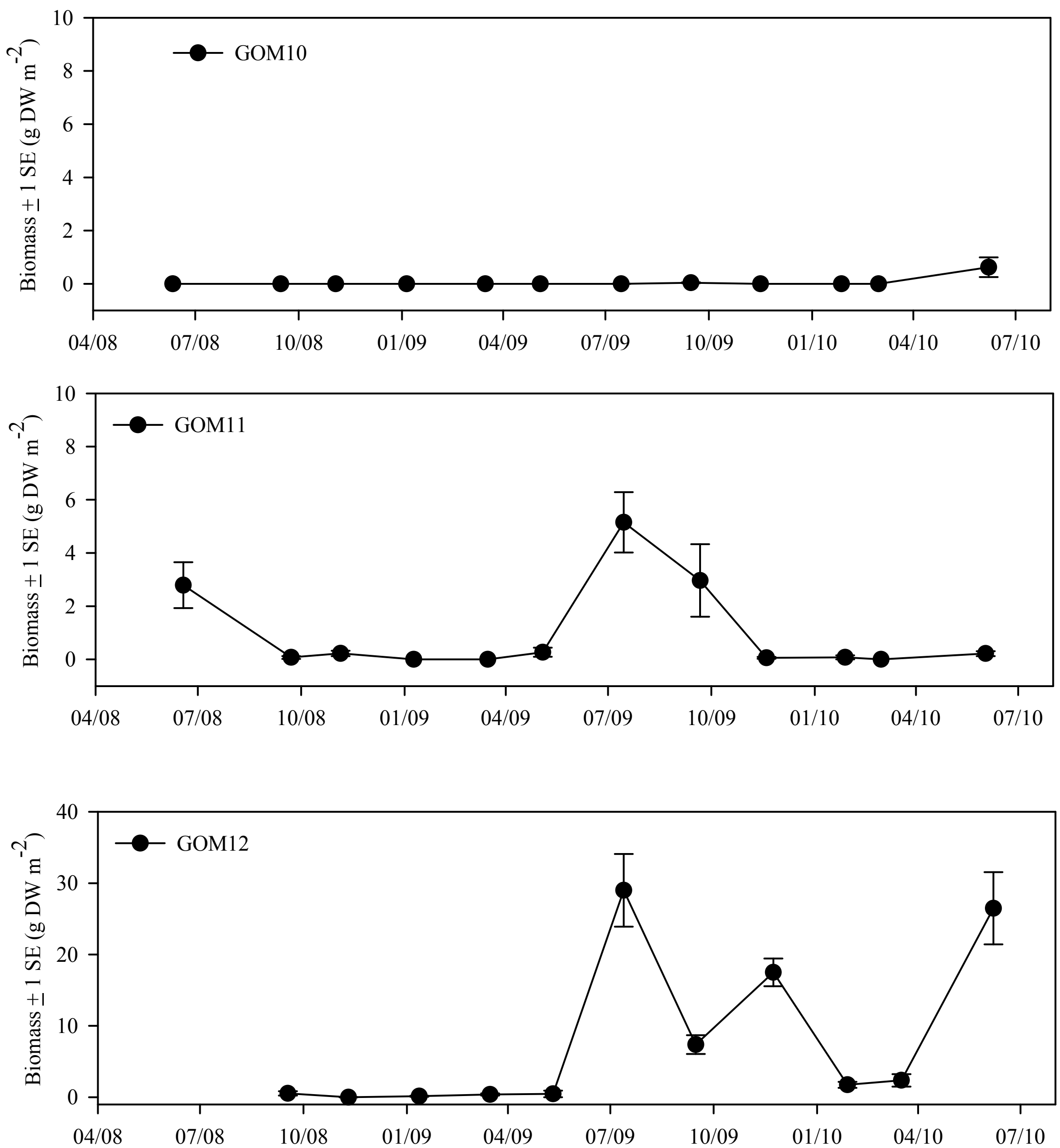


Fig. 5.4.2. Mean monthly biomass (g DW m^{-2}) by station with error estimates (±1 SE) for offshore sites GOM10, GOM11, and GOM12. Note that the scale for GOM 12 is different than the others. GOM12 was not added as a permanent station until September 2008 and samples were not collected at GOM12 in June 2008. Sampling size was 20 random quadrats per station except June 2008, where n = 30. Detailed descriptions of the stations are provided in the text.

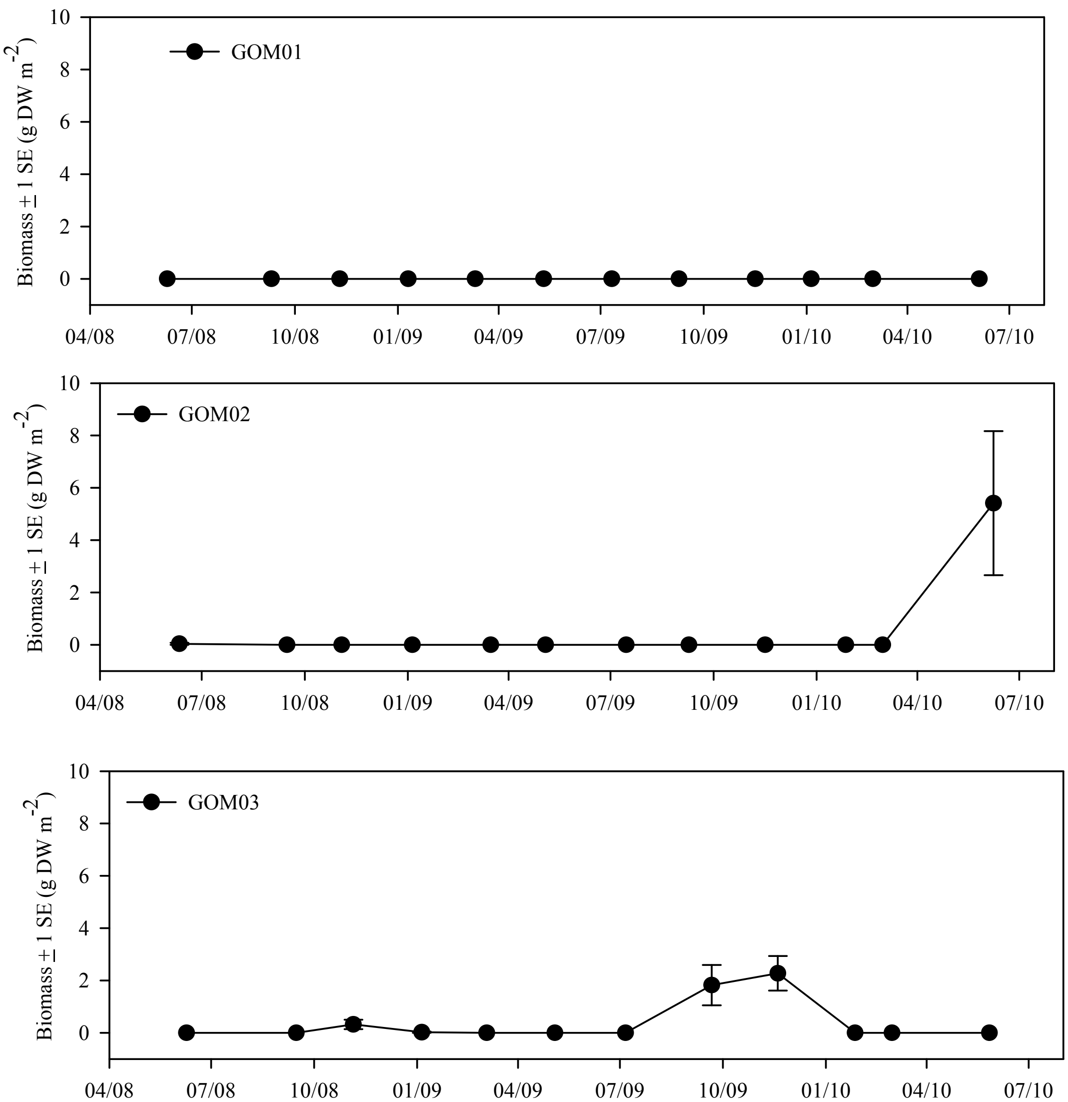


Fig. 5.4.3. Mean monthly biomass (g DW m^{-2}) by station with error estimates (+1 SE) for nearshore sites GOM01, GOM02, and GOM03. Sampling size was 20 random quadrats per station except June 2008, where n = 30. Detailed descriptions of the stations are provided in the text.

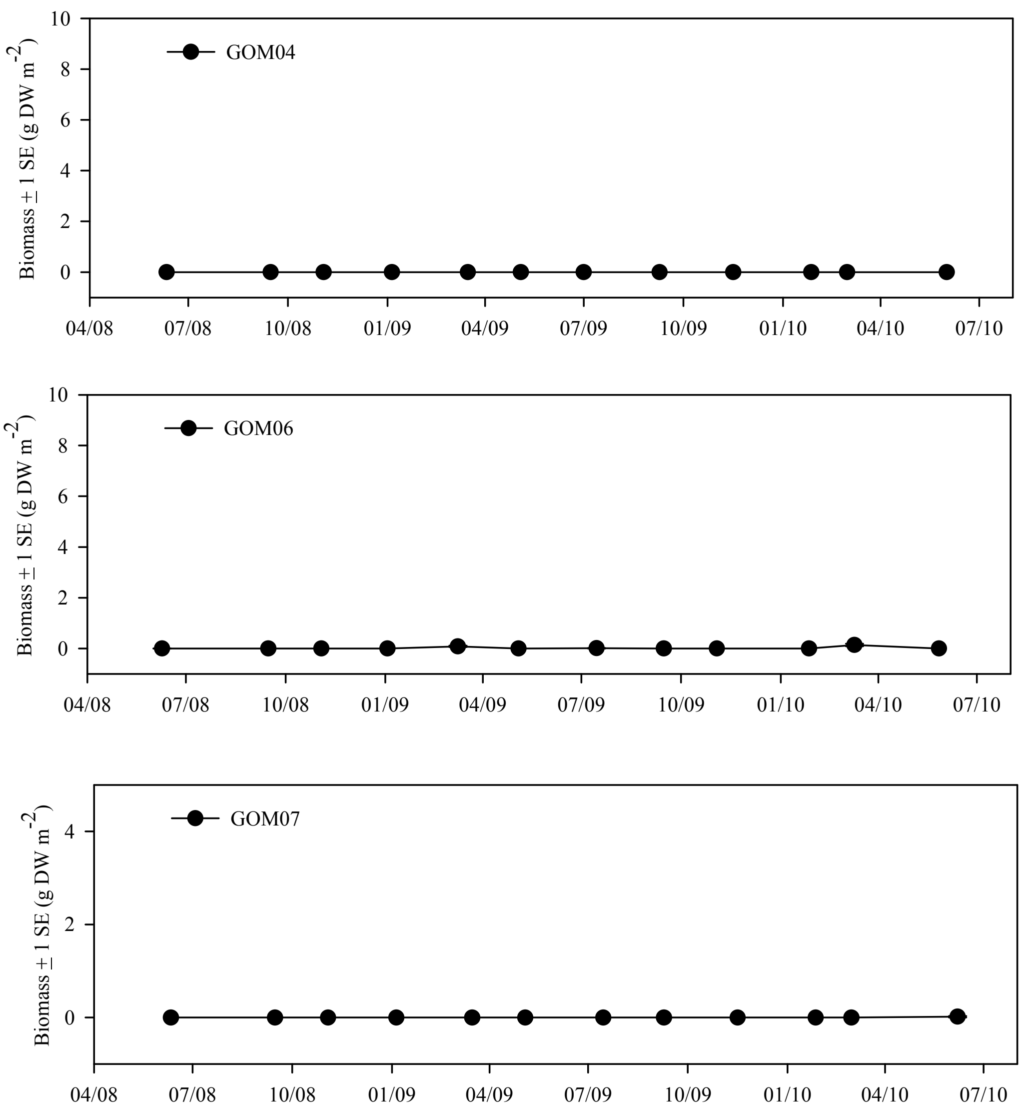


Fig. 5.4.4. Mean monthly biomass (g DW m^{-2}) by station with error estimates (±1 SE) for nearshore sites GOM04, GOM06, and GOM07. Sampling size was 20 random quadrats per station except June 2008, where n = 30. Detailed descriptions of the stations are provided in the text.

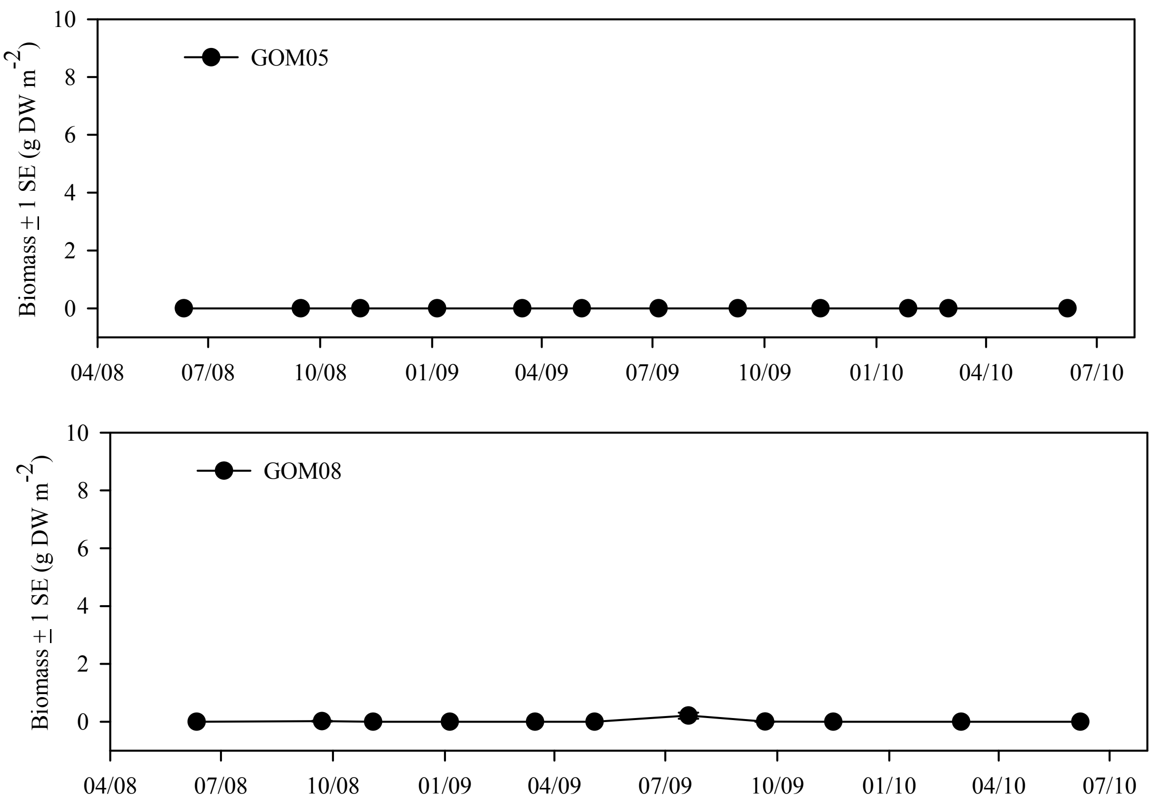


Fig. 5.4.5. Mean monthly biomass (g DW m^{-2}) by station with error estimates (+1 SE) for offshore site GOM05 and GOM08. Sampling size was 20 random quadrats per station except June 2008, where n = 30. Detailed descriptions of the stations are provided in the text.

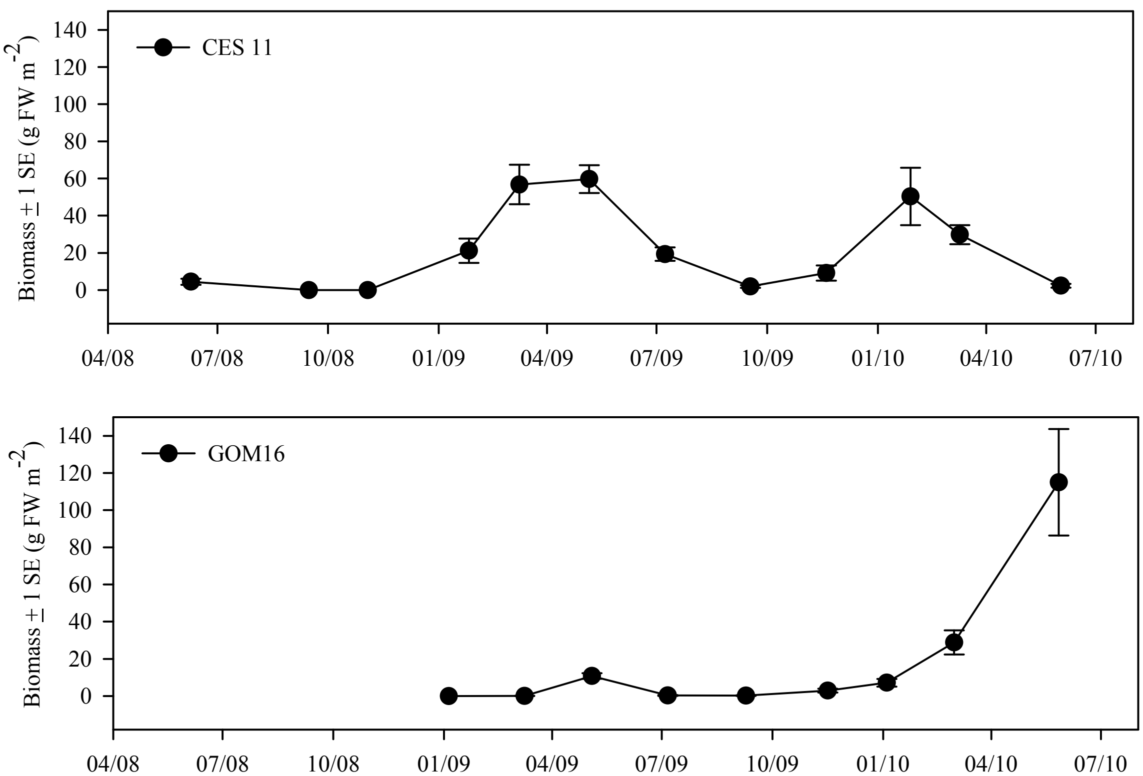


Fig. 5.4.6. Mean monthly wet weight biomass (g FW m^{-2}) by station with error estimates (+1 SE) for inshore stations CES11 and GOM16. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

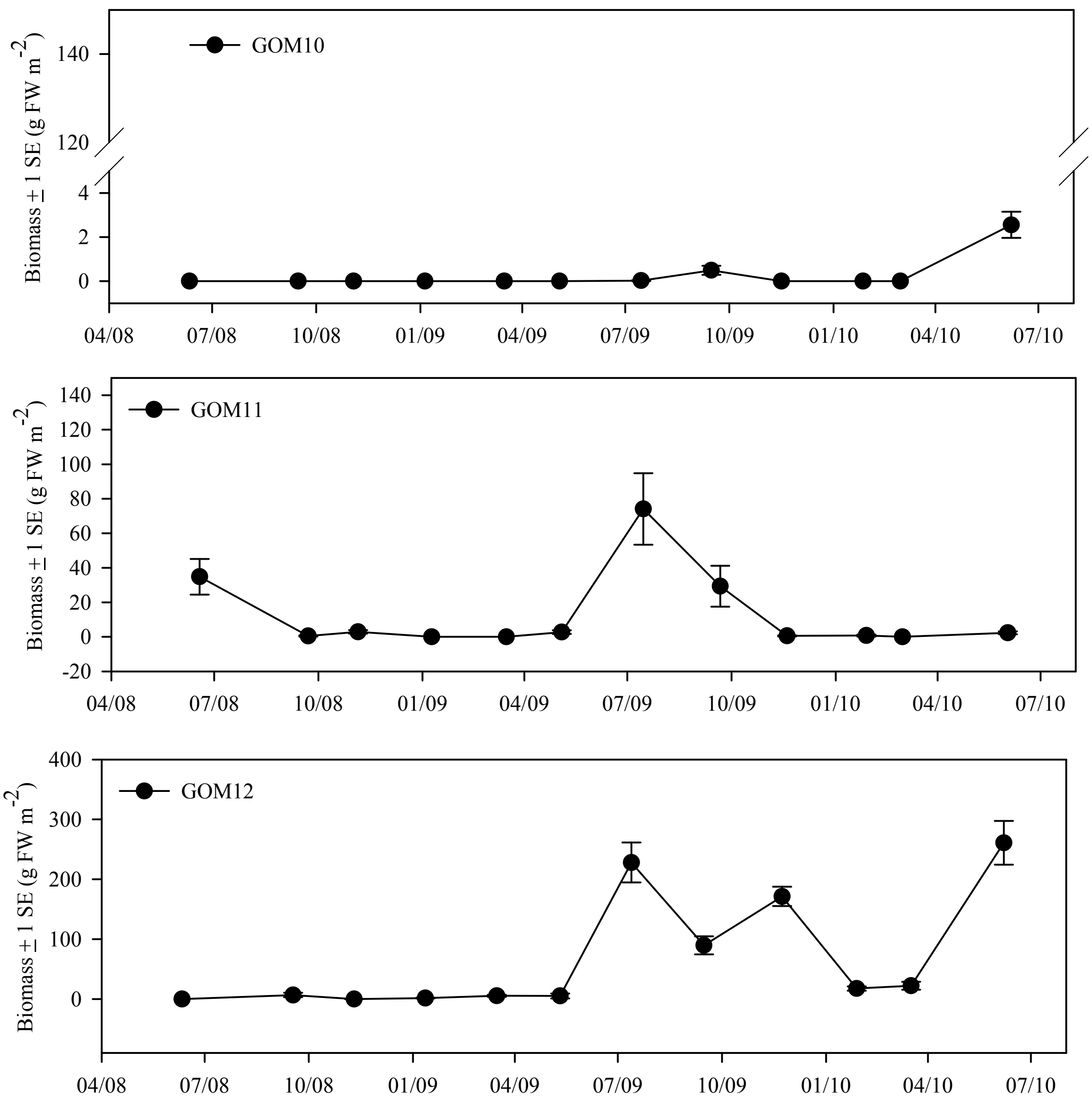


Fig. 5.4.7. Mean monthly wet weight biomass (g FW m^{-2}) by station with error estimates (+1 SE) for nearshore stations GOM10, GOM11, and GOM12. Note the difference in scale for GOM12. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

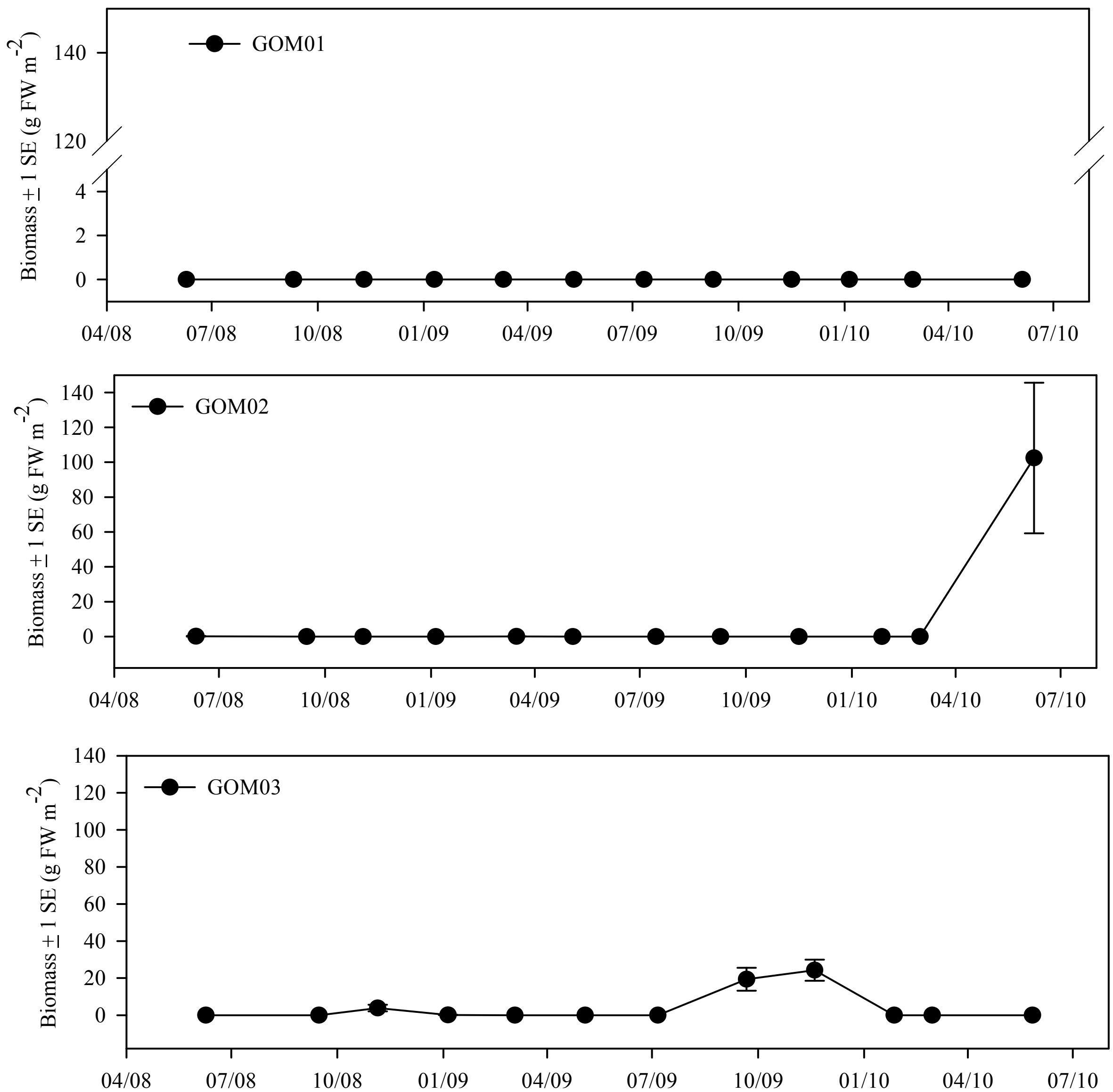


Fig. 5.4.8. Mean monthly wet weight biomass (g FW m^{-2}) by station with error estimates (±1 SE) for nearshore stations GOM01, GOM02, GOM03. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

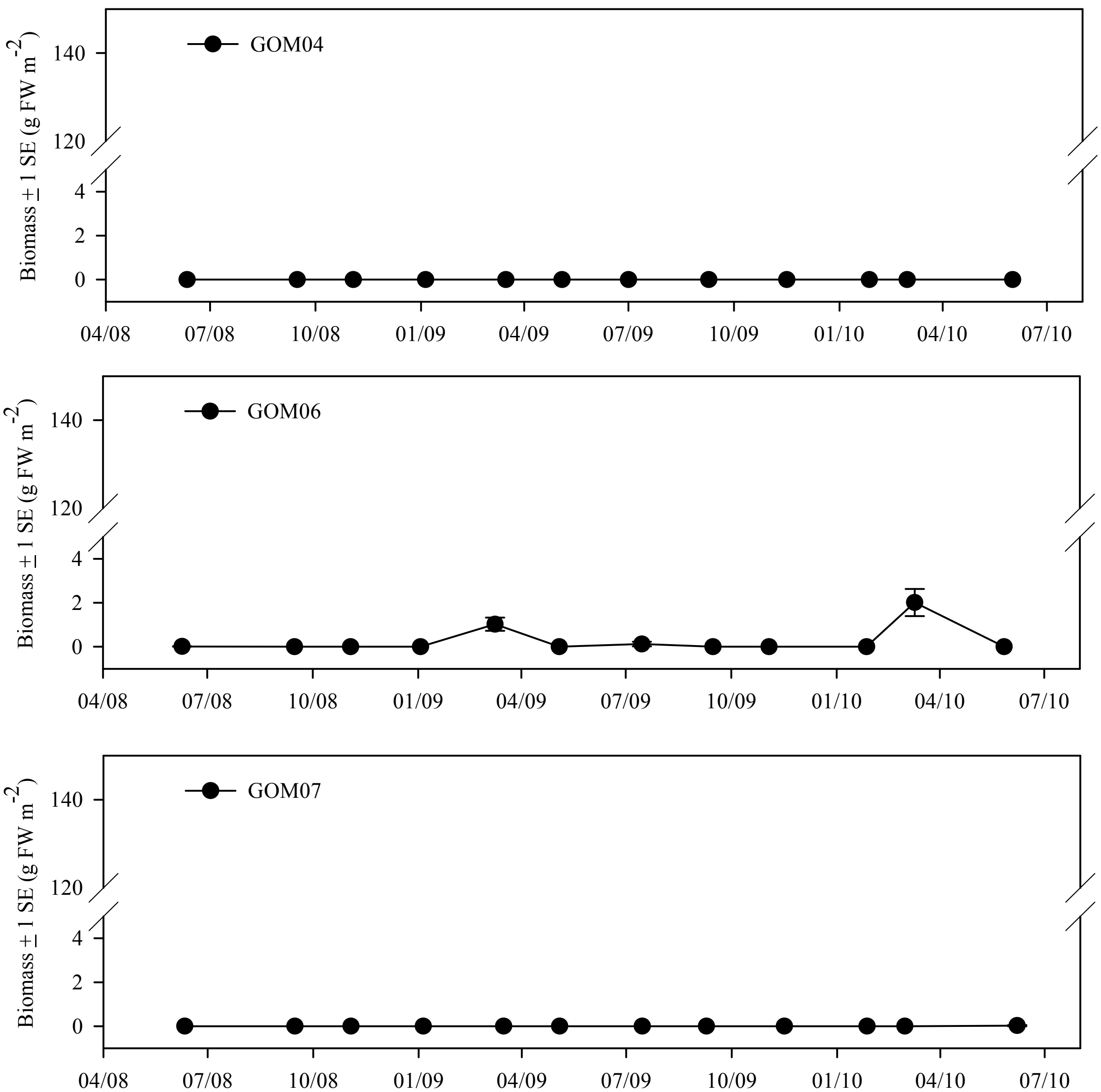


Fig. 5.4.9. Mean monthly wet weight biomass (g FW m^{-2}) by station with error estimates (±1 SE) for nearshore stations GOM04, GOM06, GOM07. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

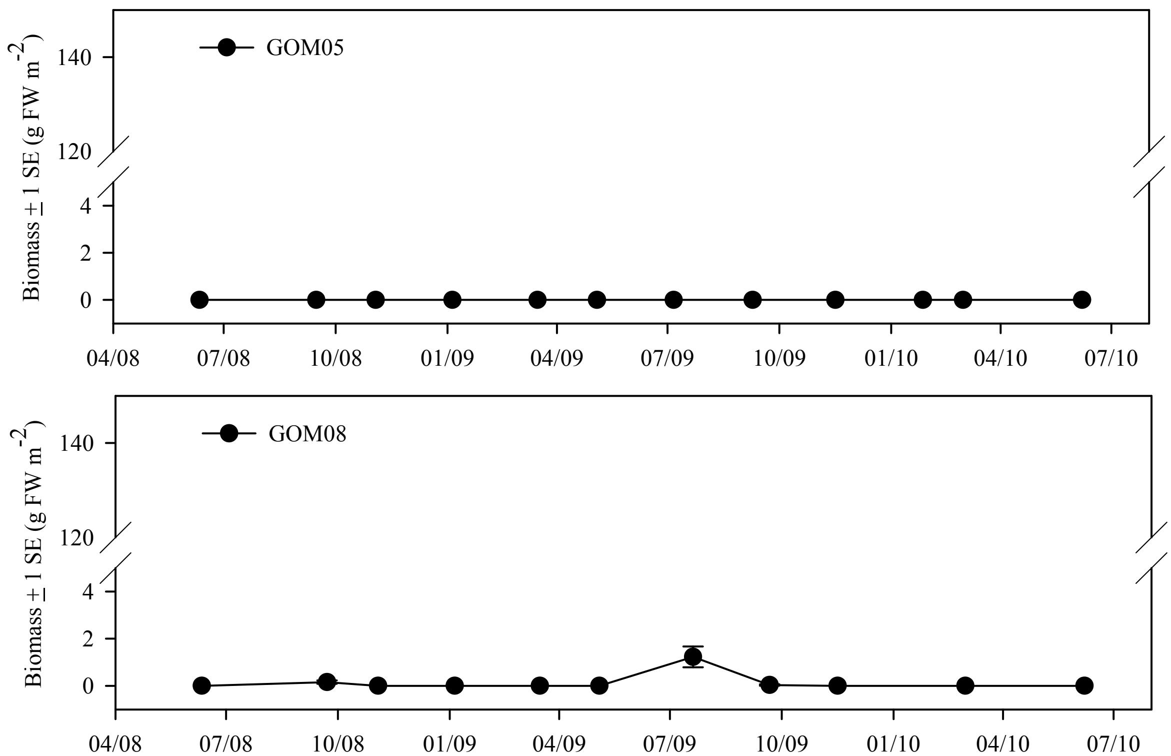


Fig. 5.4.10. Mean monthly wet weight biomass (g FW m^{-2}) by station with error estimates (±1 SE) for nearshore stations GOM05 and GOM08. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

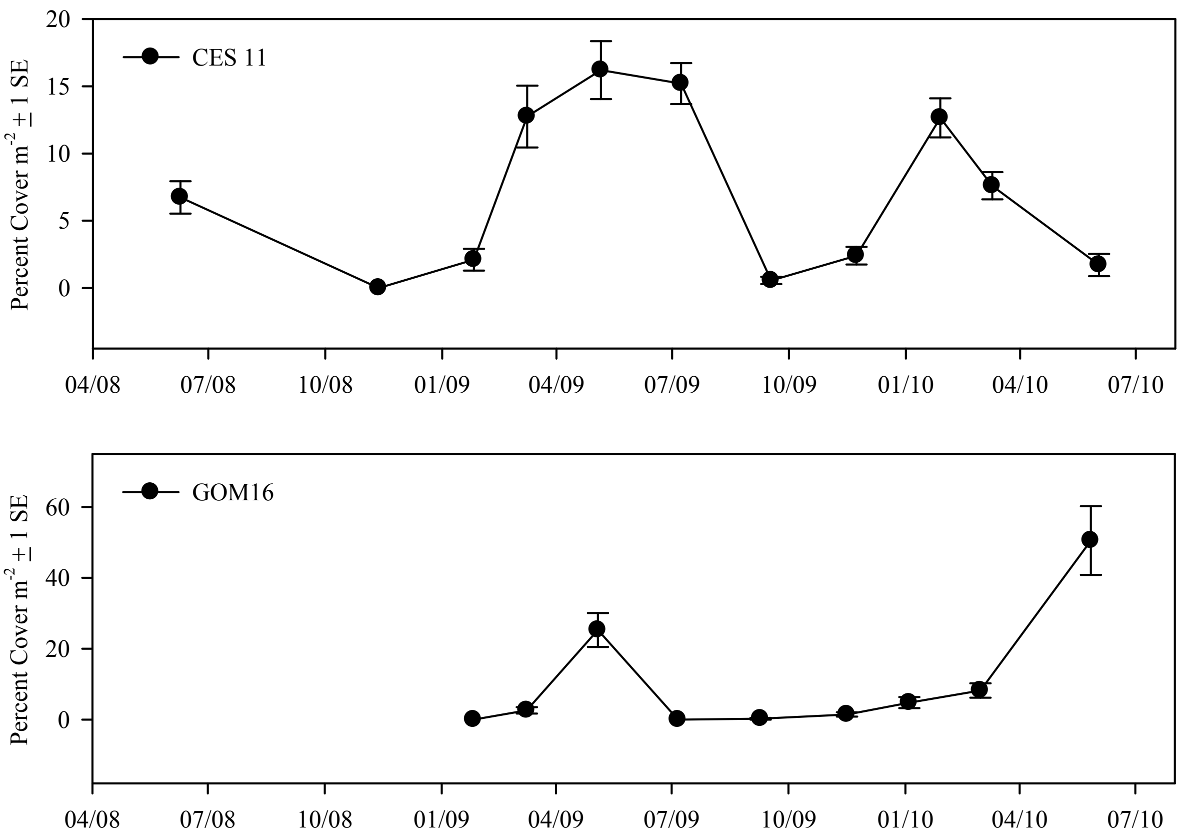


Fig. 5.4.11. Mean monthly percent cover by station with error estimates (±1 SE) for inshore sites CES11 and GOM16. Note the differences in scale among the two stations. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

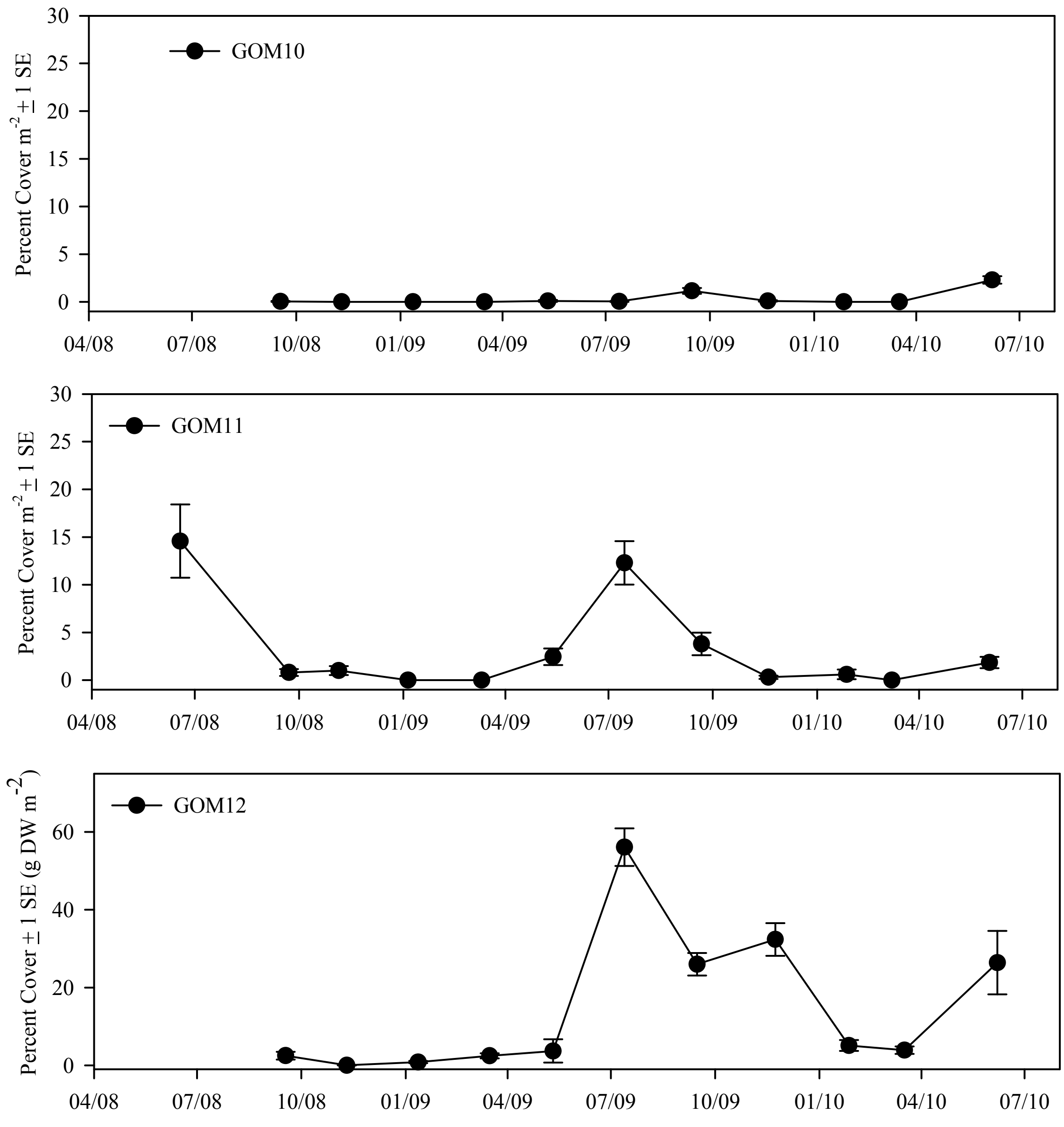


Fig. 5.4.12. Mean monthly percent cover by station with error estimates (±1 SE) for offshore sites GOM10, GOM11, GOM12. Note the difference in scale at GOM12. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

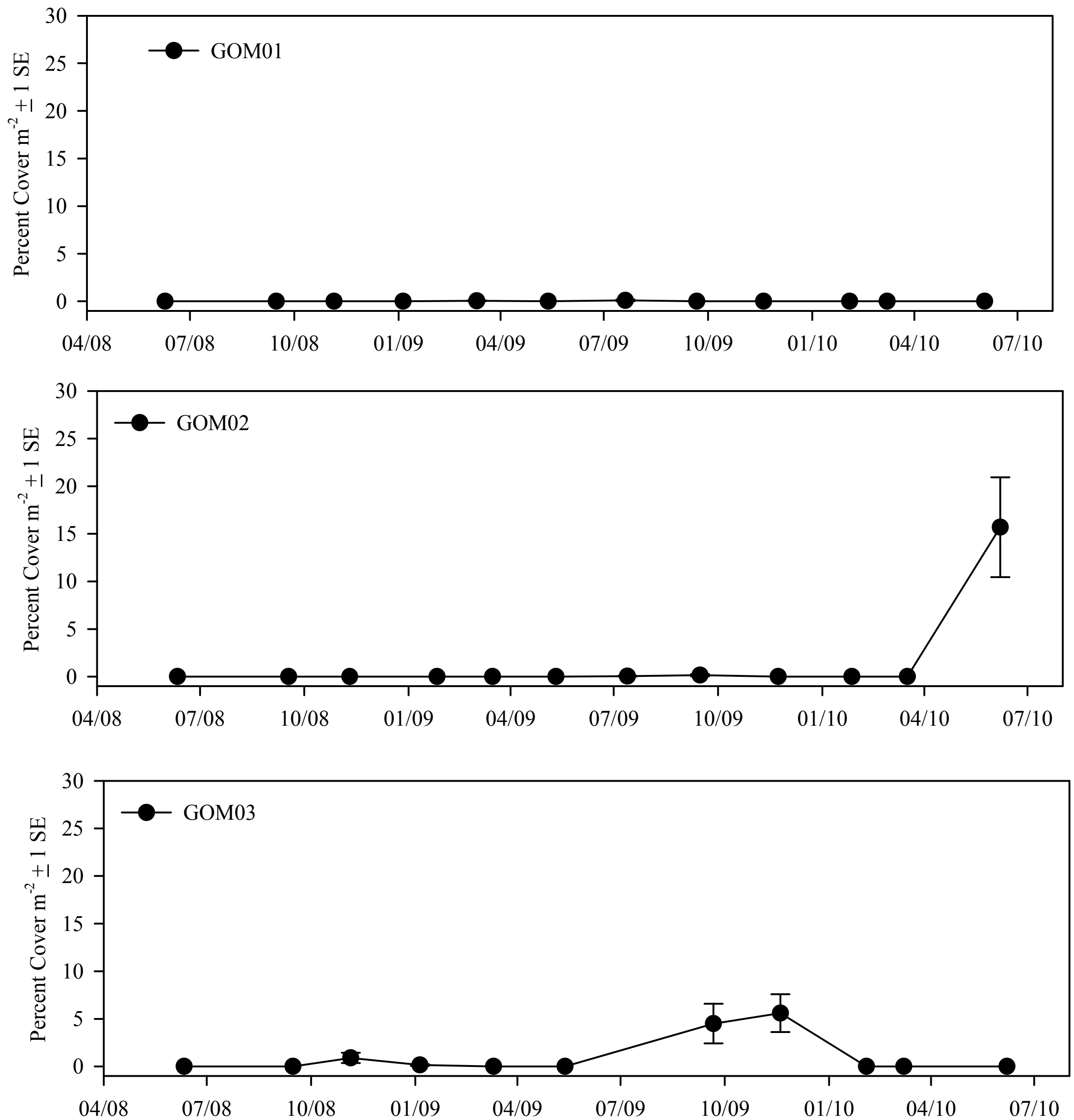


Fig. 5.4.13. Mean monthly percent cover by station with error estimates (+1 SE) for nearshore sites GOM01, GOM02, GOM03. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

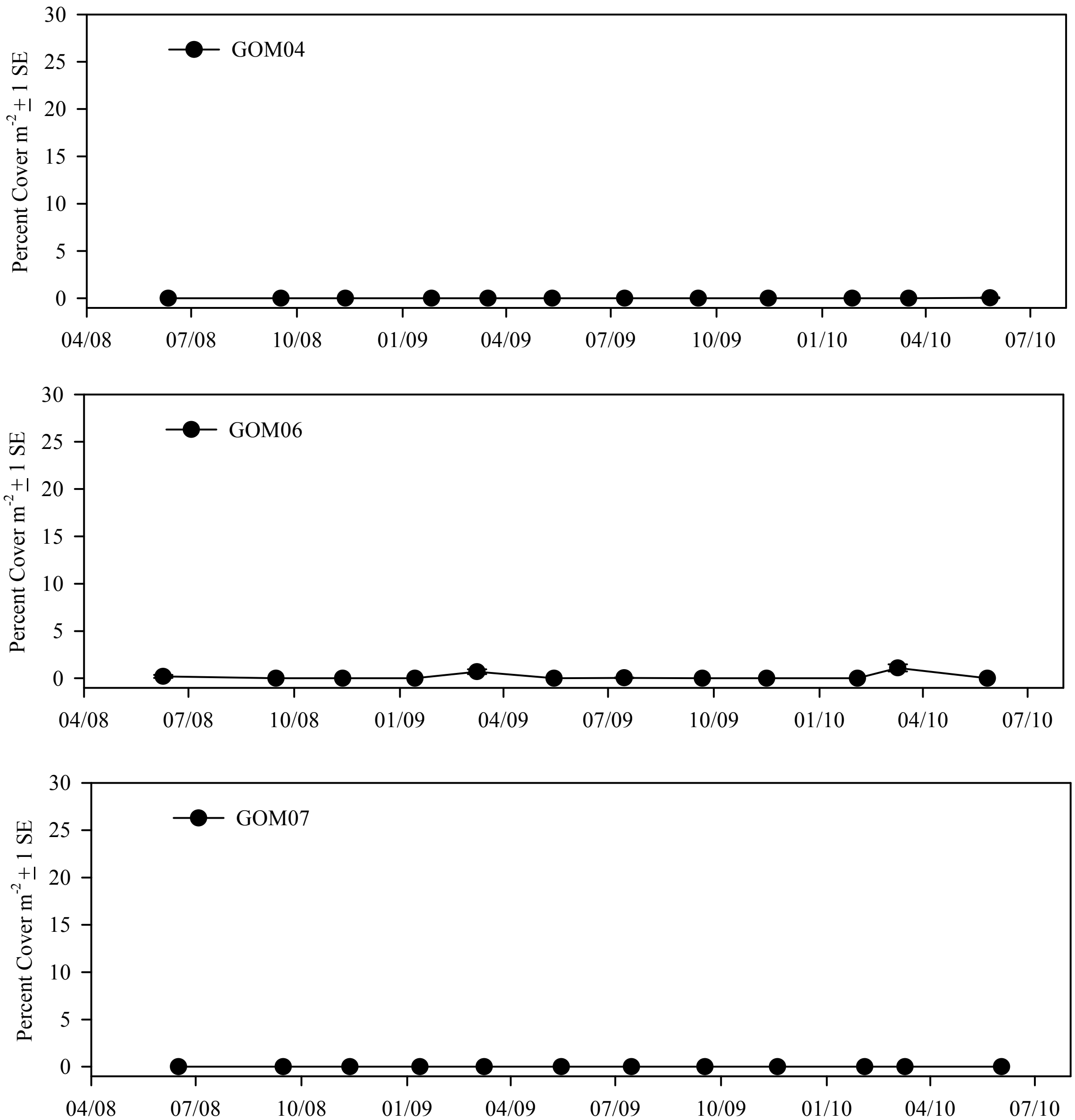


Fig. 5.4.14. Mean monthly percent cover by station with error estimates (±1 SE) for nearshore sites GOM04, GOM06, GOM07. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

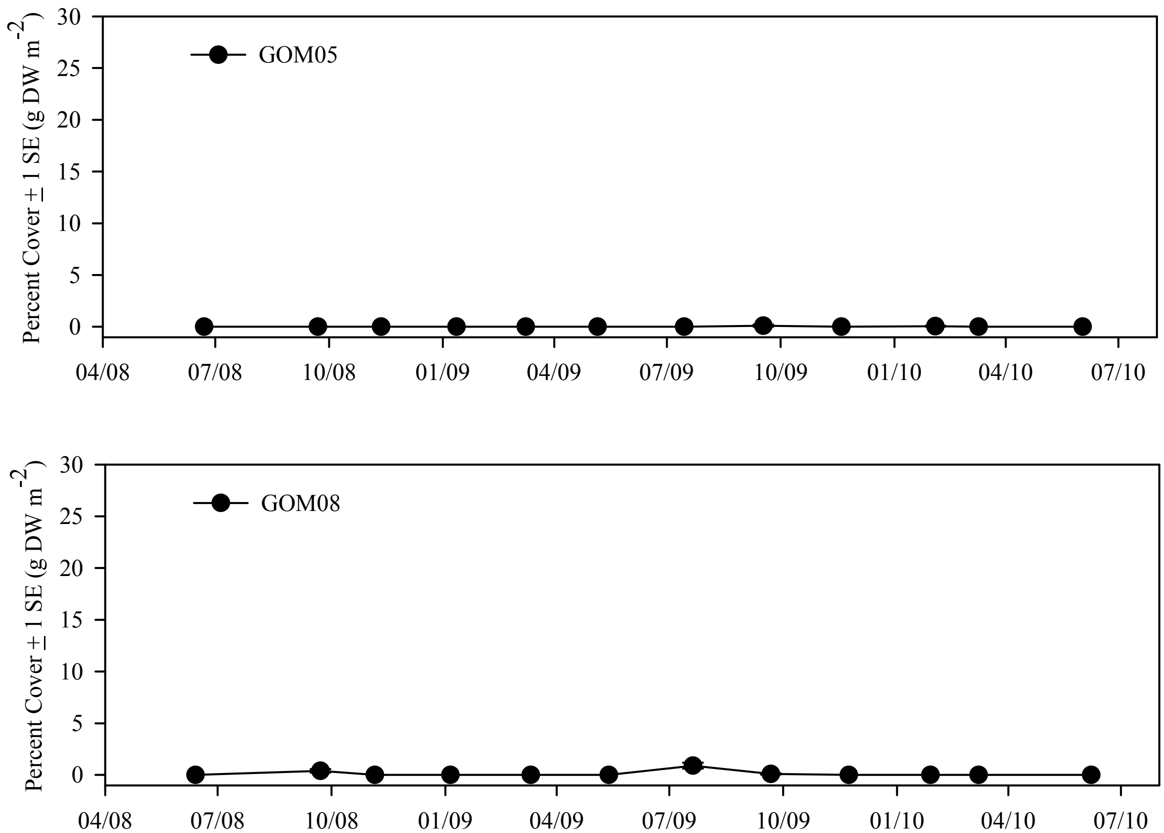


Fig. 5.4.15. Mean monthly percent cover by station with error estimates (±1 SE) for offshore sites GOM05 and GOM08. Sampling size was 20 random quadrats per station except June 2008, where n = 30.

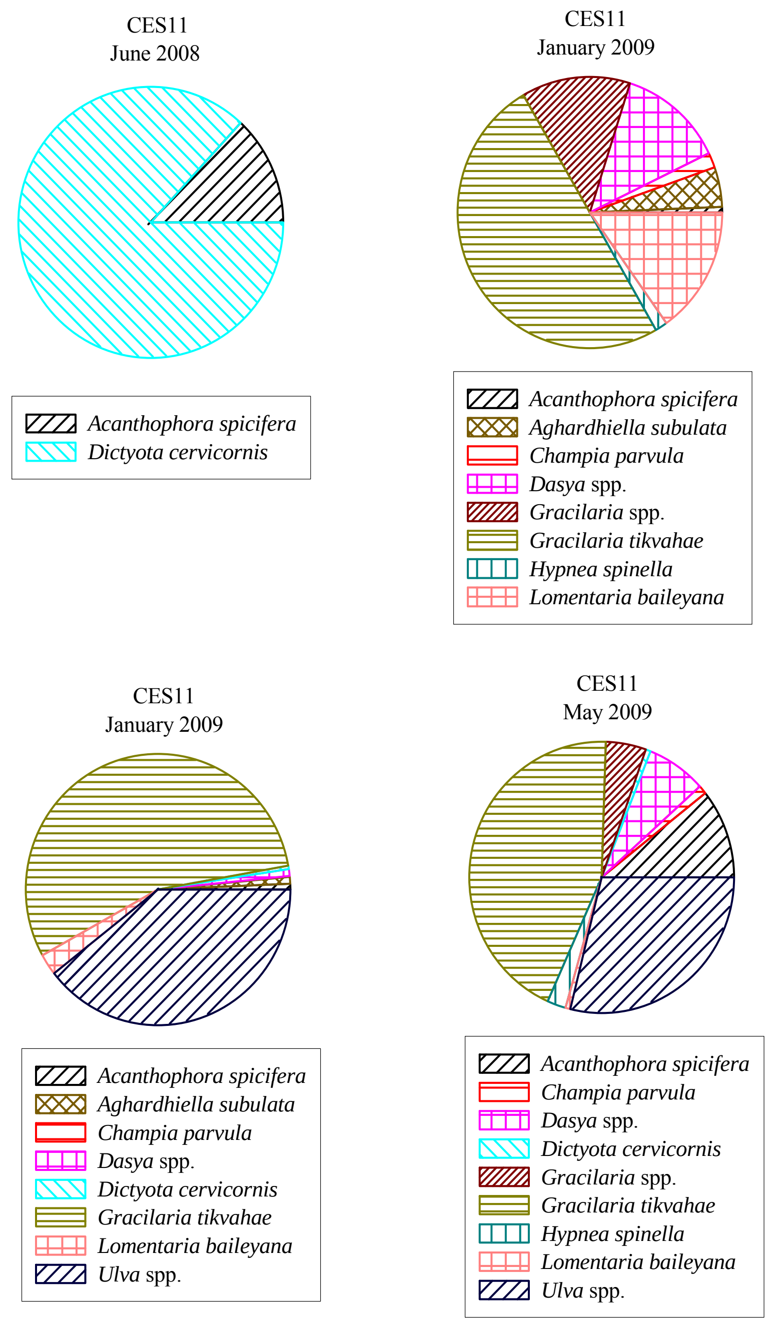


Fig. 5.4.16. Pie chart of species collected at CES11. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

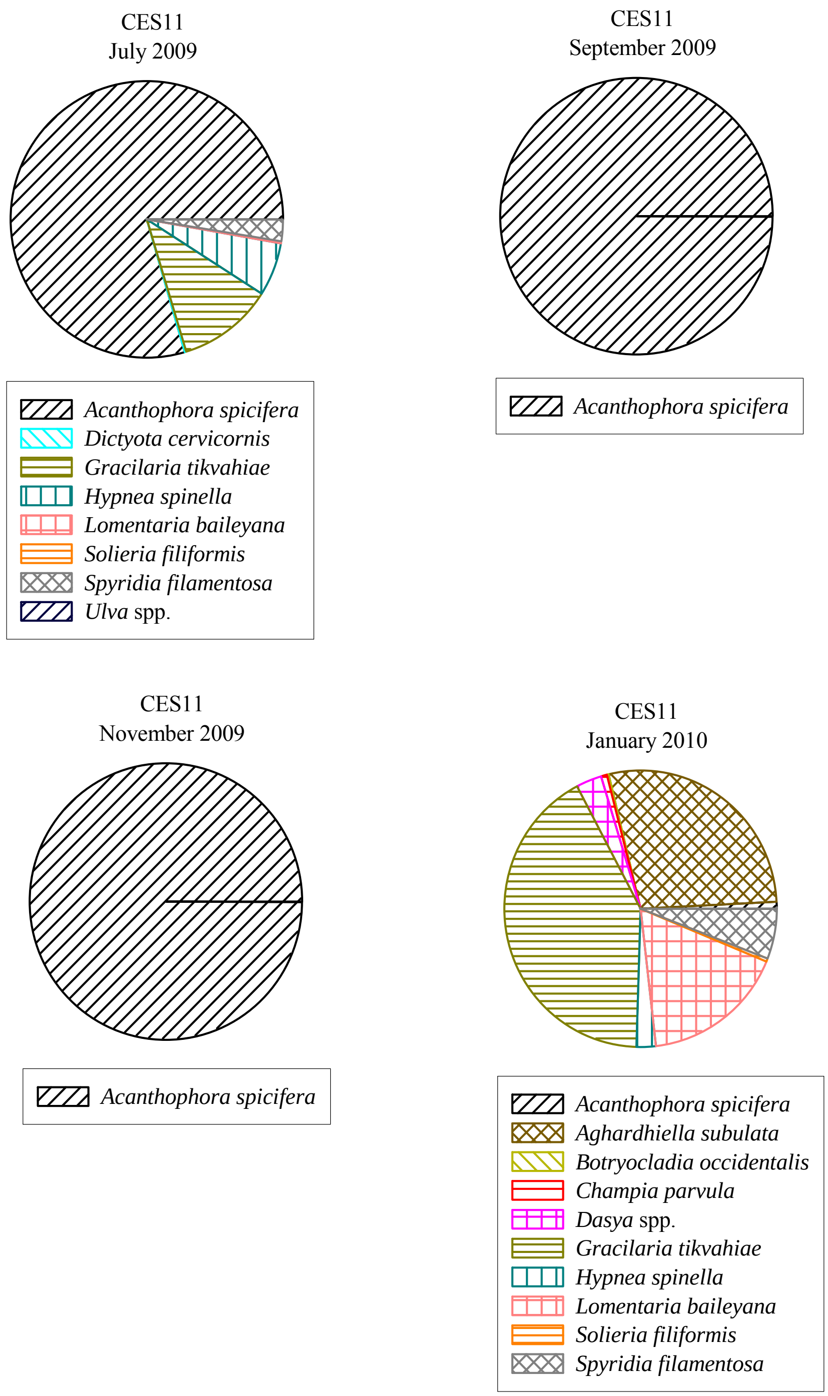


Fig. 5.4.17. Pie chart of species collected at CES11. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

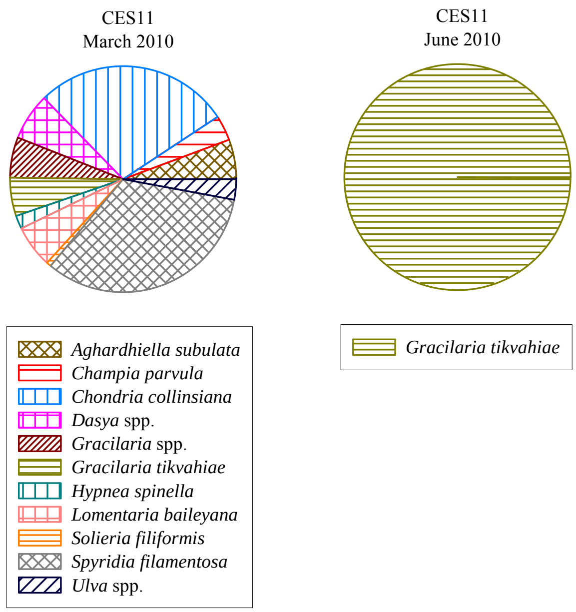


Fig. 5.4.18. Pie chart of species collected at CES11. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

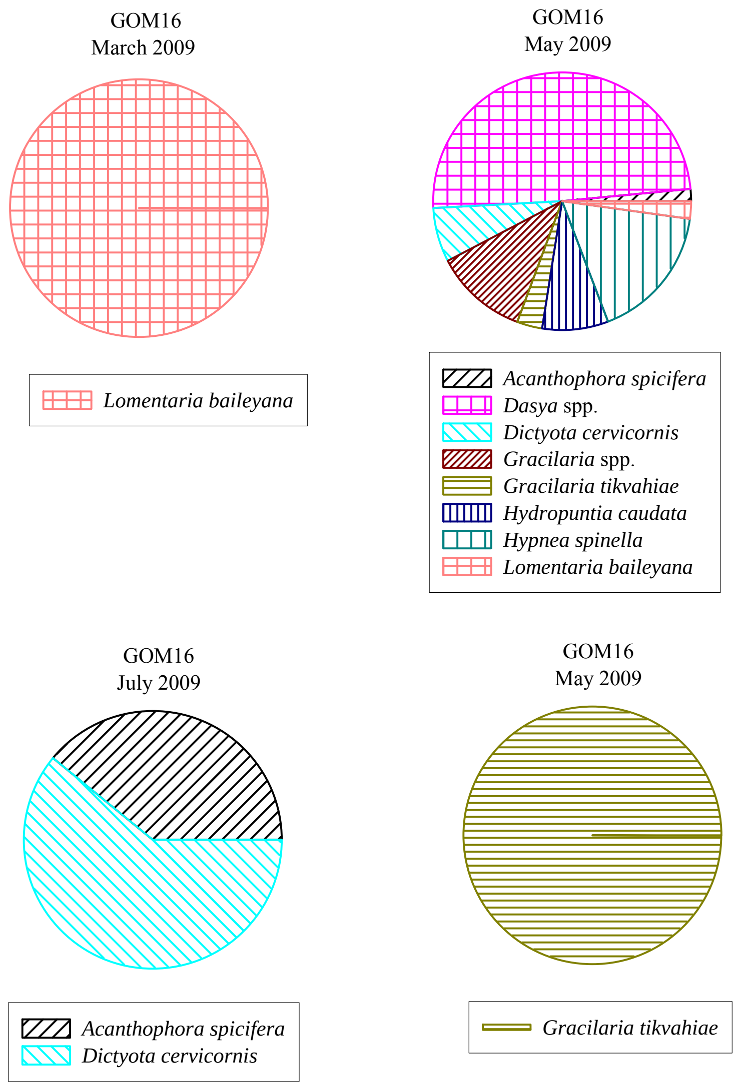


Fig. 5.4.19. Pie chart of species collected at GOM16. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

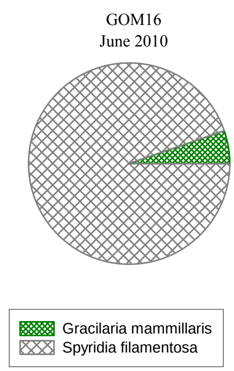


Fig. 5.4.20. Pie chart of species collected at GOM16. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

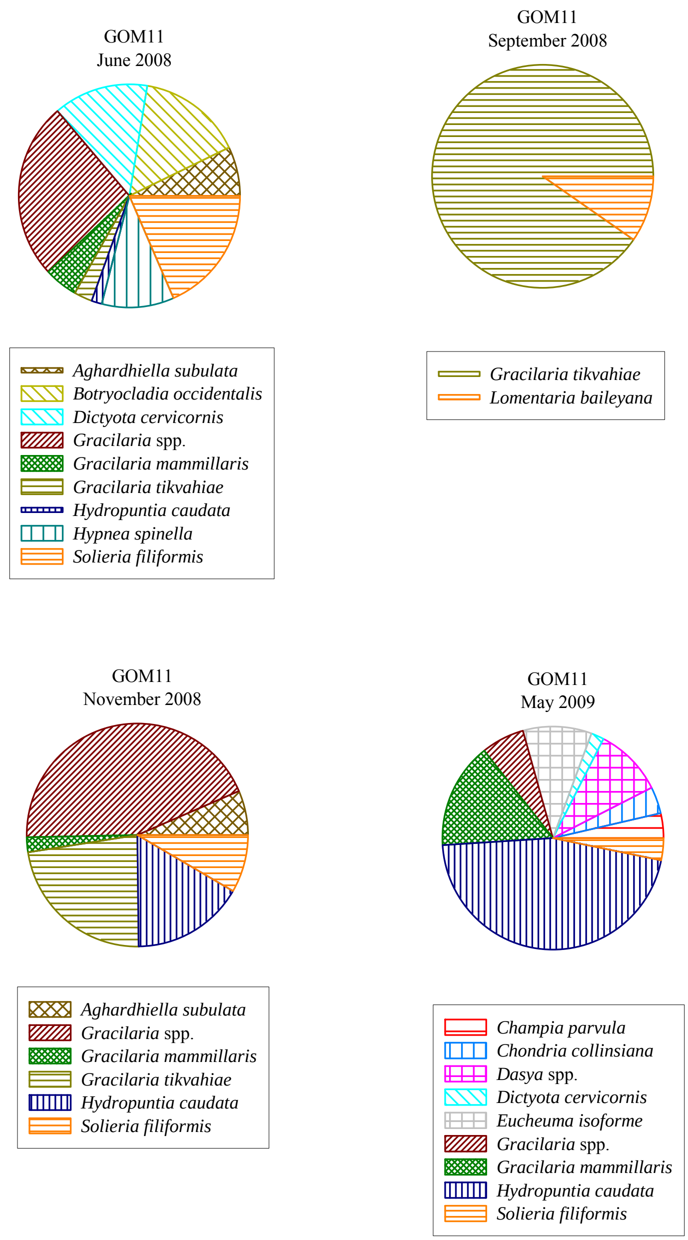


Fig. 5.4.21. Pie chart of species collected at GOM11. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

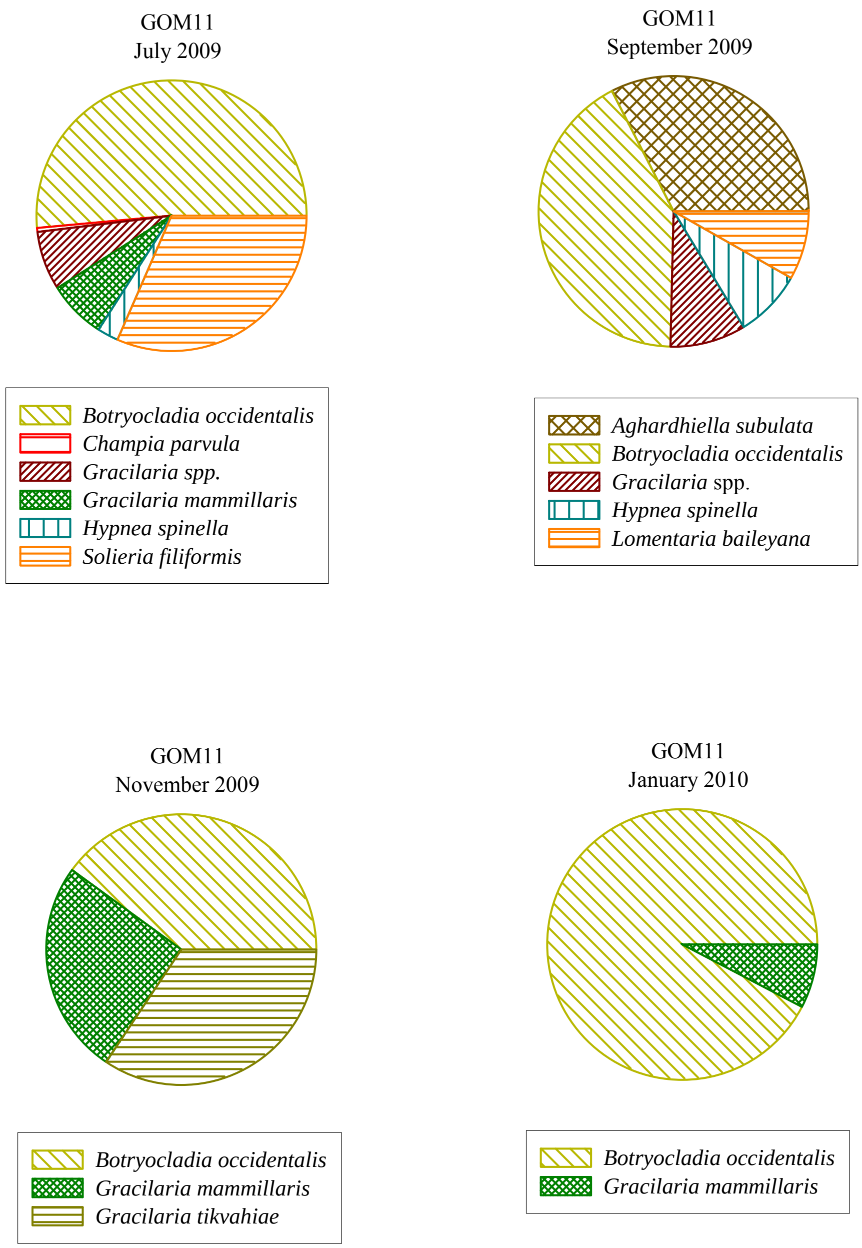


Fig. 5.4.22. Pie chart of species collected at GOM11. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

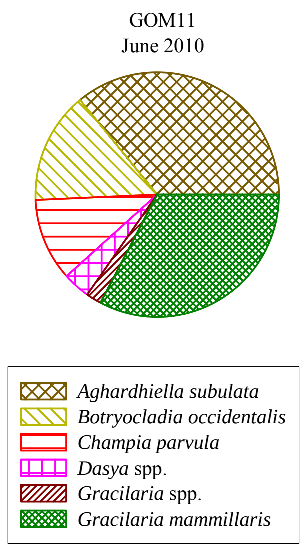


Fig 5.4.23. Pie chart of species collected at GOM11. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

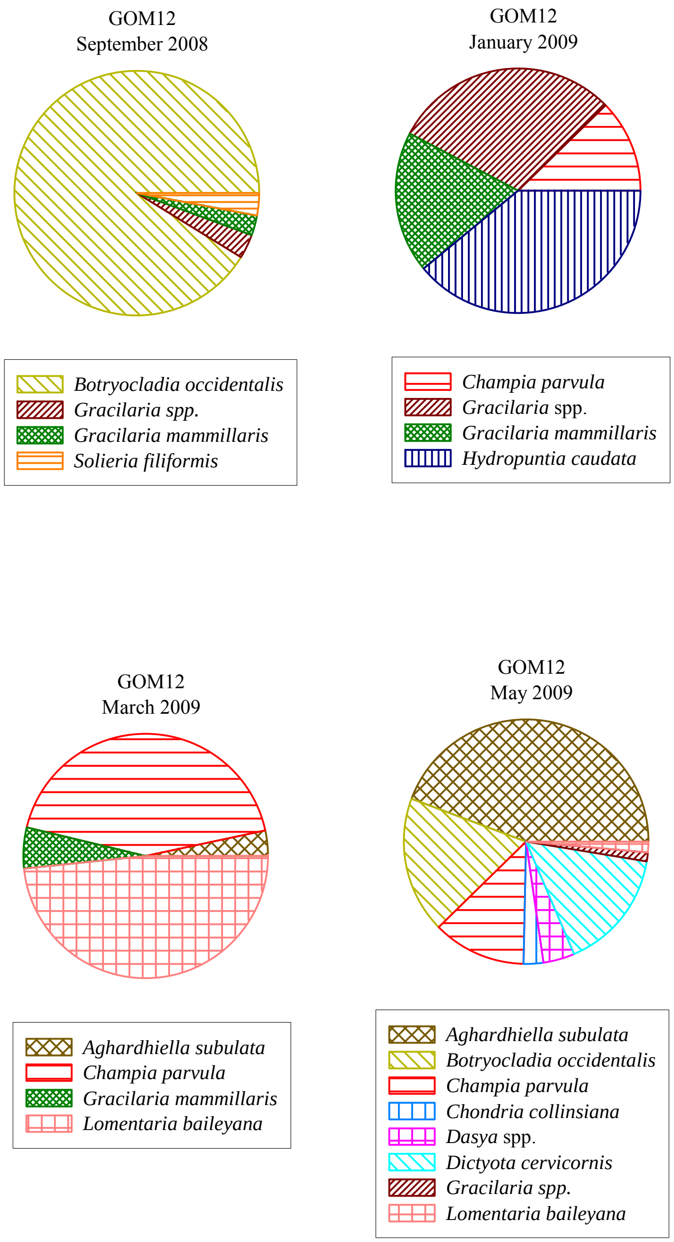


Fig. 5.4.24. Pie chart of species collected at GOM12. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

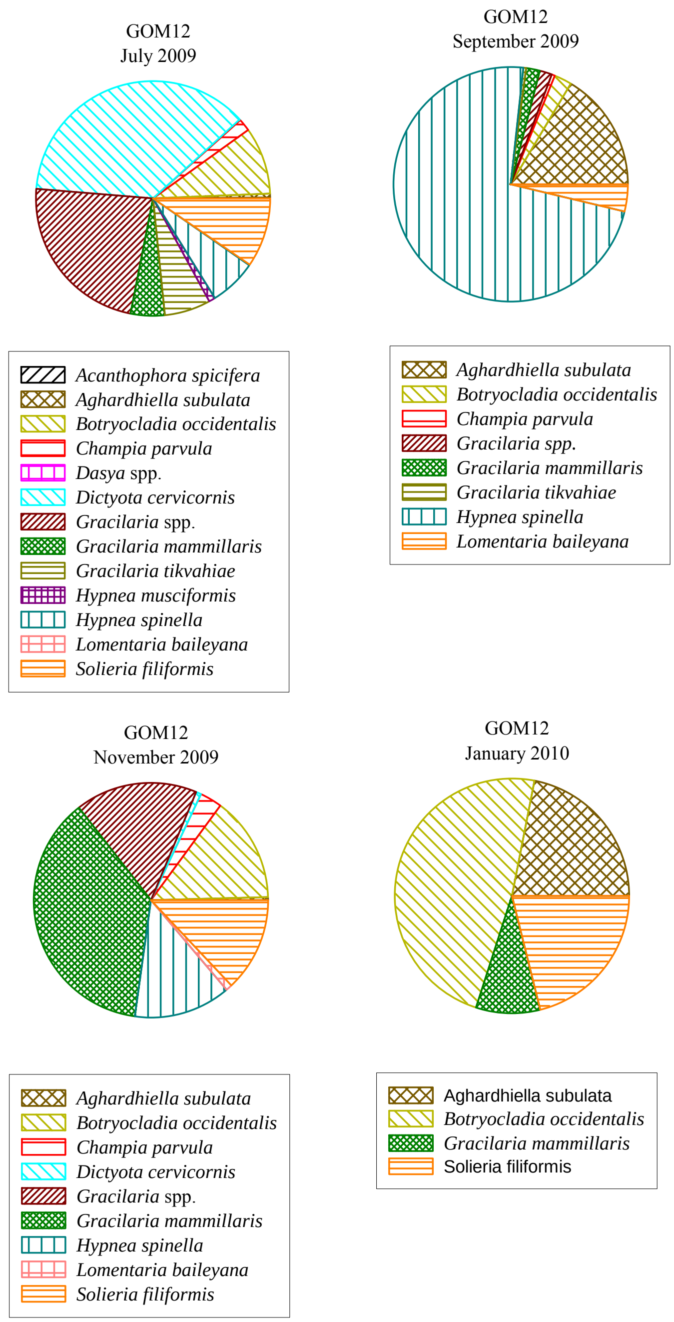
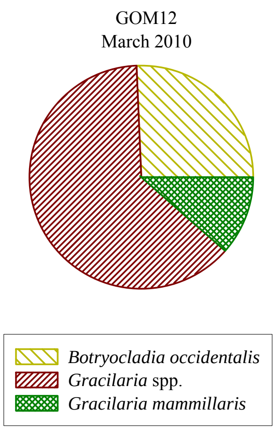


Fig. 5.4.25. Pie chart of species collected at GOM12. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.



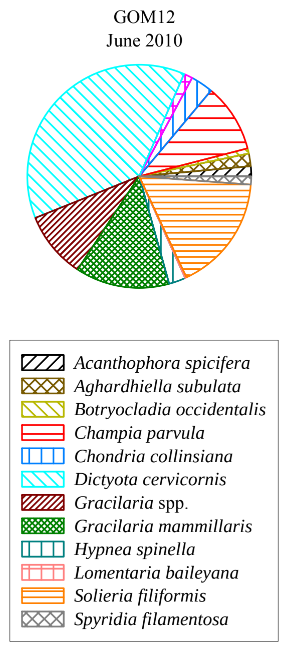


Fig. 5.4.26. Pie chart of species collected at GOM12. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

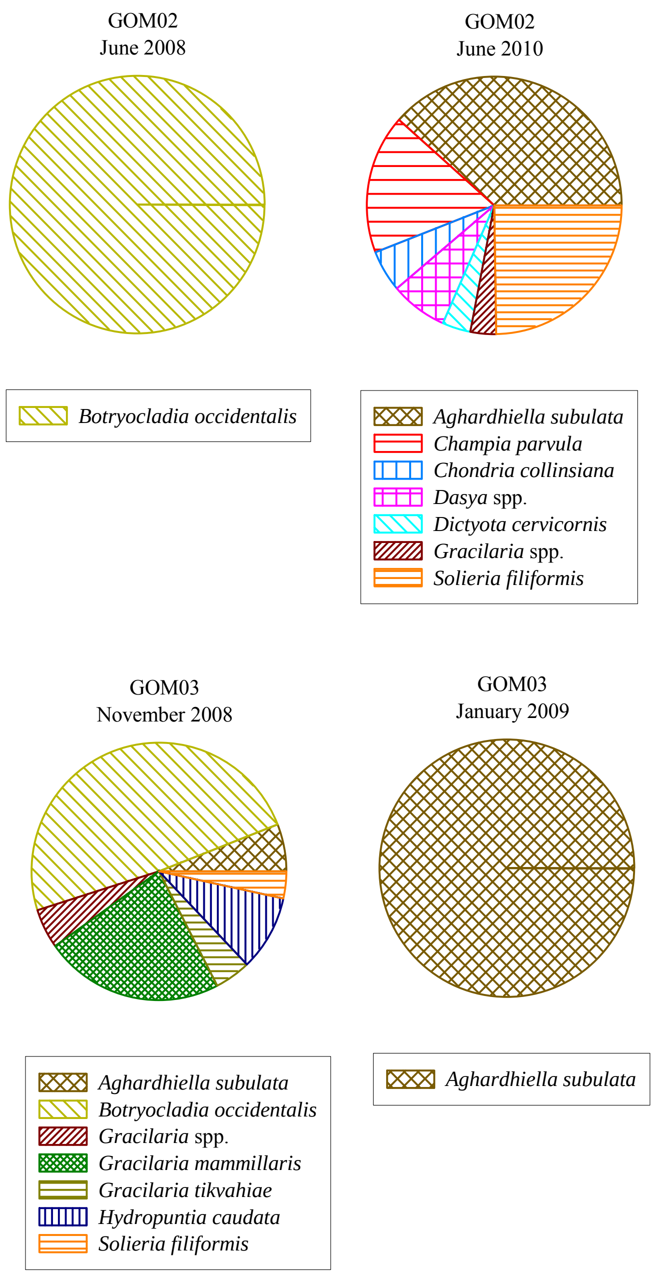


Fig. 5.4.27. Pie chart of species collected at GOM02 and GOM03. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

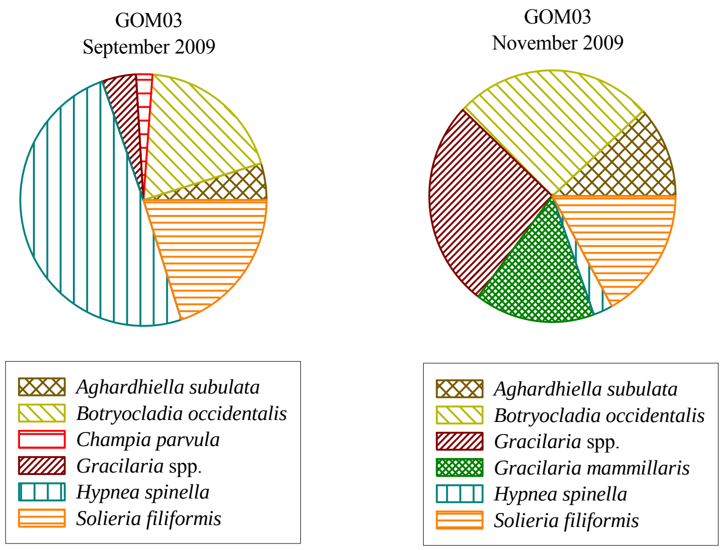


Fig. 5.4.28. Pie chart of species collected at GOM03. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

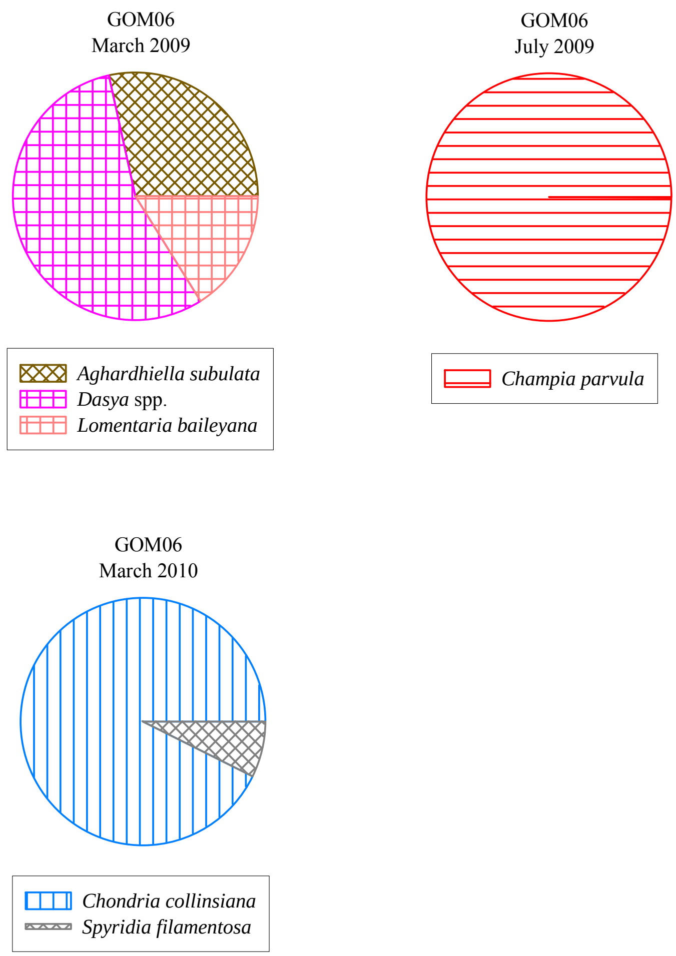


Fig. 5.4.29. Pie chart of species collected at GOM06. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

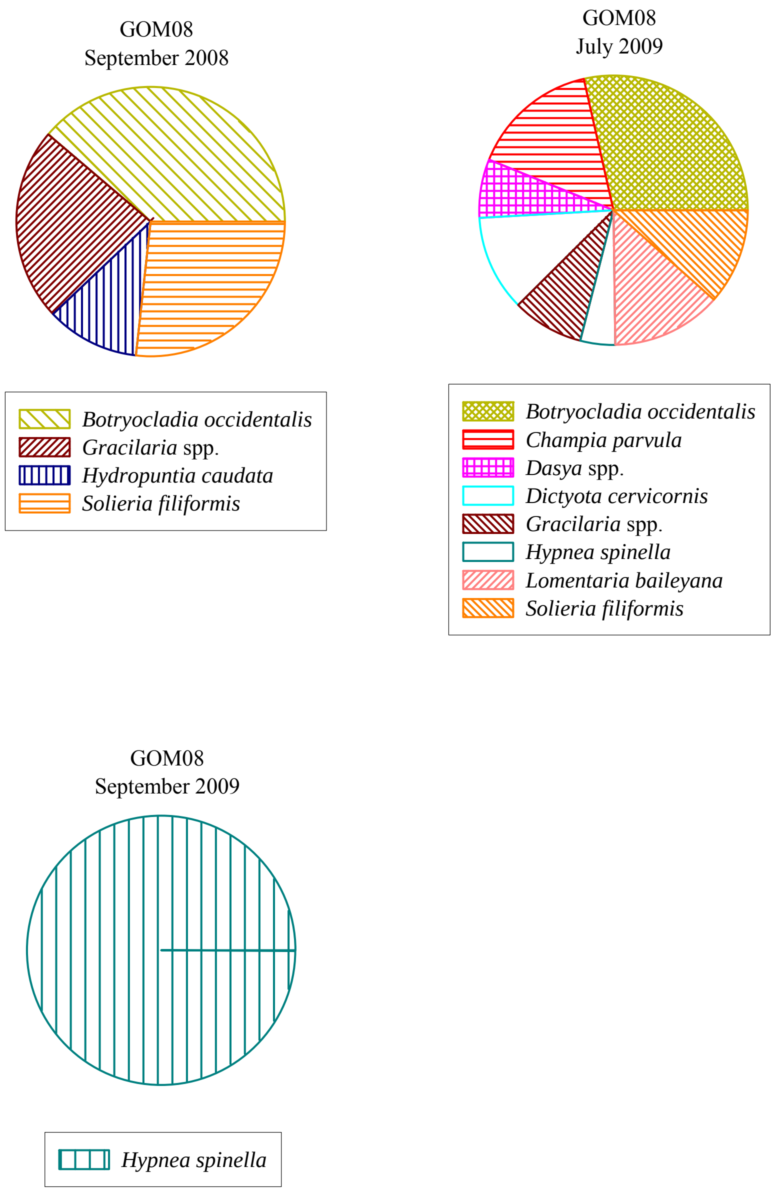


Fig. 5.4.30. Pie chart of species collected at GOM08. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

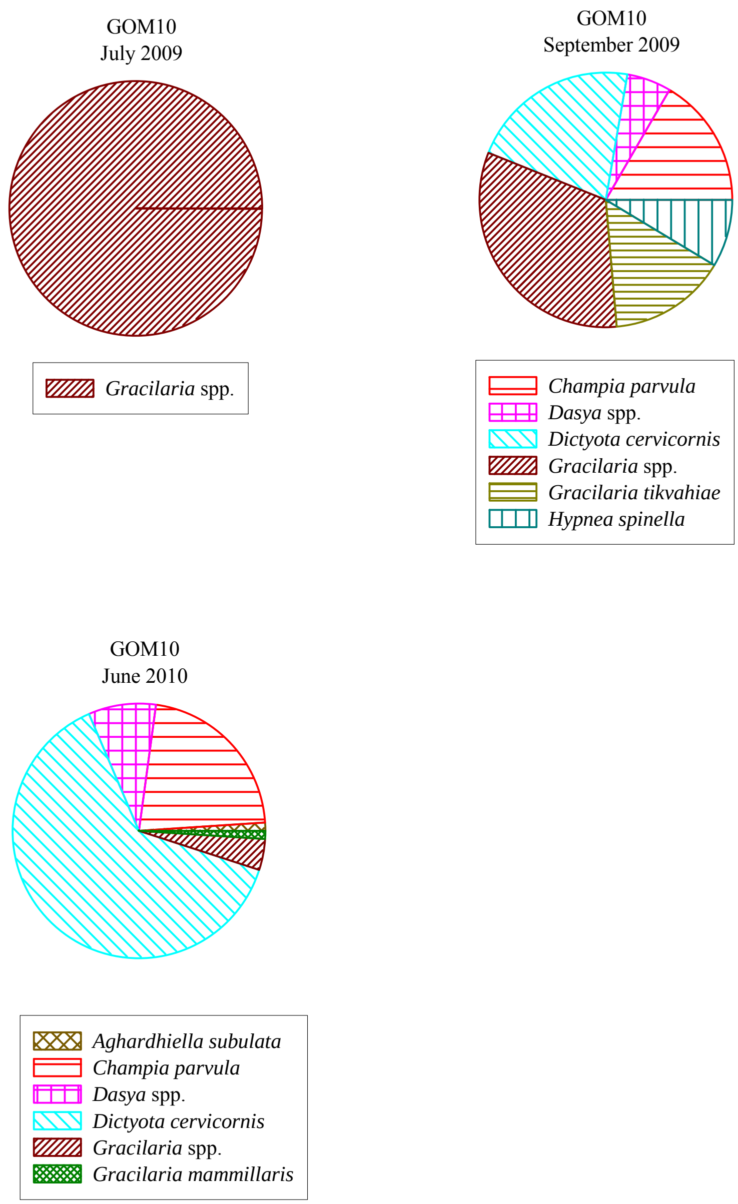


Fig. 5.4.31. Pie chart of species collected at GOM10. Dates indicate the month and year sampled. A sub-set of the most common species were selected for comparisons as many species may have only been collected rarely and are not indicative of the community composition.

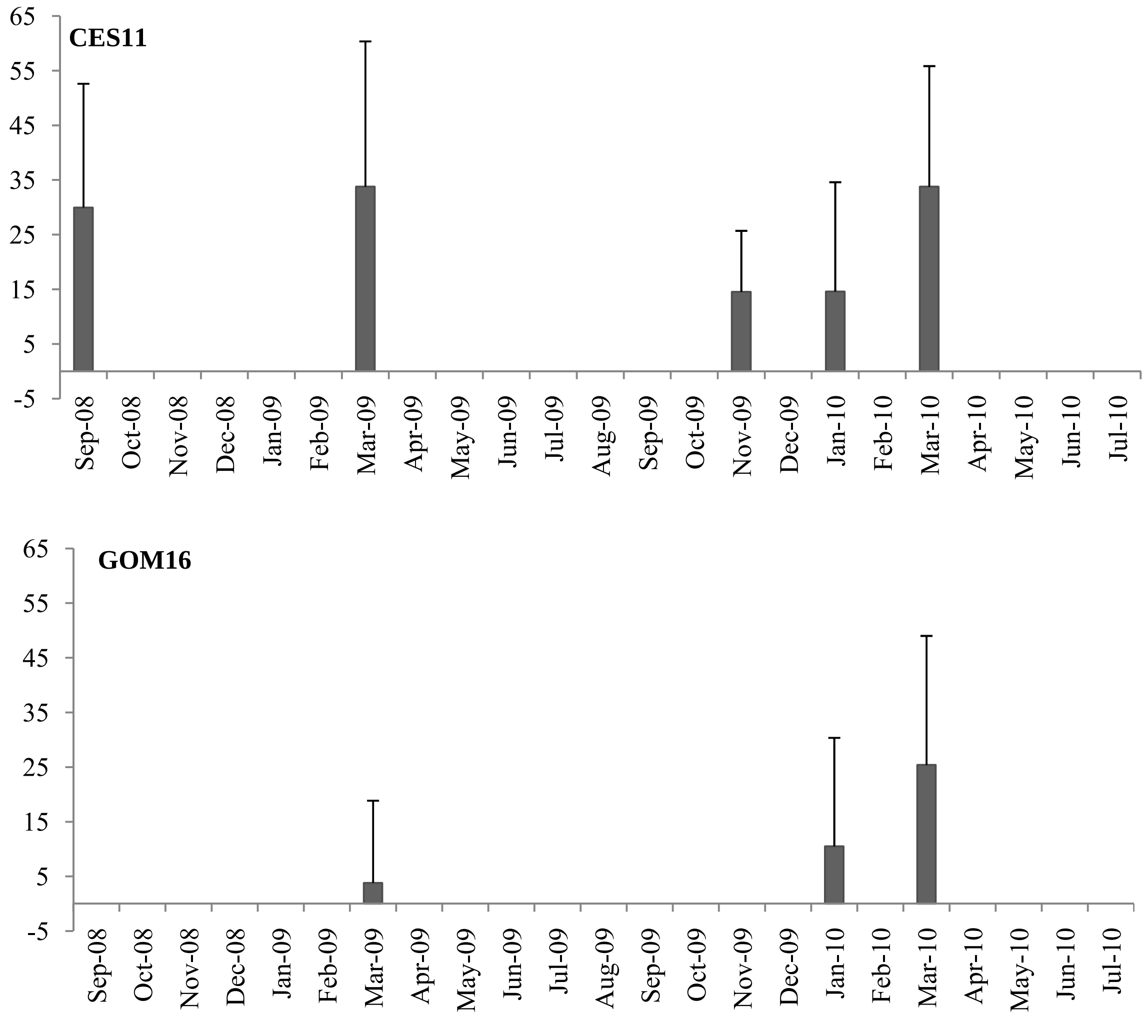


Fig. 5.4.32. Percent cover per frame based on video analysis data for entire transect for inshore soft bottom stations CES11 and GOM16. Note, video is unavailable for Sept 2008 through Jan 2009, May and July 2009 and June 2010 for CES11. Video is unavailable for GOM16 in May and July of 2009 and June 2010.

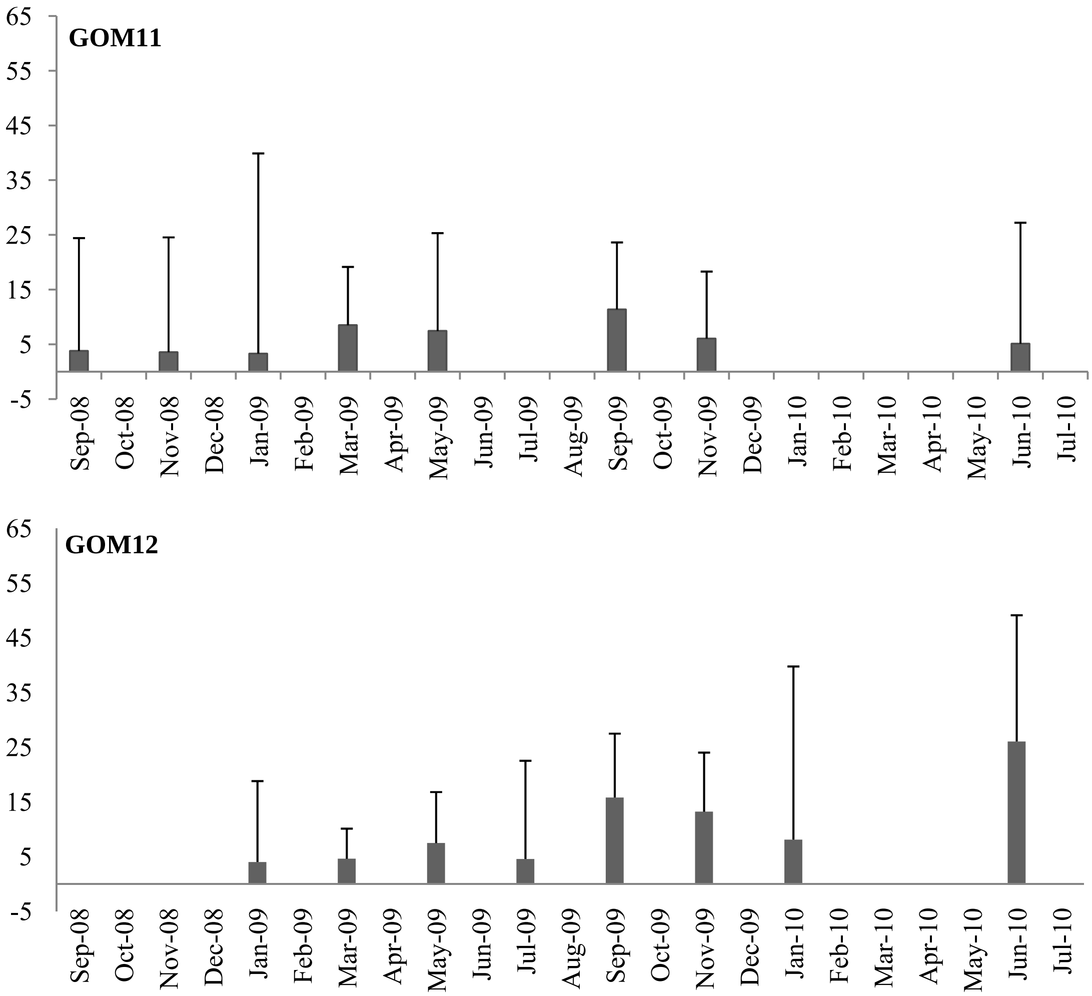
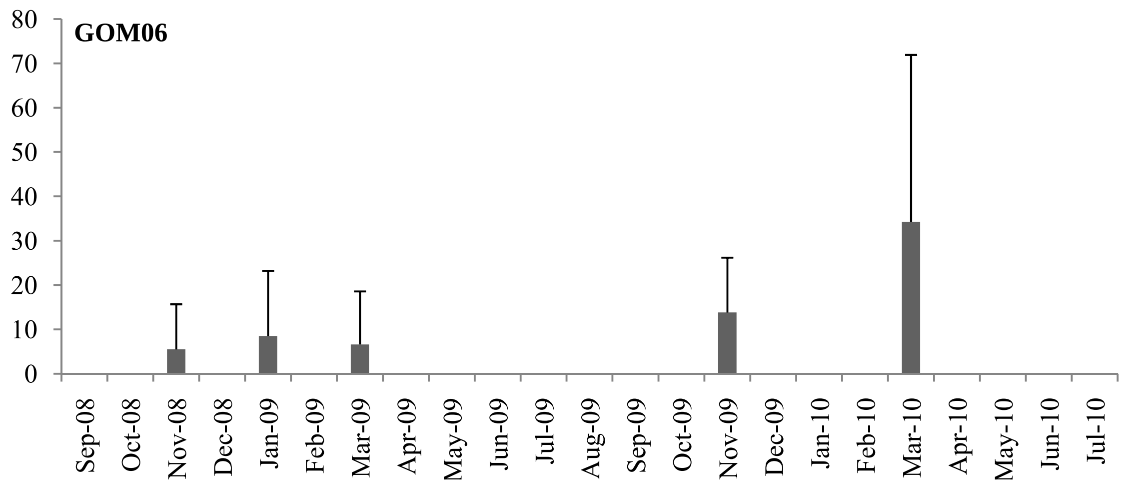


Fig. 5.4.33. Percent cover per frame based on video analysis for the entire transect for offshore live bottom stations GOM12 and GOM11. Note, video is unavailable for GOM12 in Sept and Nov 2008, and March 2010. Video is unavailable for GOM11 in July 2009.



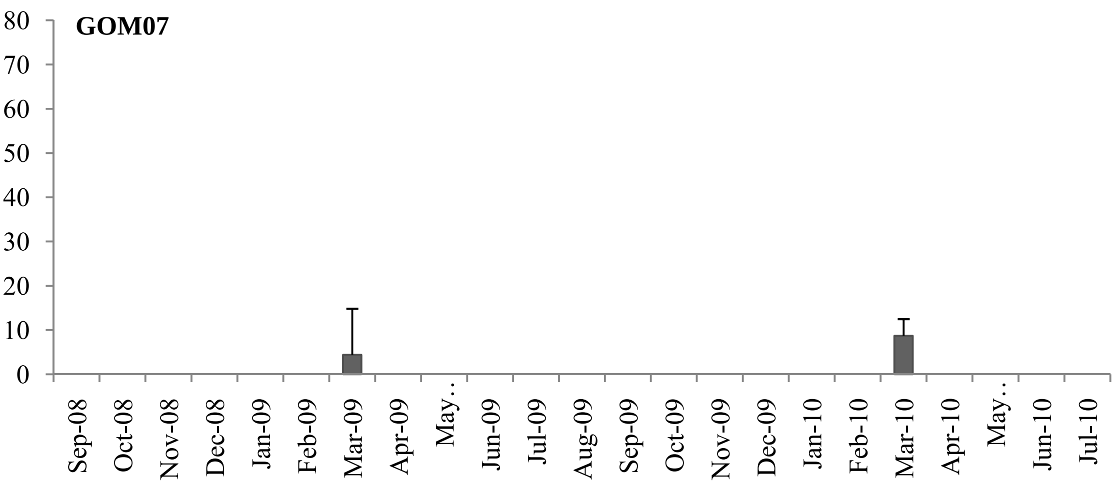


Fig. 5.4.34. Percent cover per frame based on video analysis for the entire transect for Nearshore soft-bottom station GOM07 and GOM06. Note video is unavailable for May 2009 and June 2010 for GOM06. Video is unavailable for January 2009 and September 2009 for GOM07.

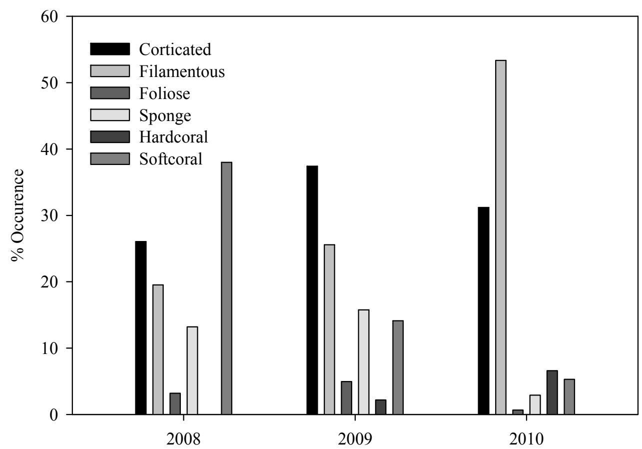


Fig. 5.4.35. Total percent occurrence of sponges, hard coral, soft coral and algal functional classes from analysis of underwater video. Underwater video analysis used a modified functional group classification (Steneck and Dethier 1996).

Appendix 5.5

May 2009 Seaweed collections around Sanibel Island Florida
Identified by Clinton Dawes (07/18/09).

1. A red alga (GOM 11; 5/13/09)
As "*Dasya rigidula*"
Cannot identify because the material was disintegrated. A few pieces had uniseriate (?) axes with cells 110 by 425 µm.

2. *Dictyota mertensii* (Maritius) Kützing (Roosevelt Channel; date?)
As "*Dictyota cervicornis*"
Fragment was about 4.5 cm long. Axes are distinct, flattened, 100 µm thick, with alternately branching tips, and with lateral branching off main (old?) axis. Medulla is 1 cell thick.

3. Probably *Scinaia halliae* (Setchell) Huisman (GOM 12; 5/11/09)
As "*Sebdenia flabellata*"
Plant was entire, small (ca 25 mm tall), and may be *S. complanata* when larger. Axes are flabellate, dichotomously branched without constrictions, and with rounded tips and a discoid base. Medulla has a core of loosely arranged filaments, which cortex is 2 cells thick with outer hexagonal ones and inner tear-shaped ones.

4. *Gracilaria bursa-pastoris* (S. G. Gmelin) P. C. Silva (CES 11; date?)
As "*Gracilaria venezuelensis*"
Fragments are highly broken up, bleached, easily squashed, and disintegrated when pressed. Axes are terete, not compressed at forks, and irregularly dichotomously branched. Medulla is parenchymatous, larger cells 125 to 150 µm in diam. and with a gradual transition between medulla and cortex. Cortex is 2 cells thick.

5. *Chondria leptacremon* (Melville) De Toni (CES 11; date?)
As "*Gracilaria cylindrica*"
Four short (3.5-1.5 cm) old, bleached, and partially broken down fragments of upper axes. Axes are not stiff, 0.2-0.4 mm in diam., with blunt tips that have a small tuft of hairs. Branchlets are club shaped and constricted at bases.

6. *Spyridia filamentosa* (Wulfen) Harvey in W. J. Hooker (Blind Pass, 5/20/09)
As "*Dasya crouaniana*"
Fragments are upper parts of old, bleached plants and with debris. Axes are uniseriate; main axes are densely corticated while branchlets are corticated only at nodes and end in a single spine.

7. *Polysiphonia subtilissima* Montagne (Colooschatchee, near Ft. Myers; 04/09)
As "*Polysiphonia subtilissima*"
Filaments are epiphytic on blades of "Tapegrass". Axes have 4 pericentral cells and branch tips lack trichoblasts so that the large apical cell is visible.

8. *Gracilaria venezuelensis* W. R. Taylor (GOM 11; 5/15/09)
As "*Gracilaria flabelliformis*"
Fragments appear to be an old and are bleached, easily squashed, but with a firm basal part. Axes are compressed at forks, with dichotomous branching near tips and irregularly alternate below; tips are pointed. Axes are parenchymatous, larger medullary cells are oval and 150 by 100 µm, and with an abrupt transition between medulla and cortex.

9. *Cladosiphon occidentalis* Kylin (Collected on *Thalassia testudinum*; "SAV")
As "*Cladosiphon occidentalis*"
Upper fragment about 8 cm long. Plants are gelatinous, soft, multiseriate, with a multiaxial filamentous medulla and radially arranged cortical filaments.

10. *Dasya collinsiana* M. Howe (GOM12; 5/11/09)
As "*Dasya ocellata*"
Fragments partially broken up and pressed together
Estimate: plants are less then 12 cm tall. Fragments of main axes are uniseriate, covered with spirally arranged and dichotomously branched branchlets, and heavily corticated in older parts. Branchlets are less than 2 mm long, in a spiral around main axes.

11. *Udotea looensis* D. Littler and M. Littler (GOM 12; 5/11/09)
As "*Udotea abbottiorum*"
An intact and very small (14 mm) plant.
Cap filaments are free (not fused into solid blade), with out appendages, and 20-25 µm in diam.; cortical siphons of stipe have pointed lateral appendages.

12. *Hypnea spinella* (C. Agardh) Kützing (GOM 12; 5/11/09)
As "*Hypnea valentiae* or *H. cornuta*"
Fragment of upper axis 5 cm long and with worm tubes attached.
Main axis alternately branched, all tips with one apical cell and the central siphon visible in cross section; axes terete, not crozier tips present (but sample is small), branching off axis is somewhat cervicorn.

13. *Chondria collinsiana* M. Howe (GOM 11, 5/13/09)
As "*Chondria collinsiana*";
Beach fragments were to 2+ cm long and bleached.
Branches and branchlets constricted at bases, tips blunt and with a tuft of hairs; younger branches have internal bands. Cystocarps are oval, ca 600 µm in diam.

July and September 2009 seaweed collections around Sanibel Island, Florida
Clinton Dawes (11/22/09)

1.*Cladophora vadorum* (Areschoug) Kützing (collected 10/06/09, NWR)
As "*Cladophora albida*"
Main axes distinct, 84 µm in diam.; apical cells 33 µm in diam.; branching flexuous.
Also: *Chaetomorpha minima* Collins and Hervey (entangled among branches).
Unbranched filaments 6.6 µm in diam; cells to 26 µm long, no rhizoids

2. *Dictyopteris polypodioides* (De Candolle in J. V. Lamouroux) J. V. Lamouroux
GOM1220090915
A fragment: Veinlets absent; blades transparent, < 1.5 cm wide

3.*Gymnogongrus griffishsiae* (Turner) Martius GOM1220090915
As "*Gelidiella trinitatensis*"
Axes stiff and terete; branching dichotomous; tips tapering; medullary cells thick walled and compact.

4. *Solieria filiformis* (Kützing) P. W. Gabrielson (no collection data)
As "*Chrysymenia*"
Plants soft, densely branched; branches elongated, constricted at forks; medulla with loosely intertwined filaments.

5. *Agardhiella subulata* (C. Agardh) Kraft and M. J. Wynne CESW1120090708
As "*Eucheuma denudatum*"
A fragment only, in poor condition, and too small to press. Branching radial, irregular; medulla consists of loosely entangled filaments; cystocarpic.

6. *Gracilaria armata* (C. Agardh) Greville? GOM1220090713
As "*Gracilaria flabelliformis*?"
Fragment only, in poor condition, and too small to press. Axes slightly compressed, 1.0-1.5 mm wide; somewhat spiny.

7. *Eucheuma isiforme* var. *denudatum* D. P. Cheney (No collection data)
Axes densely and irregularly branched at base; medulla has a compact filamentous center.

8. As "*Champia parvula*" GOM1220090713 (#6 ECM0
Fragment was dried up and too damaged to identify or press

9. *Laurencia chondrioides* Børgesen GOM1220090713 (#10 AJM)
As "*Laurencia filiformis*"
Axes red; tip blunt, with projecting hairs; surface cells 20+ µm in diam.; 4 pericentral cells.

10. *Scinaia halliae* (Setchell) Huisman GOM 1220090713 (#4 ECM)
Axes red, gelatinous; branching dichotomous, cortex 2 cells thick

11. *Caulerpa ashmeadii* Harvey GOM1220090713 (#4 ECM)
Branchlet tips are blunt.

12. *Hypnea musciformis* (Wulfen in Jacquin) J. V. Lamouroux GOM1220090713 (#7 JS)
A number of hemate branches, branch tips with a single apical cell.

13. *Gracilariopsis lemaneiformis* (Bory) Dawson *et al*. GOM12—(#8 JS)
Cystocarpic; axes tough, cartilaginous; branching irregular; medullary cells to 500 µm in diam.

14. *Chondria littoralis* Harvey GOM1220090713 (#6 KP)
As "*Chondria sedifolia*"
Branchlets smaller than 0.5 mm, constricted at bases, pointed and with apical cell exposed beyond small tuft of hairs.

15. *Gracilaria tikvahiae* McLachlan GOM08—
As "*Gelidiopsis lemaneiformis*"
Fragment too small to press. Tips with # cells, medulla with thick-walled cells, parenchymatous; medullary ells to 160 µm in diam., polygonal; cortex 1-3 layers with abrupt transition.

16. *Gracilaria armata* (C. Agardh) Greville GOM1220090713 (#4 ECM)
As "*Gracilaria flabeliformes*"
A young plant; tips have # cells, medulla parenchymatous, cells to 280 µm in diam.; cortex 2-3 layers; transition is gradual.

17. *Jania adhaerens* J. V. Lamouroux GOM1220090113 (#7 could not read initials)
As "*Jania rubens*"
A small fragment, too small to press. Calcified; branching dichotomous, ca <30° angle; axes 112 µm in diam.; conceptacles in forks.

18. *Laurencia sp*? CESII 7/8/2009.
Fragment too small and in poor shape to ID or press.

19. *Gracilaria tikvahiae* McLachlan GOM1220090713 (# 8 AT)
As “*Gracilaria bursa-pastoris*”
Pale pink; tips with # apical cells; axes compressed to flat; branching irregular to alternate; medulla parenchymatous, larger cells to 140 µm in diam.; cortex 2-layered, transition abrupt.

20. *Hypnea spinella* (C. Agardh) Kützing? GOM1220090713 (#7 JS)
Not certain, small fragment; no hemate branches.

21. *Gracilaria armata* (C. Agardh) Greville GOM112009015 (#4 JS)
As “*Gracilaria venezuelensis*”
Fragment was an upper branch; main axes slightly compressed; branching pseudodichotomous, without constrictions; ultimate branching secund; axes parenchymatous, medullary cells to 240 µm in diam.; cortex 2-3 layers, transition gradual.

22. *Agardhiella ramosissima* (Harvey) Kylin GOM1220090713 (#1 ECM)
Plant had holdfast; medulla with loosely entangled filaments.

23. *Dasya antillarum* (M. Howe) A. Millar? GOM1220090713 (#4 KP)
As “*Dasya collinsiana*”
Fragments dried, too poor to press, and uncertain on identification. Mixed in with dried material were fragments of *Ceramium* sp. and *Gracilaria* sp. Main axes corticated; branches uniseriate, spiraled.

24. *Wurdemannia miniata* (Sprengel) Feldman and Hamel GOM 12020090713 (#12 AJM)
Tips had multiple apical cells; branches terete, branching dichotomous; medulla lacked rhizines but had thick-wall medullary cells.

25. *Udotea looensis* D. Littler and M. Littler GOM1220090713 (#6 KP)
Blades thin, delicate, with numerous interwoven siphons that lack lateral appendages; stipe siphons have appendages with pointed tips.

26. *Gracilaria venezuelensis* W. R. Taylor GOM1220090713 (#4 ECM)
AS “*Gracilaria intermedia*”
Axes slightly compressed, < 2mm wide; branchlets spiny; tips with multiple apical cells; branching mostly in one plane, from margins, irregular to alternate, and delicate at tips; Medulla parenchymatous, larger cells to 210 µm in diam.; cortex 2 cells thick, transition abrupt.

27. *Dictyota cervicornis* Kützing GOM12 7/13/09 (#3 KP)
Fragment pressed together and difficult to separate without damagea. Branching cervicorn, with many proliferations; margins smooth, fronds narrow only slightly after each fork, < 3 mm wide, and ca 70 µm thick (but probably thicker when fresh); medulla 1 cell thick.

28. *Caulerpa mexicana* Sonder *ex* Kützing GOM1220090713 (#1 ECM)

29. *Acanthophora muscoides* (Linnaeus) Bory GOM1220090713 (#4 KP)
Spines are on spur branchlets and all axes.

30. *Gracilaria blodgettii* Harvey GOM1120090715 (#8 ECM)
As "*Lomentaria baileyana*"
Fragment of upper branches, shrunken (previously dried?). Axes elongated, < 1mm wide; tips with many apical cells; branches constricted at bases; medulla parenchymatous, larger cells to 350 µm in diam.; cortex with 2 layers; transition abrupt.

31. *Gracilaria flabelliformis* (P. Crouan and H. Crouan) Fredericq and Gurgel. Beach collection 07/24/09, West Gulf
As "*Dictyopteris* stage of *Padina*"
Eroded bases of dense clusters of axes covered with *Acrochaete microscopica*. Basal axes flattened, to 3 mm wide; branchlets terete with multiple apical cells; branching irregular; medulla parenchymatous, medullary cells to 240 µm in diam.; cortex with gradual transition.

Report #3: June 2010
August 2009 to May 2010 Macroalgal collections around Sanibel Island, Florida
Identified by Clinton Dawes with herbarium specimens included

1.*Gracilaria tikvahiae* McLachlan. Not Pressed
As: "unnamed", GH1, #10, 08/29/09,VSR
A decomposed fragment, bleached out, axes compressed, parenchymatous medulla, abrupt transition to cortex

2. *Agardhiella subulata* (C. Agardh) Kraft and M. J. Wynne Pressed
As: "*Agardhiella subulata*?" 35, Ledge, #7, 08/08/09, VSR
Large, robust plant, axes terete, abundant radial branching, filamentous medulla

3. *Codium decorticatum* (Woodward) M. Howe Pressed
As: "unidentified green", Sherman's Barge, #5, 0808/09, VSR
A fragment, branching dichotomous, axes 1.5-2.0 mm in diam., utricle outer wall to 3 µm thick

4. *Wurdemannia miniata* (Sprengel) Feldmann and Hamel Pressed
As: "*Dasya*?", Sherman's Barge, #4, 08/08/09, VSR
Bleached out turf, wiry axes, # apical cells per tip, mostly little branching, dense filamentous medulla with thick-walled cells

5. Cannot identify, material disintegrated Not Pressed
As: "keyed to *Gracilaria* sp.", 35 Ledge #6, 08/08/09, VSR

6. *Agardhiella subulata* (C. Agardh) Kraft and M. J. Wynne Pressed
As: "similar to red, decomposed", Bowditch #30, 01/26/10
Plant large, robust, axes terete, abundant radial branching, loose filamentous medulla, same as #2

7. *Agardhiella subulata* (C. Agardh) Kraft and M. J. Wynne Not Pressed
As: "#1", Bowditch #31, 01/26/10, TWW
Bleached out, 2 fragments, cystocarpic, terete axes, radial branching, the same as #2, 6

8. *Chondria floridana* (Collins) M. Howe Pressed
As: "*L. intricata*?", 35 Ledge, #3, 08/08/08, VSR
Fragment densely branched, branchlets with apical pits and not constricted, the 5 pericentral cells obscured in cross section

9. *Caulerpa mexicana* Sonder *ex* Kützing Pressed
As: "most like *Caulerpa mexicana*", 35 Ledge #2, 08/08/09, VSR
A fragment, but clearly the species

10. *Gracilaria tikvahiae* McLachlan (best estimate) Not Pressed
As: "#3", 53 Ledge, #21, 09/09/09, VSR
Fragments are small, bleached, broken up, axes appear compressed, medulla is parenchymatous with abrupt transition at cortex

11. *Caulerpa ashmeadii* Harvey Pressed
As: "#4", 53 Ledge, #22, 09/09/09, VSR
A small part of a plant with three erect axes, bleached

12. *Hypnea spinella* (C. Agardh) Kützing Pressed
As: "Green (#1), Decomposed", Sandpiper, #28, 01/19/10, TWW
Fragments bleached out, partially decomposed, branch tips in poor shape but appear to have single apical cells, spinosa axes

13. *Sargassum filipendula* C. Agardh Pressed
As: "green (#1)", 53 Ledge, #27, 10.27/08, VSR
Perennial bases only, leaves long, serrate, stems smooth

14. *Wurdemannia miniata* (Sprengel) Feldmann and Hamel Pressed
As: "red (#3)", Sherman's, #25, 10/10/09, VSR
A turf of small size, see #4

15. *Agardhiella subulata* (C. Agardh) Kraft and M. J. Wynne Not Pressed
As: "red (#2)", 53 Ledge, #26, 10/24/09, VSR
Bleached fragment at base, secund branchlets, an old poorly preserved plant

16. *Hypnea cornuta* (Kützing) J. Agardh Pressed
As: "green, decomposed", Sandpiper, #29, 01/19/10, TWW
Two bleached fragments, tip with a single apical cell, spines cornute; also with epiphytic branching bryozoans (orange pigment)

17. *Hypnea spinella* (C. Agardh) Kützing Pressed
As: "—(#1)", 53 Ledge, #23, 09/19/09, VSR
A dense, bleached from, tips with 1 apical cell, axes parenchymatous, spinosa

18. Dichotomously branching bryozoans Not Pressed
As: "— (#10)", 53 Ledge, #20, 09/19/09, VSR
A colonial bryozoan that is a common epiphyte of seagrasses

19. *Gracilaria* sp. Not Pressed
As: "— (#8a)", 53 Ledge, #24, 09/19/09 VSR
Probably *Gracilaria tikvahiae*, But too decomposed to identify

20. *Halymenia floresia* (Clemente y Rubio) C. Agardh Pressed
As: "— (#2)", 53 Ledge, #19, 09/19/09, VSR
Bleached out base of small plant, flat, foliose, blade divided alternately, filamentous medulla

21. *Agardhiella subulata* (C. Agardh) Kraft and M. J. Wynne Not Pressed
As: "— (#6)", 53 Ledge, #18, 09/19/09, VSR
Bleached out base of plant with filamentous medulla

22. *Codium isthmocladum* Vickers Pressed
As: "most similar to *Codium* sp. (#2)", 60 ft Ledge, #15, 09/19/09, VSR
Small entire plant, bleached out, dichotomous branching, main axis 3 mm in diam, utricle outer wall ca 2-3 µm thick

23. *Dictyopteris delicatula* J. V. Lamouroux Pressed
As: "— (#8)', 53 Ledge, #17, 09/19/09, VSR
Two fragments, blades to 5 mm wide, medulla 2-celled, no veinlets

24. *Agardhiella subulata* (C. Agardh) Kraft and M. J. Wynne Pressed
As: "*Agardhiella subulata*?", 35 Ledge, #1, 08/08/09, VSR
Large, well preserved plant, see #2, 6, 7

25. Probably a *Dasya* sp., but fragment too decomposed Not Pressed
As: "*Dasya crouaniana*; sparsely covered with fine branchlets" CESII, #2, JS

26A. Two different algae:
Agardhiella subulata (C. Agardh) Kraft and M. J. Wynne Pressed
As: "*Gracilaria* sp.?, 35 Ledge, #9, 08/08/09, VSR
Filamentous medulla, a more delicate plant, see #2, 6, 7, 24

26B. A mixed set of algae:
Gracilaria damaecornis J. Agardh Pressed
As: "*Gracilaria* sp.?" 35 Ledge, #9, 08/08/09, VSR
Main branching dichotomous below, irregular above, axes spiny, medullary cells to 200

27. *Sargassum hystrix* J. Agardh Pressed
As: "keyed to *Sargassum* sp." GHI, #11, 08/29/09, VSR
A plant base, axes smooth, blades serrate and lanceolate, cryptostomata few

28. A "non-alga", some sort of fibers without internal structure Not Pressed
As: "filamentous red in color (#1)", 60ft Ledge, #14, 09.19.09, VSR
Reddish-brown filaments, non algal

29. *Wurdemannia miniata* (Sprengel) Feldmann and Hamel Pressed
As: "filamentous red in color (#1)", 60 ft Ledge, #14, 09/19/09, VSR
Bleached turf, axes terete, wiry, medulla with densely packed filaments with thick walls and polygonal in cross section.

30. *Lomentaria baileyana* (Harvey) Farlow Pressed
As: "*Hincksia mitchelliae*", GOM16, JS #2
Bleached out mat, badly preserved, hollow axes, pointed tips, with abundant filamentous epiphyte *Acrochaetium microscopicum* that has monosporangia

31. *Gracilaria tikvahiae* McLachlan. Pressed
As: "*G. tikvahiae*, x-section, flat axis, abrupt transition in medullary cells" CESII, #10, KP
Large fragments, decomposed, cystocarpic cortex is abrupt from medulla, compressed at forks

32. Non-alga, a hydroid with brown color Not Pressed
As: "?", Edison #13, 08/29/09, VSR

33. *Eucheuma isiforme* (C. Agardh) J. Agardh Pressed
As: "*Gracilaria tikvahiae*", Beach sample, 02/23/10
Medulla has densely packed filamentous center, unlike shallow water, Florida Keys plants, this one is densely branched and with secund branchlets.

34. *Hydropuntia caudata* (J. Agardh) Gurgel and Fredericq Pressed
As: "*G. tikvahiae*? Most similar to", 35 Ledge #8, 08/08/09, VSR
Large plant, densely branched throughout, alternate to irregular, medulla parenchymatous with abrupt transition to cortex

35. Cannot identify the decomposed fragment Not Pressed
As: "*Polysiphonia flaccidissima*", CESII, #2, JS
Material totally decomposed, fragments appear to have 5 pericentral cells, axes ecorticate

36. *Chondria capillaris* (Hudson) M. J. Wynne Pressed
As: "*Champia parvula*, segmented, not holdfast", CESII, #2, JS
Two fragments, bleached out, branchlets with basal constrictions, tips withy tuft of short hairs, apical cell exposed

37. *Lomentaria baileyana* (Harvey) Farlow Pressed
As: "*Lomentaria baileyana*", CESII, #2, JS
Bleached out, axes hollow, tubular, with irregular branching, pointed tips

38. *Palisdada poiteaui* (J. V. Lamouroux) Nam Not Pressed
As: "*Laurencia filiformis*, no obvious cells in terminal pits, vegetative", GOM12, #10, JS
Fragments, slightly decomposed, with hydroid epiphyte, also a mix of algae (*Lomentaria baileyana, Champia parvula, Ceramium* sp.)

39. *Sargassum filipendula* C. Agardh Pressed
As: "*Sargassum ramifolium*, no spines on thallus or air bladder, holdfast", GOM12, #8, KP
A small entire plant (20 cm long) with holdfast, also a fragment of *Caulerpa mexicana*, blades are serrate, ca 10 widths long, axes smooth, cryptostomata scattered, vesicles stalked, lack spines

40. *Caulerpa mexicana* Sonder *ex* Kützing Pressed
As: "*Caulerpa taxifolia*", GOM12, #10, KP
A fragment, blades flat, divided into bladelets with a spine at tip

41. *Solieria filiformis* (Kützing) Gabrielson Pressed
As: "*Solieria filiformis*", GOM12, #10, KP
Axes delicate, to 1.5 mm in diam., subdichotomously branched, medulla with loose filaments and a central pack, filaments not intertwined

42. *Hypnea spinella* (C. Agardh) Kützing Pressed
As: "*Hypnea spinella*", GOM12, #10, KP
See #12, tips have a single apical cell, axes spiny; also *Solieria filiformis* and *Palisdada poiteaui*,

43. *Champia parvula* (C. Agardh) Harvey Pressed
As: "*Champia parvula*", GOM12, #10, KP
Bleached out entire plants, axes segmented, hollow

44. *Polysiphonia subtilissima* Montagne Pressed
As: "*Polysiphonia* sp.", CESII, #1, KP
Fragments decomposed, axes ecorticate, 4 pericentral cell, apical cells exposed, tetrasporic, with basal creeping axes

45. *Codium isthmocladum* Vickers Pressed
As: "*Codium taylorii*, one point of attachment", GOM12, #5, JS
Entire young plant, ca 7 cm tall, upper axes dichotomously branched, utricle to 250 µm in diam. and outer wall thin

46. *Spyridia filamentosa* (Wulfen) Harvey Not Pressed
As: "*Spyridia filamentosa*- collection at end of branchlets", GOM15, #2, EM
Fragments decomposed, branchlets mostly lost but nodal banding evident

47. *Spyridia filamentosa* (Wulfen) Harvey Not Pressed
As: "*Spyridia filamentosa* filaments bushy, attenuate branching, CESII, JS #2
Fragments decomposed, typical branchlet nodal cortication and single terminal spine

48. *Gracilaria damaecornis* J. Agardh Pressed
As: "*Gracilaria venezuelensis* – x section: parenchymatous medullary cells, delicate tips", GOM032009, 1119
Two entire plants, densely, alternately to irregularly branched, medulla parenchymatous, cells to 180 µm in diam.

49. *Caulerpa mexicana* Sonder *ex* Kützing Pressed
As: "*Caulerpa mexicana*", GOM12, #10, KA
A mat-clump of plants with typical erect flat, divided blades

Table 6.1 – Beach monitoring sites. Georeferencing in Universal Transverse Mercator (UTM).

Sanibel and Captiva Survey Sites	UTM Coordinates
Alison Hagerup Beach Park	381020 E, 2934530 N
Blind Pass	382200 E, 2929470 N
Bowman's Beach	384660 E, 2927050 N
Beach Access #2	388720 E, 2923960 N
Tarpon Bay Road	392280 E, 2922860 N
Beach Road	396330 E, 2924520 N
Lighthouse	398662 E, 2925330 N
Additional Lee County Sites	
Causeway	399890 E, 2929790 N
Bunche Beach	403580 E, 2928750 N
Bowditch Point	403580 E, 2927290 N
Ft. Myers Beach Access #19	407880 E, 2924490 N
Ft. Myers Beach Holiday Inn	409720 E, 2922170 N
Lover's Key State Recreation Area	412270 E, 2919170 N
Little Hickory Island Beach Access #10	414230 E, 2915650 N
Bonita Beach Access #1	415570 E, 2912615 N
Bonita Beach Development	416120 E, 2911040 N

Table 6.2 – Beach decomposition experiments, location and dates of initiation. Each replicate experiment ran for two months.

Location	Date	Season
Barefoot Beach, Bonita Springs	7/20/09	wet
Little Hickory Island, Bonita Springs	7/20/09	wet
Algiers, Sanibel	7/10/09	wet
Tarpon Bay Road, Sanibel	7/10/09	wet
Gulfside Beach, Sanibel	7/10/09	wet
Blind Pass, Sanibel	7/10/09	wet
Bowditch Point, Ft. Myers Beach	1/26/10	dry
Bunche Beach	1/26/10	dry
Tarpon Bay Road, Sanibel (plot 1)	3/12/10	dry
Tarpon Bay Road, Sanibel (plot 2)	3/12/10	dry
Holiday Inn, Ft. Myers Beach (plot 1)	3/11/10	dry
Holiday Inn, Ft. Myers Beach (plot 2)	3/11/10	dry
Barefoot Beach, Bonita Springs	5/21/10	dry/wet
Holiday Inn, Ft. Myers Beach	5/21/10	dry/wet
Bowdtich Point, Ft. Myers Beach	5/21/10	dry/wet
Bunche Beach	5/21/10	dry/wet
Algiers, Sanibel	5/21/10	dry/wet
Blind Pass, Sanibel	5/21/10	dry/wet

Table 6.3 – Bimonthly sampling of 16 sites to establish background levels of algae deposition, arranged north to south. Scale ranged from 0 – no algae on the beach, to 5 - deposition event.

Sites	7/08	9/08	11/08	1/09	3/09	5/09	7/09[1]	10/09[2]	11/09	1/10	4/10	5/10	7/10
16. Alison Hagerup Beach Park	0	0 0		0	0 0 0			0	0	1	0 0 1		
15. Blind Pass	0	1 0		0	0 1 1			0	0	0	0 0 1		
14. Bowman's Beach	0	0 0		0	0 1 0			0	0	0	1 0 0		
13. Beach Access #2	0	0 0		1	1 1 0			0	0	1	0 0 0		
12. Tarpon Bay Road	0	1 0		0	0 1 0			0	0	1	0 0 0		
11. Beach Road	0	0 0		0	0 1 0			0	0	1	0 0 0		
10. Lighthouse	0	0 0		0	0 1 1			0	0	1	0 0 0		
9. Causeway	1	0 0		0	1 1 0			0	0	1	1 0 0		
8. Bunche Beach	1	1 0		1	1 2 1			1	2	2	1 4 0		
7. Bowditch Point	0	0 1		0	0 2 1			1	0	0	0 1 5		
6. Ft. Myers Beach Access #19	0	0 0		1	0 1 3			0	0	1	0 0 1		
5. Ft. Myers Beach Holiday Inn	0	0 0		0	0 1 3			0	0	0	0 0 0		
4. Lover's Key State Recreation Area	0	0 0		0	0 0 0			0	0	1	0 1 0		
3. Little Hickory Island Beach Access #10	0	0 0		0	0 0 1			0	0	1	0 0 0		
2.Bonita Beach Access #1	0	0 0		0	0 0 0			0	0	0	0 0 0		
1.Bonita Beach Development	0	0 0		0	0 0 1			0	0	0	0 0 0		

[1] Bimonthly sampling done in July 2009 after the deposition event
[2] Sampling done first week of October

Table 6.4 Summary of drift algae deposition events 2008 – 2010 Lee County. (estimated duration of the deposition appears in parentheses. Dimension measurements in meters, Dry biomass in metric tons. Biomass converted to wet tons (English units), to allow assessment of removal costs.

Location	Date	Length (m)	Width (m)	Depth (m)	Dry Biomass (mt)	Total Wet Biomass
Sandpiper Resort, Fort Myers Beach	June 2008 (two weeks)	1344	8.4	0.18	216.0	1049.6
Gulfside Beach, Sanibel	March 2009 (< one week)	800	½	0.02	1.2	4.8
Sanibel	July 2009 (two weeks)	32990	4.2	0.07	212.0	751
Bunche Beach	May 2010 (one week)	176	4.5	0.04	0.75	3.1
Bowditch Point	July 2010 (one week)	548	14.6	0.01	9.8	45.2

Figure 6.1 – Biomass sampling using the 0.25m^2 quadrat during the Ft. Myers Beach deposition event, July 2008). All alga biomass within the quadrat is collected, returned to the laboratory, dried and weighed.

Figure 6.2 – Beach decomposition field experiment, showing the four preweighed samples, to be collected after one, two, four, and eight weeks.

Figure 6.3 – Laboratory decomposition experiment using microcosms. Preweighed samples of algae were placed in the aquaria and flushed with seawater. Nutrient concentrations were determined from the effluent.

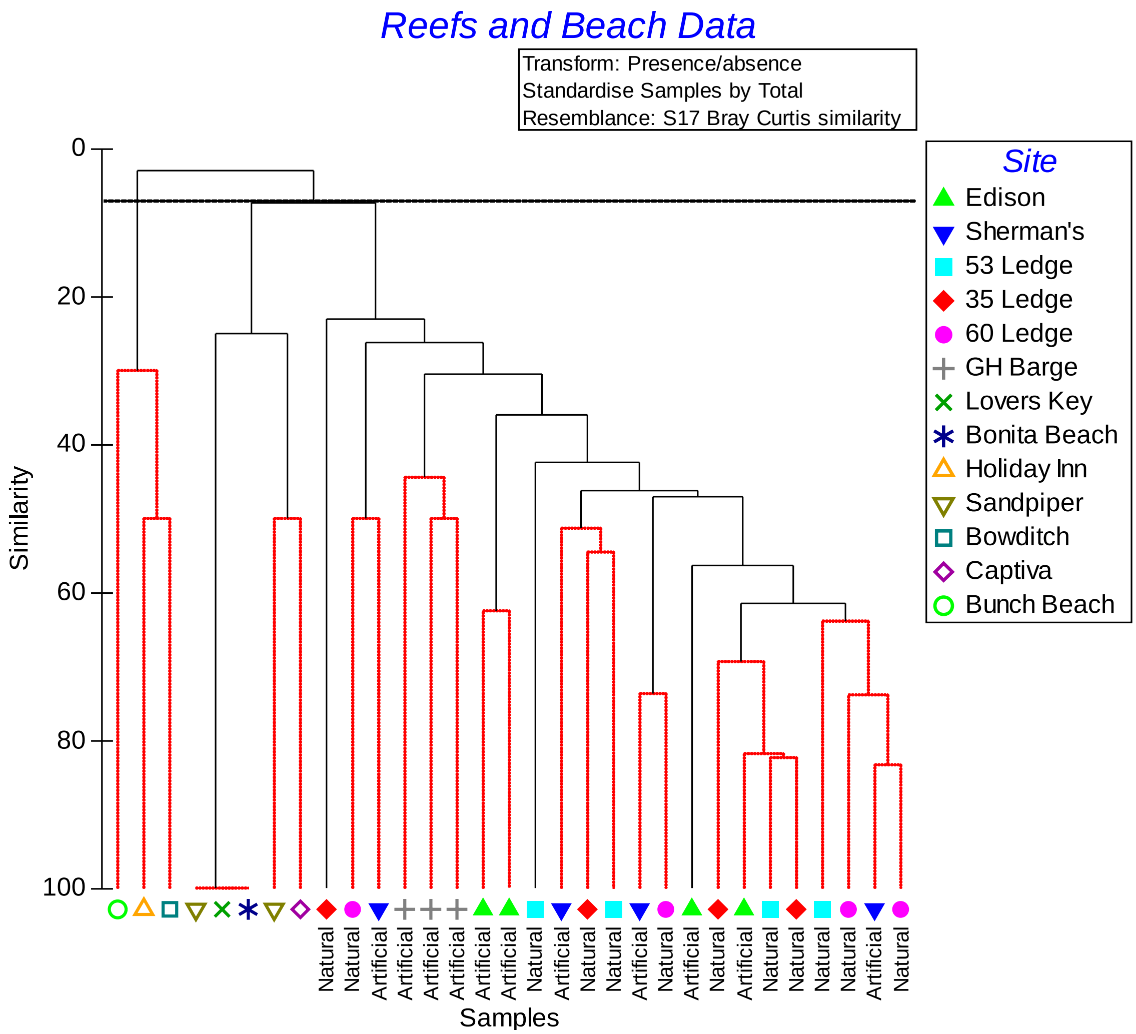


Figure 6.4 – A hierarchical clustering of all reef algae samples and beach sampling events where data has been standardized to account for variable sampling techniques and transformed to presence/absence to match beach data set. Note that all beach samples are significantly different than all reef sample collections and separate in the cluster with less than 7% similarity (93%) where slice has been inserted.

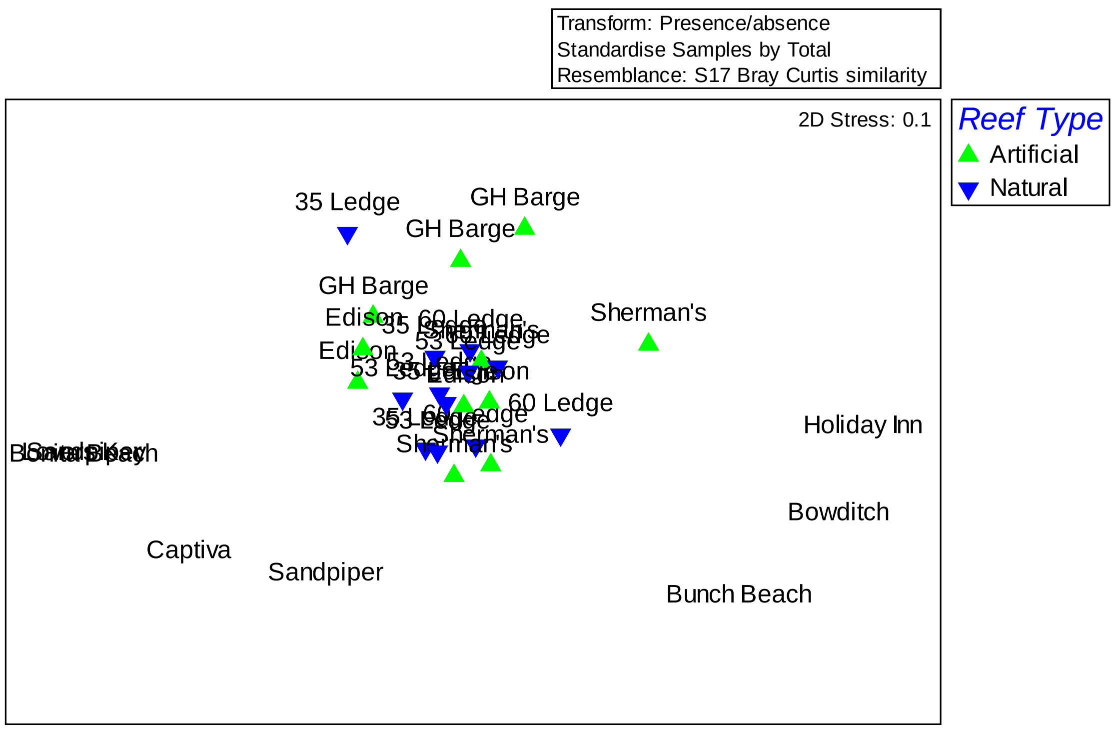


Figure 6.5 – MDS ordination of all natural and artificial reef samples and the beach algae sampling events. The 2D stress value of 0.1 indicates a good ordination with little prospect of a misleading interpretation.

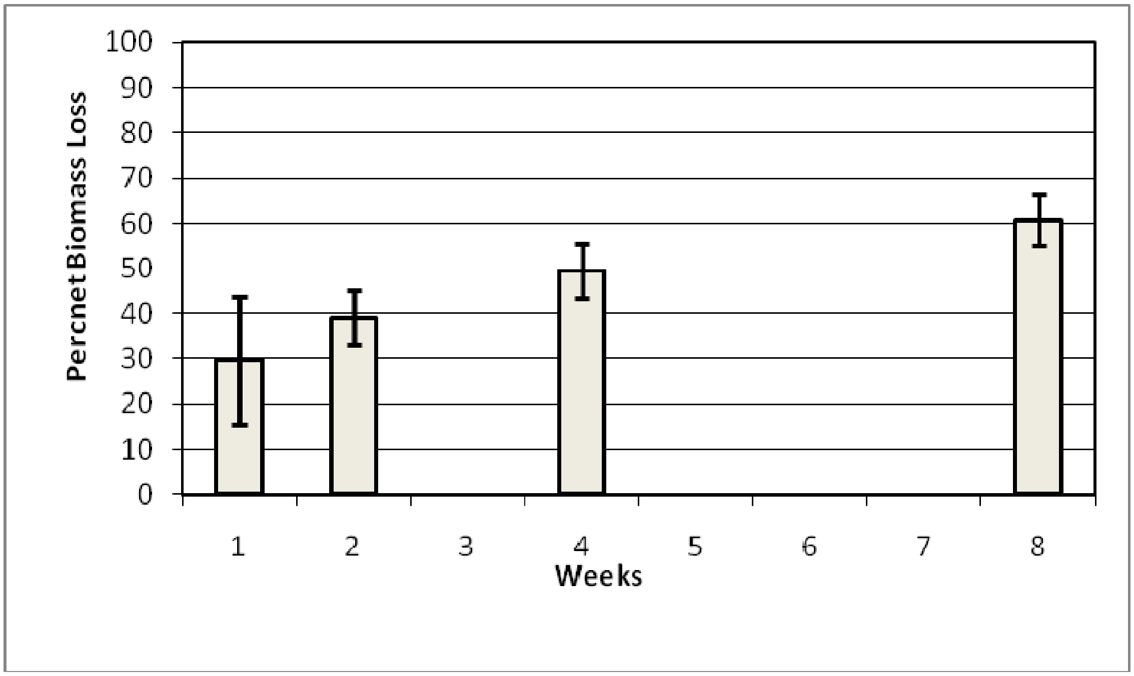


Figure 6.6 – Mean biomass decomposition rates from sixteen beach experiments. No significant differences between sites or season.

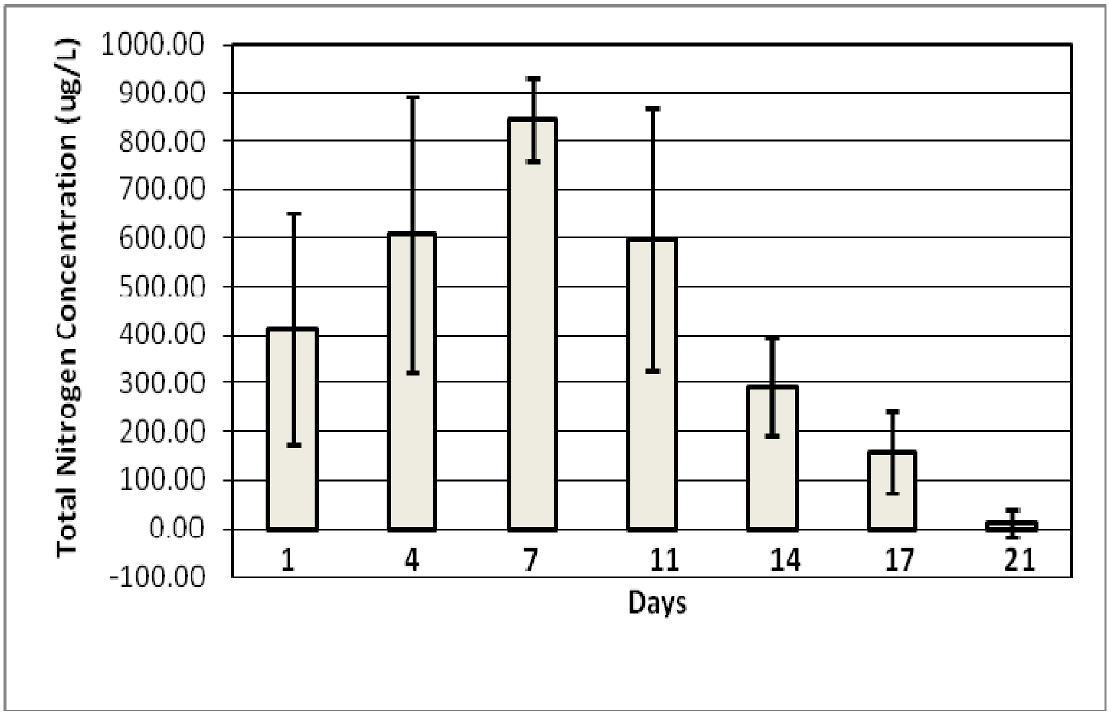


Figure 6.7 – Mean total nitrogen release from microcosm experiments. Concentration is multiplied by effluent volume to determine total nitrogen release per unit biomass

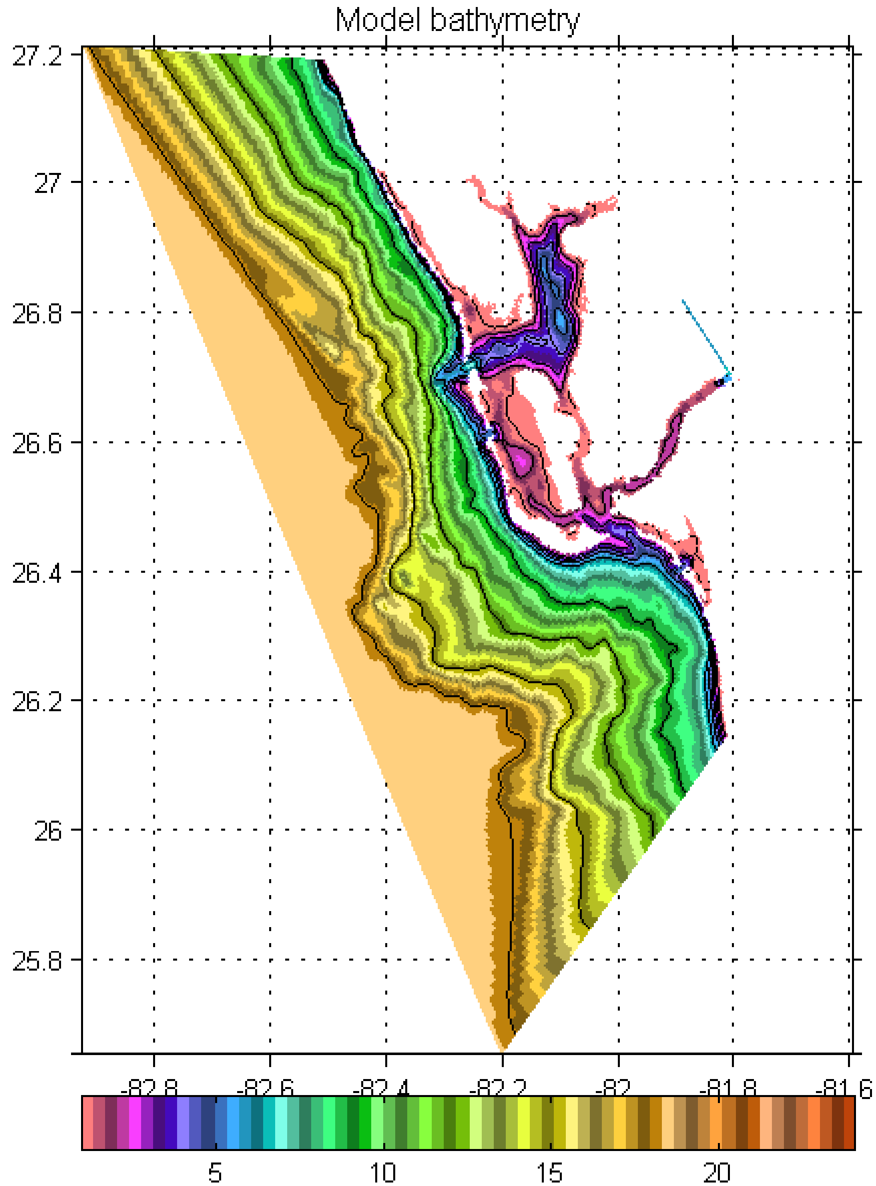


Fig 7-1 Hydrodynamic grid extent and bathymetry

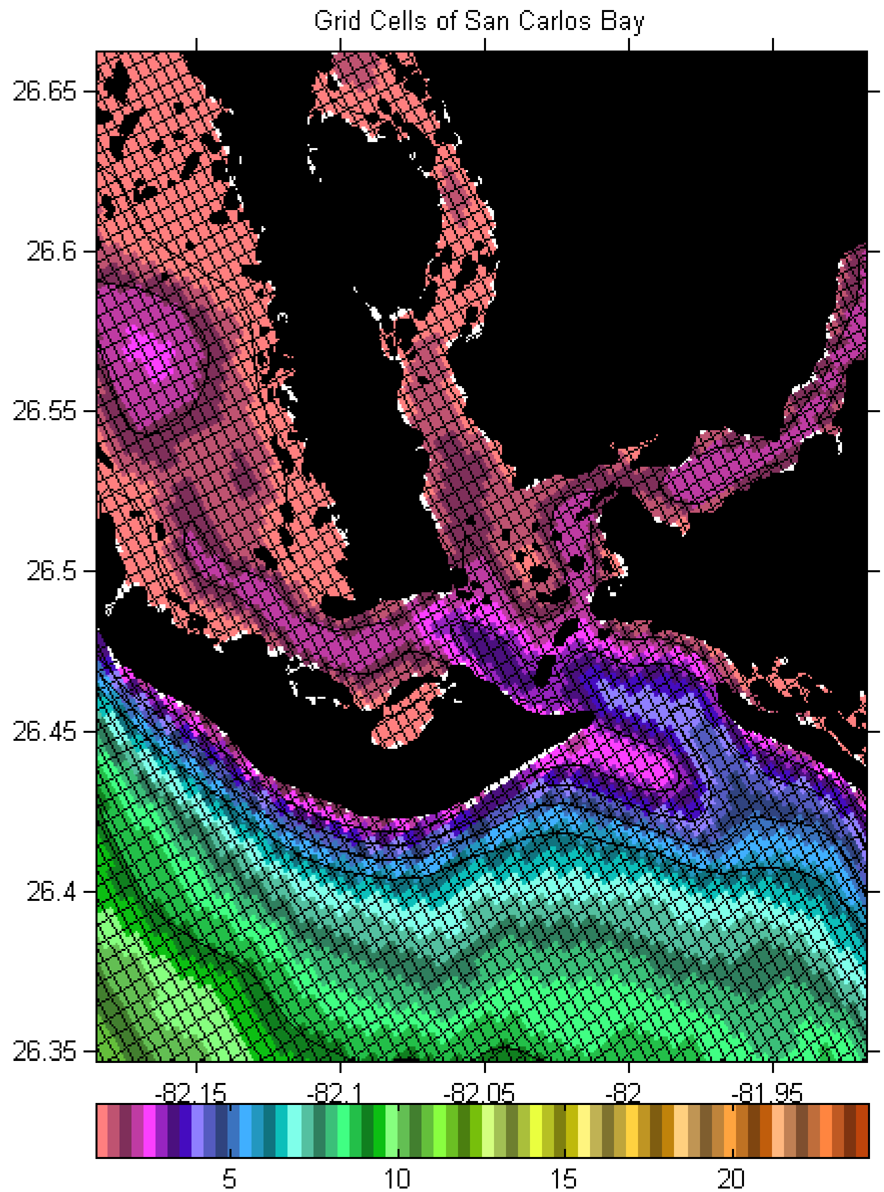


Fig 7-2 Representative grid cells in San Carlos Bay

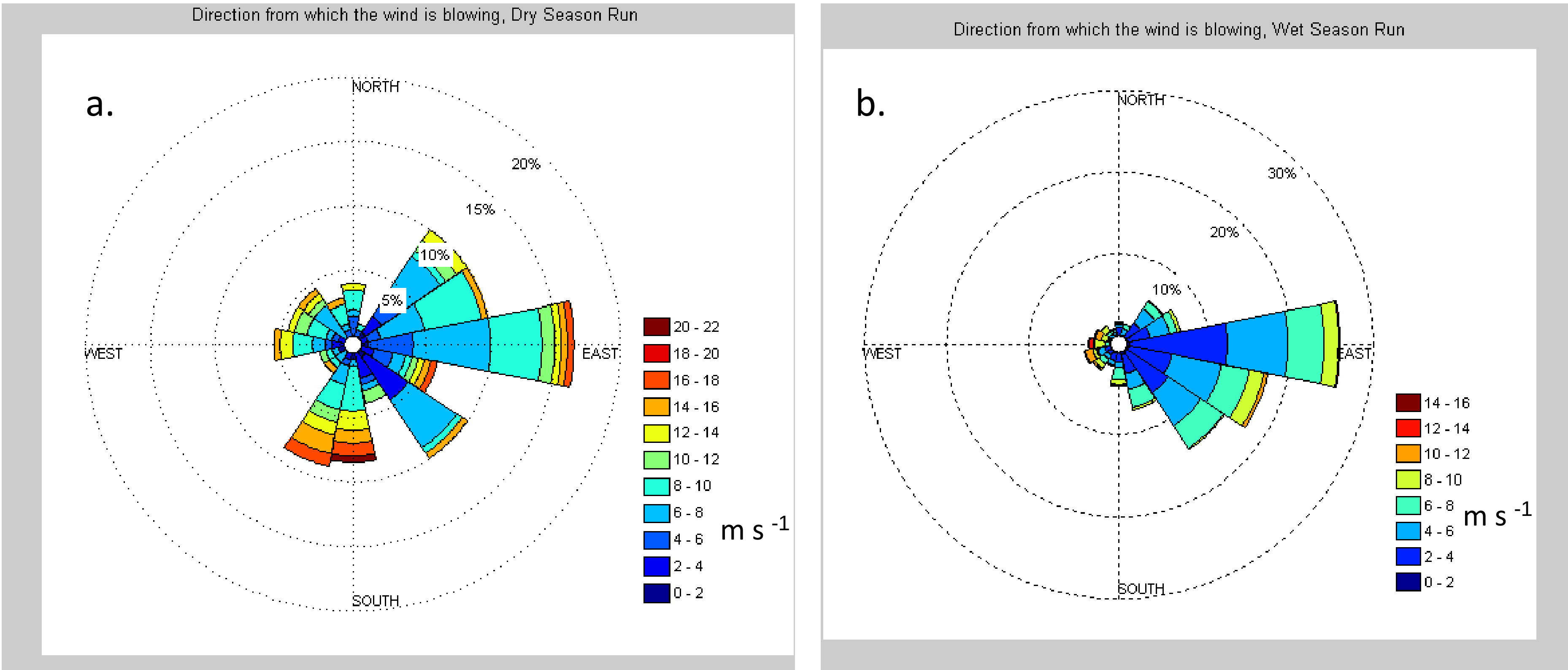


Fig 7-3 Wind speed and direction (from which the wind is blowing) distributions during the a) dry and b) wet season simulations

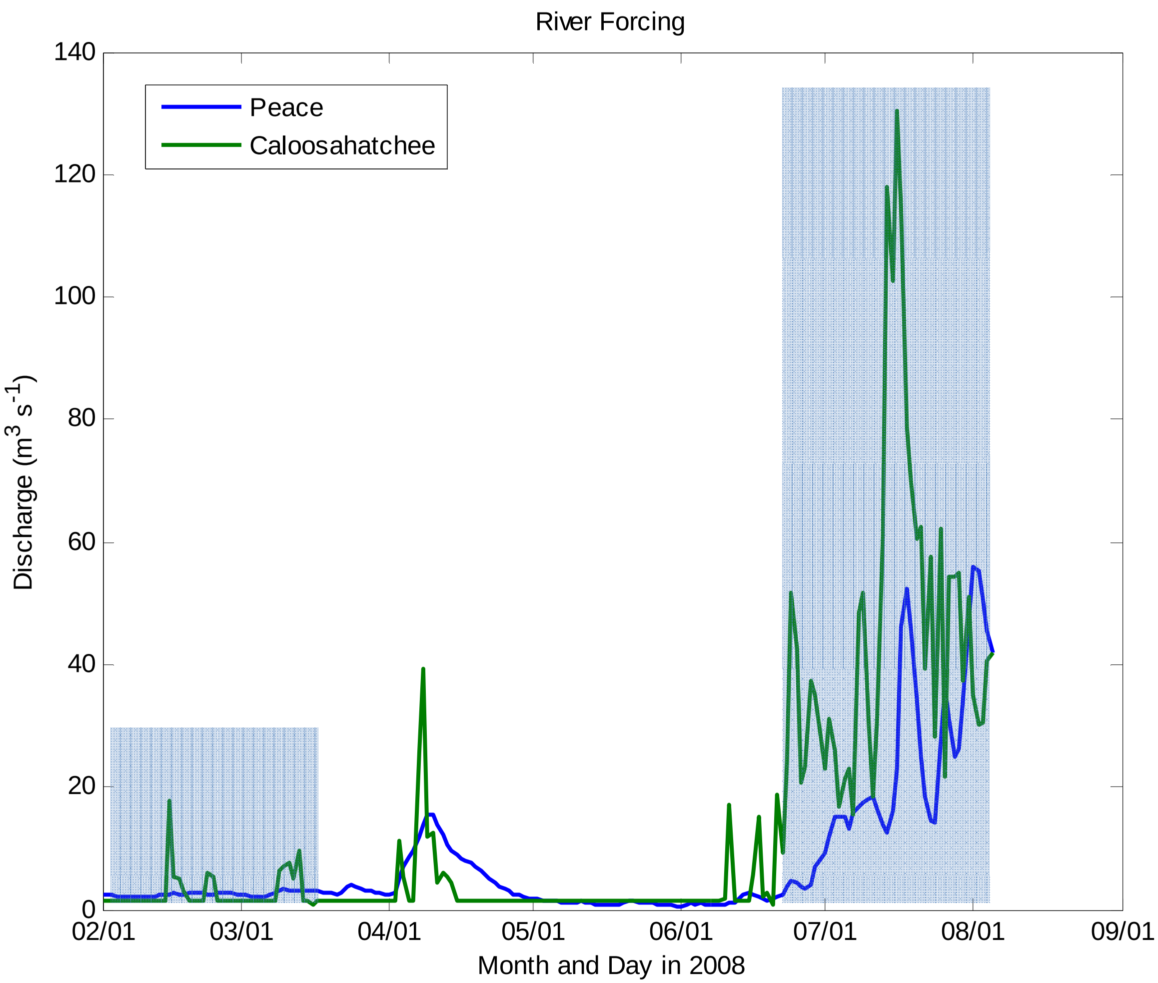


Fig 7-4 River discharge levels in 2008, shaded areas show times of the dry and wet season simulations.

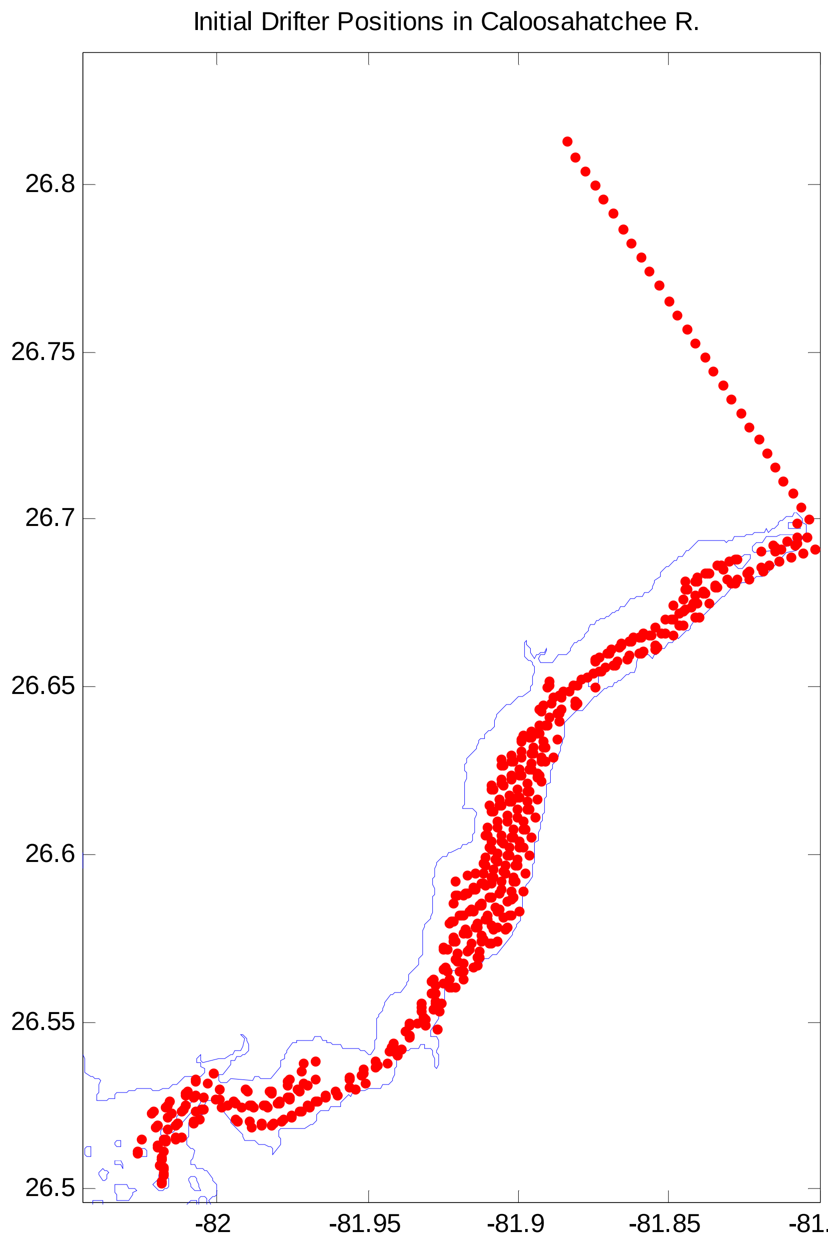


Fig 7-5 Initial drifter locations within the Caloosahatchee R

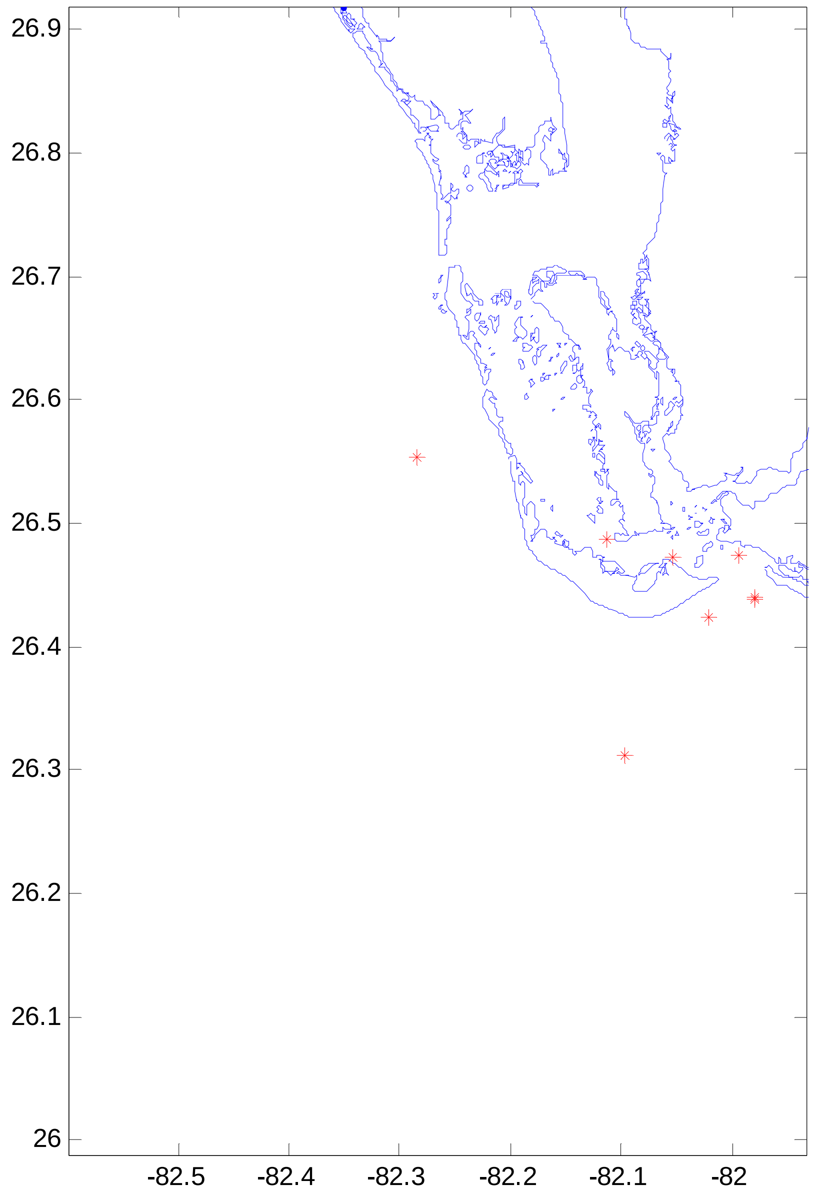


Fig 7-6 Initial drifter locations outside the Caloosahatchee R

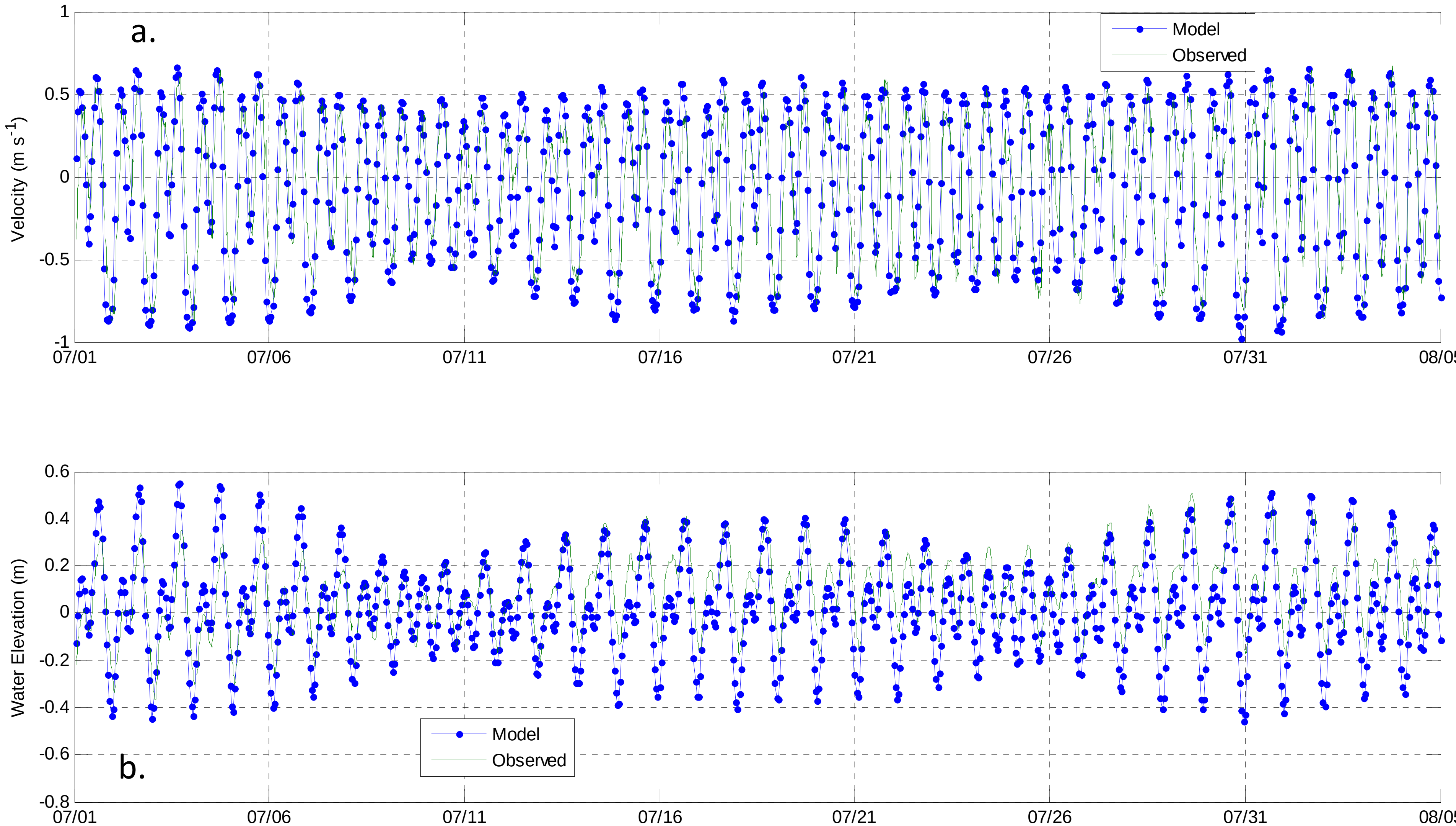


Fig 7-7 Observed and predicted a) water currents and b) water level at Marker 52

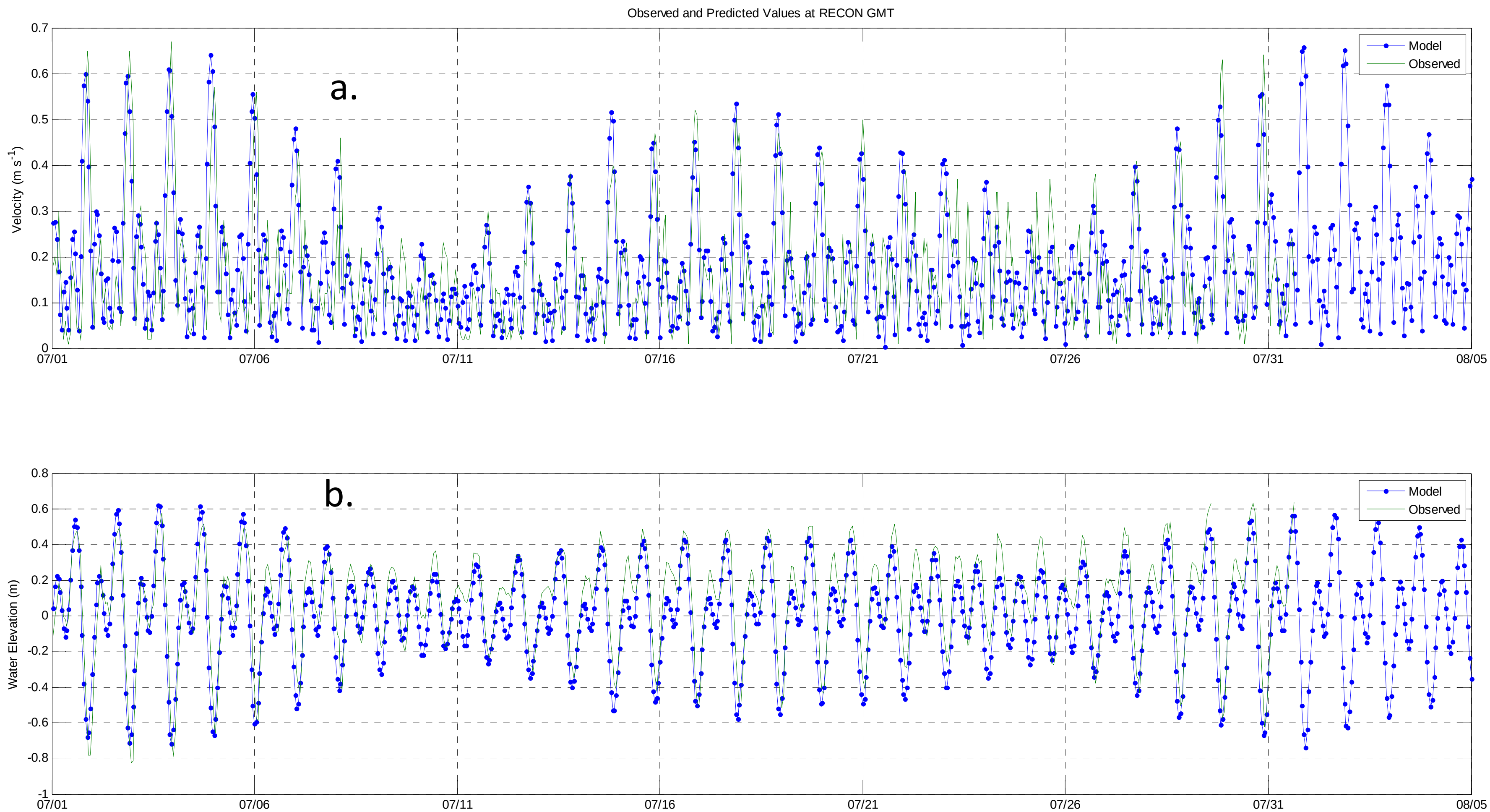


Fig. 7-8 Observed and predicted a) water currents and b) water level at RECON GOM

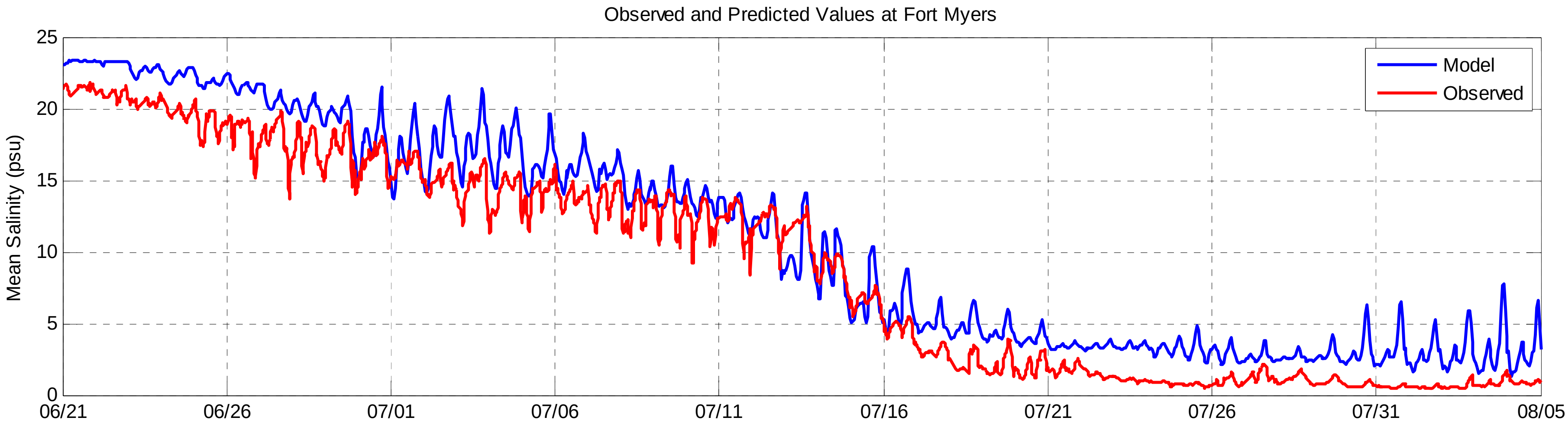


Fig. 7-9 and predicted mean salinity in the Caloosahatchee R. at Fort Myers

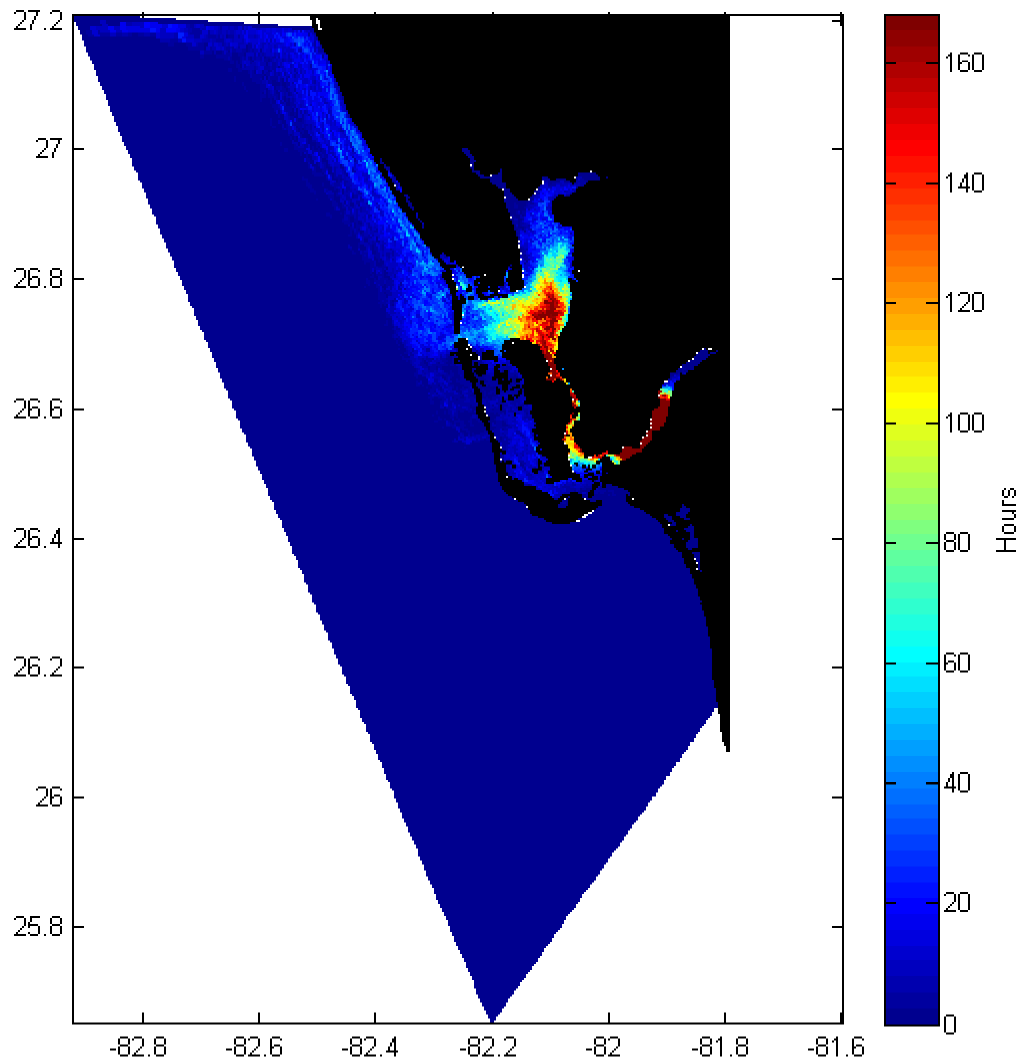


Fig. 7-10 Time each grid cell was occupied by drifters originating in the lower Caloosahatchee R. during the wet season

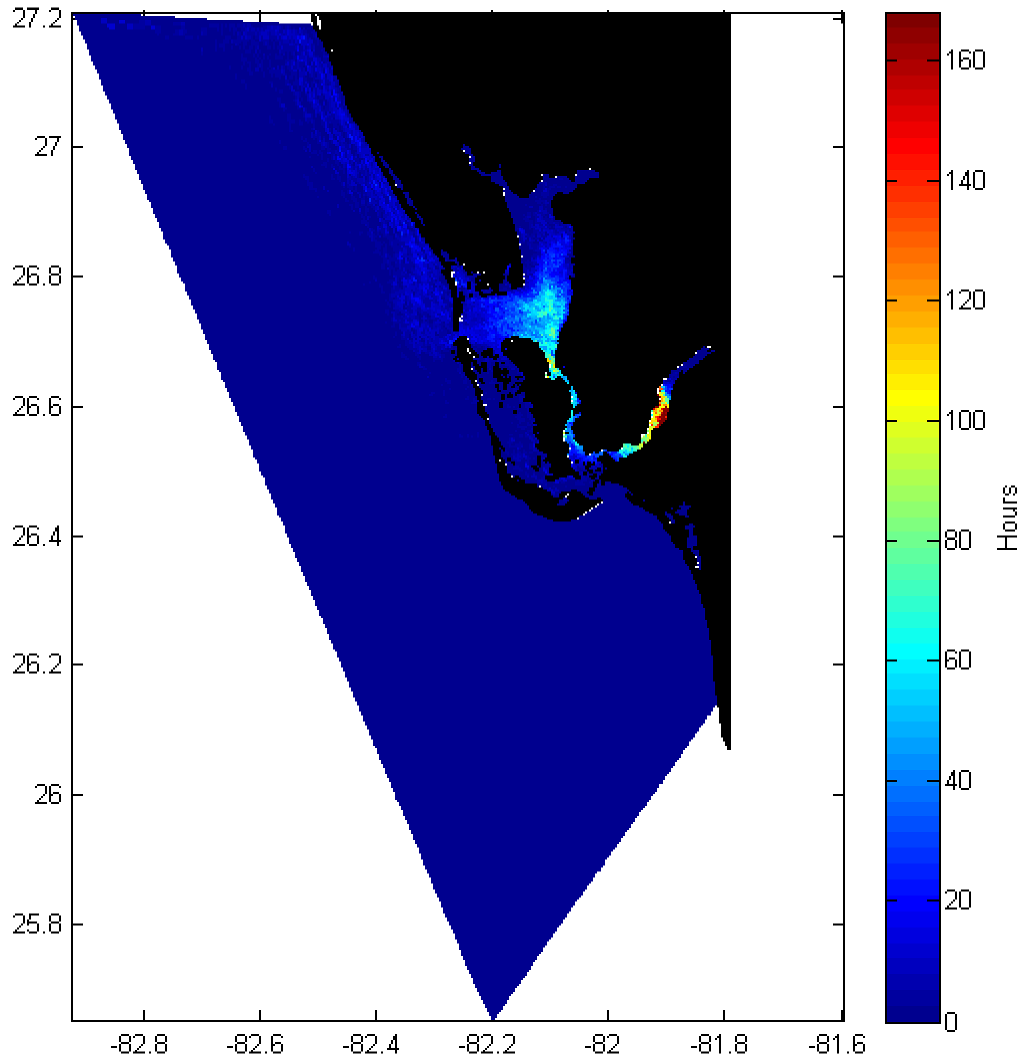


Fig. 7-11 Time each grid cell was occupied by surface drifters originating in the lower Caloosahatchee R. during the wet season

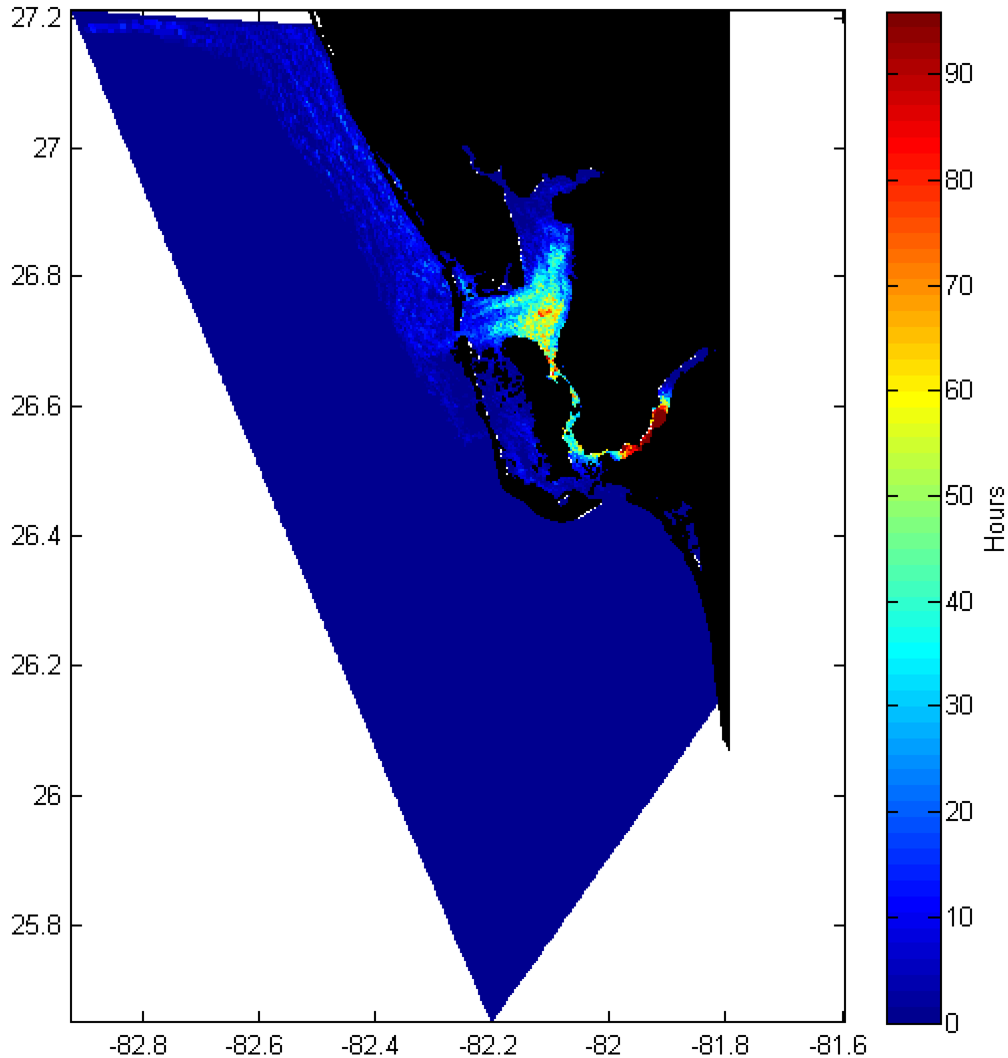


Fig. 7-12 Time each grid cell was occupied by mid level drifters originating in the lower Caloosahatchee R. during the wet season

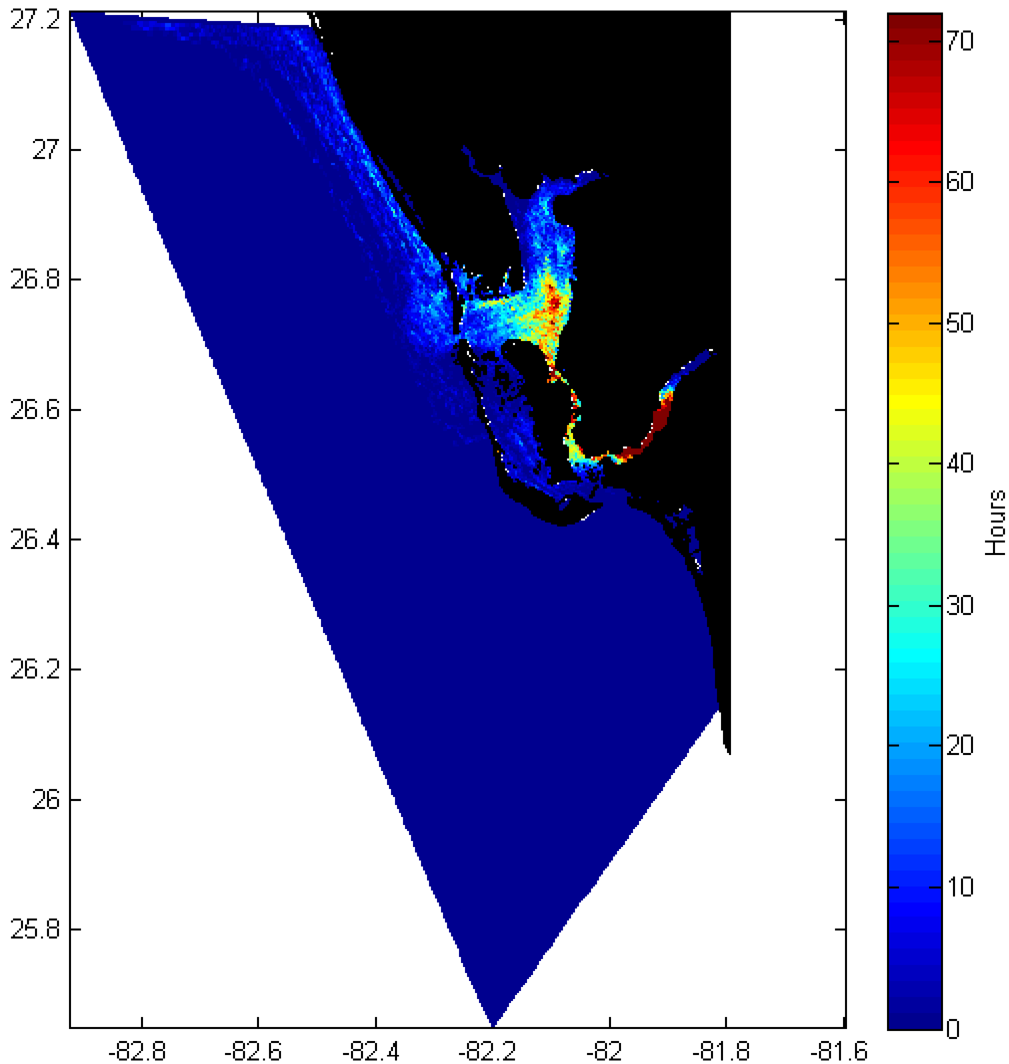


Fig. 7-13 Time each grid cell was occupied by bottom drifters originating in the lower Caloosahatchee R. during the wet season

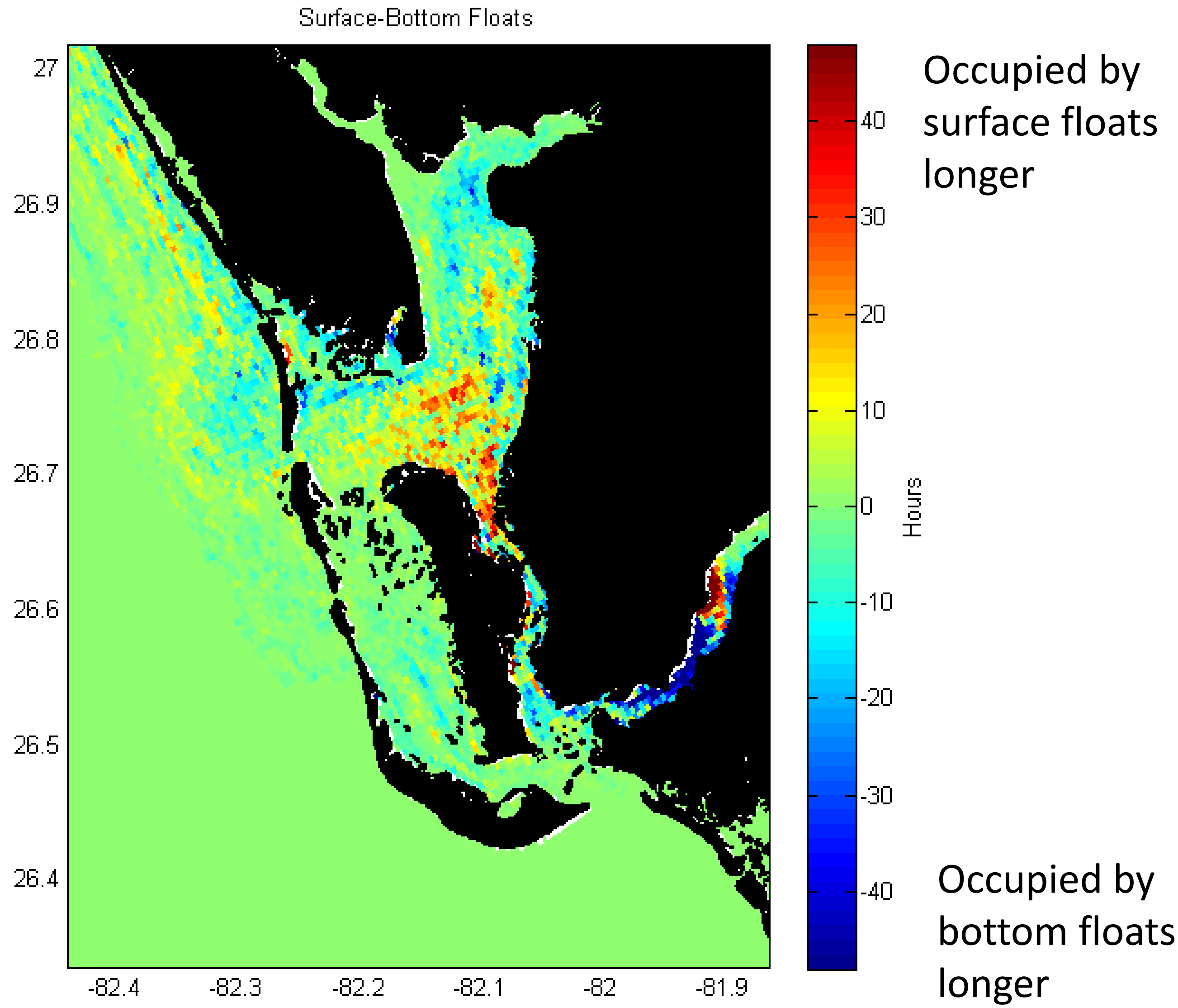


Fig. 7-14 Difference in the time between surface and bottom drifters originating in the lower Caloosahatchee R in each grid cell during the wet season.

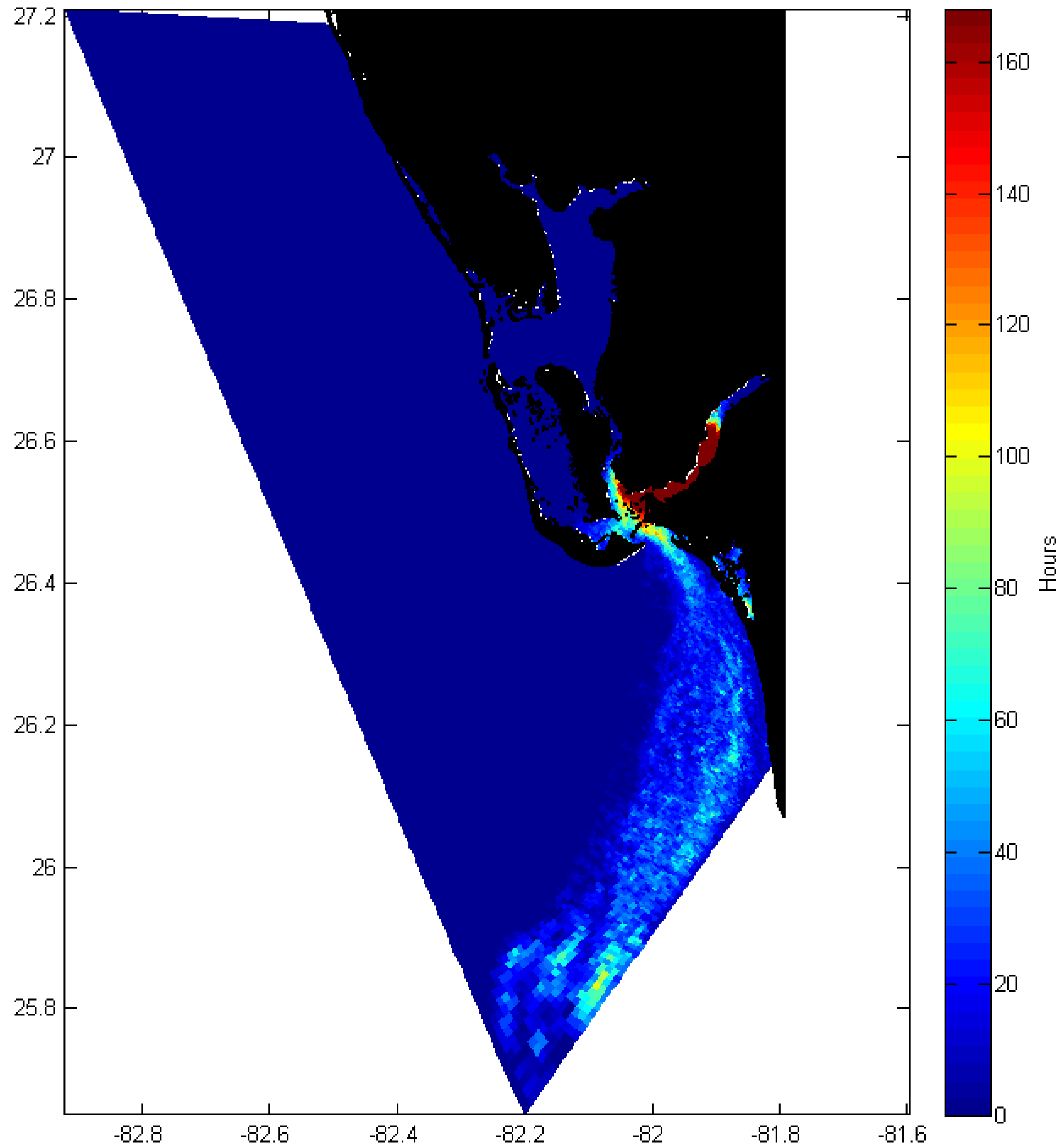


Fig. 7-15 Time each grid cell was occupied by drifters originating in the lower Caloosahatchee R. during the wet season with northwest winds.

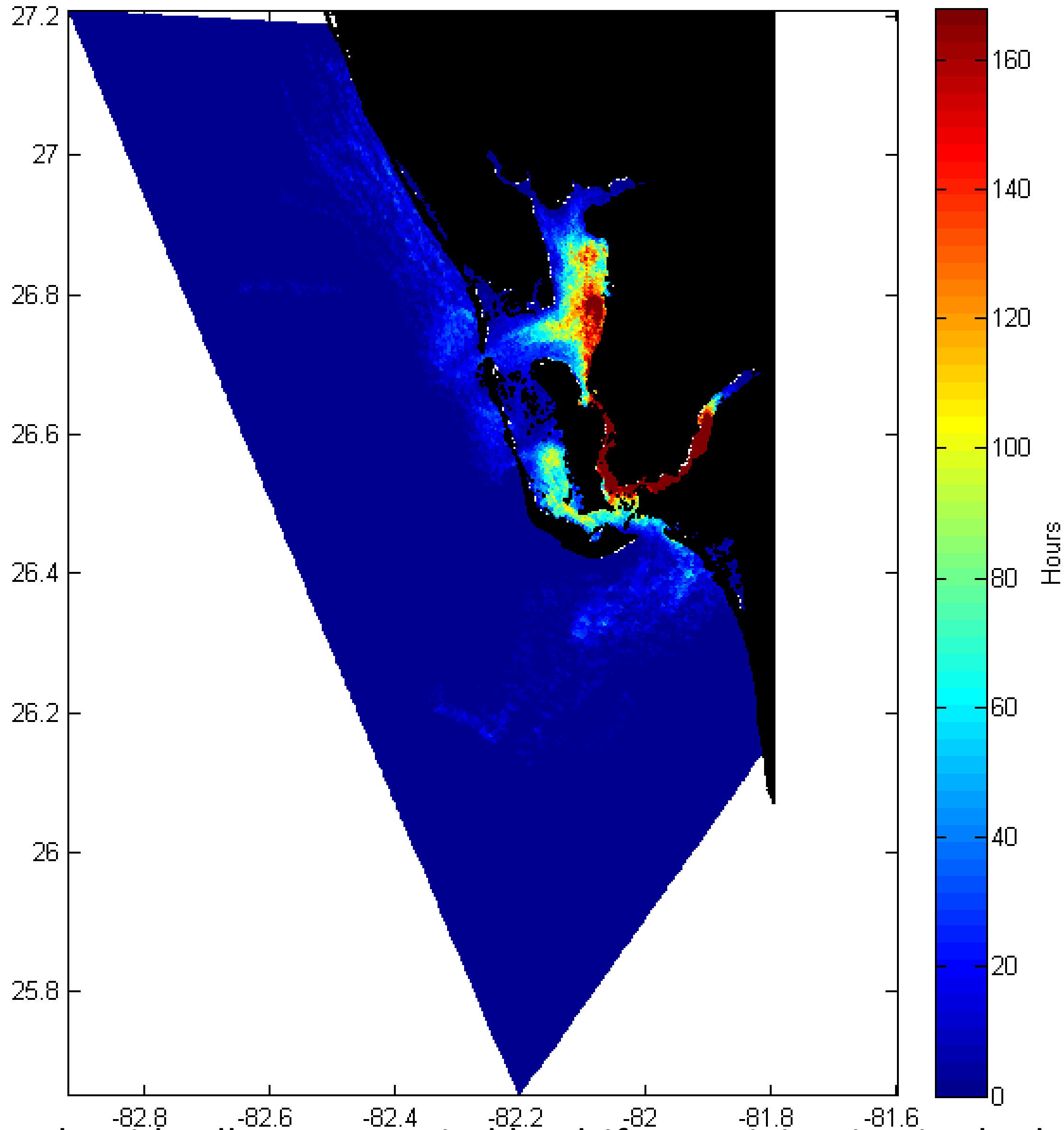


Fig. 7-16 Time each grid cell was occupied by drifters originating in the lower Caloosahatchee R. during the wet season with southwest winds.

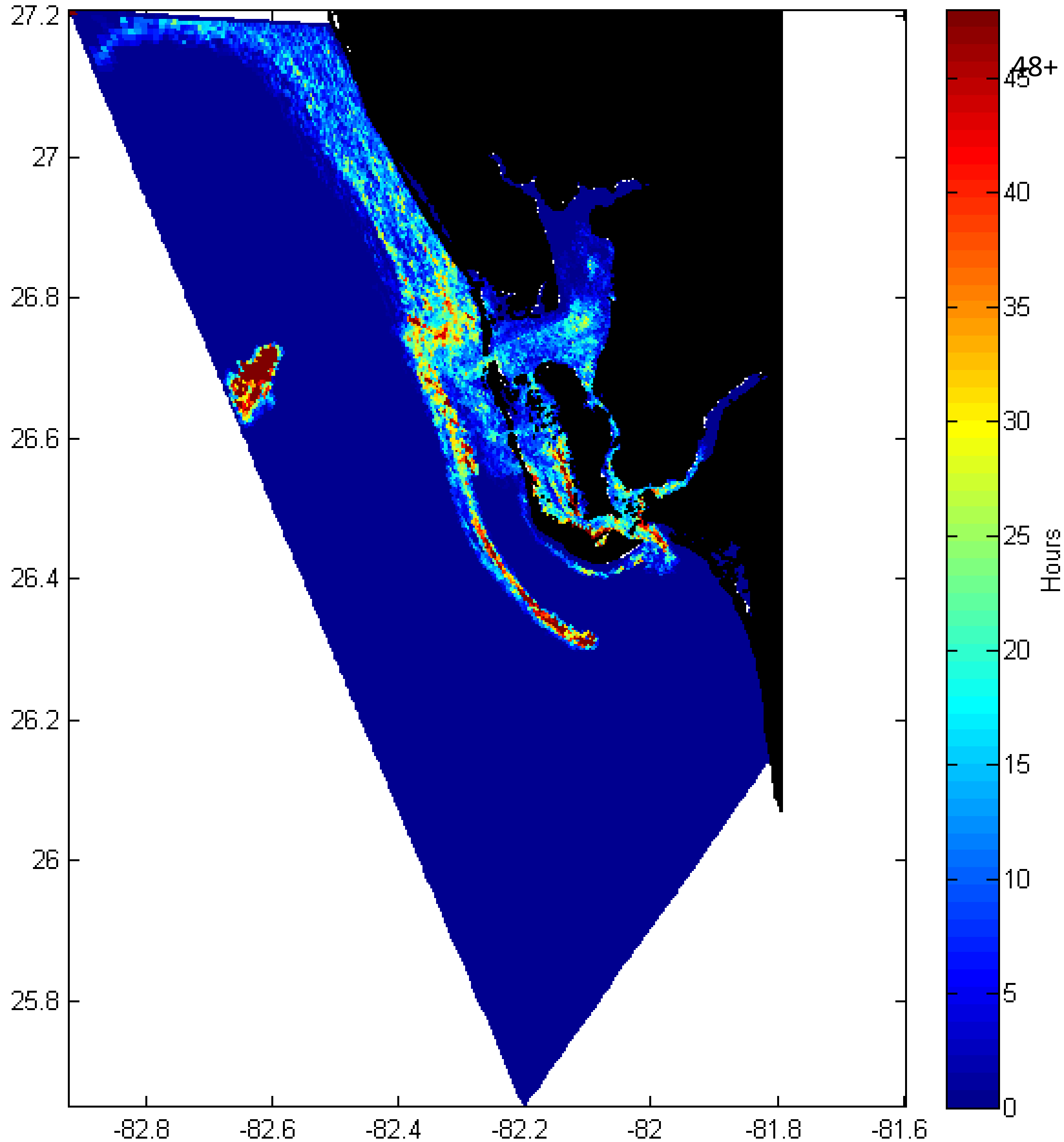


Fig. 7-17 Time each grid cell was occupied by bottom drifters originating from locations outside of the Caloosahatchee R. with observed winds during the wet season

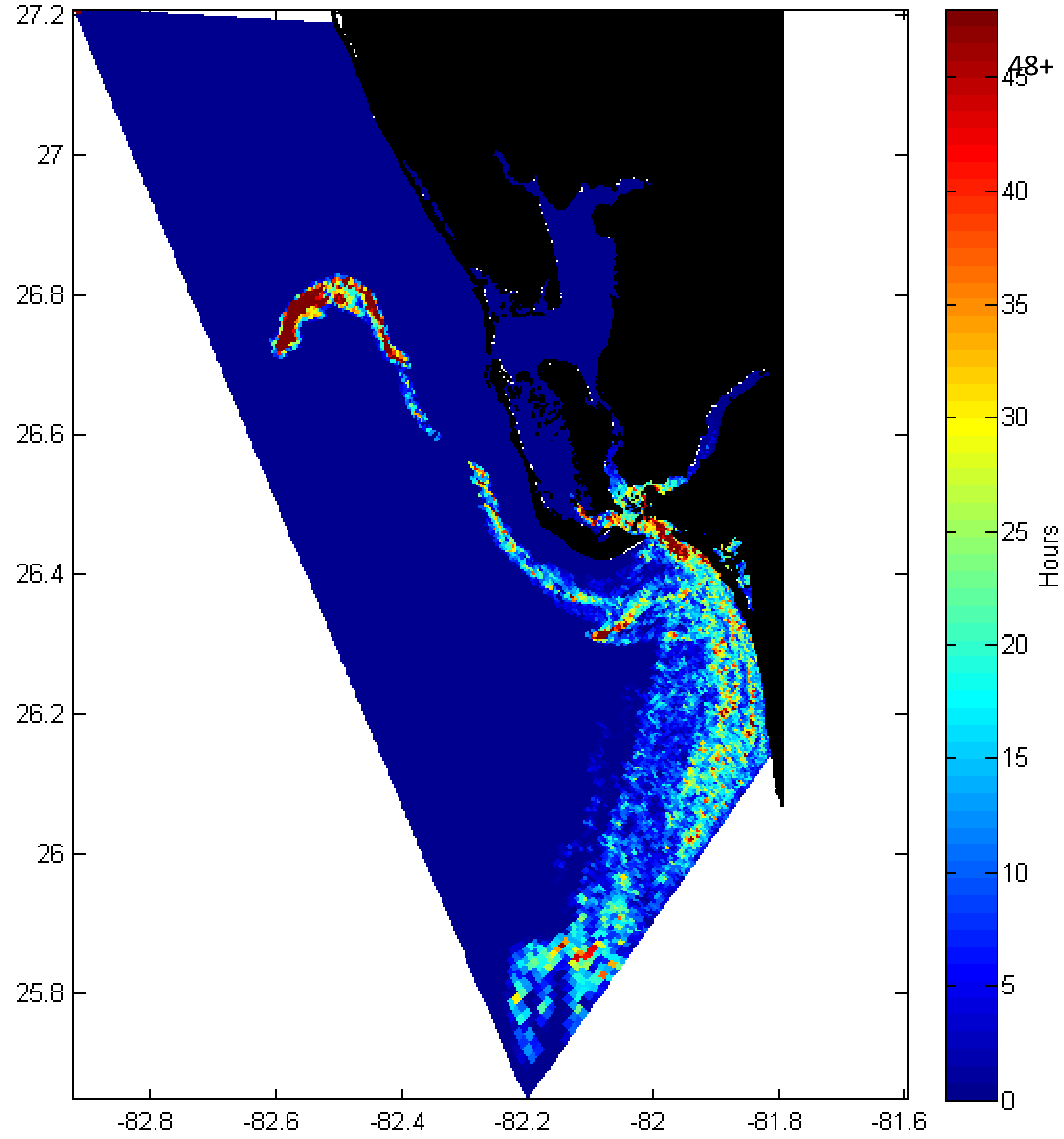


Fig. 7-18 Time each grid cell was occupied by bottom drifters originating from locations outside of the Caloosahatchee R. during the wet season with northwest winds.

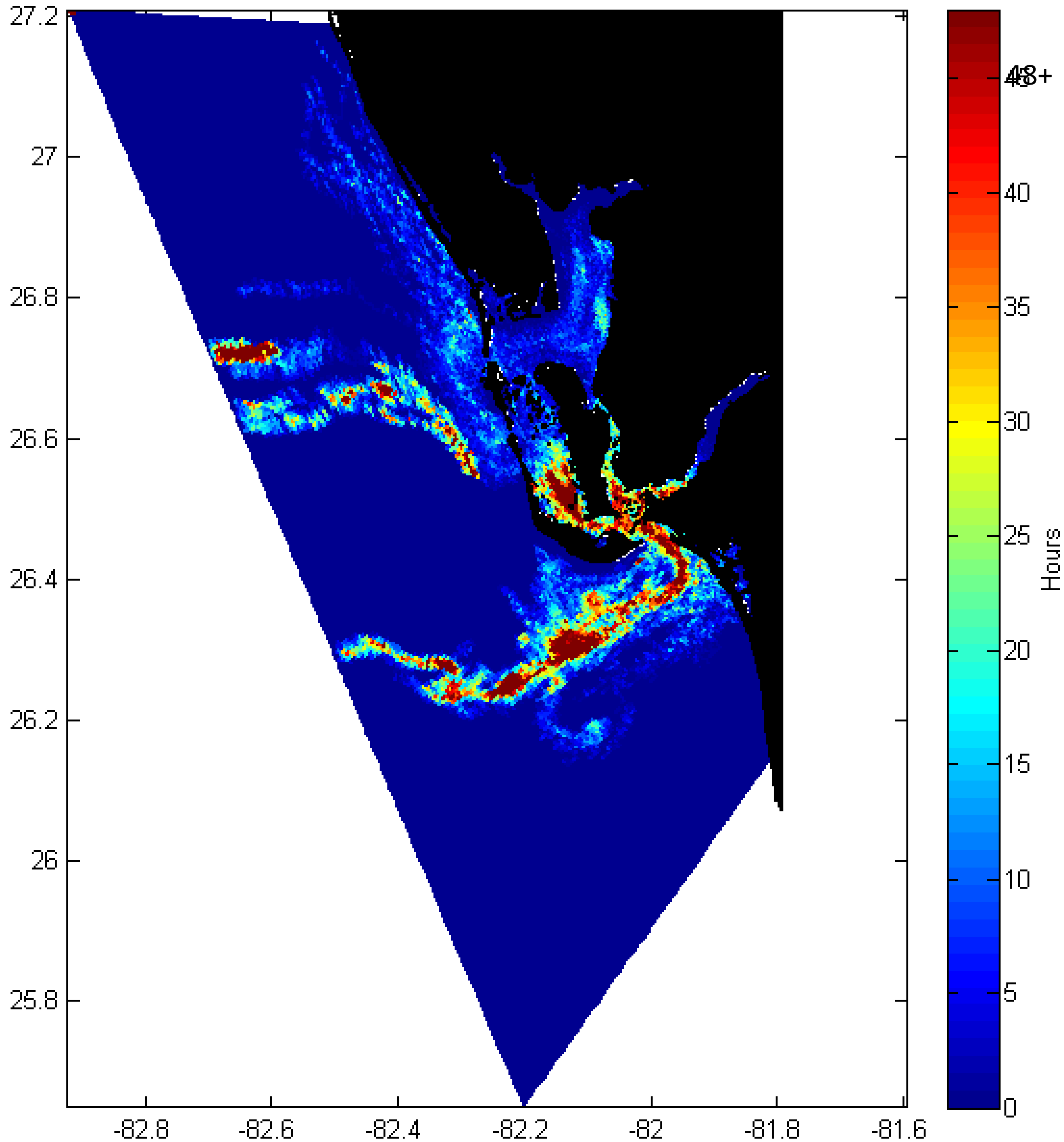


Fig. 7-19 Time each grid cell was occupied by bottom drifters originating from locations outside of the Caloosahatchee R. during the wet season with southwest winds.

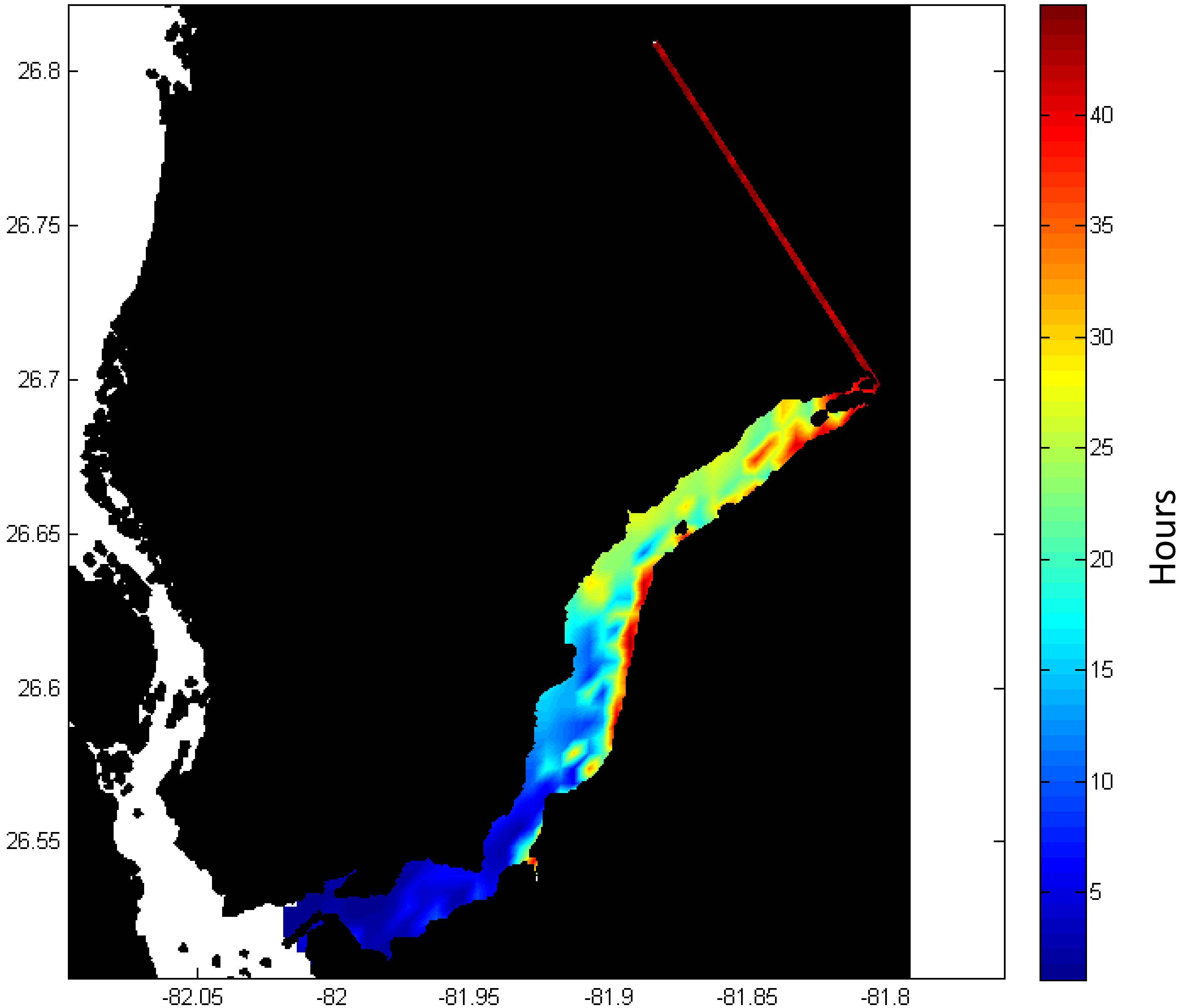


Fig. 7-20 Residence times of drifters in the Caloosahatchee R. during the wet season simulation

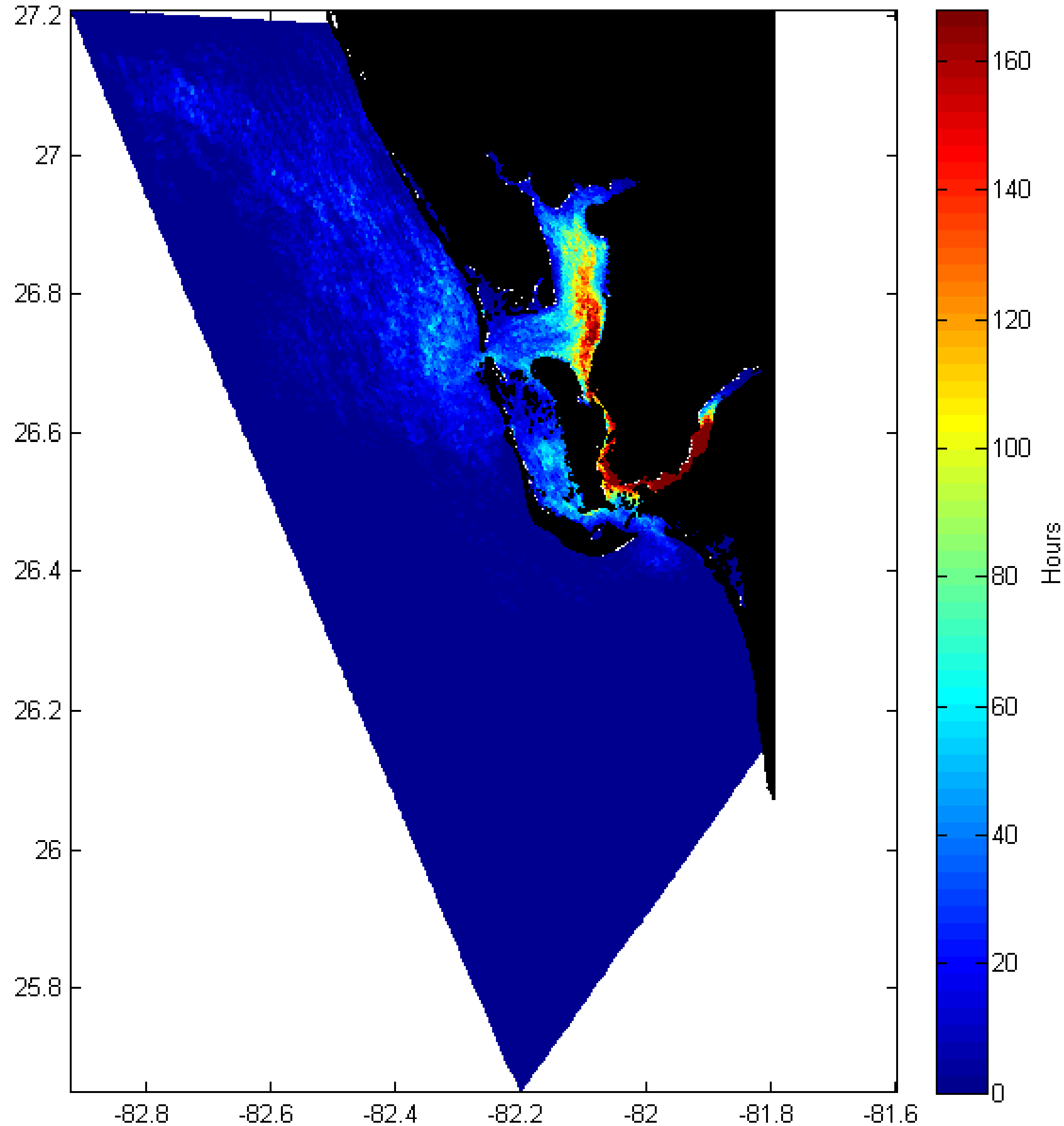


Fig. 7-21 Time each grid cell was occupied by drifters originating in the lower Caloosahatchee R. during the wet season with Redfish Pass closed

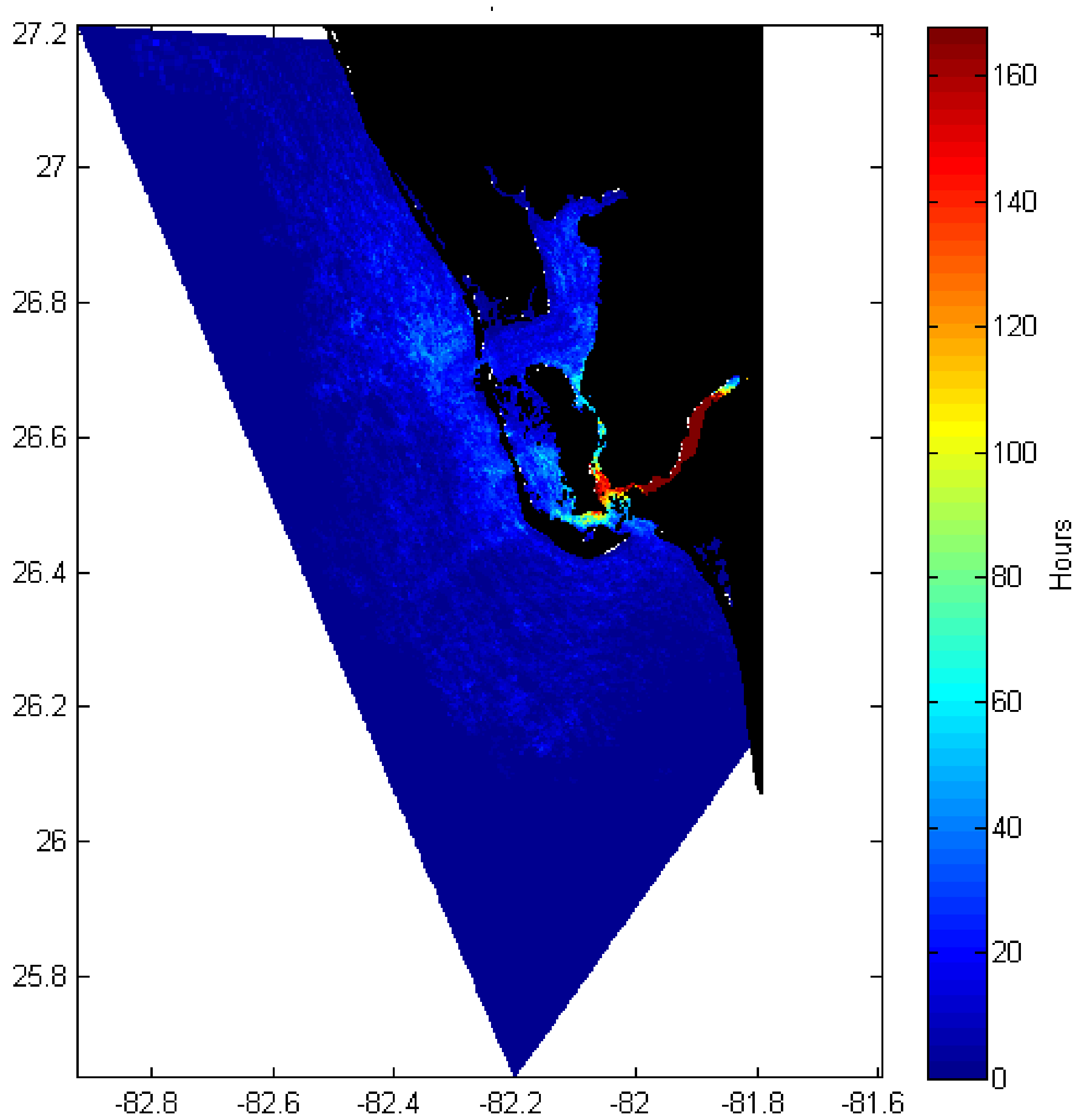


Fig. 7-22 Time each grid cell was occupied by drifters originating in the lower Caloosahatchee R. during the dry season with observed winds

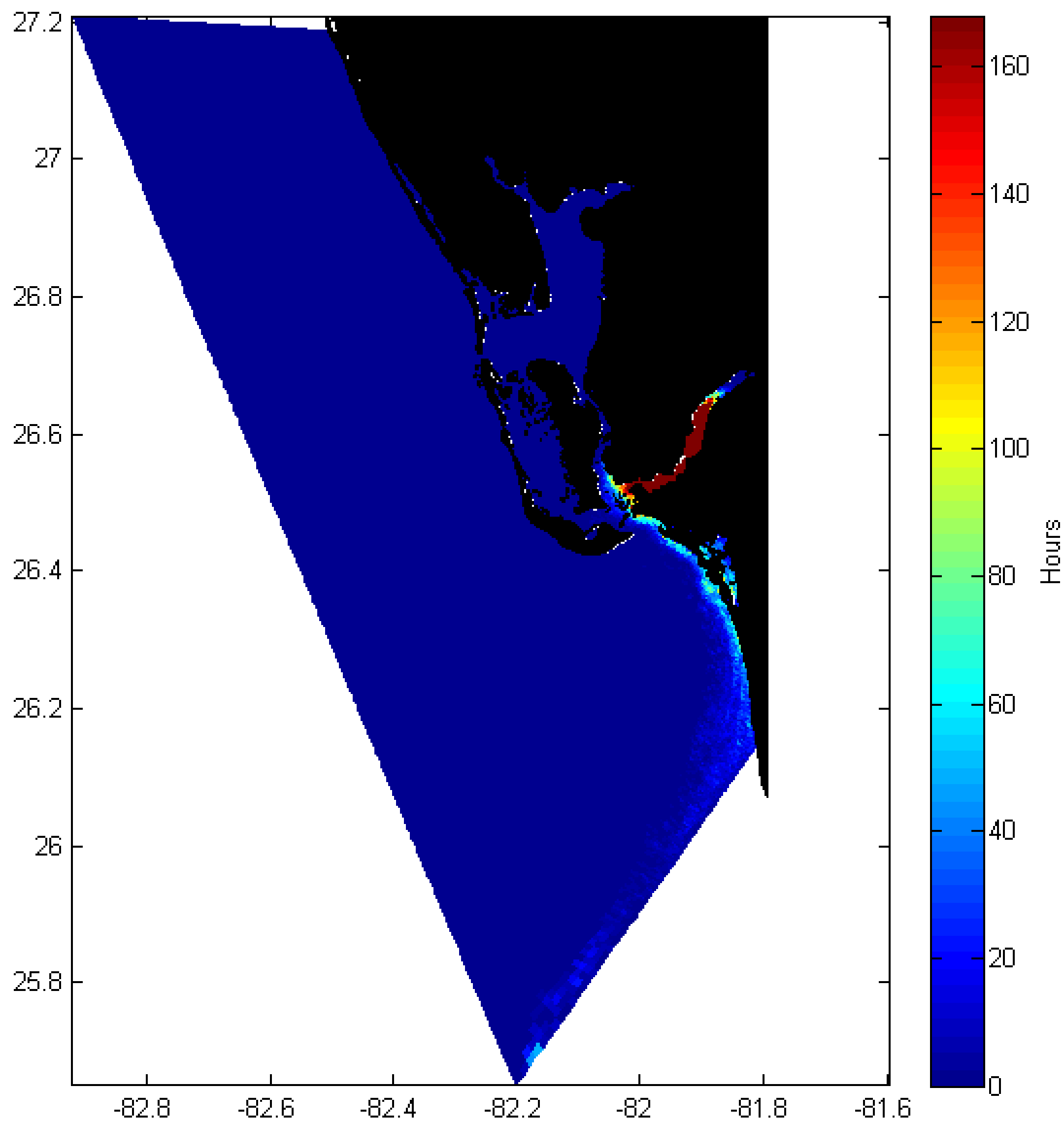


Fig. 7-23 Time each grid cell was occupied by drifters originating in the lower Caloosahatchee R. during the dry season with northwest winds.

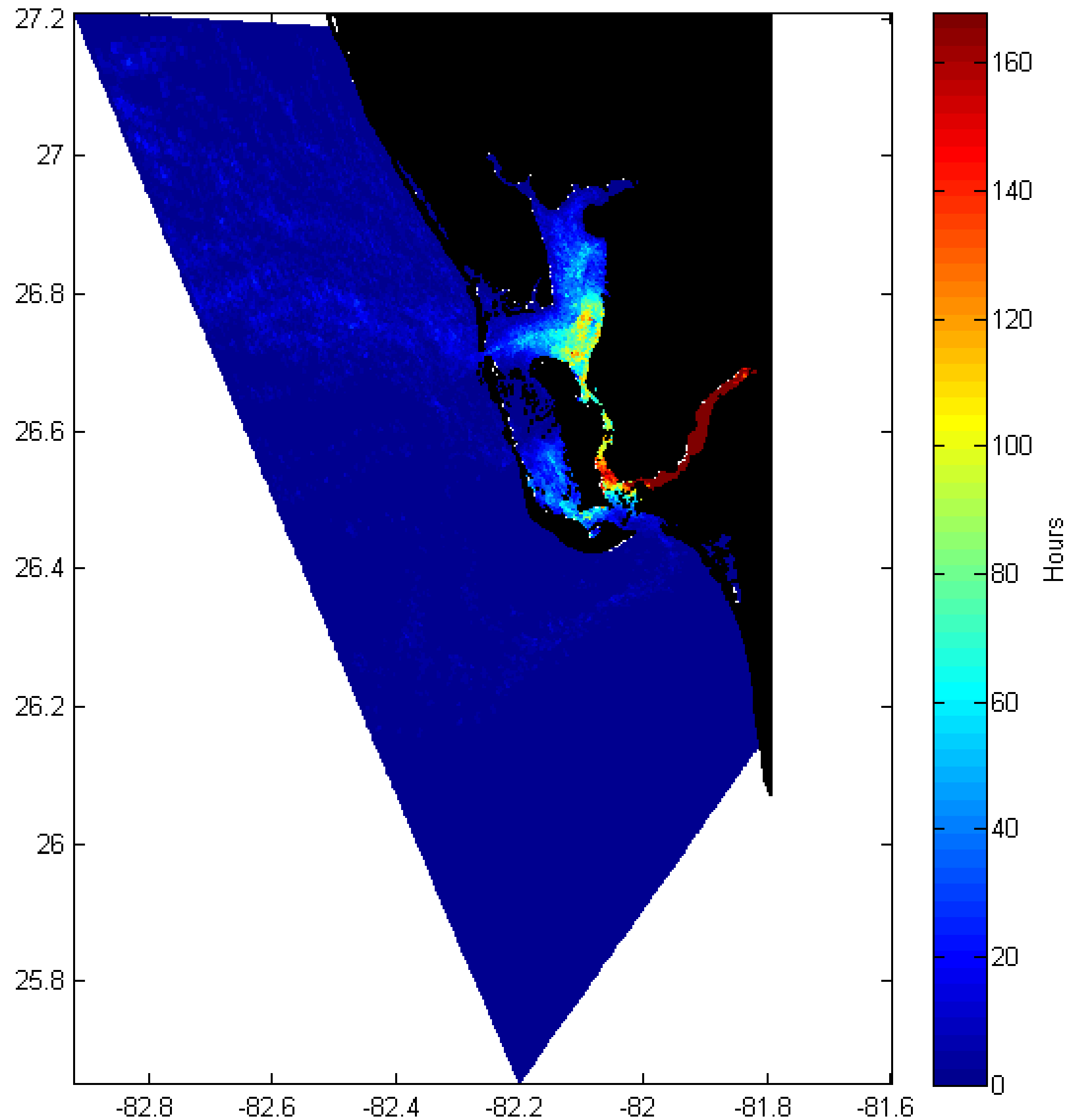


Fig. 7-24 Time each grid cell was occupied by drifters originating in the lower Caloosahatchee R. during the dry season with southwest winds.

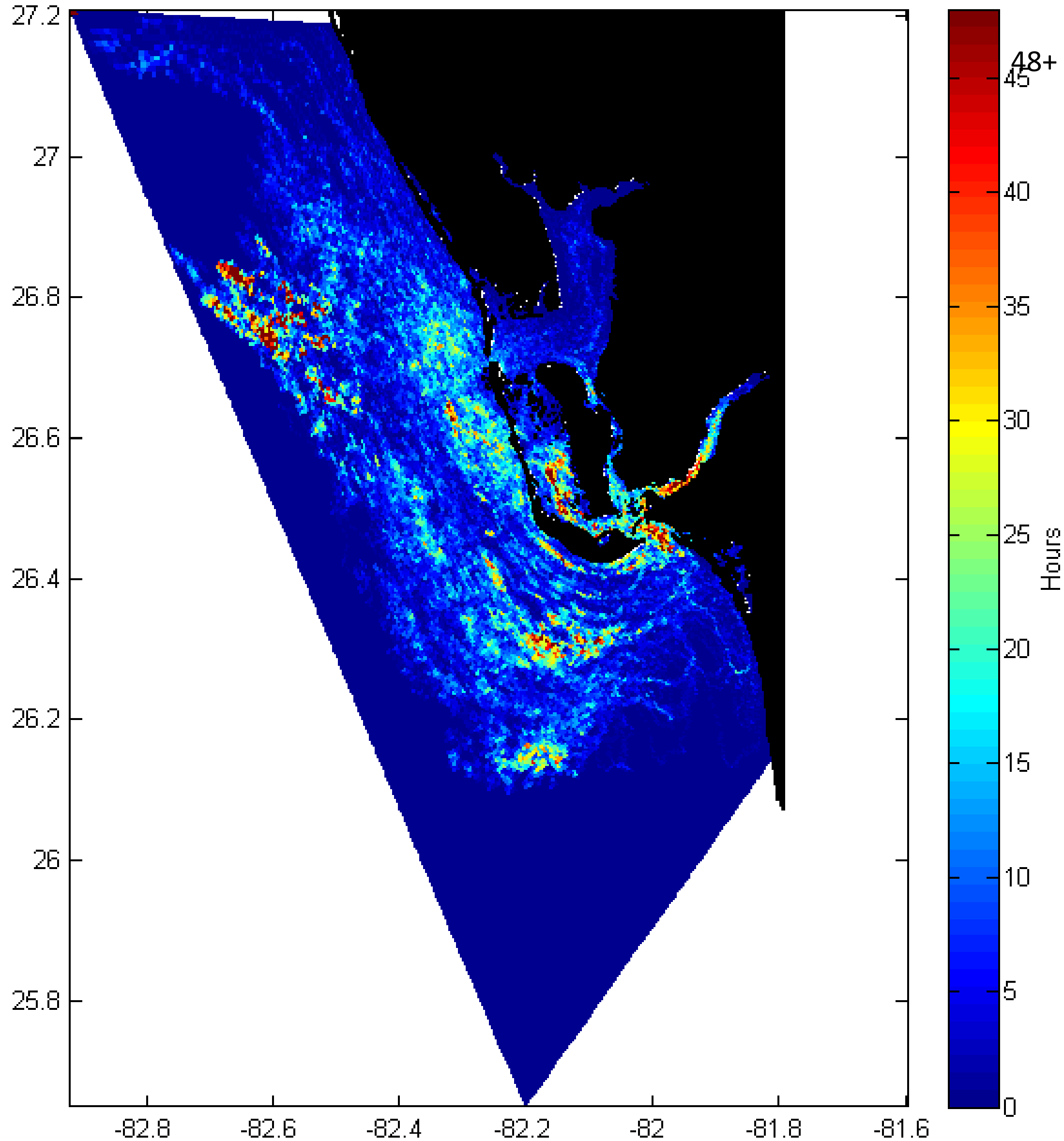


Fig. 7-25 Time each grid cell was occupied by bottom drifters originating from locations outside of the Caloosahatchee R. with observed winds during the dry season

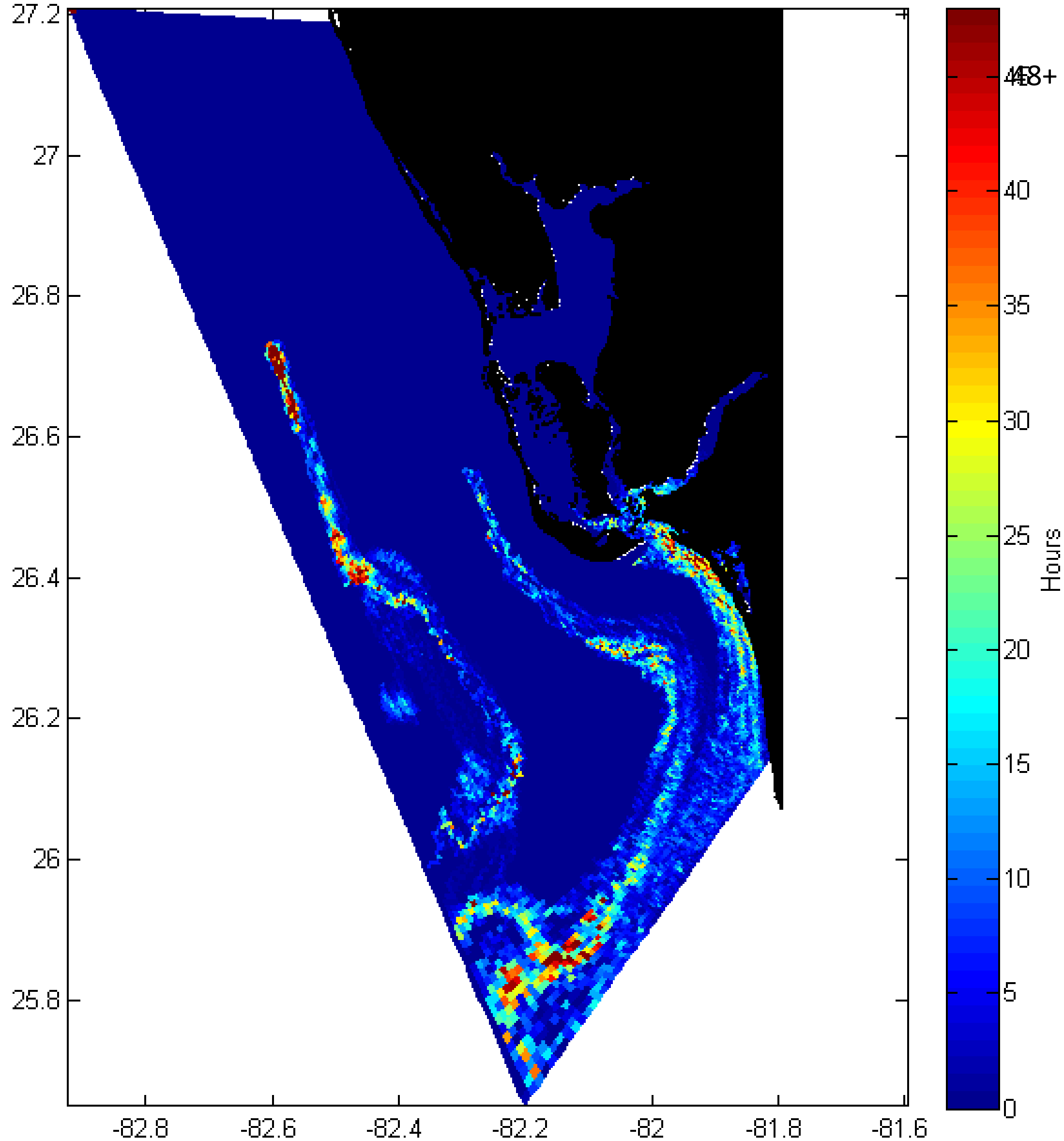


Fig. 7-26 Time each grid cell was occupied by bottom drifters originating from locations outside of the Caloosahatchee R. during the dry season with northwest winds.

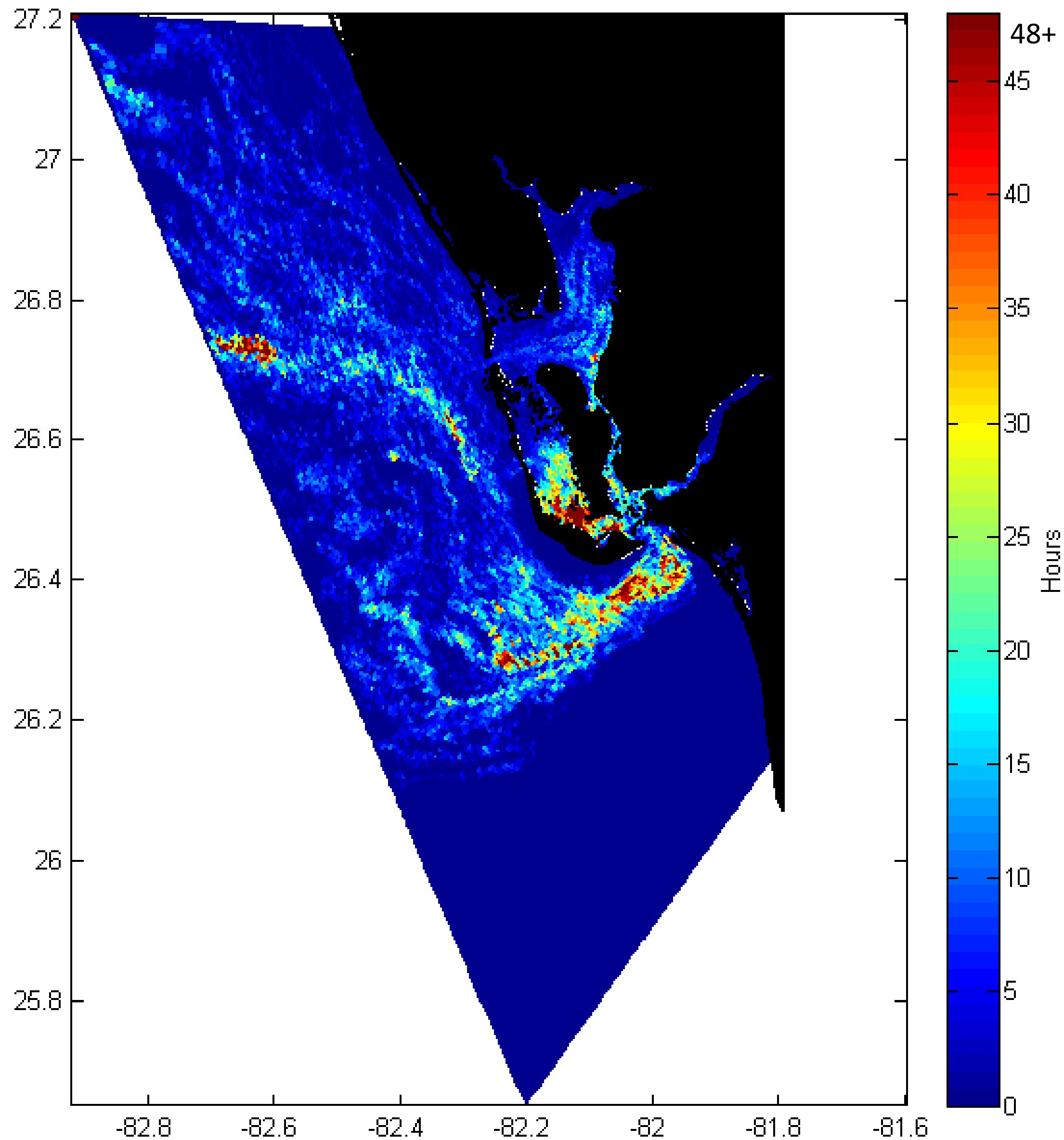


Fig. 7-27 Time each grid cell was occupied by bottom drifters originating from locations outside of the Caloosahatchee R. during the dry season with southwest winds.

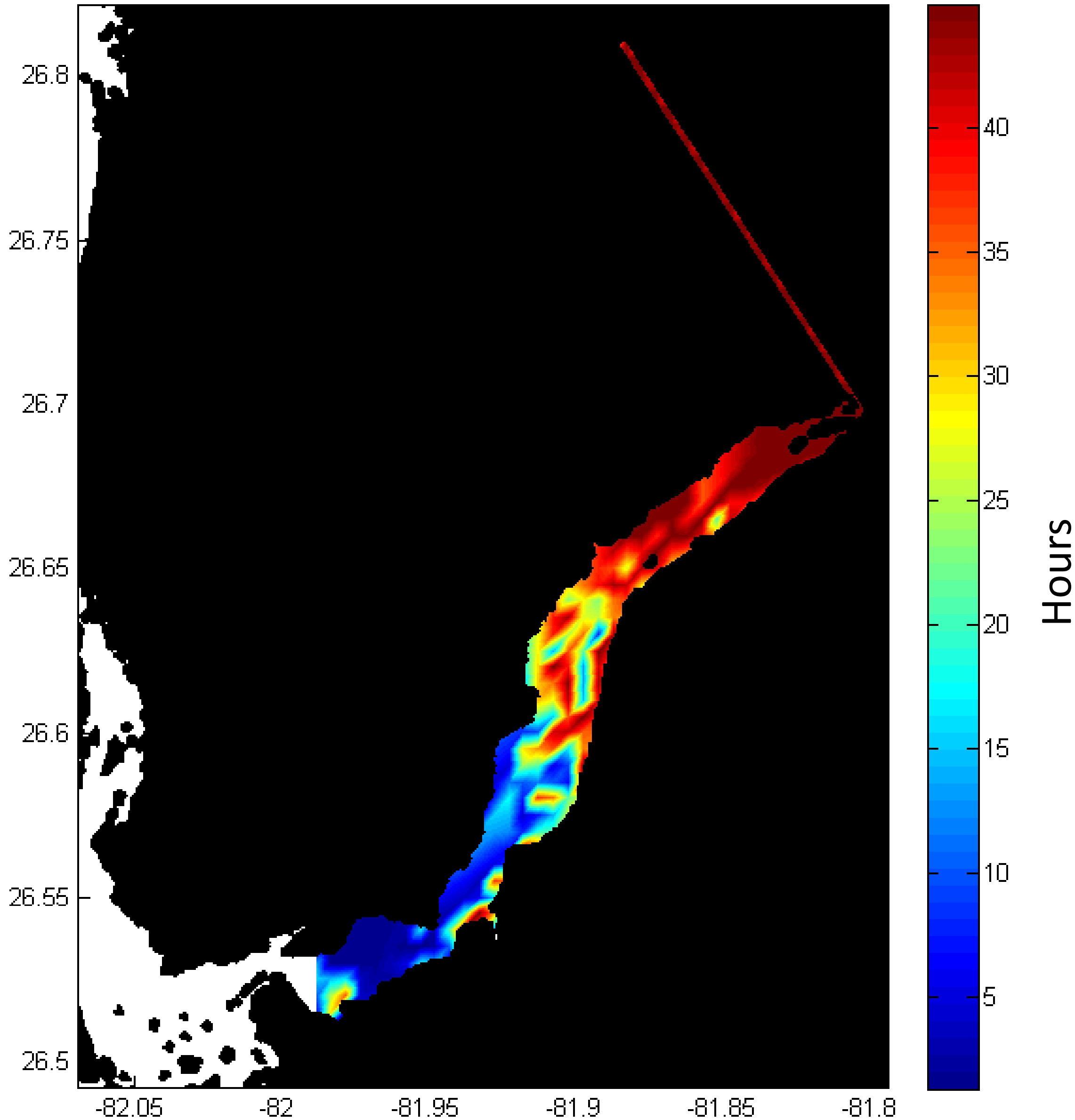


Fig. 7-28 Residence times of drifters in the Caloosahatchee R. during the dry season simulation

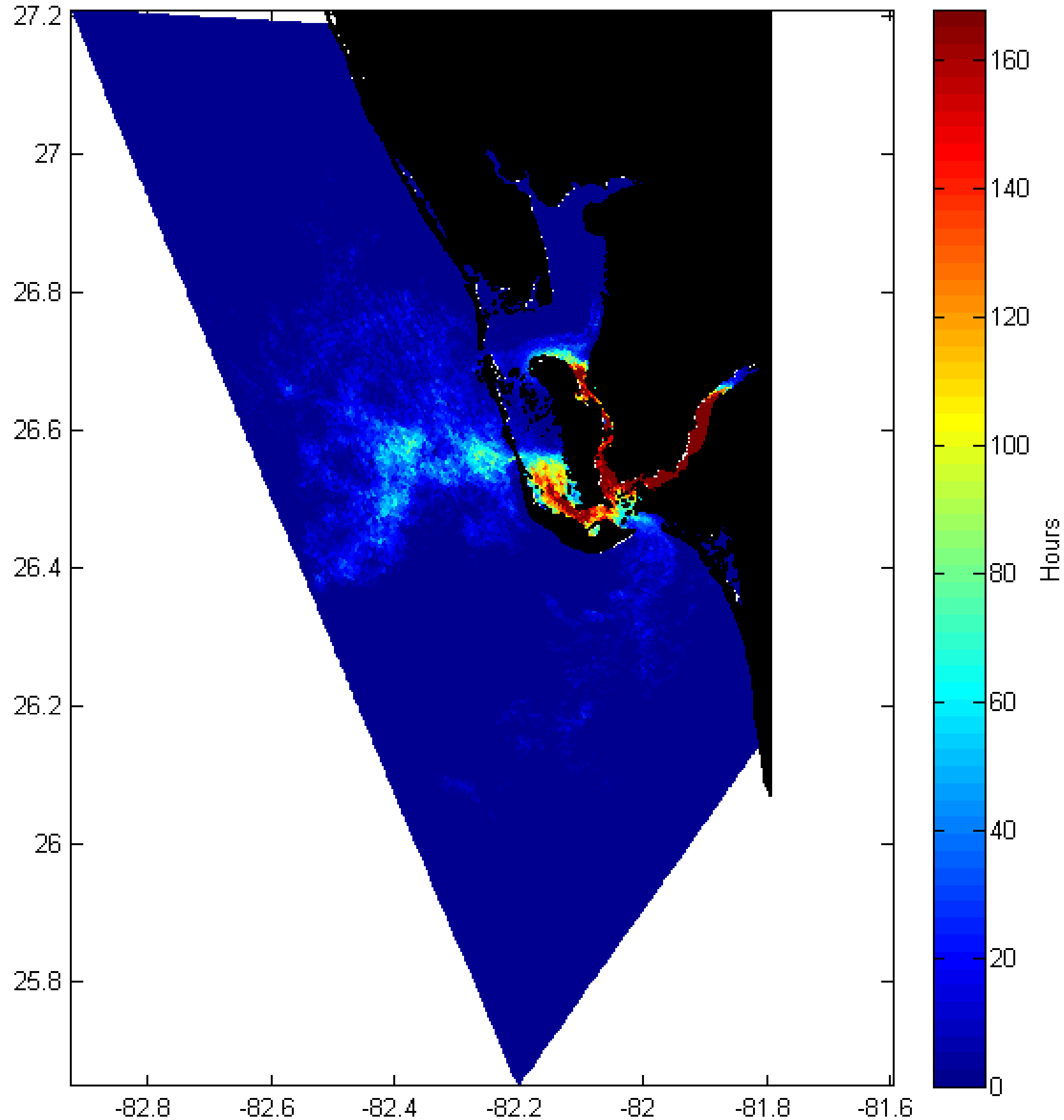


Fig. 7-29 Time each grid cell was occupied by drifters originating in the lower Caloosahatchee R. during the dry season with no wind forcing.

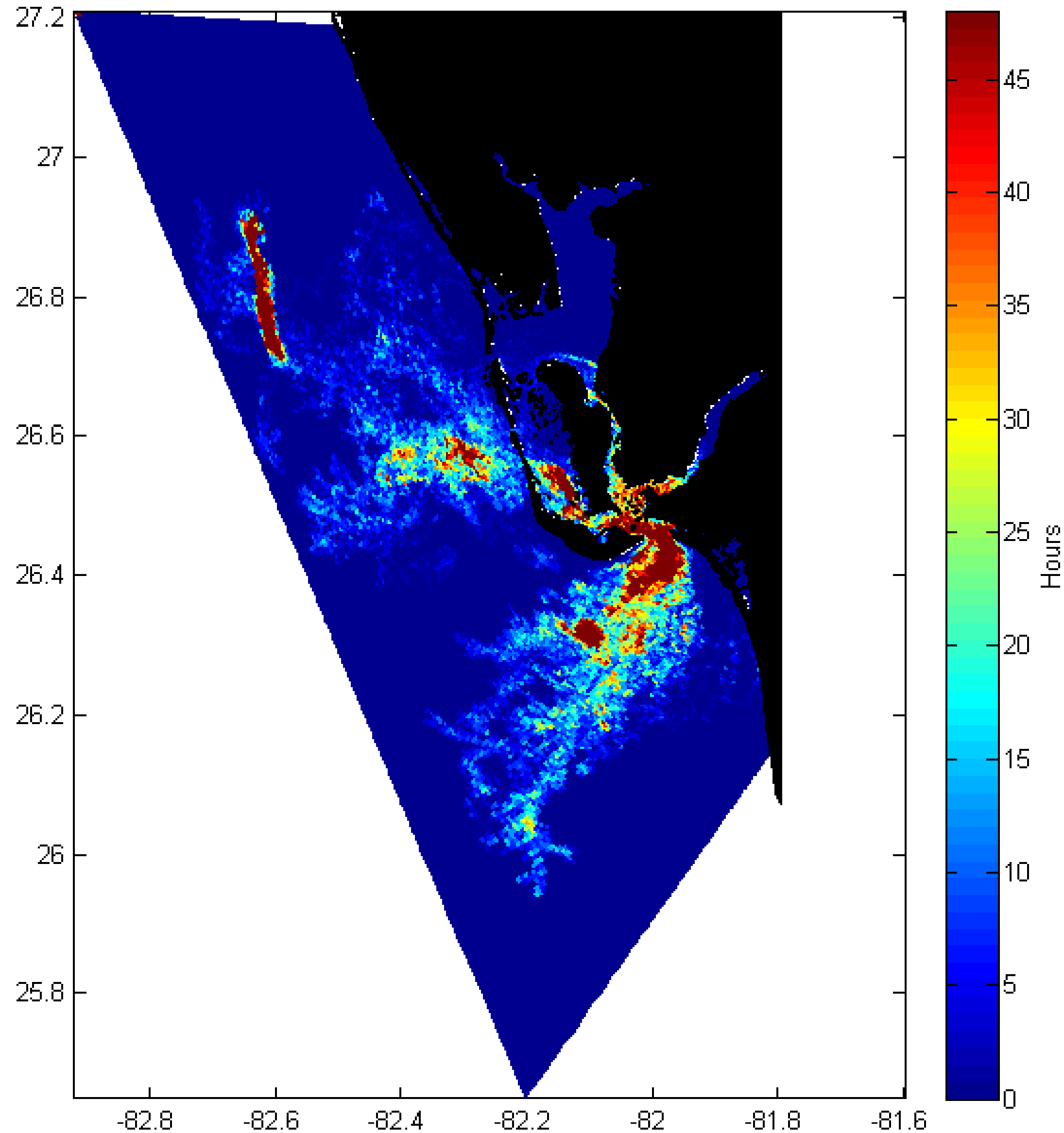


Fig. 7-30 Time each grid cell was occupied by bottom drifters originating from locations outside of the Caloosahatchee R. with no wind forcing during the dry season

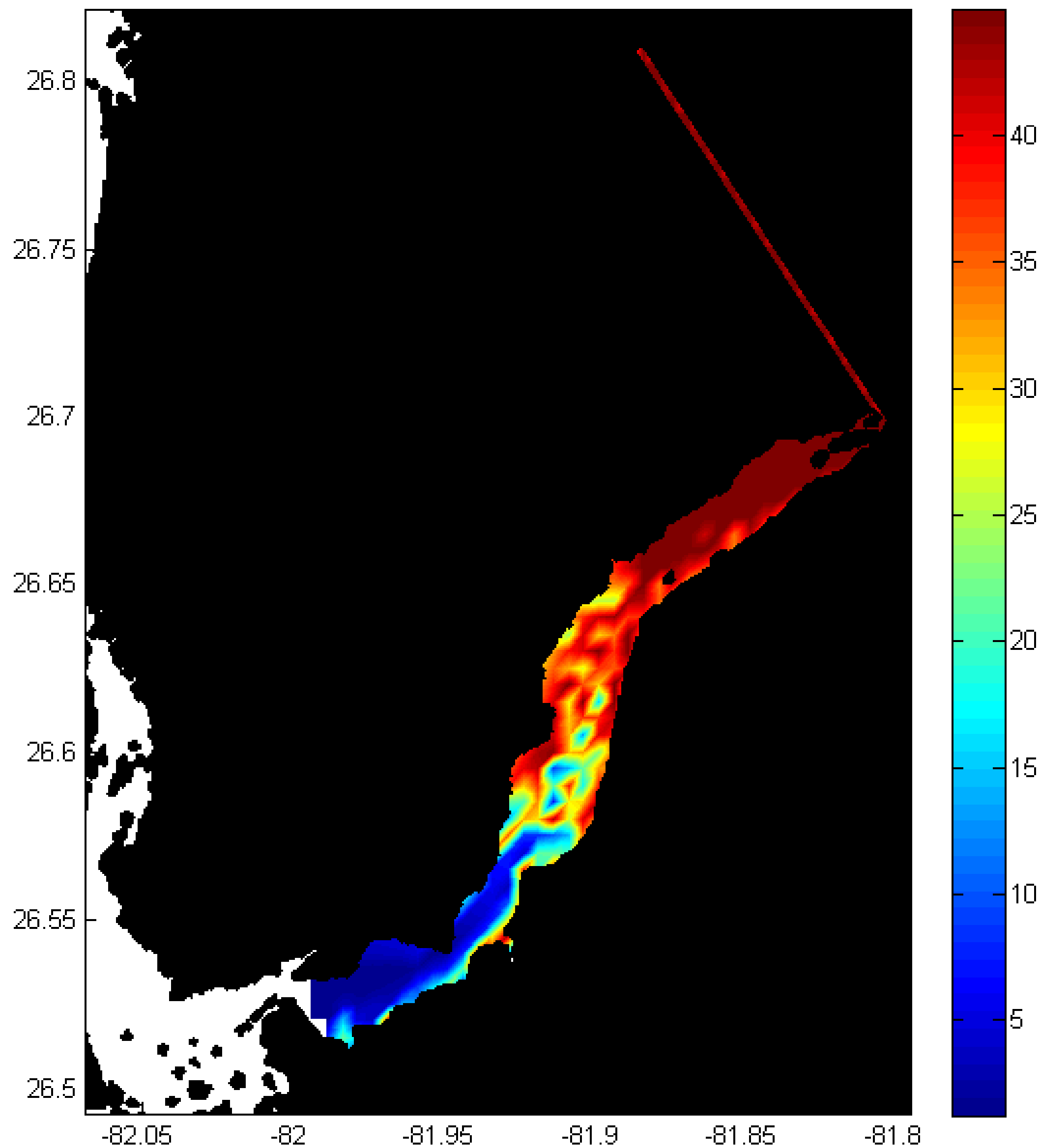


Fig. 7-31 Residence times of drifters in the Caloosahatchee R. during the dry season with no wind forcing simulation

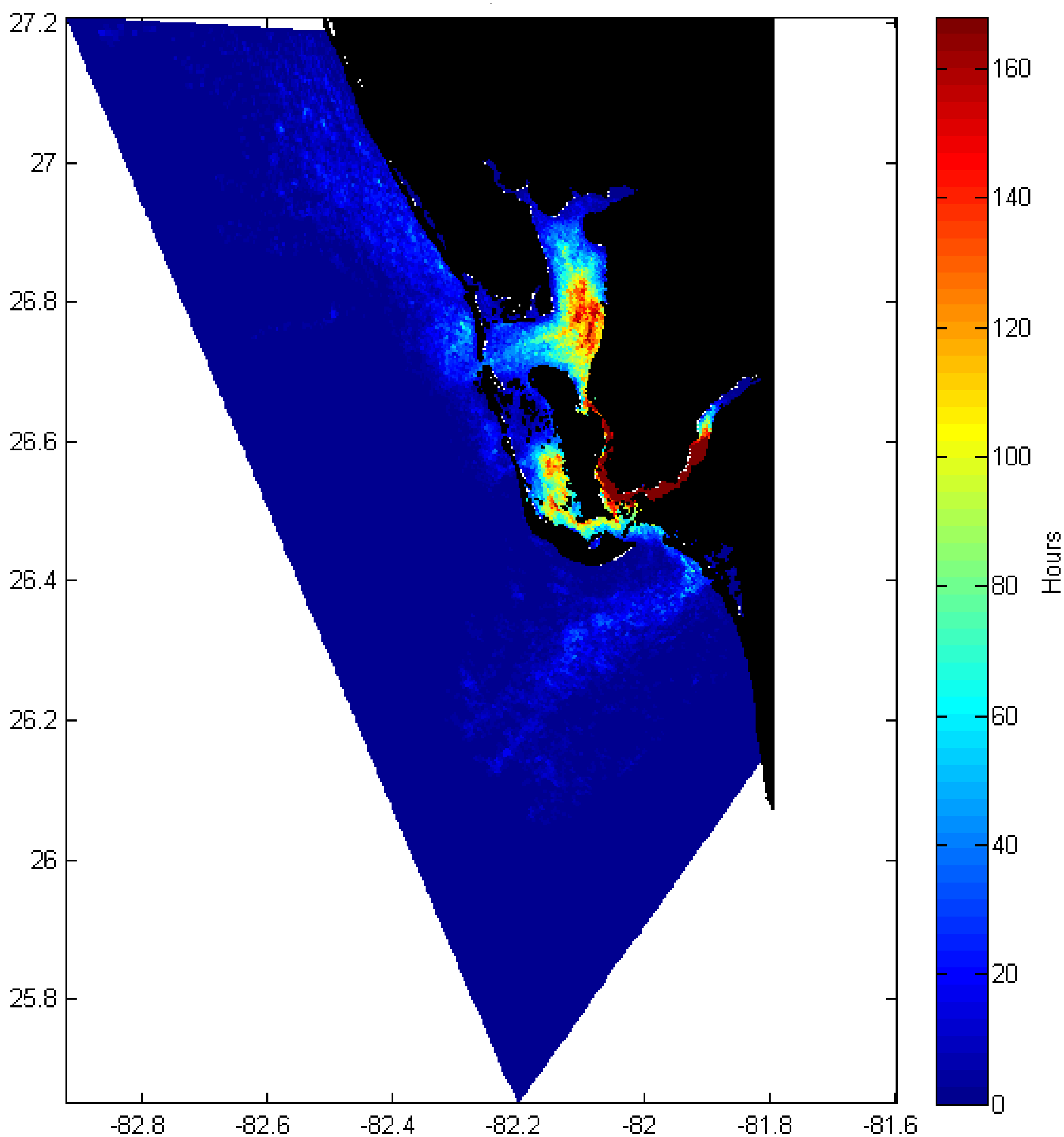


Fig. 7-32 Time each grid cell was occupied by drifters originating in the lower Caloosahatchee R. during high discharge in August 2008 with observed winds.

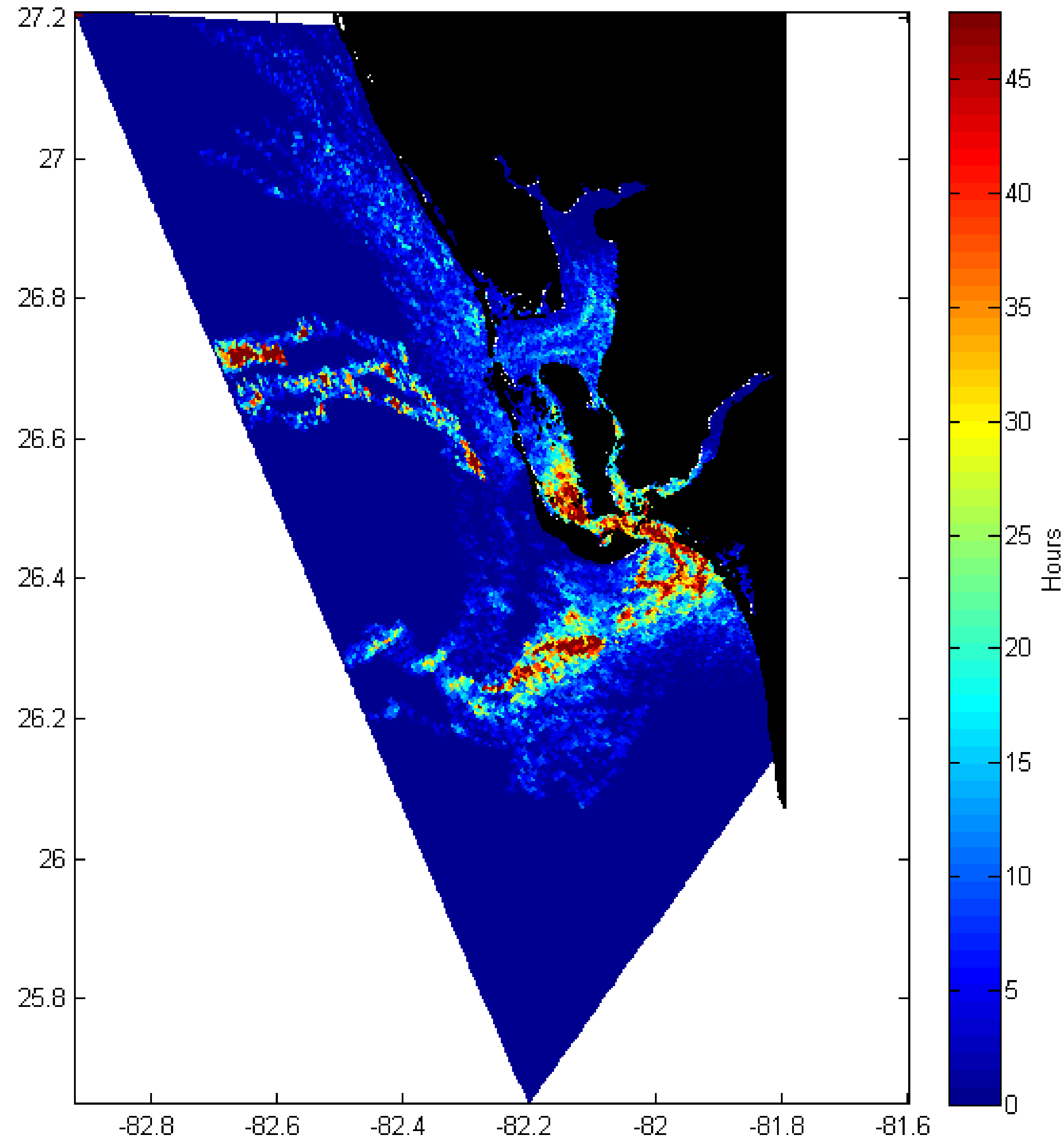


Fig. 7-33 Time each grid cell was occupied by bottom drifters originating from locations outside of the Caloosahatchee R. during high discharge in August 2008 with observed winds.

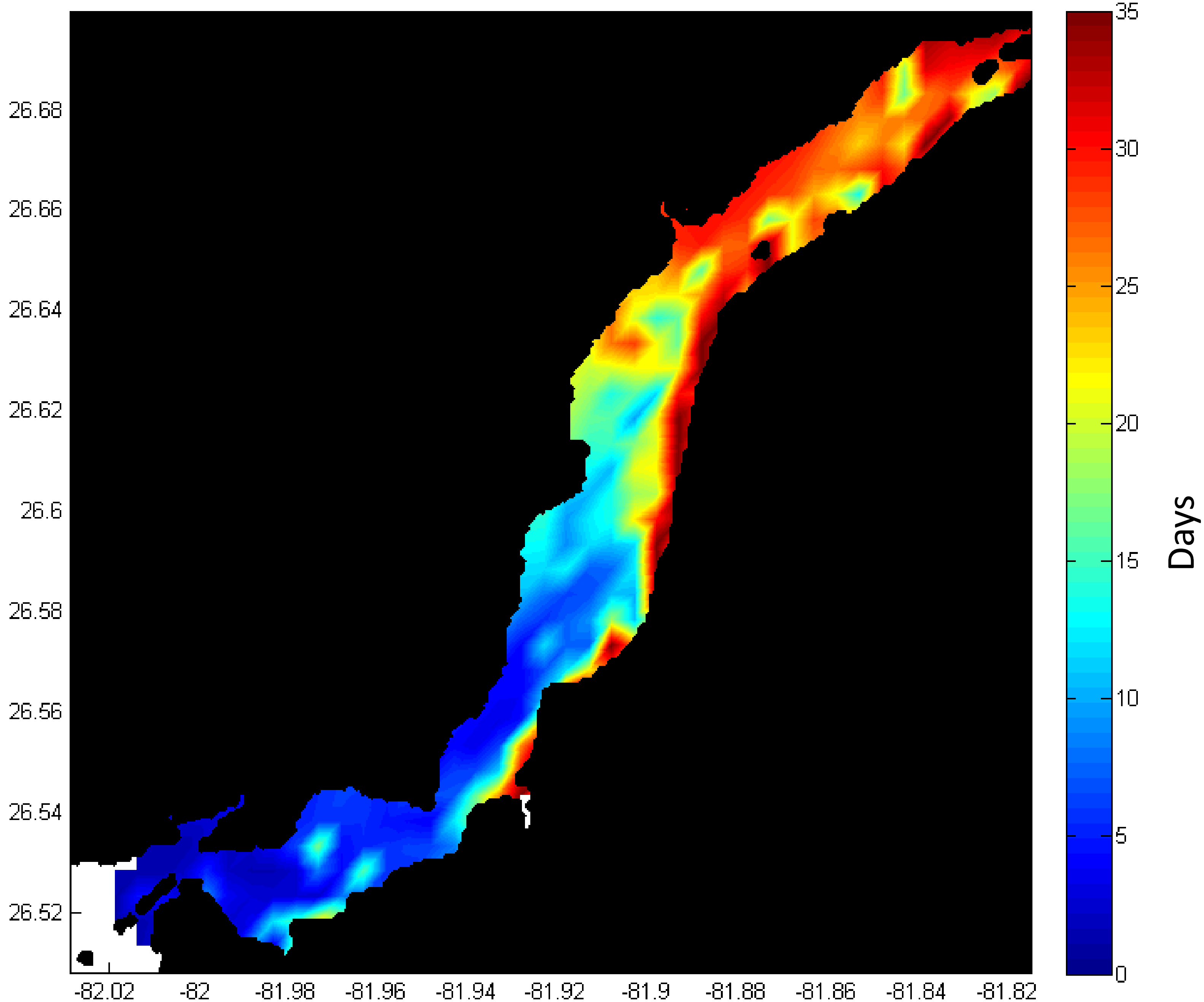


Fig. 7-34 Residence times of drifters in the Caloosahatchee R. during high discharge in August 2008 with observed winds.

Table 8.1. Nutrient loading figures for each sub-watershed within the Caloosahatchee Watershed. Please refer to Figure 8.1 for the locations of these sub-watersheds. Figures are provided for total nitrogen (TN) and total phosphorus (TP) in units of metric tons per year (mt/yr). Data were obtained from the Caloosahatchee River Watershed Protection Plan (2009).

Sub-watershed	Annual TN load (mt/yr)	Annual TP load (mt/yr)
Lake Okeechobee	1,950.9	104.46
S-4	93.0	13.58
East Caloosahatchee (S77 to S78)	460.4	41.26
West Caloosahatchee (S78 to S79)	1,121.9	118.29
Tidal Caloosahatchee (S79 to Shell Point)	863.6	118.22
Coastal (Shell Point to Causeway)	360.8	34.77
Total	4,850.6	430.65

Table 8.2. Average nutrient loads in metric tons/year (mt/yr) at S-77, S-78, S-79 in the Caloosahatchee (C-43) Basin (based on data from SFWMD DBHYDRO). Table adapted from SWFMD (2005).

Parameter	S-77	S-78	Increase (mt/yr)	S-79	Increase (mt/yr)
TN	1,087	1,287	210	2,635	1,338
TP	44.8	91.6	46.8	236	144.4
Period of Record	1973-2003	1998-2003			1981-2003

Table 8.3. Estimated 2000 existing water and nutrient loads within the Caloosahatchee River/Estuary Watershed Basin (from USACE and SFWMD 2005). Table adapted from SFWMD (2005).

Watershed Source	Flow (hm^3/yr)	TN load (mt/yr)	TP load (mt/yr)
Lake Okeechobee	680	1,127	48
Caloosahatchee (above S-79)	988	2,002 284	
Agriculture	640	1,469 218	
Urban/Disturbed	129	260	39
Upland Forest	89	97	4
Wetland/Water	130	176	23
Caloosahatchee (below S-79)	493	836 116	
Agriculture	101	187	25
Urban/Disturbed	270	503	77
Upland Forest	57	63	3
Wetland/Water	65	83 11	
Total Watershed	2,161	3,965	448

Table 8.4. Total nitrogen (TN) and phosphorus (TP) loadings for discharges into the Tidal Caloosahatchee during dry and wet season. Values are given as kilograms per day (kg/d) as reported by ERD (2003) and as metric tons per year (mt/yr) as reported elsewhere in this section of the report. The % increase between dry and wet season loadings is also provided for each input. "nd" indicates that the percentage could not be determined. The % of total discharges for the wet season is also calculated.

Site	dry season		wet season		dry season		wet season		% increase (dry to wet)		% of total (wet season)	
	TN (kg/d)	TP (kg/d)	TN (kg/d)	TP (kg/d)	TN (mt/yr)	TP (mt/yr)	TN (mt/yr)	TP (mt/yr)	TN	TP	TN	TP
Trout Creek	2.8	0.2	80	9.7	1	0.1	29.2	3.5	2757%	6353%	97%	98%
Telegraph Creek	8.5	0.3	329	24.1	3.1	0.1	120	8.8	3766%	8210%	97%	99%
Popash Creek	3.4	0.8	75	12.1	1.2	0.3	27.4	4.4	2112%	1376%	96%	94%
Daughtrey Creek	4.2	1.3	111	10.8	1.5	0.5	40.5	3.9	2556%	724%	96%	89%
Powell Creek	0	0	12.8	1.9	0	0	4.7	0.7	nd	nd	100%	100%
Hancock Creek	0.5	0.2	2.31	0.4	0.2	0.1	0.8	0.1	344%	64%	82%	67%
Billy Creek	-0.3	-0.1	25.3	5.5	-0.1	-0.04	9.2	2	8624%	5380%	101%	102%
Whiskey Creek	0.3	0.02	19	2.4	0.1	0.01	6.9	0.9	6233%	12050%	98%	99%
Orange River	97.9	4.2	356	26.2	35.7	1.5	130	9.6	264%	527%	78%	86%
S79	2,408	355	11,051	1,040	879	129.6	4,034	380	359%	193%	82%	75%
Waterway Estates STP	3.7	0.2	5.5	0.3	1.4	0.1	2	0.1	47%	63%	60%	60%
Fort Myers South STP	40	8.3	108	15.8	14.6	3	39.4	5.8	170%	90%	73%	66%
Fiesta Village STP	5	0.3	7.7	0.7	1.8	0.1	2.8	0.3	54%	119%	61%	70%
Fort Myers Central STP	28.7	3.2	81.6	4.8	10.5	1.2	29.8	1.7	184%	49%	74%	60%
Total (or average %)					950	136	4,476	421	2113%	2708%	85%	83%

Table 8.5. Nutrient loading figures total nitrogen (TN) and phosphorus (TP in metric tons per year (mt/yr) for the Tidal Caloosahatchee Watershed (from CHNEP 1999). Each sub-watershed refers to a location shown on Figure 8.2.

Sub-watershed	TN (mt/yr)	TP (mt/yr)
Pine Island Sound/Matlacha Pass	236	70
Telegraph Swamp	77	15
Orange River	201	54
Lower Caloosahatchee	391	83
Total	905	221

Table 8.6. Total nitrogen (TN) and phosphorus (TP) loading (mt/yr and %) of the various land use activities within the Pine Island Sound/Matlacha Pass sub-watershed (data from CHNEP 1999).

Land use type	TN		TP	
	mt/yr	%	mt/yr	%
Residential	29	12%	5	6%
Commercial	3	1%	0	1%
Industrial	36	15%	6	9%
Mining	1	0%	0	0%
Utilities, other	1	0%	0	0%
Range lands	93	39%	46	67%
Barren lands	2	1%	0	0%
Pasture	5	2%	2	3%
Groves	1	0%	0	0%
Feedlots	1	1%	0	0%
Nursery	1	0%	0	0%
Row and field crops	1	0%	0	1%
Upland forests	63	27%	9	13%
Total	236	100%	69	100%

Table 8.7. Total nitrogen (TN) and phosphorus (TP) loading (mt/yr and %) of the various land use activities within the Telegraph Swamp, Orange River, and Lower Caloosahatchee sub-watersheds (data from CHNEP 1999).

	Telegraph Swamp				Orange River				Lower Caloosahatchee			
	TN		TP		TN		TP		TN		TP	
Land use type	mt/yr	%	mt/yr	%	mt/yr	%	mt/yr	%	mt/yr	%	mt/yr	%
Residential	0	2%	0	0%	71	35%	11	22%	154	39%	24	29%
Commercial	0	0%	0	0%	2	1%	0	0%	26	7%	4	4%
Industrial	0	0%	0	0%	4	2%	1	10%	7	2%	1	1%
Mining	0	0%	0	0%	2	1%	0	10%	5	1%	1	1%
Utilities, other	0	0%	0	0%	4	2%	0	0%	8	2%	1	1%
Range lands	2	2%	1	6%	51	25%	25	47%	24	6%	12	15%
Barren lands	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Pasture	25	33%	7	49%	18	9%	5	10%	91	23%	28	33%
Groves	0	0%	0	0%	1	0%	0	0%	1	0%	0	0%
Feedlots	0	0%	0	0%	27	14%	5	10%	4	1%	1	1%
Nursery	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Row and field crops	0	0%	0	0%	4	2%	1	3%	9	2%	4	4%
Upland forests	50	65%	7	45%	21	10%	3	6%	62	16%	9	11%
Total	77	100%	15	100%	201	100%	54	100%	391	100%	83	100%

Table 8.8. Total nitrogen (TN) and phosphorus (TP) loadings from known sources into the Tidal Caloosahatchee. Estimated seasonal loadings are given in italics (see text).

	Dry Season		Wet Season		Total Annual		Percent Annual	
Inputs	TN (mt/yr)	TP (mt/yr)	TN (mt/yr)	TP (mt/yr)	TN (mt/yr)	TP (mt/yr)	TN (%)	TP (%)
[1]Lake Okeechobee	*293*	*17.8*	*1,658*	*86.7*	1,951	104	27	18
[1]S-4	*14*	*2.3*	*79*	*11.3*	93.0	13.6	1	2
[1]East Caloosahatchee (S-77 to S-78)	*69*	*7.0*	*391*	*34.2*	460	41.3	6	7
[1]West Caloosahatchee (S-78 to S-79)	*168*	*20.1*	*954*	*98.2*	1,122	118	16	20
Total S-79	*544*	*47.2*	*3,082*	*230*	3,626	278	51	47
[2]Total Sewage Treatment Plants (STP)	28.3	4.4	74	7.9	102	12.3	1	2
[3]Total Non-point Sources (S-79 to Shell Point)	*114*	*18*	*647*	*88*	761	106	11	18
[1]Total Tidal Caloosahatchee (S-79 to Shell Point)	*142*	*22*	*721*	*96*	864	118	12	20
[1]Coastal (Shell Point to Causeway)	*54*	*6*	*307*	*29*	361	34.8	5	6
[4]Submarine Groundwater	1,245	81.0	511	76.1	1,756	157	25	27
[5]Sediment Fluxes (S-79 to Shell Point)	179	5.48	*179*	*5*	358	11	5	2
[6]Sediment Fluxes (San Carlos Bay)	208	37.8	-70.5	-46.9	137	-9.1	2	-2
Total Sediment Fluxes	387	43.3	108	-41.4	495	1.9	7	0
Total Inputs	2,372	200	4,729	390	7,101	590	100	100

[1]From Table 8.1 (CRWPP, 2009); seasonal loadings were estimated (see text).

[2]From Table 8.4 (ERD, 2003).

[3]Total non-point sources are calculated by subtracting the total STP loads from the total Tidal Caloosahatchee loads. Seasonal loadings were estimated (see text).

[4]From Objective 3 (this study, see text).

[5]South Florida Water Management District (2008); wet season loadings were estimated (see text).

[6]From Objective 2 (this study, see text).

Table 8.9. Total nitrogen (TN) and phosphorus (TP) Residence Times for Tidal Caloosahatchee.

Inputs	Dry Season TN	Dry Season TP	Wet Season TN	Wet Season TP
[1]Total Inputs (mt/yr)	2,372	200	4,729	390
Total Inputs (kg/d)	6,498	547	12,957	1,068
[2]Average Concentration (ug/L)	918	59.9	999	84.3
Average Concentration (kg/m3)	9.18E-04	5.99E-05	9.99E-04	8.43E-05
[3]Total Volume (m3)	1.36E+08	1.36E+08	1.36E+08	1.36E+08
Residence Time (days)	19	15	10	11

[1]From Table 8.8.

[2]From Objective 1 (this study, see text).

[3]From C. Buzzelli (personal communication).

Figure 8.10: Average monthly discharges (cfs) and rainfall (inches) recorded at S-79 (data from DBHYDRO) for three time periods: 2003 – 2005 (P1); 2005 – 2007 (P2); and 2008 – 2010 (P3). The Multivariate ENSO Index (MEI) indicates El Niňo conditions (positive values) and La Niňa conditions (negative values). MEI data are from the Earth System Research Laboratory, NOAA.

Period	**P1 2003-2005**	**P2 2005-2007**	**P3 2008-2010**	**% diff P1 vs P3**
Average flow through S79	3810	2260	1467	61%
Maximum monthly-averaged flow through S79	11592	11592	5815	50%
Average rainfall at S79	0.42	0.32	0.13	69%
Maximum monthly-averaged rainfall at S79	2.80	2.28	0.53	81%
Average flow through S79: dry season (Dec - May)	1689	967	850	50%
Maximum monthly-averaged flow through S79: dry season (Dec - May)	3860	5726	4674	-21%
Average precipitation at S79: dry season (Dec - May)	0.10	0.06	0.08	26%
Maximum monthly-averaged precipitation at S79: dry season (Dec - May)	0.23	0.23	0.27	-16%
Average flow through S79: wet season (Jun - Nov)	5707	3235	2116	63%
Maximum monthly-averaged flow through S79: wet season (Jun - Nov)	11592	11592	5815	50%
Average precipitation at S79: wet season (Jun - Nov)	0.74	0.57	0.18	75%
Maximum monthly-averaged precipitation at S79: wet season (Jun - Nov)	2.80	2.28	0.53	81%
MEI	0.39	0.09	-0.23	159%

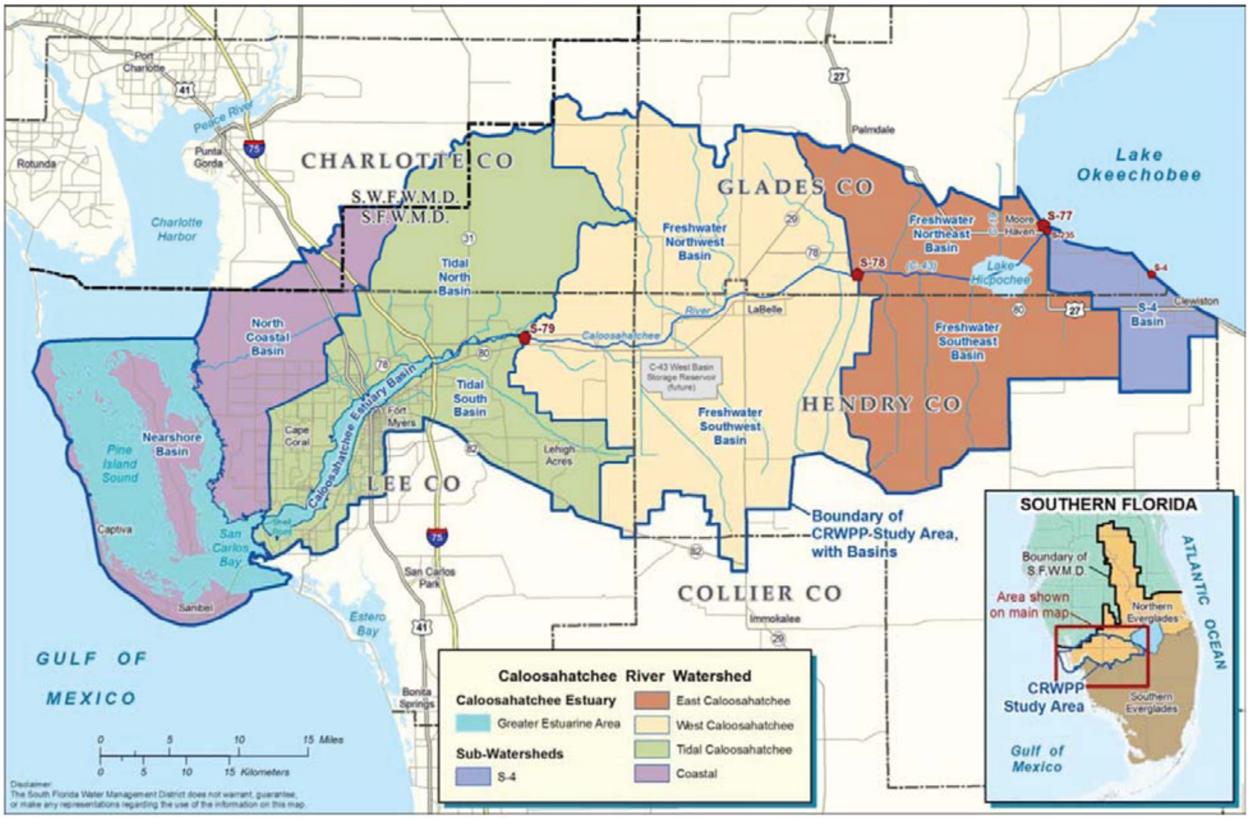


Figure 8.1. Caloosahatchee River watershed and sub-basin watershed map (adapted from CRWPP 2009).

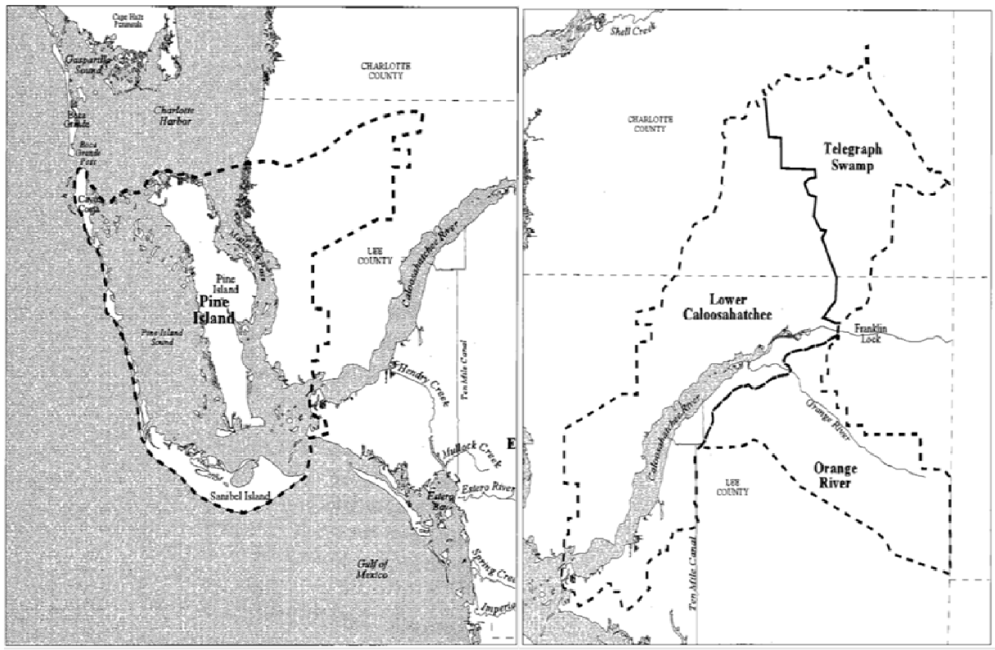


Figure 8.2. The sub-watersheds of Pine Island Sound/Matlacha Pass (left) and the Lower Caloosahatchee, Telegraph Swamp, and Orange River (right). Adapted from CHNEP (1999).

Table 9.1. Lee Counties logged artificial reef additions by year, with reef relief totals (height from depth). Information about spread, or length of additions was not available.

Year	**Added Reef Relief Totals (ft)**
2008	16
2007	135
2006	73
2005	29
2004	34
2003	8
2002	39
2001	74
2000	109
1999	64
1998	32
1997	80
1996	no Data
1995	12
1994	46
1993	166
1992	8
1991	8
1989	26
1988	14
1987	no data
1986	no data
1985	no data
1984	no data

Table 9.2. Species list for trawls completed in October of 2009 and April of 2010. The relative occurrence of each species is also listed, from abundant, common to uncommon, or rare.

Genus species	Common Name	Relative Occurrence Oct-2009	Relative Occurrence Apr-2010
**Lagodon rhomboides*	Pinfish (diet size shift)	abundant	abundant
**Nicholsina usta*	Emerald parrotfish	uncommon	uncommon
Echinaster sentus	Spiny seastar	common	common
Paralichthys lethostigma	Gulf flounder	common	common
Orthopristis chrysoptera	Pigfish	abundant	abundant
Serranus subligarius	Belted sandfish	uncommon	common
Chaetodipterus faber	Spade fish	uncommon	common
Sphoeroides nephelus	Southern pufferfish	common	common
Syngnathinae spp.	Pipefish	common	common
Parablennius marmoreus	Seaweed blenny	common	common
Scartella cristata	Molly miller blenny	uncommon	common
Panopeus sp.	Mudcrab	abundant	abundant
Haemulon favolineatum	Grunt	common	abundant
Acanthostracion sp.	Cowfish	common	common
Hippocampus sp.	Seahorse	uncommon	uncommon
Opsanus tau	Oyster toadfish	uncommon	uncommon
Diplodus argenteus	Porgie	common	common
Lactophrys sp.	Trunkfish	common	common
Monacanthus ciliatus	Filefish	abundant	uncommon
Eucinostomus argenteus	Spotfin mojara	common	common
Prionotus scitulus	Sea robin	uncommon	uncommon
Amaroucium stellatum (?)	Sea pork probably	common	common
Penaid spp.	commercial shrimp	abundant	abundant
Bairdiella chrysoura	Silver perch	uncommon	uncommon
Diopatra cuprea	Onuphid worm	uncommon	uncommon
Libinia spp.	Spider crabs	common	common
Tozeuma carolinense	Arrow shrimp	uncommon	common
**Lytechinus variegatus*	Varigated sea urchin	uncommon	uncommon
Ogcocephalus nasutus	Shortnose batfish	rare	uncommon
Metaporhaphis calcarata	Long leg crab	rare	rare
Scorpaena brasilensis	Scorpion fish	uncommon	uncommon
Lutjanus synagris	Lane snapper	abundant	common
Chilomycterus atinga	Striped burrfish	common	common
Lutjanus griseus	Mangrove snapper	abundant	uncommon
Epinephelus itajara	Goliath grouper	common	rare
Petrolisthes spp.	Porcelain crabs	abundant	abundant
Mycteroptera microlepis	Gag grouper	uncommon	rare
Archosargus probatocephalus	Sheepshead	uncommon	common
Callinectes sapidus	Blue Crab	uncommon	uncommon

* Indicates potential macroalgae grazer species.

Table 9.3. Palatability designated based on the literature. Column 1, the % of each individual species contributes to overall study combined biomass. Column 2 from Steneck and Watling (1985) with palatability based on the algal morphology. Colum 3 from Duffy and Hay (1990), based on algal "tolerance" to herbivory from low (unable to withstand heavy grazing) to high (turfy, will not affect entire plant). Column 4 from Littler and Littler (1980), scale using successional stage of algae with early colonizers susceptible to grazers, late successional species or less susceptible stages. Column 5 from Cobb and Lawrence (2005), diet preferences of two urchin species, *Lytechinus variegatus* ("L") and *Arbacia punctulata* ("A"). Scale also includes preferrred "+" or "-" avoided. Column 6 from Klinger (1982) uses feeding apparatus (Aristotle's lantern) ease of algal manipulation (not flat or blade-like). This scale is the effectiveness of urchin feeding on algae, easy for urchins to ingest vs. hard to ingest.

2010	% of Total Biomass	Steneck and Watling, 1985	Duffy and Hay 1990	Littler and Littler, 1980	Cobb and Lawrence, 2005	Klinger 1982
**Spyridia filamentosa*	9.2	1	2	1		easy
Chondria collinsiana	5.9	2	3	2		mod
Polysiphonia flaccidissima	5.7	1	2	1		easy
Ŧ *Gracilaria tikvahiae*	5.6	2	3	2		mod
**Gracilaria blodgettii*	4.8	2	3	2		mod
2009						
**Hypnea spinella*	9.6	2	3	2		mod
**Acanthophora spicifera*	6.3	2	3	2		mod
* Ŧ *Solieria filiformis*	5.8	2	3	2		mod
Ŧ *Gracilaria tikvahiae*	5.6	2	3	2		mod
* Ŧ *Botryocladia occidentalis*	5.4	2	3	2	L+,A+	mod
2008						
* Ŧ *Solieria filiformis*	12.8	2	3	2		mod
* Ŧ *Botryocladia occidentalis*	12.4	2	3	2	L+,A+	mod
**Gracilaria blodgettii*	10.7	2	3	2		mod
**Hypnea spinella*	9.4	2	3	2		mod
Ŧ *Gracilaria mammillaris*	6.4	3	4	2		hard

*****Indicates species used single species feeding trials; **Ŧ**, indicates species used in multiple choice experiments.

Table 9.4. Field notes and dates of deployment and assessment of exclusion cages. Note: three-1 m quadrats were placed at each site at random locations, field notes are as follows: L = *Lytechinus variegatus*, A = *Arbacia punctulata*, P = Pen shells.

Site	Date deployed	Check date	Check date	Check date	Check date	Check date	Check date
Redfish Pass RECON	June 9 2010	July 8, 2010	July 13, 2010	Aug. 9, 2010	Aug. 17, 2010	Sept.14, 2010	Note: Cages pulled
Notes		Some algae outside of cages on shells, light fouling, no algae inside cages, 1 cage pulled because of missing rebar	Redeployed cage #166, algae growing inside cages at 5% cover, 1 m^2 quadrats: (1) 15, (2) 10 and (3) 10 % cover, observed same species inside and outside (*G. mammillaris*)	No visibility, cages could not be seen	No urchins, no algae inside or outside. 1 cage is completely blocked by encrusting bryozoans and hard things, no light getting in.	All cages severely fouled, pulled for cleaning.	
Blind Pass RECON	June 9, 2010	July 8, 2010			Aug 17, 2010	Sept ember 14, 2010	
Notes		Light fouling, no algae inside			No visibility, cages could not be seen	Very bad visibility, seemed to be intact, no algae	No algae found in any cages, but algae found in 1 m^2 quadrats outside cage; (1) 15 % Cover, no urchins, (2) 25 % cover, no urchins, (3) 25 % cover, no urchins. Algae identified as *Gracilaria tikvahiae* and *Spyridia filamentosa*
GOM10	June 7, 2010	July 7, 2010	July 28, 2010		August 19, 2010	September 17, 2010	
Notes		1 cage missing, other one up above the sediment from possible scouring. Cage fixed, 2 cages remained	1 cage re-deployed, hitting hard bottom with rebar. 2 cages above the sediment level.		2 cages left, both above the sediment line. Rebar could not be pounded in.	Cages still above the sediment, concluded experiment at this site in September.	

Table 9.4 cont. Field notes and dates for deployment and checking of exclusion cages. Note, three-1 m^2 quadrats were placed at each site at random locations, field notes are as follows: L=*Lytechinus variegatus*, A=*Arbacia punctulata*, P=Pen shells.

Site	Date deployed	Check date	Check date	Check date	Check date	Check date	Check date
GOMRECON	April 29, 2010	May 12 and May 27, 2010	July 14, 2010		August 15, 2010	September 17, 2010	October 19, 2010
Notes		Light fouling, no algae inside. May 27- No algae inside, numerous small urchins	2 of 4 cages were above sediment level, no algae outside or inside cages. Light fouling, no urchins of any size.		Very poor visibility, cages intact, no algae or urchins observed	2 of 4 cages above sediment line, 1 stone crab inside, no algae however; one cage pulled as it could not be inserted into sediment. Outside 1 m^2 quadrats: (#1) 2L; (#2) 3L; (#3) 1L	No algae found in any of the cages, 1 m^2 quadrats.:(1) 5L, 6A (2) 14L (3) 3L, urchins found inside cages also; (1) 8 L inside, (2) 7 A, 10 L inside (3) 7L inside. All cages removed.
GOM04	July 7, 2010			July 28, 2010	August 19, 2010	September 17, 2010	October 13, 2010
Notes				No urchins, 1% algae in cage #160 (drifting *Halymenia* sp.) quadrats: (1) 1% algae cover (*Halymenia* sp.), no urchins,(2) nothing,(3) nothing	No algae inside or out, quadrats: (1) 2P, 2L; (#2) 2P 1A; (#3) 3P	Not many urchins outside of cages, those observed on cage itself outside. Quadrats: (#1) 3P, 1L; (#2) 2P; (#3) 3P, 1L, a school of spadefish observed surrounding cages; no urchins inside of cages, all cages intact. Very small individual *G. mammillaris* found in 1 cage, (<1%). Jellyfish abundant.	Small urchins found in cages. Also algae found inside of cages: % cover per cage (#1) 100% cover, with 8 small urchins inside; (#2) 25% with 1 small urchin inside; (#3) 40% cover, with 5 small urchins inside. Quadrats outside cages (#1) 10% algal cover, 3 *Arbacia;* (#2) 5 % algal cover with 1 *Arbacia*; (#3) 25% algae with 5 *Arbacia* outside. Algal species both and outside the cages identified as *Agardhiella subulata*, and *Botryocladia occidentalis*.

Table 9.4 Cont. Field notes and dates for deployment and checking of exclusion cages (see above).

Site	**Date deployed**	**Check date**	**Check date**	**Check date**	**Check date**	**Check date**	**Check date**
GOM03	July 7, 2010			July 28 2010	August 19 2010	September 17, 2010	October 13, 2010
Notes				Quadrats: (#1)1L 1P; (#2) 2L; (#3) 3L 1P, no algae in cages. Cage #1, 8 *Lytechinus* inside, sand was scoured around cage edge.	Cage: (#1) urchins inside; (#2) 10 urchins inside; (#3) 12 urchins inside, 1 flounder and also a red drum inside. Quadrats: (#1) 12L; (#2) 1P, 13L; (#3) 2P, 4L,; lots of very small *Lytechinus* outside	Quadrats: (#1) 5L; (#2) 5L; (#3) 10L; no algae inside or outside, very poor visibility. Small *Lytechinus*, about 2 inches, some small enough to fit through cage mesh, within 3 cages 8, 5 and 2 urchins inside cages, respectively.	No algae found, Quadrats: (#1) 1L; (#2) 3L; (#3) 1A, 1L. One of three cages were securely attached, others were laying on their sides, with several legs detached and still in the sediment. One had a stone crab. A number of juvenile fish in area, including Atlantic spadefish and snapper individuals.
GOM01	July 7, 2010			July 28, 2010	August 19, 2010	September 17, 2010	October 13, 2010
Notes				No algae, lots of *Arbacia*. Quadrats: (1) 2L 1A,(2) (3)1A 1P, 1P 1 seastar.	1 cage missing, lots of small *Lytechinus*, replaced cage. Quads: (#1) 2L; (#2) 6L; (#3) 1P, 2L.	Cages not found, too poor visibility.	No algae found, cages intact. Inside cages: (#1) 3L; (#2) 5L; (#3) 8L. Quadrats: (#1) 1P, 5L; (#2) 1A 6L; (#3) 10L.
Light 1	July 7, 2010			July 28, 2010	August 19, 2010	September 17, 2010	October 13, 2010
Notes				Cage #1 partly open on top, more cableties used. Light fouling, all cages in sediment. Quadrats outside: (#1) 1 L, 1 A; (#2) 1L 1P; (#3) 1A 1L. No algae outside.	No algae, light fouling, small *Lytechinus*, 1 cage missing. Did not replace. Other cages intact.	Replaced 1 cage, 2L, 3A urchins in one cage; flounder inside also. Quadrats: (#1) 5L; (#2) 3L; (#3) 1L;	No algae found, all three cages were intact, with small urchins inside. Cage: (#1) 3L; (#2) 3L; (#3) 1A. Quadrats : (#1) 4L; (#2) 1A, 1L; (#3) 1P, 1A

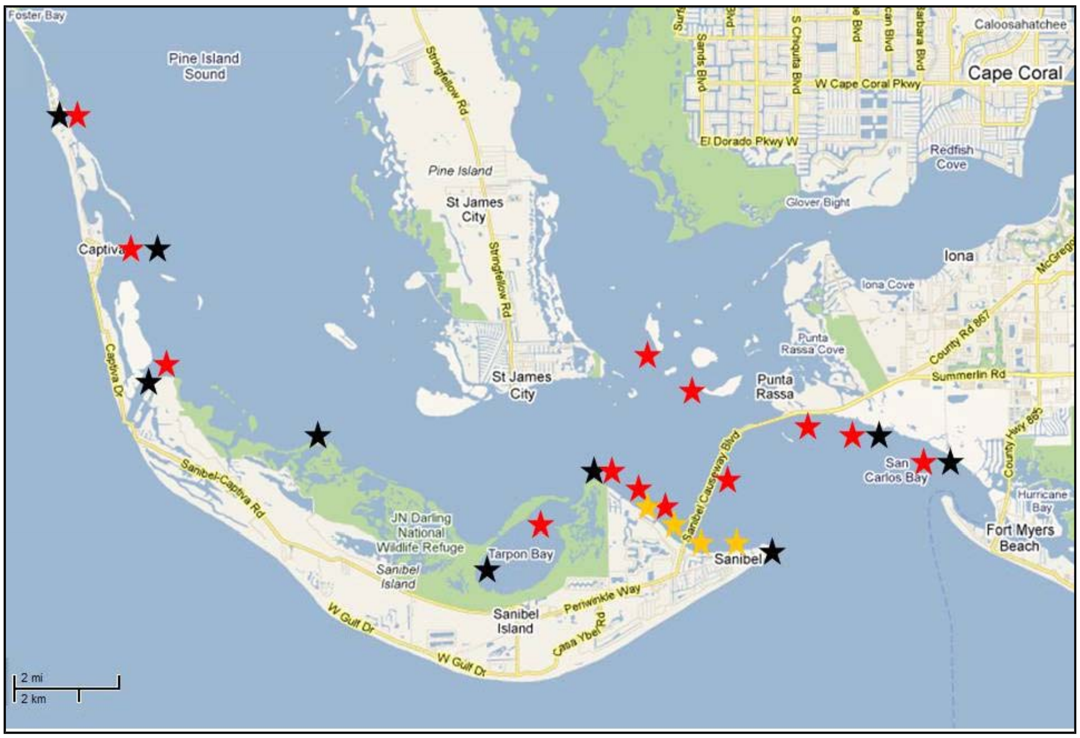


Fig. 9.1. Trawls made in October 2009 (black) and April 2010 (red). A survey made on September 10, 2010 by L. Coen and M. Thompson (orange), indicated that areas just east and west of the causeway have urchins 1-2 per m^2 also.

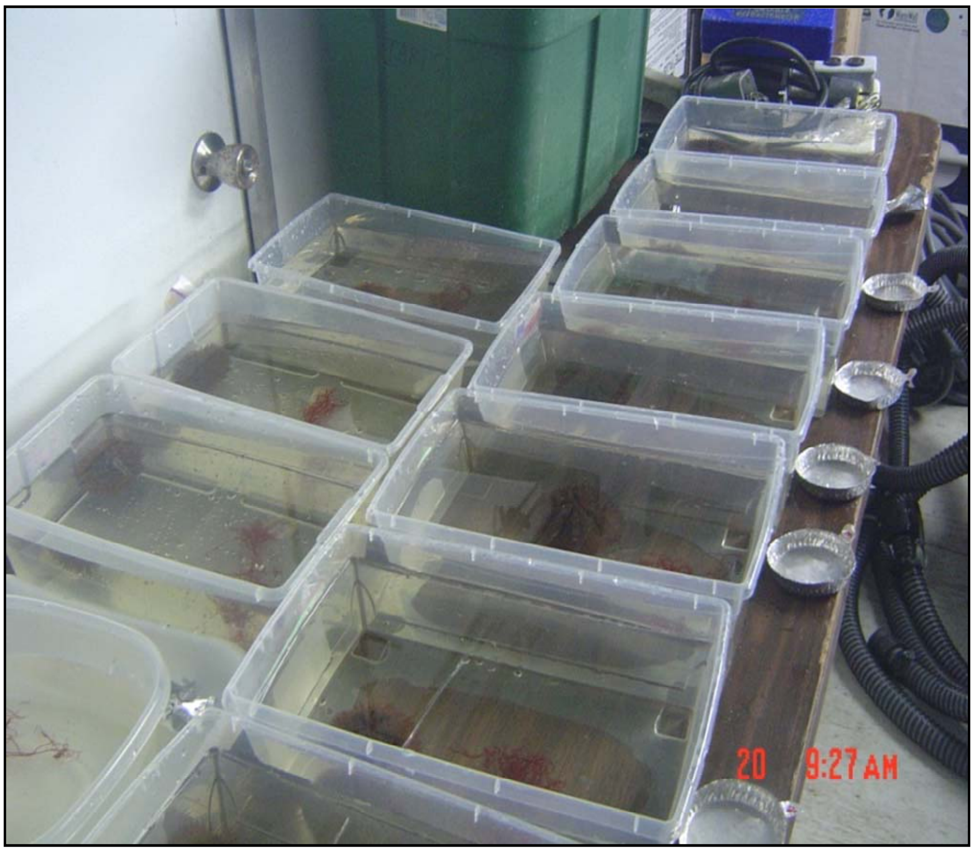


Fig. 9.2. Lab feeding trials utilized 1g (± 0.3g) of single species of algae, and also 1g (± 0.3g) multiple species of algae for the multiple choice experiment.

Fig. 9.3. SCCF Marine Lab mesocosm facility, three-300 gallon insulated holding tanks refitted with new circulating pumps/filters for holding urchins and macroalgae.

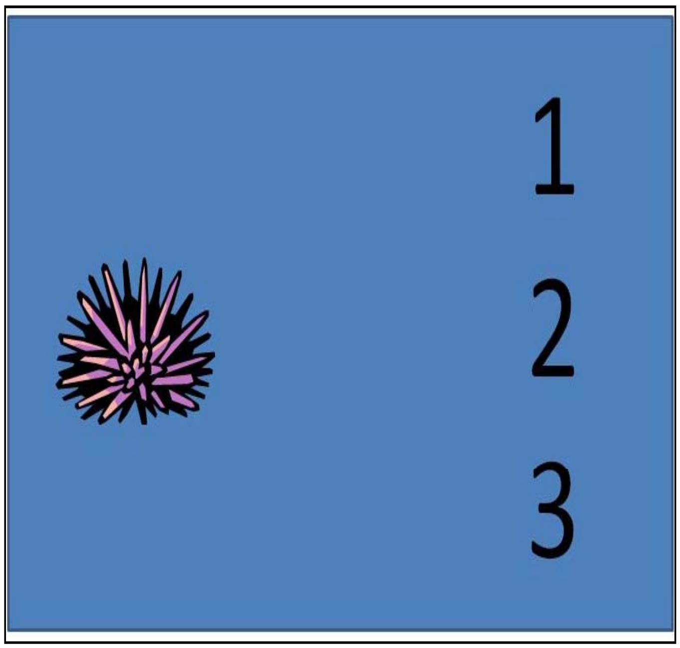


Fig. 9.4. Multiple choice experiments. Urchins were placed in 1 liter containers with the three species placed in random order on one side of the container. Urchins were observed every 15 minutes for 2 hours, and then every 30 minutes for 2 hours, for a total of 4 hours feeding time. Wet weight of algae left was measured following completion.

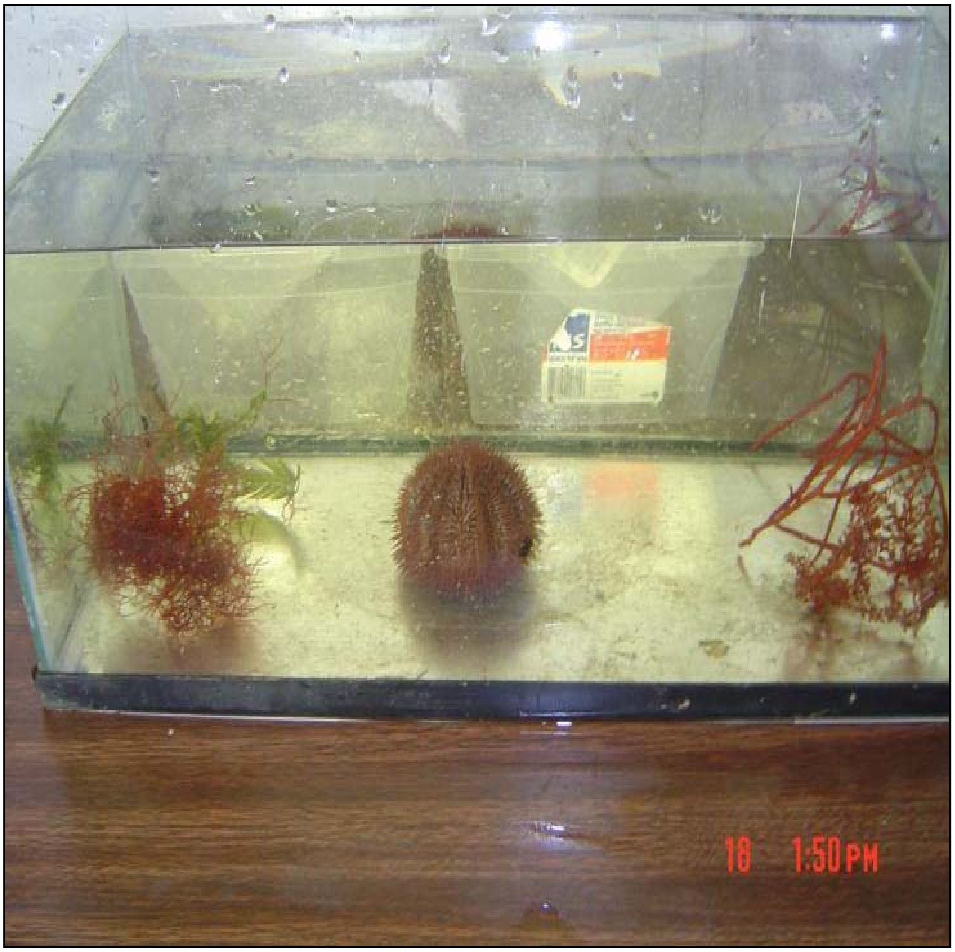


Fig. 9.5. Extended multiple choice feeding trial (n = 4 replicates). Urchins were allowed to feed overnight, (16 hours). Urchins (*Lytechinus* shown here) were placed in the center of a ten gallon tanks, with algae placed in each corner, thus urchins had an equal change of arriving at each species. Urchins were observed every 15 minutes or until they started to feed. Wet weight of algae remaining was taken the following morning (16 hours).

Fig. 9.6. Cage design, each cage had PVC frame, including legs, with rebar supports that were pounded into the sediment for deployment. Cages were numbered, and checked every 2-3 weeks for analysis. The same cage design was employed for both exclusion and inclusion experiments. Urchins were stocked at 3 per inclusion cage for the survival experiments, and 0 per exclusion cage. They were deployed so that the mesh bottom was embedded in sediment as deep as possible (14 cm generally).

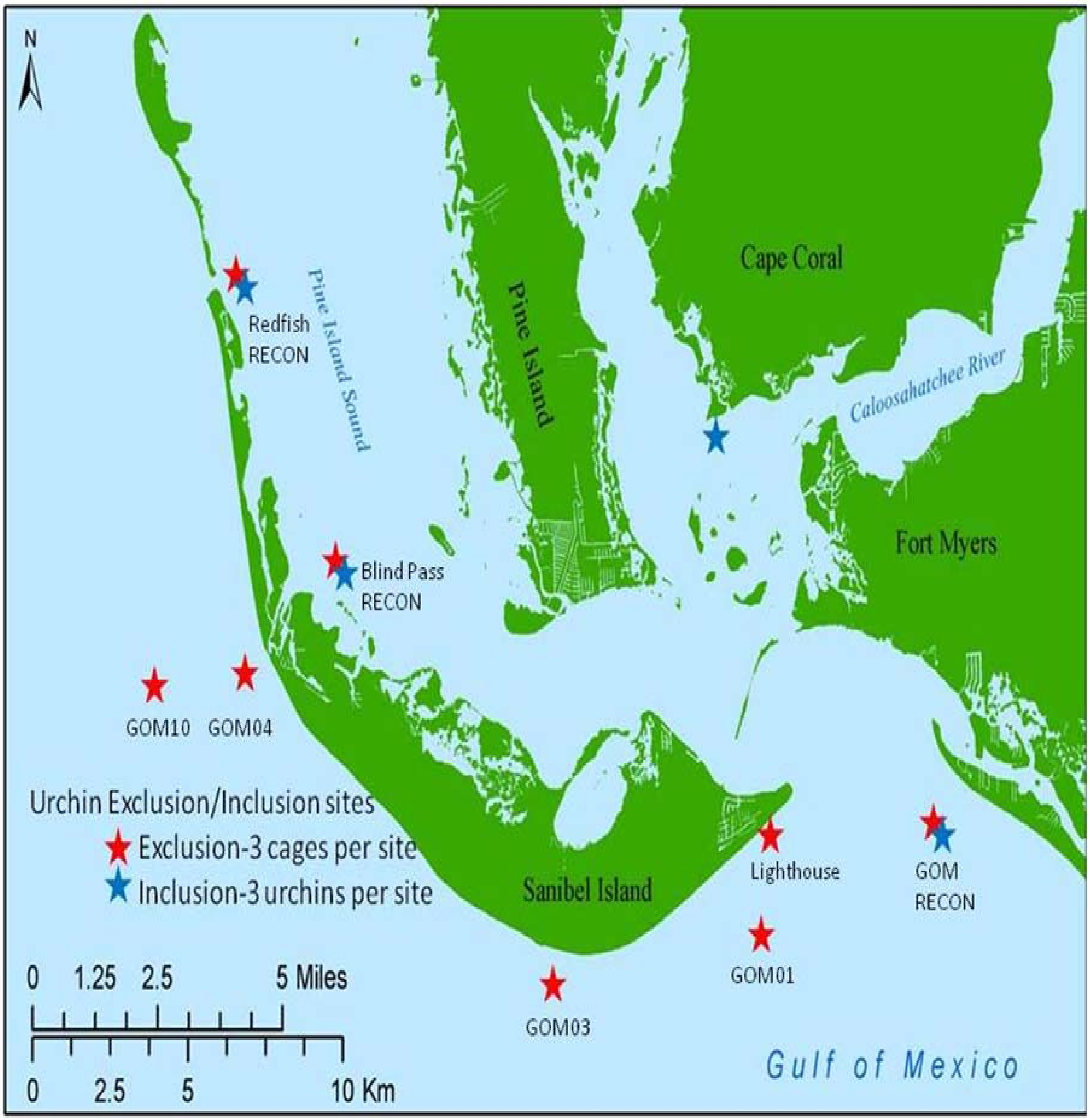


Fig. 9.7. Urchin exclusion/inclusion caging experiment placement. Cages were left for at least 3 months in the exclusion experiments, and 1 month (April 29, 2101 to end of May 2010) for the survivability experiment. Inclusion cages were located at the base of several of SCCF's real-time monitoring stations (RECON). These RECON sites were also used for the exclusion cages, deployed after the inclusion cage experiments were pulled.

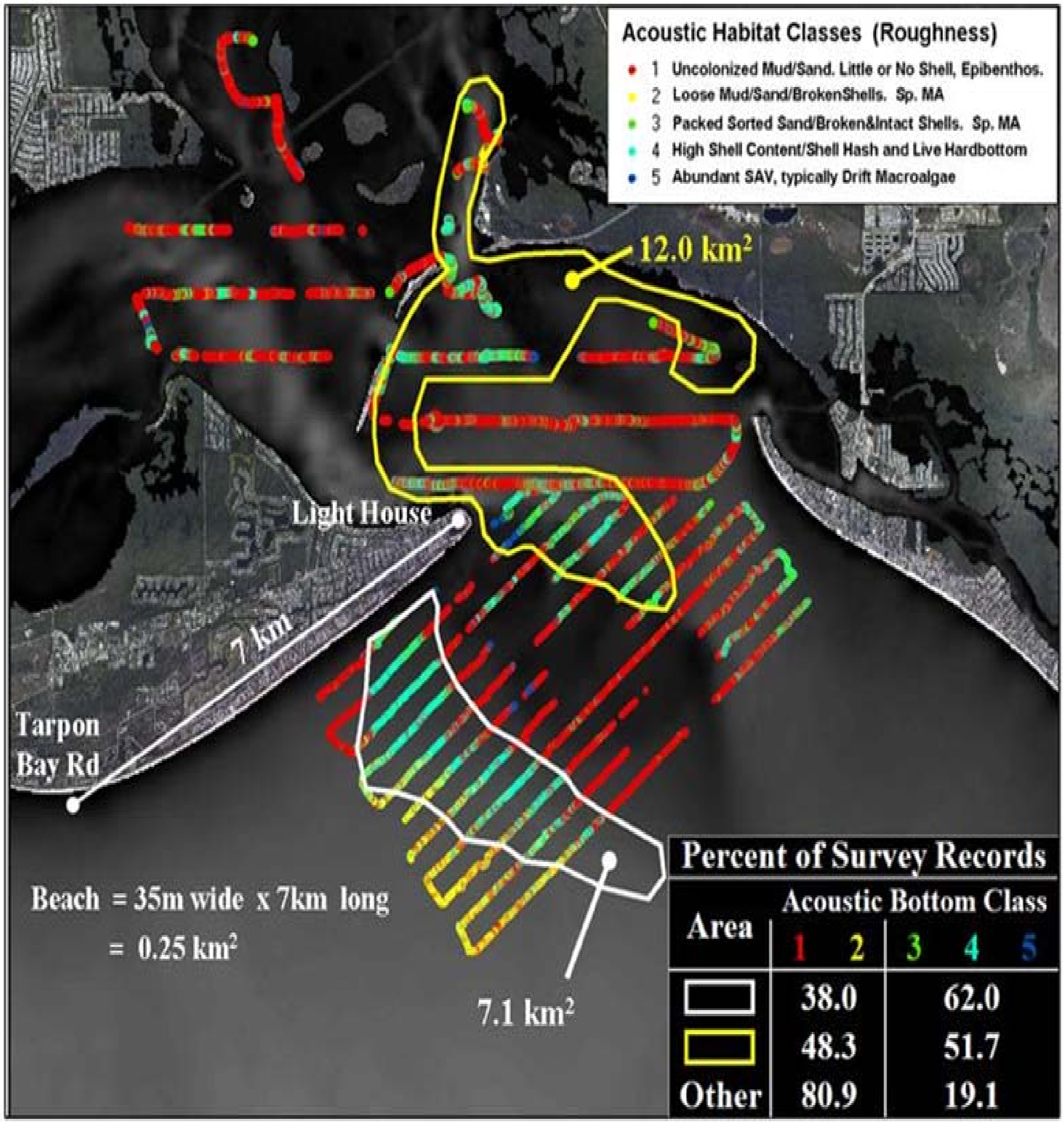


Fig. 9.8. Suitable or available habitat for algae attachment, taken from Hydroacoustic Video surveys conducted in 2010 by NOVA and UNH. Outlined area indicates areas of potential algae attachment sites. The Lighthouse Beach, Light 1 station was chosen within the outlined area, or high shell hash, live or hard-bottom sites close to Sanibel and Captiva and Ft. Myers Beach where urchins (*Lytechinus variegatus, Arbacia punctulata*) are often very abundant.

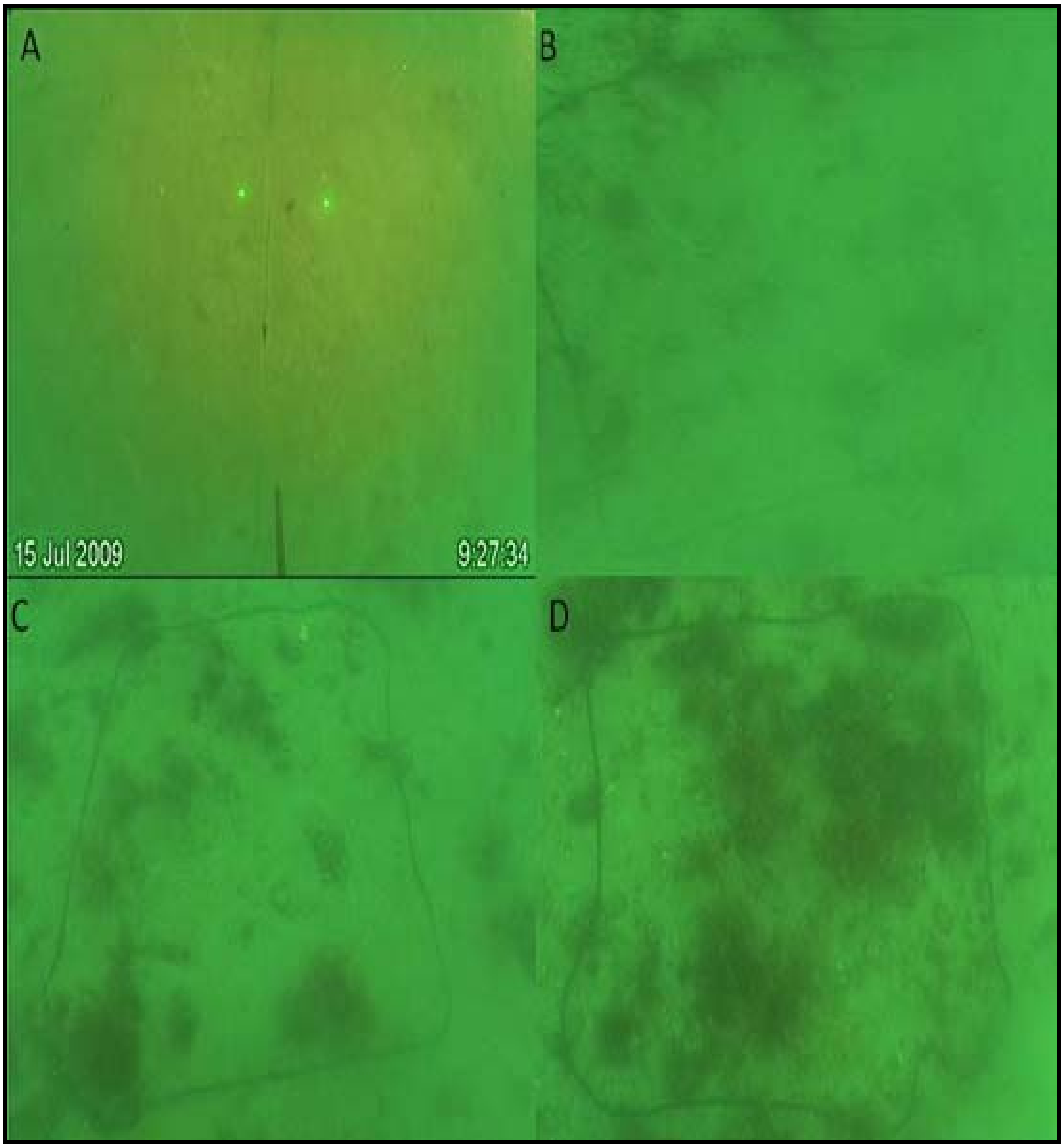


Fig. 9.9. Percent cover examples taken from GOM12 site. Visualization by divers was a 10 x 10 square grid, and divers estimated algal cover in each quadrat. (A) 0% cover, (B) 15% cover, (C) 30% cover; (D) 80% cover.

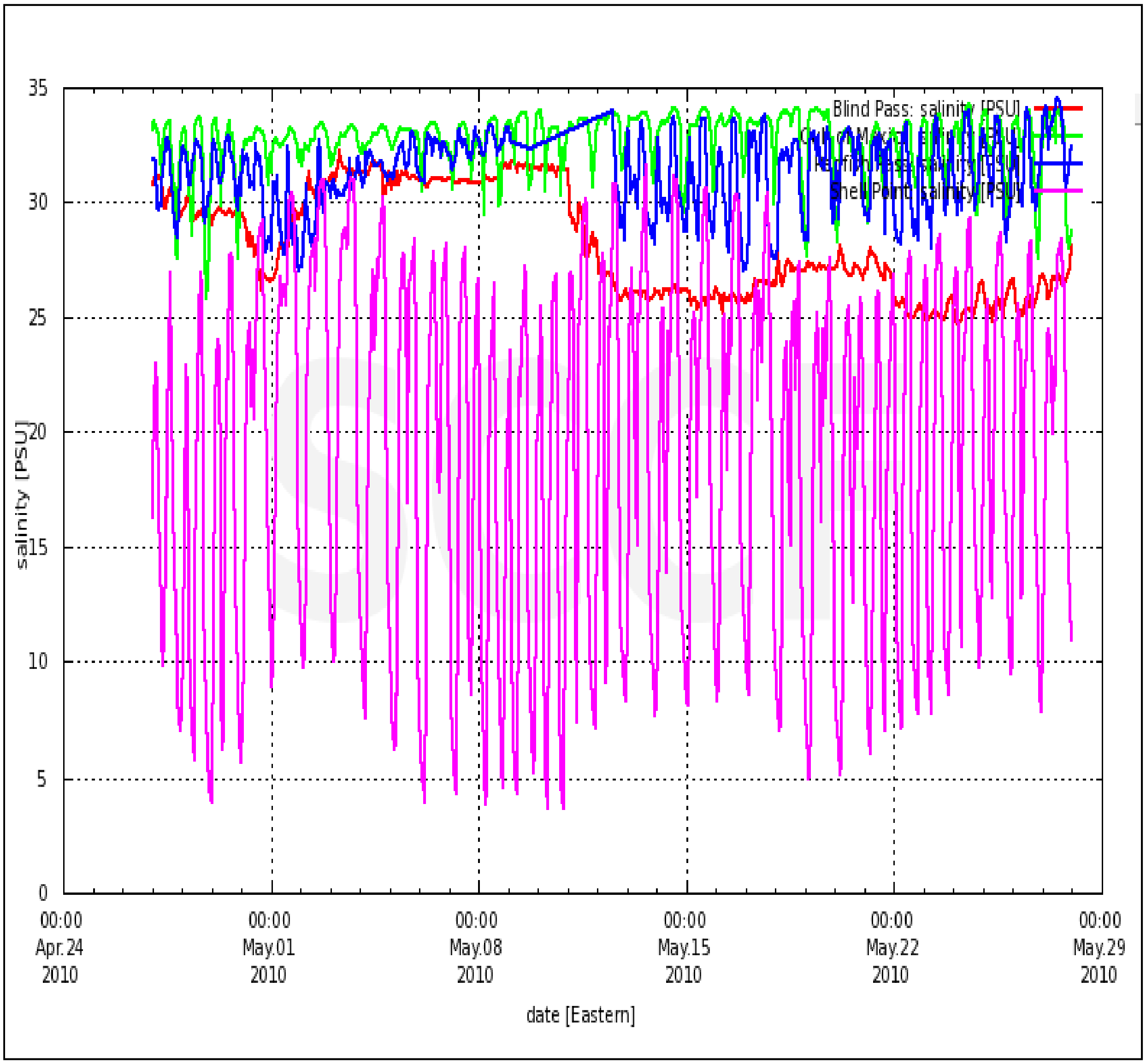


Fig. 9.10. Salinity data for the four *Lytechinus* urchin cage inclusion experiment. Cages were deployed at RECON stations on April 27, 2010, and were left for one month to assess urchin survival. Plot colors: pink is Shell Point RECON, blue is Redfish Pass RECON, green is Gulf of Mexico RECON, and red is Blind Pass RECON. Note that Shell Point (pink) varies over each tidal cycle often from near 5 over 30 ppt.

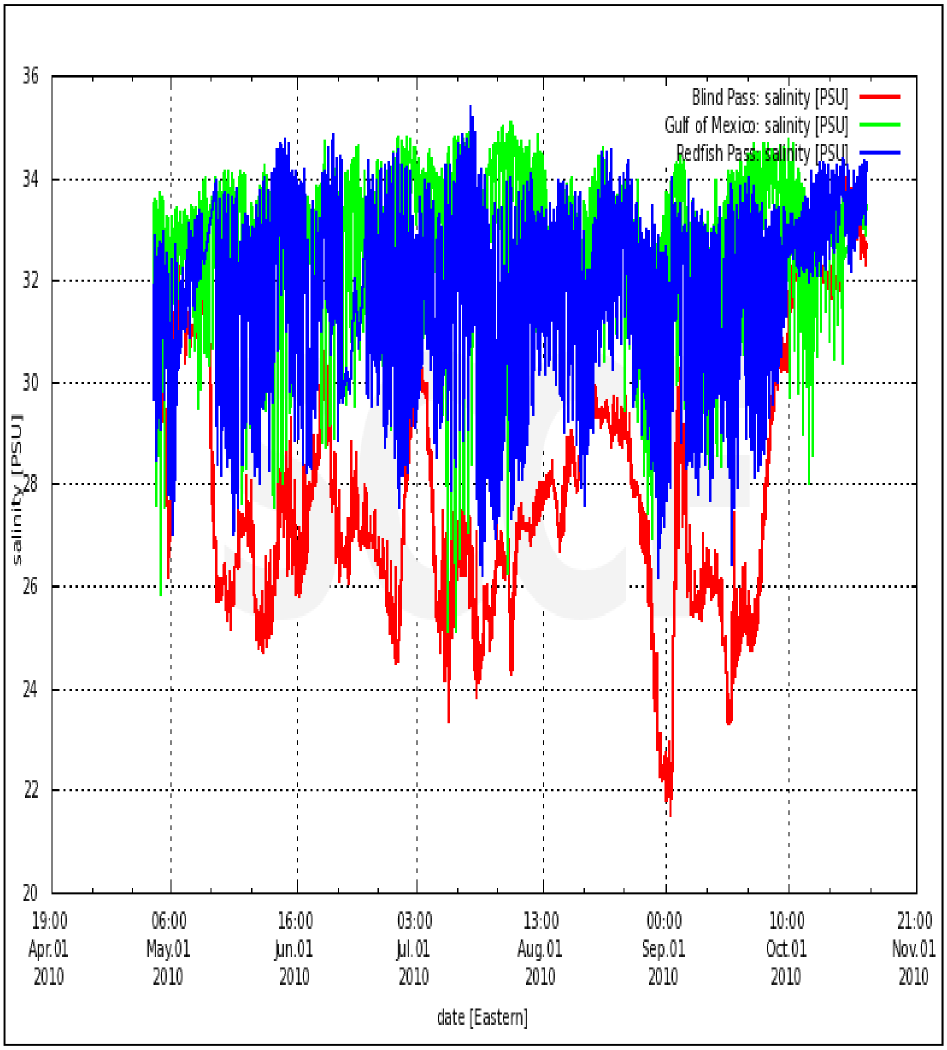


Fig. 9.11. Salinities at associated RECON sites for cages exclosure during the experiments. Cages were deployed starting in late May 2010, and left until October 2010.

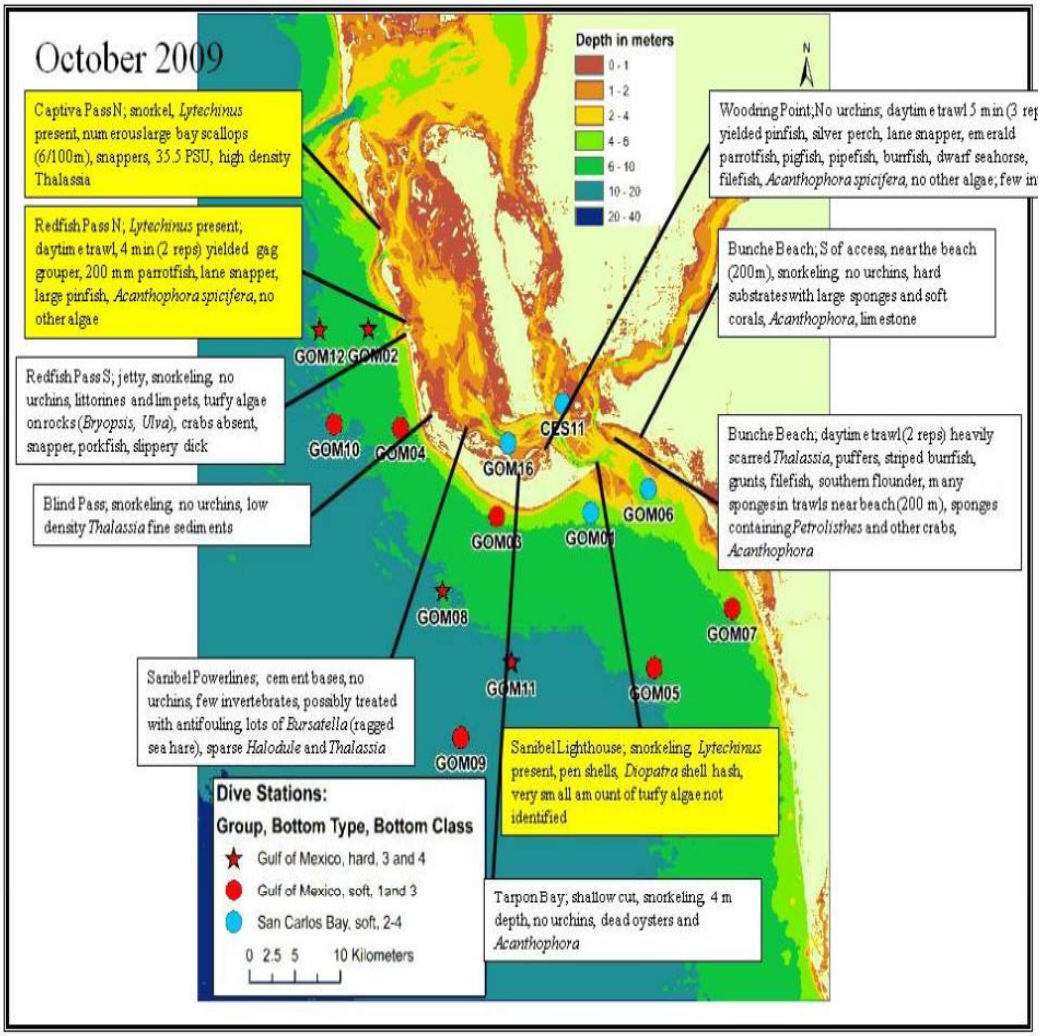


Fig. 9.12. Bathymetric map, dive stations, and locations of snorkeling and trawl surveys for October 2009. Highlighted boxes indicate areas where urchins were found based on information from focused sampling.

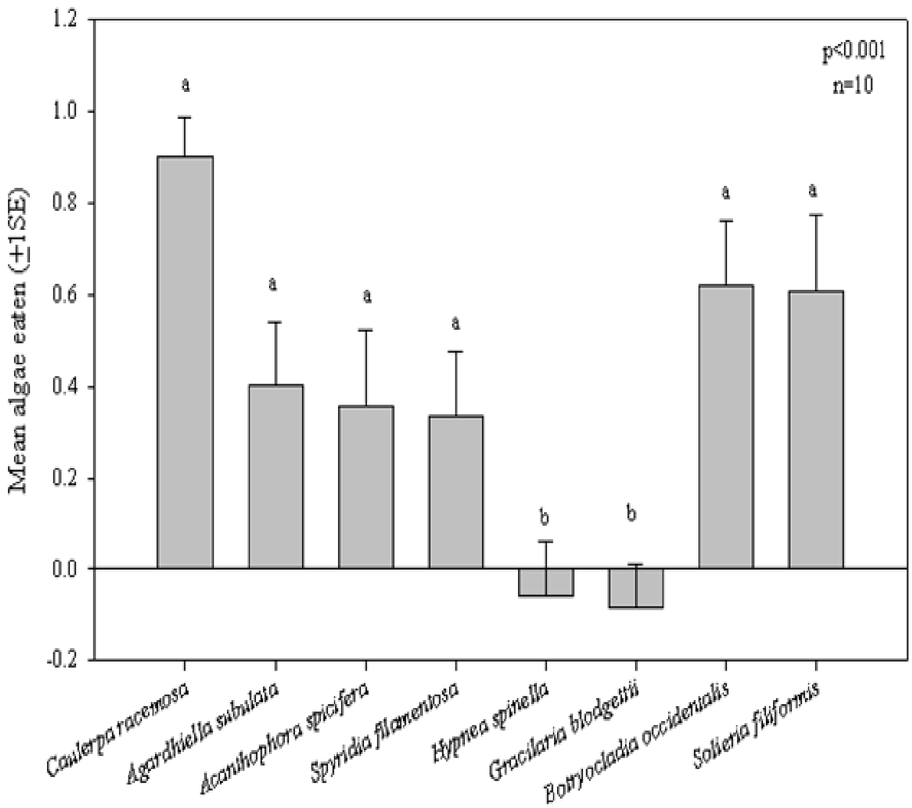


Fig. 9.13. Mean algae eaten per standardized urchin wet weight (+1SE) after four hours of single species feeding trials, a One-Way ANOVA (Sigma Stat) indicated a significant difference between means for group a vs. the rest of the trials ($P < 0.001$; $n = 10$ replicates per species). Note, *Gracilaria blodgettii, Agardhiella subulata,* and *Caulerpa racemosa, Botryocladia occidentalis* are species common to offshore and nearshore sites, while *Acanthophora spicifera, Spyridia filamentosa* and *Hypnea spinella* are more common at inshore sites. *Solieria filiformis* has been found in both areas that commonly have algae present.

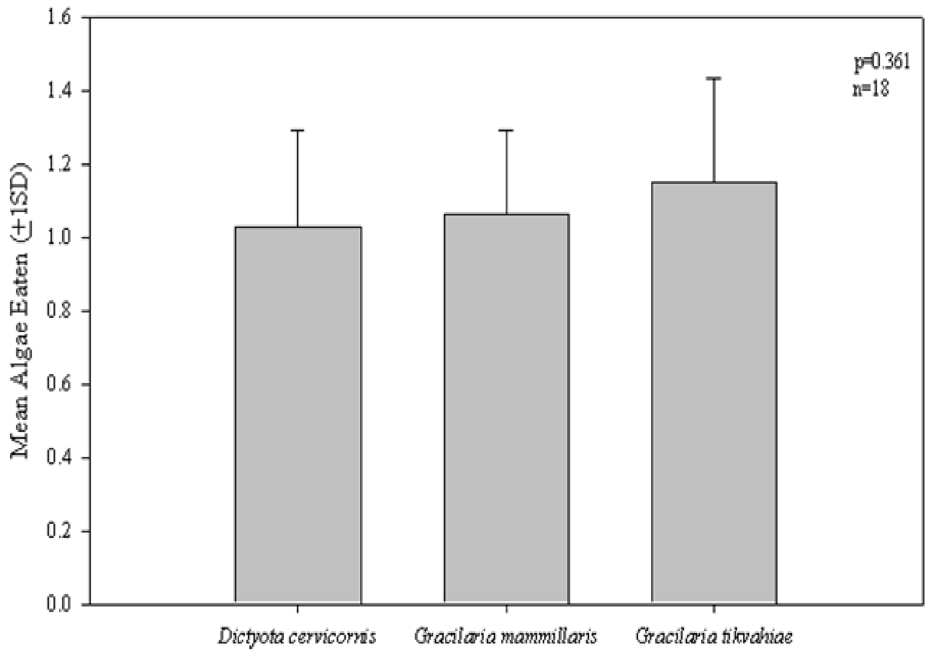


Fig. 9.14. Multiple choice feeding experiments. Mean algae eaten per standardized urchin wet weight (+1SE). Urchins were offered 1 g of each species of algae above, in random order. There was no statistical difference between algae eaten. This multiple choice experiment was run three separate times, with 18 replicates total (n = 18). Urchins arrived at *Dictyota cervicornis* first in 5 of the 18 (28%) trials; at *Gracilaria mammilllaris* 1 out of 18 (5.5%); for *Gracilaria tikvahiae* 6 out of 18 (33%), or did not move, 6 out of 18 (33%) runs. *Gracilaria tikvahiae* consumption was highest, with urchins arrived at this algae first more times than others (1.147 g eaten vs. 1.02 and 1.06 for *Dictyota cervicornis* and *Gracilaria mammillaris,* respectively).

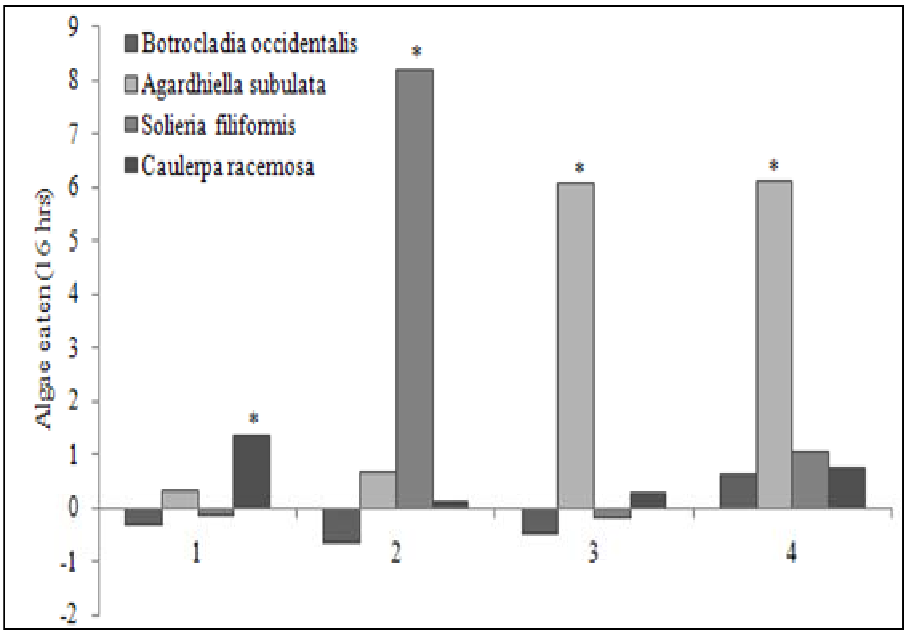


Fig. 9.15. Extended multiple-choice feeding experiment. Bars are algae eaten after 16 hours per mean *Lytechinus* urchin wet weight (109.73 g) for four trials. ***** indicates algal species that urchins went to first.

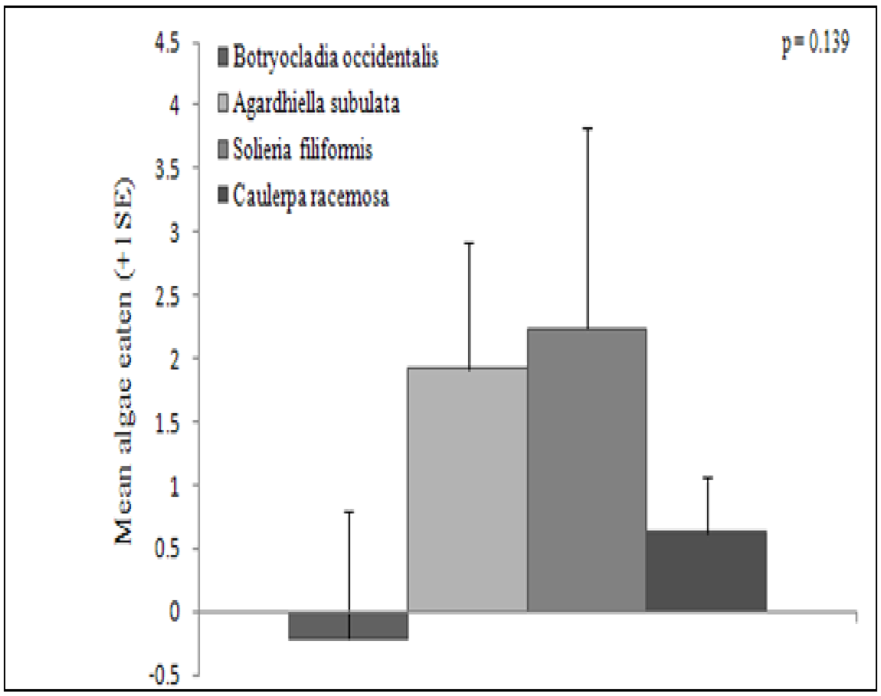


Fig. 9.16. Extended multiple choice feeding experiments. Bars are mean algae eaten after 16 hours per mean *Lytechinus* urchin wet weight (109.73 g). Mean of four replicates. *Lytechinus* arrived at *Agardhiella subulata* two out of four trials, *Solieria filiformis* one out of four trials, and *Caulerpa racemosa* one out of four trials.

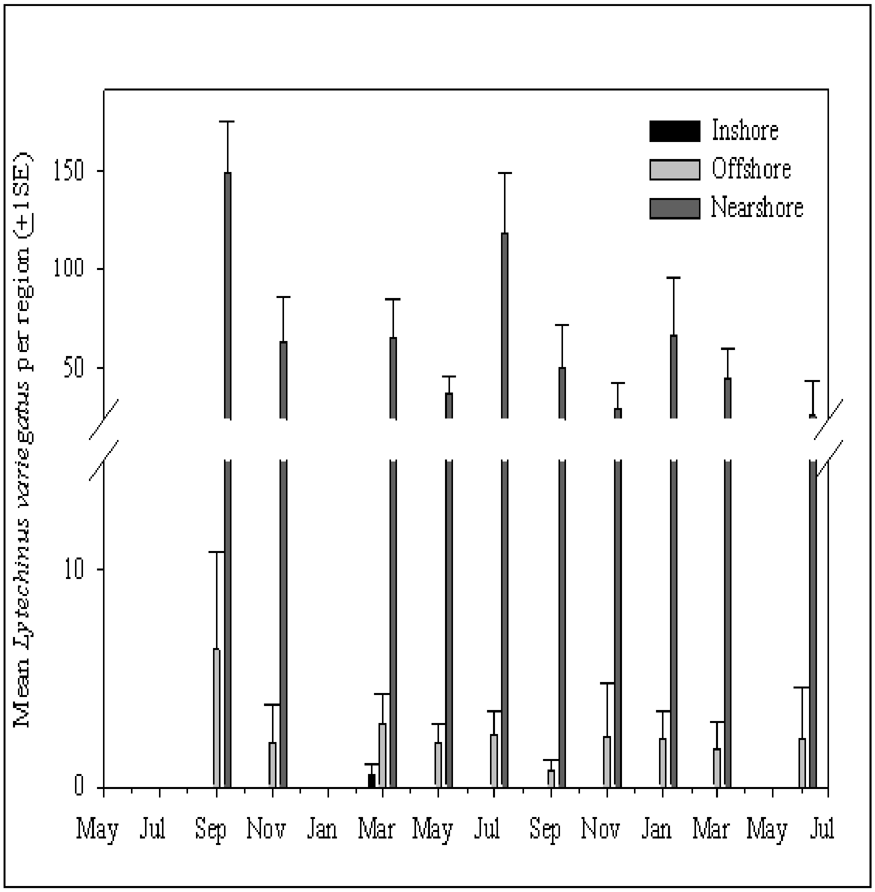


Fig. 9.17. Mean *Lytechinus variegatus* per 100 m^2 at study sites for the macroalgae biomass (Objective 5) section. Data were taken from video transect analysis. Note: scale break from 13 to 45. Nearshore regions had more urchins per 100 meters than other regions. Note, Table 9.4. is used to produce these estimates, for total m surveyed by video associated with each section.

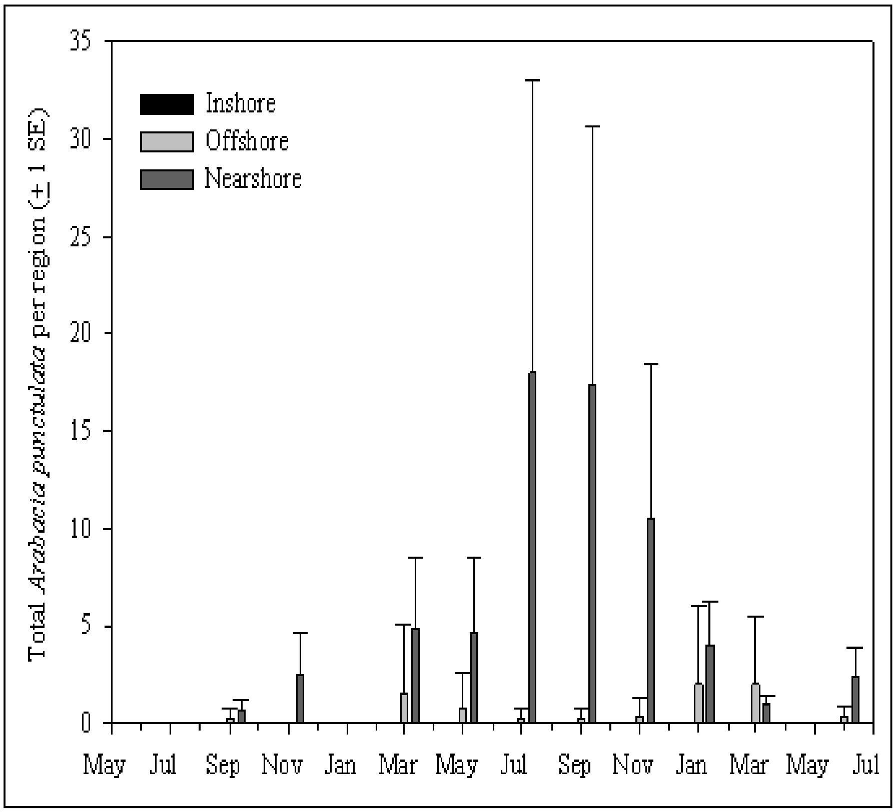


Fig. 9.18. Total *Arbacia punctulata* per 100 m^2 at study sites for the macroalgae biomass (Objective 5) section. Data taken from video transect analysis. Note scale break from 13 to 45. Nearshore regions had more urchins per 100 m than other regions. Note: Table 9.4 was also used to produce these estimates, and for finding total meters surveyed by video for each date.

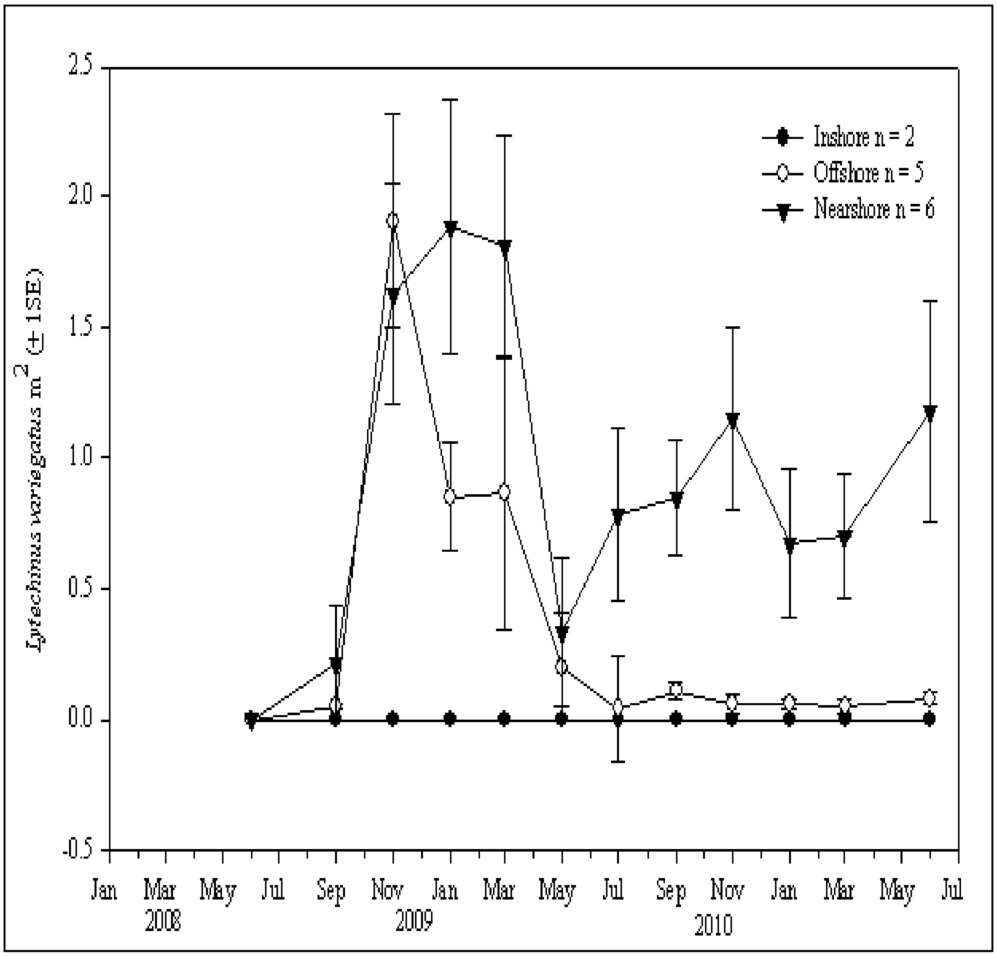


Fig. 9.19. Mean *Lytechinus variegatus* per m^2 ±1SE, from scheduled sampling sites associated with Objective 5. Data taken from diver analyses. Inshore group includes two stations, CES11 and GOM16; nearshore includes six stations GOM01, GOM02, GOM03, GOM04, GOM06 and GOM07; offshore includes five stations GOM05, GOM08, GOM09, GOM10, GOM11 and GOM12. Note: consistently 0 or low numbers of urchins for either inshore site.

Fig. 9.20. Cages were pulled in September 2010 due to extreme fouling. Sponges and encrusting bryozoans had to be removed with stiff brushes and chiseled off and often could not be cleaned sufficiently in the field.

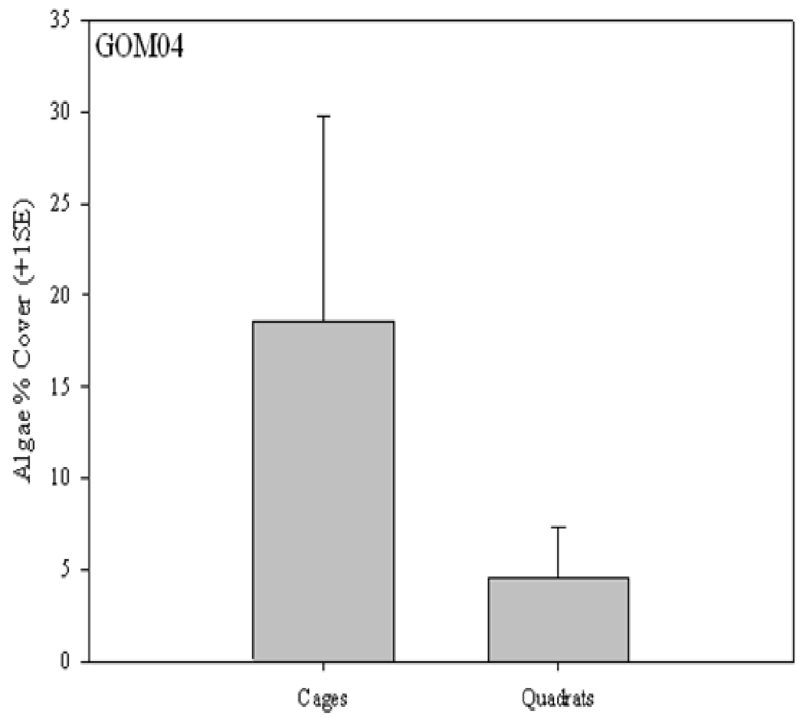


Fig. 9.21. Mean algae percent cover +1SE for station GOM04 for all dates checked (n = 12 cages, n = 12 quadrats; 3 cages and quadrats per visit, 4 visits), inside exclusion cages and surrounding quadrats outside of exclusion cages. Cages were checked every month for 4 months, three cages per site, and three quadrats per site per visit.

Fig. 9.22. Cage located at the Light 1 site. This station often had very poor visibility. Urchins (note with shells held at arrow) and pen shells were common at this site.

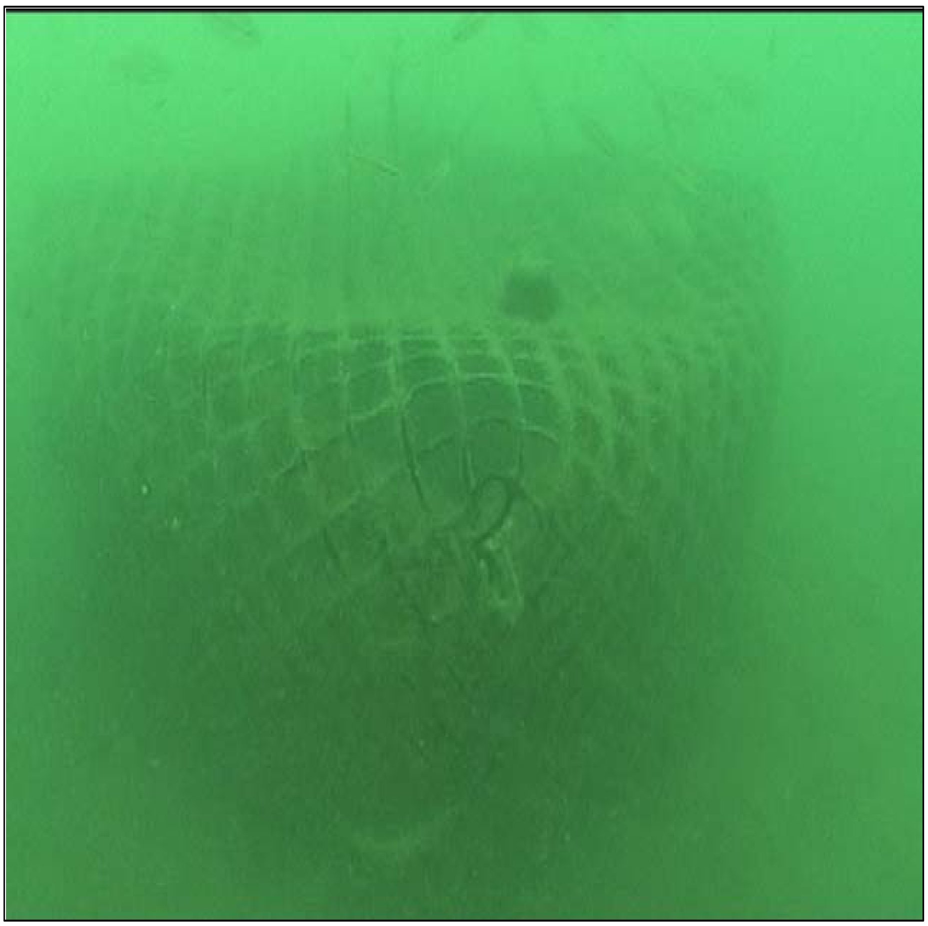


Fig. 9.23. Cages at GOM01. Fouling was minimal at this site; however, visibility was typically poor for assessing cages and outside community. Note *Lytechinus variegatus* on top of cage, and fish school behind it.

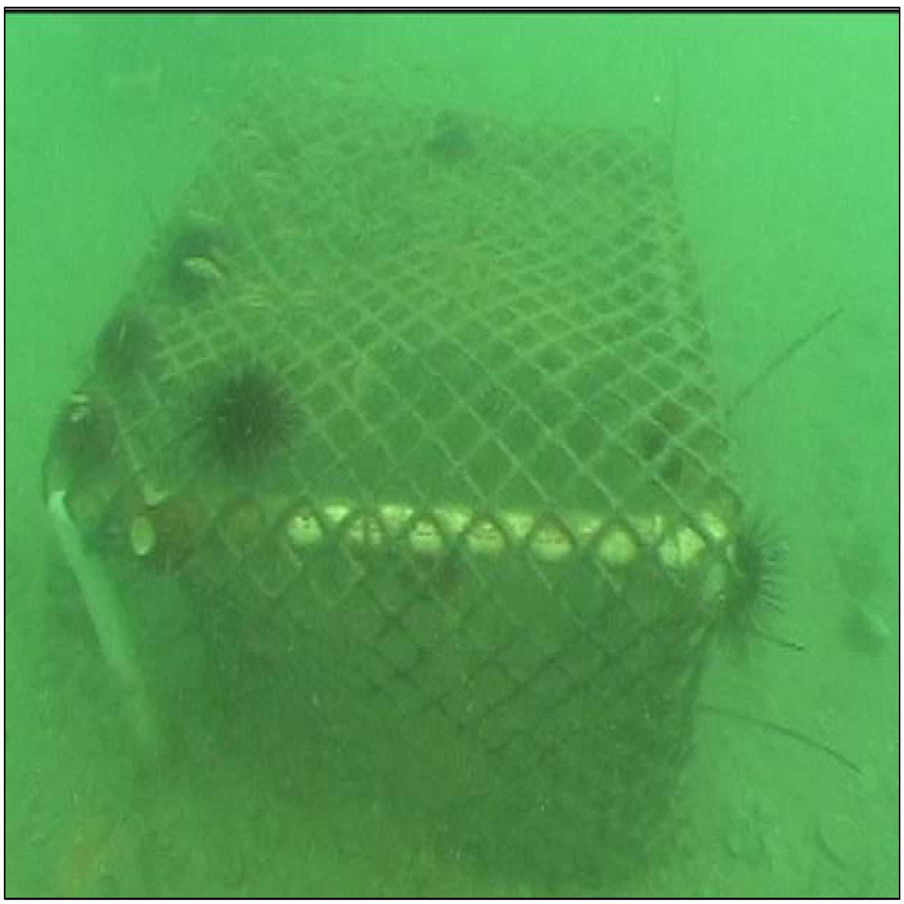
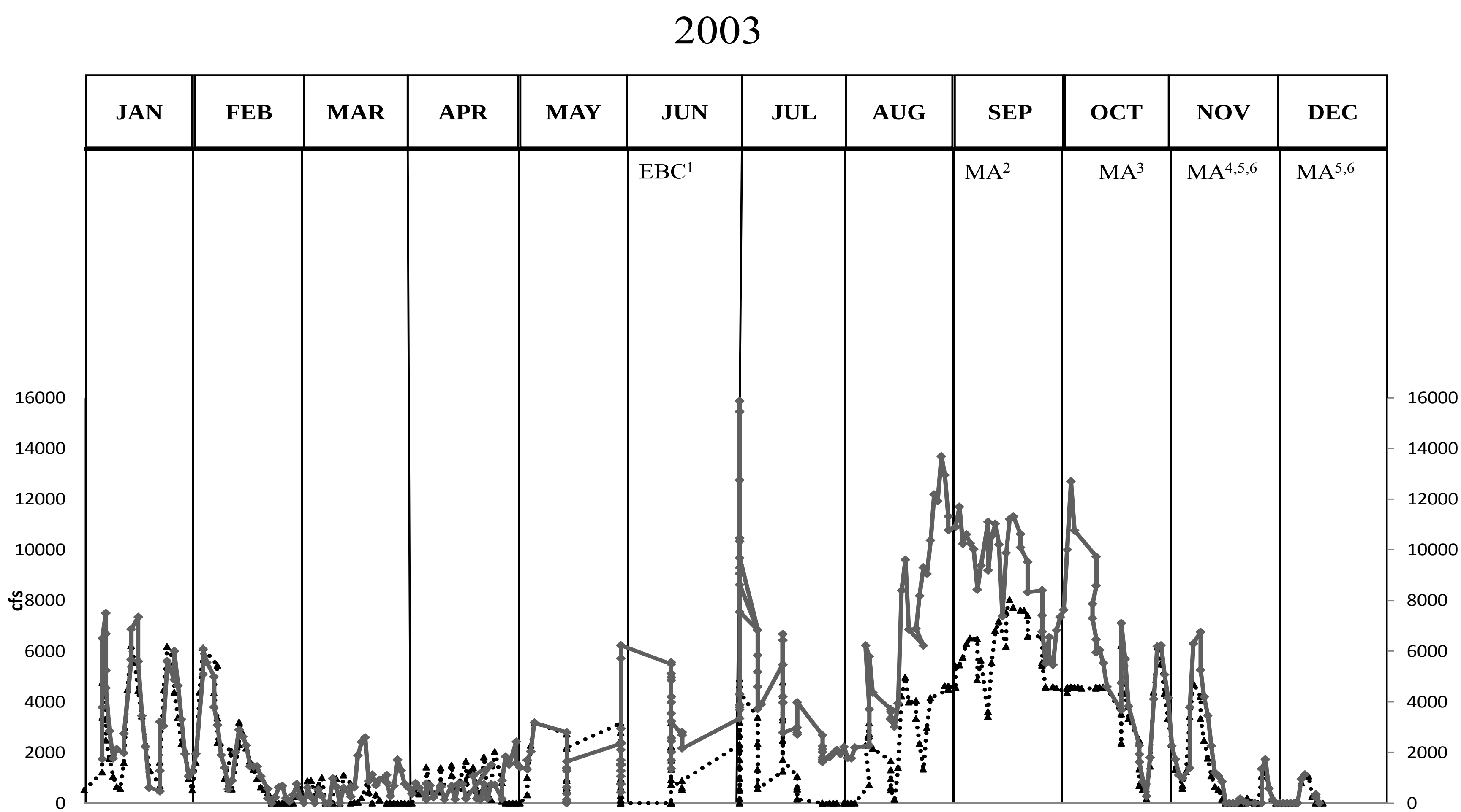


Fig. 9.24. Cages at GOM03. Note two species of urchins (*Lytechinus variegatus* and *Arbacia punctulata* with long spines) on the outside of cage. Fouling was moderate at this site, and visibility was sometime good enough to see or photograph the cages.

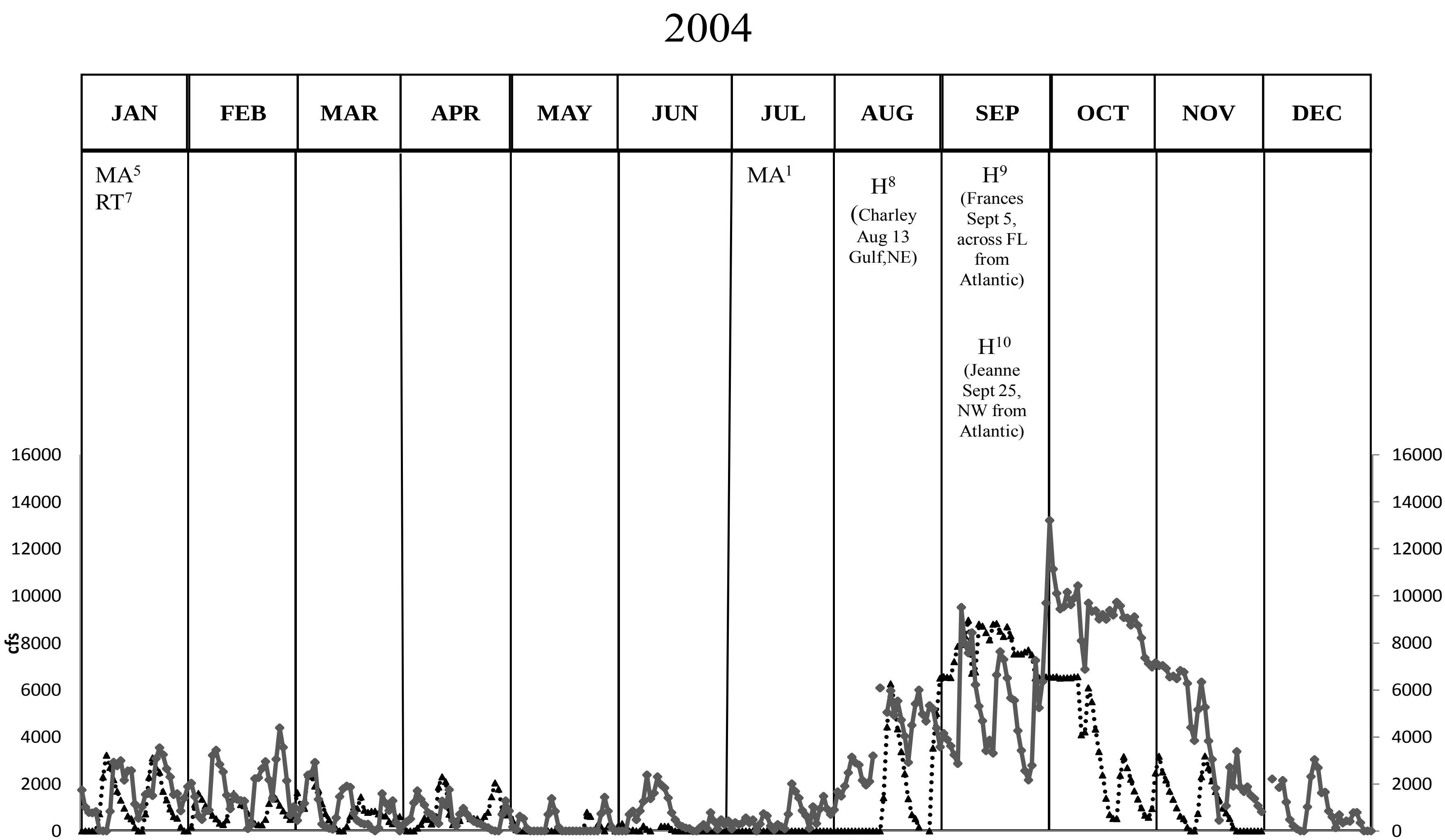
Fig. 9.25. Cage located at GOM04. Note algae inside the lower right corner, small *Halymenia psuedofloresia* individual found in July 29, 2010. Note sediment texture in photo with coarse shell material.

Appendix 9.1. Timeline of events from 2003-2010 related to drift algae project, including bloom events, beach closures, red tide, hurricanes and other relevant data; 2003 detail below.



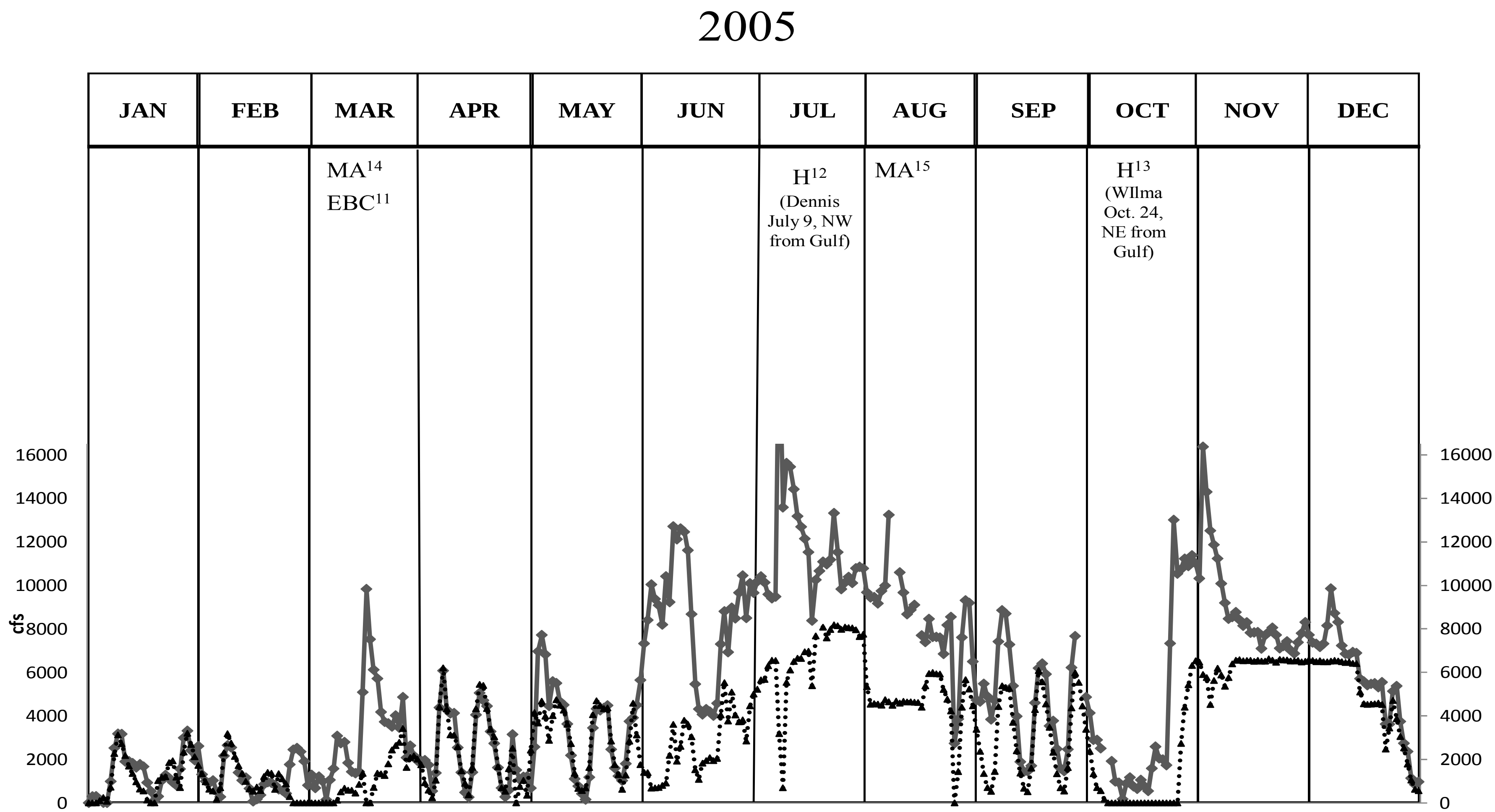
*Flow Data from DBHydro (South Florida Water Management District). Dotted Line is S77 and solid line is S79 (discharge in cfs). Event Code: **MA**-Macroalgae, **EBC**-Enterococcus Beach Closure, **RT**-Red Tide, **H**-Hurricane.

Appendix 9.1. Cont. Timeline of events from 2003-2010 related to drift algae project, including bloom events, beach closures, red tide, hurricanes and other relevant data; 2004 detail below.



*Flow Data from DBHydro (South Florida Water Management District). Dotted Line is S77 and solid line is S79 (discharge in cfs).
Event Code: **MA**-Macroalgae, **EBC**-Enterococcus Beach Closure, **RT**-Red Tide, **H**-Hurricane.

Appendix 9.1. Cont. Timeline of events from 2003-2010 related to drift algae project, including bloom events, beach closures, red tide, hurricanes and other relevant data; 2005 detail below.

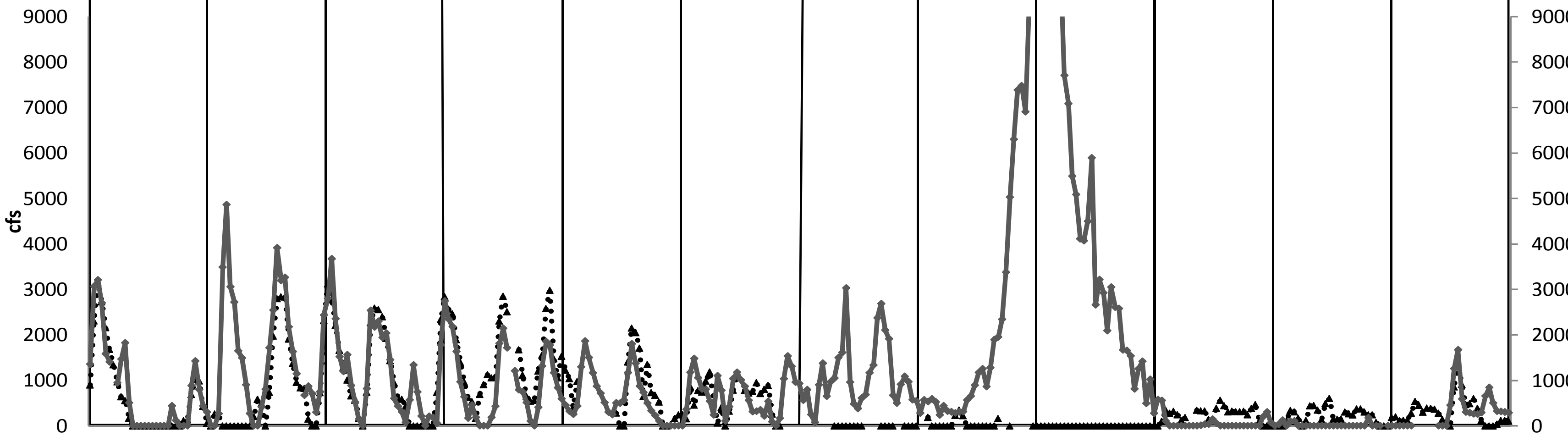


*Flow Data from DBHydro (South Florida Water Management District). Dotted Line is S77 and solid line is S79 (discharge in cfs). Event Code: **MA**-Macroalgae, **EBC**-Enterococcus Beach Closure, **RT**-Red Tide, **H**-Hurricane.

Appendix 9.1. Cont. Timeline of events from 2003-2010 related to drift algae project, including bloom events, beach closures, red tide, hurricanes and other relevant data; 2006 detail below.

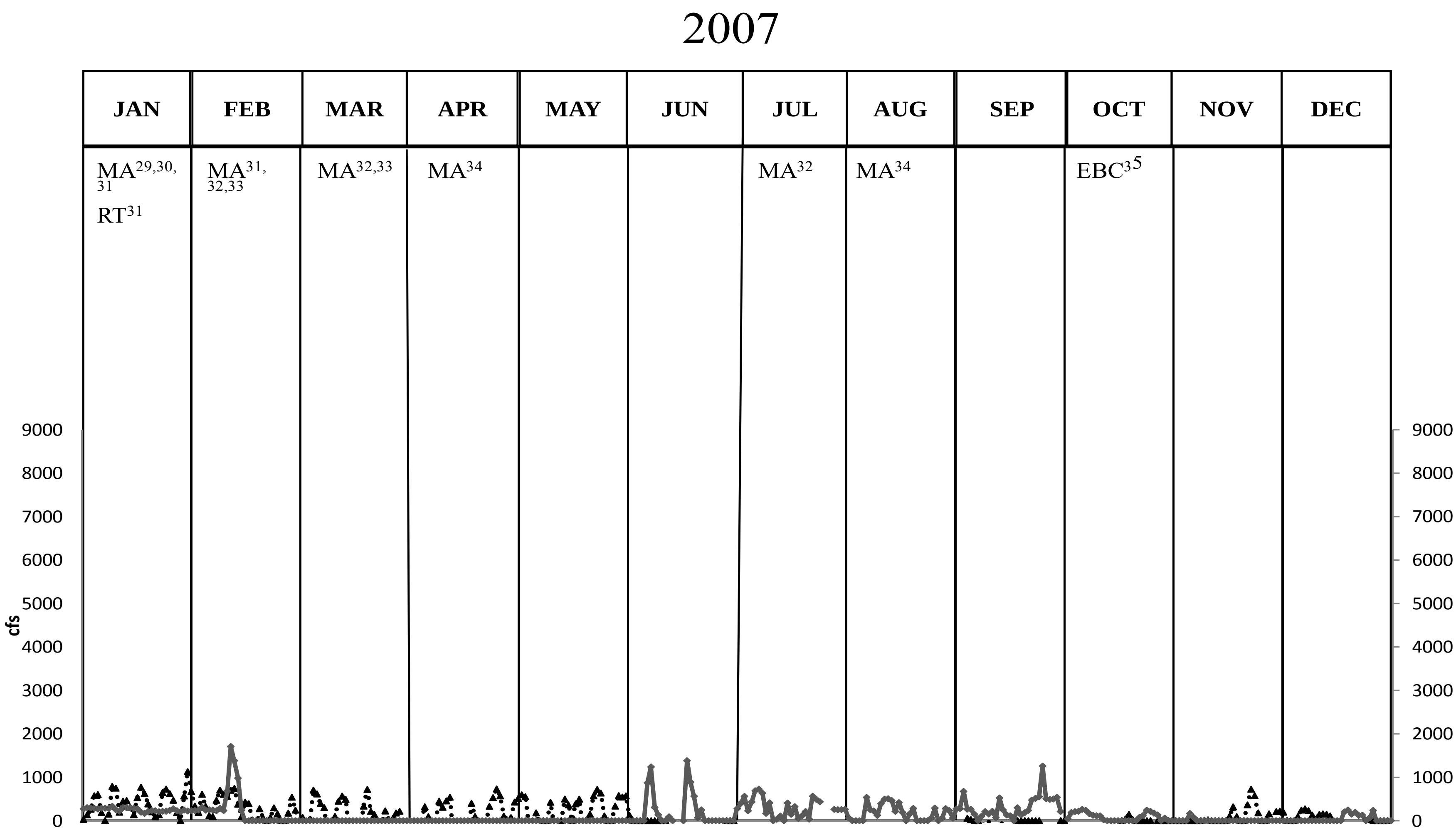
2006

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MA[16,17,18]			MA[17]	MA[19,23] RT[16]	MA[18,20,21,22,23]		MA[23] H[26] (Ernesto Aug 29, moving NE from Gulf.)	MA[16,17,24,25] RT[28] EBC[27]	RT[21,28]	MA[20,23]	MA[20] RT[28]



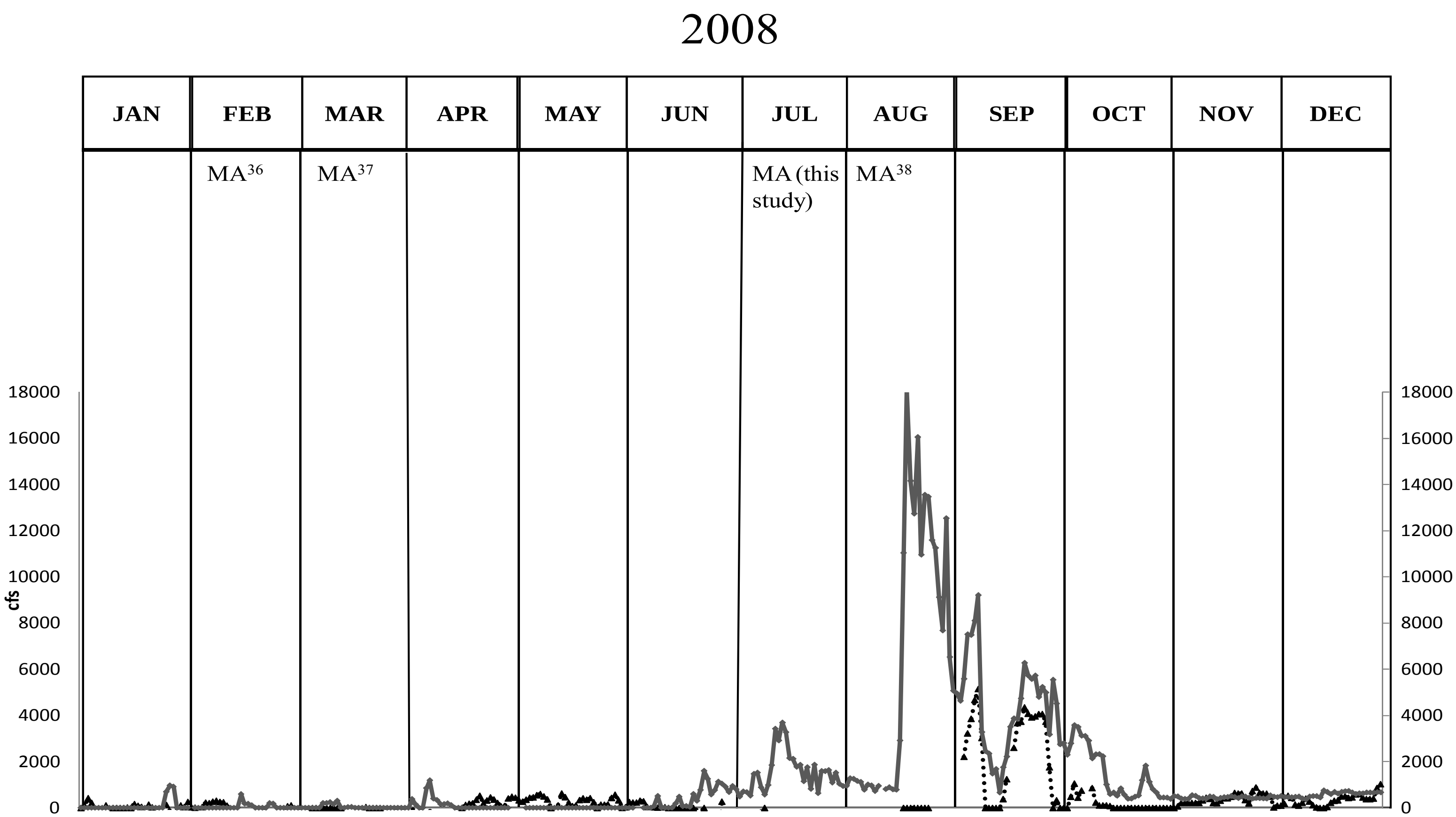
*Flow Data from DBHydro (South Florida Water Management District). Dotted Line is S77 and solid line is S79 (discharge in cfs). Event Code: **MA**-Macroalgae, **EBC**-Enterococcus Beach Closure, **RT**-Red Tide, **H**-Hurricane.

Appendix 9.1. Cont. Timeline of events from 2003-2010 related to drift algae project, including bloom events, beach closures, red tide, hurricanes and other relevant data; 2007 detail below.



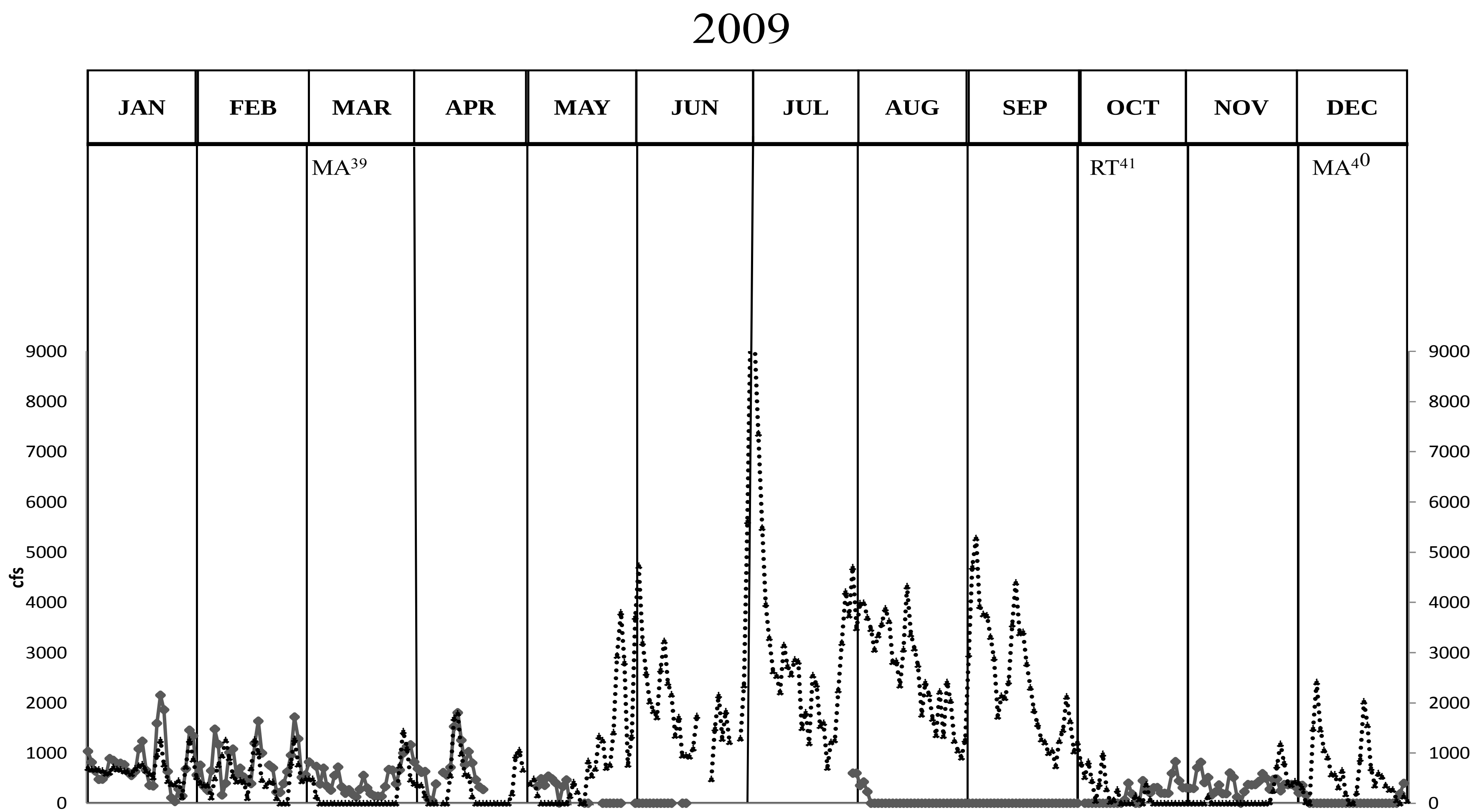
*Flow Data from DBHydro (South Florida Water Management District). Dotted Line is S77 and solid line is S79 (discharge in cfs). Event Code: **MA**-Macroalgae, **EBC**-Enterococcus Beach Closure, **RT**-Red Tide, **H**-Hurricane.

Appendix 9.1. Cont. Timeline of events from 2003-2010 related to drift algae project, including bloom events, beach closures, red tide, hurricanes and other relevant data; 2008 detail below.



*Flow Data from DBHydro (South Florida Water Management District). Dotted Line is S77 and solid line is S79 (discharge in cfs).
Event Code: **MA**-Macroalgae, **EBC**-Enterococcus Beach Closure, **RT**-Red Tide, **H**-Hurricane.

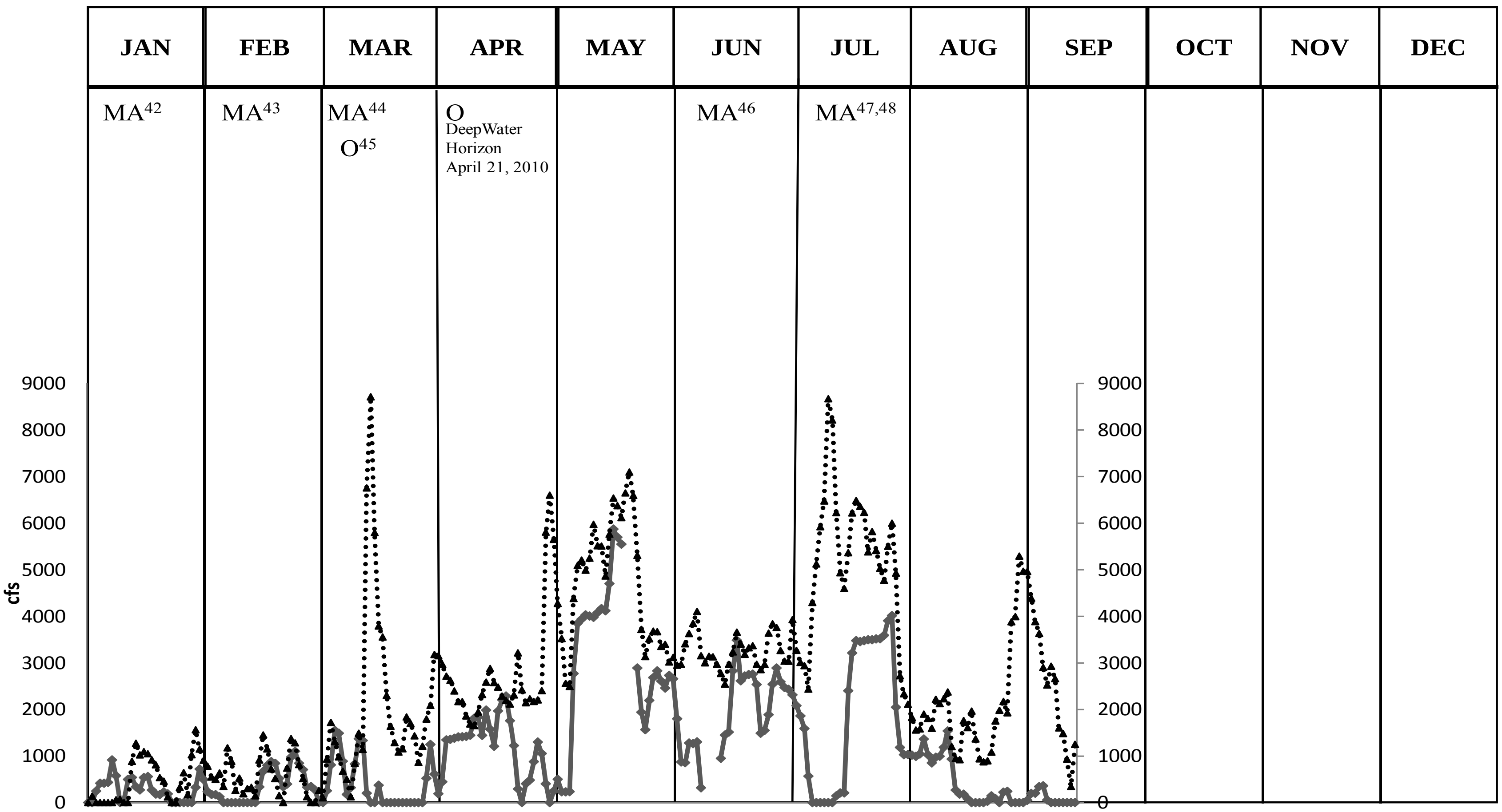
Appendix 9.1. Cont. Timeline of events from 2003-2010 related to drift algae project, including bloom events, beach closures, red tide, hurricanes and other relevant data; 2009 detail below.



*Flow Data from DBHydro (South Florida Water Management District). Dotted Line is S77 and solid line is S79 (discharge in cfs).
Event Code: **MA**-Macroalgae, **EBC**-Enterococcus Beach Closure, **RT**-Red Tide, **H**-Hurricane.

Appendix 9.1. Cont. Timeline of events from 2003-2010 related to drift algae project, including bloom events, beach closures, red tide, hurricanes and other relevant data; 2010 detail below.

2010



*Flow Data from DBHydro (South Florida Water Management District). Dotted Line is S77 and solid line is S79 (discharge in cfs).
Event Code: **MA**-Macroalgae, **EBC**-Enterococcus Beach Closure, **RT**-Red Tide, **H**-Hurricane. **O**-Other.

Key to Appendix 9.1 Observations

[1]Florida Department of Health, Healthy Beaches (archived *Enterococcus* findings, see http://esetappsdoh.doh.state.fl.us/irm00beachwater/default.aspx). Only "poor" findings used for *Enterococcus* as they resulted in a beach advisory. June 25, 2003. Lighthouse Beach. A "poor" result is defined as 105 or greater *Enterococcus* sp. per 100 ml of seawater or a geometric mean of $\geq$36 cfu (colony forming units/100 ml of *Enterococcus* sp.

[2]C. Mansell (City of Sanibel, Florida), September 2003, National Healthy Beaches Campaign (NHBC), Healthy Beaches Reports, 2003-2007. "Dead" red algae reported from Tarpon Bay to Lighthouse Beach, with a rating of 3 out of 4 for in severity (range of 0, absent to 4, 'infested'). Beach cleaned 9/12/2003.

[3]C. Mansell (City of Sanibel, Florida), October 2003, NHBC, Healthy Beaches Reports, 2003-2007. Red algae piled as high as 18-24", with a rating of 3 out of 4 for in severity (range of 0, absent to 4, 'infested'). Beach mechanically cleaned 10/25 and 10/27/2003.

[4]C. Mansell (City of Sanibel, Florida), November 2003, NHBC Healthy Beaches Reports, 2003-2007. November 2003, red algae was rated as a 4 out of 4 ("infested").

[5] C. Dawes, 2004 (USF, Dept. of Biology). Drift Algae in the Charlotte Harbor area. Report to the SFWMD. . December 2003 also contained two red algae, *Hypnea spinella and Soleria filiformis.* Dominant species for samples in 2004 are red algae, *Chondria atropurpurea, Gracilaria caudata, Hypnea spinella,* and *Solieria filiformis.* Collector, J. Evans (City of Sanibel) from Sanibel beaches

[6]S. Lundy, Dec. 16, 2003, News-Press. "Beach rakes seaweed from shore"; additional comments, "unusual" accumulation around Thanksgiving on Fort Myers Beach also.

[7]Florida Fish and Wildlife Conservation Commission (FWC). October 27, 2009, Red Tide Counts Archive, Red Tide online.com, see http://research.myfwc.com/gallery/image_details.asp?id=17081. Estimates are generic for the entire Sanibel/Ft. Myers area.

[8-10]NOAA Satellite and Information Service, Query Results, "Tropical storm and Hurricanes in Florida. Hurricanes to hit near or in Lee county, including coastal Collier County included for 2004: ([8])*Charley*, hit Lee County August 13th, 2004, moving northeast from the Gulf; ([9]) *Frances*, hit Lee County on Sept 5th, 2004, moving northwest from the Atlantic ; ([10]) *Jeanne*, hit Lee County on Sept 25th, 2004, moving northwest from the Atlantic.

[11]Florida Department of Health, Healthy Beaches (archived *Enterococcus* findings, see http://esetappsdoh.doh.state.fl.us/irm00beachwater/default.aspx) for Blind Pass/Turner Beach, March 18, 2005. Only "poor" counts for *Enterococcus* that result in advisory are reported.

[12-13]NOAA Satellite and Information Service, Query Results, "Tropical storm and Hurricanes in Florida. Hurricanes to hit near or in Lee or Collier counties included for 2005: ([14])*Dennis,* hit Dennis hit coastal Collier and Lee counties on July 9, 2005, northwest from the Gulf. ([15])*Wilma* hit Collier and Lee counties on October 24th, 2005, moving northeast from the Gulf.

[14]J. Evans, pers. obs., Picture reference for 2006 (City of Sanibel). Beaches affected include Blind Pass Beach, Lighthouse Beach, Bowman's Beach, Pier 2-5 and Tarpon Bay Beach (see Figures 9.1). Red tides are also documented for October 2006.

[15]B.E. Lapointe et al., 2006. Harmful algal blooms in coastal waters of Lee County, FL: Bloom dynamics and identification of land-based nutrient sources. Phase II Final Report. In: Harmful Algae 4:1106–1122. "Bloom event" sampled in 2005 was lower in biomass estimates than 2004, but species composition similar (e.g., *Hypnea spinella, Agardhiella subulata, Gracilaria tikvahiae, Acanthophora spicifera).* Blooms of *Enteromorpha* sp. and *Ulva lactuca* (Chlorophyta) also occurred on beaches in southern Lee County during August of 2005.

[16]K. Lollar, 2006. The News-Press, "Excessive *Cladophora* mats in Ding Darling Center and off of Sanibel."

[17]R.D. Bartleson, et al., 2006. Macroalgae and seagrass monitoring during spring and summer of 2006. Report to City of Sanibel by SCCF Marine Lab. In the April 2006 a bloom dominated by *Ceramium* spp. in the Refuge's impoundments. Algae in the Refuge's embayments was thick near shore and dominated by Rhodophyta *(*e.g., *Gracilaria)* and some Phaeophyta *(*e.g., *Dictyota* spp.).

[18]K. Lollar, 2006. The News-Press, "Drift algae: water woes continue on Lee beaches."

[19]H. Downing, pers. obs., 2006. City of Sanibel, field notes and pictures, May 2006.

[20]C. Mansell (City of Sanibel, Florida), National Healthy Beaches Campaign (NHBC), Healthy Beaches Reports, 2003-2007. June 2006, red algae documented on Sanibel as level 3; November 2006, red algae documented on Sanibel as level 3; December 2006. Red algae documented on Sanibel beaches as level 4 (infested).

[21]J. Evans, pers. obs., June 2006 (City of Sanibel), picture reference of red algae accumulations. Photos indicate another red algae bloom on Sanibel. Photos also document Red tide event in October 2006, and late December 2006/early January 2007. Aerial photos included courtesy of City of Sanibel.

[22]K. Spinner, 2006. Sarasota Herald Tribune, June 28, 2006. Algae makes foul return to Southwest Florida coast. Large amount of red algae at Fort Myers Beach (FMB). R. Bartleson, SCCF Marine Lab referenced. *Lyngbya* (Cyanobacteria) bloom on Sanibel also.

[23]City of Sanibel Beach Conditions, 2006. April 2006, large quantities of macroalgae at Lighthouse and Blind Pass beaches. June 2006, Lighthouse beach affected by red algae, no sp. listed. Lighthouse beach also had a swimming advisory June 12th, 2006 (Lee County Health Department Advisory was cleared on the June 13, 2006. November 2006 reports large amounts of red algae, 2-12"deep. Donax, Algiers and Tarpon Bay beaches were also strongly affected by red algae accumulation. Beach reports did not indicate specific algal species.

[24]K. Lollar, Sept. 29, 2006. The News-Press. "The September strandings indicate that the drift (macroalgae) is related to Tropical Storm *Ernesto*."

[25]M. Krzos, 2006. The News-Press, Sept. 2nd 2006, Red drift algae expand southward. Red algae reported to be 4ft wide, 4 inches high, extends from the north end of Little Hickory Island to Bonita Beach.

[26]NOAA Satellite and Information Service, Query Results, "Tropical storm and Hurricanes in Florida. Hurricanes that hit near Lee or Collier counties-2006. Hurricane *Ernesto* hit Collier County on Aug 29th, 2006, moving northeast from South Florida.

[27]Florida Department of Health, Healthy Beaches (archived *Enterococcus* findings, see http://esetappsdoh.doh.state.fl.us/irm00beachwater/default.aspx). Archived *Enterococcus* counts for Blind Pass, Turner and Tarpon Bay beaches on September 20-22, 2006. Only "poor" counts for *Enterococcus* that result in advisory reported here.

[28]Florida Fish and Wildlife Conservation Commission. Red Tide Counts Archive. Red Tide online.com, http://research.myfwc.com/gallery/image_details.asp?id=17081. Estimates are generic for the entire Sanibel/Ft. Myers area.

[29]Ochoa, Sept. 22, 2007. The New-Press. " FGCU scientists to study red drift algae: Rhodophyte bloom at Ft. Myers Beach (R. Loflin, City of Sanibel cited)."

[30]C. Mansell (City of Sanibel, Florida), January 2007, National Healthy Beaches Campaign (NHBC), Healthy Beaches Reports, 2003-2007. Reports of Sanibel beaches at level 4 (infested) with red algae. No species information.

[31]J. Evans, pers. obs., 2007. City of Sanibel. Pictures of macroalgal accumulations, January 2007 pictures indicate another macroalgal bloom on Sanibel, as well as a Red Tide event. Also included, Feb. 2007 aerial survey photo of red algae bloom.

[32]K. Laakkonen, pers. obs. 2007. Environmental Sciences Coordinator, Town of Fort Myers Beach. The July 07 event was mostly Sargassum on the beaches of Sanibel, and the Feb/March 2007 event was many species.

[33]L. Ruane, January 5,2008. The News-Press. "Lee Tourism officials want algae study Council seeks to rid beaches of problem." February and March, 2007 included large amounts of macroalgae that were cleaned from on Ft. Myers Beach and the City of Sanibel.

[34]City of Sanibel Beach Conditions, 2006-2007. Red algae reported on Sanibel, specifically Algiers and Lighthouse beach for April 10 and 16, 2007. On August 7, 2007, Lighthouse beach again was implicated; however on August 8, 2007, an announcement that Sanibel beaches were in excellent condition was reported.

[35]Florida Department of Health, Healthy Beaches website. Archived *Enterococcus* counts for Blind Pass and Turner beaches, October 1 and 8, 2007. Only "poor" counts for *Enterococcus* that result in advisory are reported here.

[36]B. Klement, pers. obs., 2008. From Feb 8th, 2008 SCCF ML beach assessments, Bowman's Beach (1029h): Tide was fairly high with the surf looking very large at times. Larger waves, not a great deal of fresh macroalgae, however. Most of what was present on the beach was composed of material stranded at least one day or more. A large amount of drift macroalgae, however, was observed in Clam Bayou towards Bowman's beach beneath the bridge (this appeared to be mostly red algae, often in rather large accumulations).

[37]B. Klement, pers. obs., 2008. From March 8, 2008. SCCF ML beach assessments, Tarpon Bay Beach (1100h). Surf larger at Tarpon Bay than at Bowman's beach. A very large wrack line accumulating, composed primarily of marine invertebrates. Sea urchins made up the majority of the stranded animals with dying or dead scallops, cockles, mussels, sea cucumbers, and parchment worm tubes (photos *TB_10Mar08_4*). There were also some large amounts of drift macroalgae scattered amongst the wrack line. Also, from March 3, 2008. SCCF ML beach assessments, Bowman's beach (1000h), tide very high. Relatively large amounts of macroalgae on beach as compared to past weeks – significant accumulations apparent very near the tide line, composed primarily of red algae; however, some browns and greens were observed also. Many fragments in the wrack line appeared to be fairly old, however.

[38]SCCF Turtle volunteers (for the Mote Marine Laboratory, Beach Conditions Reporting System) noted on August 20th and 21, 2008. "Thick" macroalgal accumulations on the surf line and beach at Lighthouse Point.

[39]Special to the Island Reporter, March 6, 2009. "Drift algae appears in Pine Island Sound." Heavy fouling of seagrass blades by *Hincksia* sp. Have been reported around Sanibel. SCCF cited in article.

[40]K. Provost, pers. obs., December 2009. SCCF ML beach assessments. Report algae up to 6 inches deep on Tarpon Bay Beach access. Algae ID as *Hypnea spinella, Agardhiella subulata, Gracilaria tikvahiae, and Acanthophora spicifera.* Observed algae not considered large "bloom".

[41]C. Mansell, (City of Sanibel, Florida), October 2009. City Receives Algal Bloom (Red Tide) Notice and an Update from Lee County Health Department. Red tide report, City of Sanibel. October 30, 2009. October 28, 2009 and October 29, 2009; South Seas Plantation 56,300 cells/L Low (b) Respiratory irritation and possible fish kills, Tarpon Road Beach 560,000 cells/L Medium Respiratory irritation/shellfish harvesting closures/fish kills: Lighthouse Beach 2,000 cells/L, Very Low (a) Possible respiratory irritation; Lynn Hall Park, 0 cells/L; Lovers Key Park 0 cells/L; Bonita Beach Park, 0 cells/L.

[42]L. Coen and J. Raffensperger, pers. obs., 2010. Algae collected at Tradewinds Dr., southeast of Bowman's beach, near beach access #7. Algae mostly *Hypnea spinella, Agardhiella subulata* and *Gracilaria mammalaris*. Large numbers of dead snook were reported at this beach location. The majority of this algae is what is mostly found at inshore sites, and may be accumulating because of the cold weather swing, or increased currents

[43]NBC-2, WBBH, February 21-22, 2010. "Algae continues to line Ft. Myers Beach." Pictures indicate algae was "typical" of what occurs in the winter months. Algae was collected and identified by SCCF staff *Gracilaria tikvahiae, Solieria filiformis, Chondria collinsiana*, *Agardhiella subulata, Spyridia filamentosa,* and *Halymenia pseudofloresia*

[44]L. Coen and K. Provost, March 2010. Several calls received at Marine Lab related to macroalgae on beaches (March 9th and 10th, 2010) from Keith Laakonnen (Ft. Myers Beach). Lab staff out that day sampling offshore sites collected material 10 March, and collected algae on Ft. Myers Beach. Algae identified as *Chondria collinsiana, Gracilaria bursa-pastoris, Polysiphonia* sp.*, Daysa baillouviana* and *Solieria filiformis* (material was included in other analyses). J. Evans also collected material from three beaches (name them) on Sanibel Island. Algae were similar to Ft. Myers Beach samples, including several *Chondria* sp.*, Daysa baillouviana* and *Gracilaria* sp.

[45]A. Bryant, pers. obs., February 132010. Turtle and Beach Condition assessment by volunteers reported mass strandings of large jellyfish (identified later as *Rhopilema verrilli*) on several beaches, especially near the Sundial Resort on Sanibel.

[46]M. Campbell and E. Milbrandt, August 2010. *Ectocarpus* sp. bloom noted by Lee County and SCCF staff at offshore Drift Algae study sites GOM12 (June 8, 2010) and also at a Lee County artificial reef (Belton-Johnson in August 2010). Alga identified as *Ectocarpus* sp. by K. Provost and E. Milbrandt. Video sent by M. Campbell (Lee County Natural Resources).

[47]H. Downing, pers. obs., July 15, 2010. Algae was collected at Tarpon Bay beach and at the beaches off of Rabbit Road and West Gulf Drive, July 15, 2010. Collection and identification at SCCF by K. Provost and E. Milbrandt. Species were two rhodophytes, *Halymenia pseudofloresia* and *Agardhiella subulata*. Algae included in UC Davis isotope analyses, as it had been found also at several nearshore and offshore sites in the recent SCCF Drift Algae sampling (June 7, 2010).

[48]K. Laakonen, and L. Coen, pers. obs., July 19, 2010. Species appeared to be different from those reported earlier on July 152010 by City of Sanibel; however, B. Reynolds (Lee County Environmental Lab) reported no algae on beach by July 20th, 2010.