ECOLOGICAL EFFECTS of HARMFUL ALGAL BLOOMS on the WILDLIFE COMMUNITIES ASSOCIATED with SUBMERGED AQUATIC VEGETATION
ANNUAL REPORT
July 1, 2006 – June 30, 2007

FWC Agreement No. 06013

MOTE MARINE LABORATORY

Prepared For:
Florida Fish and Wildlife Conservation Commission
State Wildlife Grant Program

Submitted By:
Damon Gannon, Deborah Fauquier, Elizabeth Berens, Sandra Camilleri, Janet Gannon, Jason Allen and Randall Wells

Mote Marine Laboratory
Sarasota, FL 34236

July 15, 2007

MOTE MARINE LABORATORY TECHNICAL REPORT No. 1267

Annual Report

Project Number: SWG05_028

FWC Agreement No.: 06013

Project Title: Ecological Effects of Harmful Algal Blooms on the Wildlife Communities Associated with Submerged Aquatic Vegetation

Project Director: Damon Gannon, PhD

Project Assistants: Deborah Fauquier, Elizabeth Berens, Sandra Camilleri, Janet Gannon, Jason Allen, Randall Wells

Dates Covered by Report: July 1, 2006 – June 30, 2007

Date Report Submitted: July 15, 2007

ABSTRACT

Seagrass habitats are highly productive and ecologically rich areas for estuarine fish and bird species. Among all the sources of stress to seagrass habitats, harmful algal blooms (HABs) are ranked in the highest category. HABs are a source of ecological disturbance that are thought to alter water quality (physical and chemical), species composition, and patterns of primary productivity in seagrass meadows. This project will investigate the extent to which red tide affects the local abundance and habitat use of individual species, and composition of the fish and avian communities utilizing submerged aquatic vegetation habitats in Sarasota Bay. Data will be obtained by conducting seasonal surveys of fish (purse seining) and bird communities (visual surveys) during periods of red tide and in the absence of red tide. Our study design will include surveys of (1) fishes, (2) birds, (3) *K. brevis* cell counts, and (4) water quality (dissolved oxygen, salinity, temperature). Surveys conducted in summer 2006 and winter 2006/2007 have been completed and preliminary data analysis performed. Abundance and diversity of fishes associated with the seagrass community rebounded following the major red tide disturbance of 2005. A smaller red tide event began in early August 2006 and lasted until October. This red tide event appeared to coincide with increases in the local abundance of some bird (gulls) and fish (clupeids) species, but also corresponded with a decrease in fish diversity. This is the first annual report for this three-year project. Thus, results are preliminary. However, much progress has been made in the first year of the project and we are confident that our proposed methods will allow us to test all of the hypotheses outlined in the grant application.

INTRODUCTION

Seagrass habitats are highly productive and ecologically rich areas for wildlife (Heck et al. 2003). Florida's *Comprehensive Wildlife Conservation Strategy* lists submerged aquatic vegetation (i.e., seagrass) as a priority habitat with a statewide threat status of "Very High" and a condition of "Poor and Declining". Among all the sources of stress to seagrass, harmful algal blooms (HABs) are ranked in the highest category. HABs are a source of ecological disturbance that are thought to alter water quality (physical and chemical), species composition, and patterns of primary productivity in seagrass meadows.

Globally over the past 30 years, HABs have been becoming more frequent and widespread (Van Dolah 2000). In Florida, the most prevalent HAB is the red tide organism, *Karenia brevis*, a dinoflagellate that produces brevetoxins (Baden et al. 1989; Kirkpatrick et al. 2004). Brevetoxins are neurotoxins that can cause acute respiratory and neurological symptoms including death in marine mammals, sea turtles, birds, and fish (Gunter et al. 1948; Steidinger *et al.*, 1973; Bossart et al. 1998; Foote et al. 1998; Landsberg & Steidinger 1998, Kreuder et al. 2002; Flewelling et al. 2005). HABs can also increase biochemical oxygen demand, resulting in hypoxia or anoxia, and causing fish to die or abandon habitat (Smith 1975; Paerl & Pinckney 1996; Paerl et al. 1999; Eby & Crowder 2002, 2004).

The ecological impact of HABs on wildlife communities is not well documented. Red tides are well known to cause episodes of high mortality among marine vertebrates. However, little information exists on whether red tides have significant effects at either the population or community level. This study aims to determine how red tide influences the abundance and species composition of fish and sea birds utilizing seagrass habitats in Sarasota Bay, FL. It is impossible to develop effective management strategies when the exact nature of a problem is not understood. This project will quantify the level of threat that red tide poses to seagrass communities, which should inform the management process.

METHODS

General Approach and Study Area

We are attempting to understand how red tide affects the fish and bird communities found in seagrass habitats. To accomplish this, our research design includes seasonal (summer and winter) surveys of (1) fishes, (2) birds, (3) *K. brevis* cell counts, and (4) water quality (dissolved oxygen, salinity, temperature). All four types of data are collected simultaneously at a minimum of 20 sampling sites per field season (× 2 field seasons per year × 3 years = 120 samples). Additional bird, water quality, and *K. brevis* surveys are conducted at another 40 sampling sites per field season. Finally, *K. brevis* cell counts and water quality are monitored every other week at 10 fixed stations, distributed throughout our study area (including all Gulf passes). Supplementing the sampling described here, Mote Marine Laboratory's Phytoplankton Ecology Program also monitors *K. brevis* cell counts daily at two sites in Sarasota Bay: New Pass and City Island Grass Flats.

The study area encompasses the estuarine waters from Anna Maria Sound (27.5528° N / 82.7423° W) southward to Phillippi Creek (27.27096° N / 82.53757° W), including the waters of Sarasota, Palma Sola, and Roberts Bays (Figure 1). Selection of sampling sites for bird and fish surveys uses a random sampling system developed with GIS, relational databases, and visual basic programming. Potential seagrass habitat to be sampled in the study area is identified from digitized polygons obtained from FWC's biennial seagrass surveys. A sampling grid having 200 m × 200 m resolution is overlaid on the seagrass polygons in our study area. Grid cells to be sampled are chosen at random using a custom Visual Basic program. Sampling sites are located at the centroids of each grid cell and are located in the field with a WAAS-enabled GPS unit (Garmin GPS Map 162).

Water Quality Measurements and *Karenia brevis* Cell Counts

Water quality parameters were measured at the surface and on the bottom at each sampling station using a YSI 85 multiprobe. The multiprobe was calibrated weekly. Surface water samples were collected to quantify *K. brevis* cell densities. Water samples were immediately preserved in Utermohl's solution and stored in the dark at room temperature. Cell counts were performed in the laboratory using an inverted Olympus CK40 microscope. Protocols for water collection, preservation, and *K. brevis* enumeration followed the methods of Lund et al. (1958), Sournia (1978), and Sellner et al. (2003).

Fish Sampling

Fish surveys are carried out with a 183-m purse seine net. The methods used are similar to those used by the Fishery Independent Monitoring Program of the Florida Fish and Wildlife Conservation Commission (Wessel & Winner 2003). The mesh size is 2.5-

cm (diamond), made from No. 7 nylon twine. The net is symmetrical (no bunt), and is 6.6 meters deep. The cork line is 1.3-cm twisted polypropylene line with SB10 "can" floats spaced every 45 cm. The footrope is a doubled, 39-kg leadcore line. The purse rings are 10.2-cm stainless steel alpine clips attached to 91-cm of 9.5-mm braided polypropylene line, which are fastened to the footrope at 2.8-m intervals. The lead tom weight weighs 68 kg. The purseline is 366 m of 18-mm, non-rotating, 12-strand braided polytron. This purse seine is used to capture all fish from the surface to the benthos when used in water depths between 0.4 and 4.0 meters (Sarasota Bay's maximum depth = 4 m). All fish and invertebrates captured in the net are identified to species and counted and up to 100 individuals from each species are measured from every deployment of the net. Relative densities of fish are measured by catch per unit effort (CPUE), or the number of fish captured in each standardized deployment of the net.

Bird Sampling

Boat-based point transect surveys are conducted by two observers for 5-minute observation periods. Observers scan 360 degrees around the boat and record individual birds to species, location and activity. Foraging activity is noted and prey species are identified visually when possible. Relative abundance is calculated by sightings per unit effort (SPUE, the number of individual birds sighted within the 5-minute sampling period).

PROGRESS

Water Quality Measurements and *Karenia brevis* Cell Counts

To capture data at appropriate temporal and spatial scales, measurements of water quality (dissolved oxygen, salinity, temperature) and *K. brevis* cell counts were made under four independent sampling schemes, one supported by this grant and three supported by other sources. Water quality measurements and water samples for *K. brevis* cell counts were taken (i) simultaneously with every bird (n=170) and fish (n=69) survey sample taken in the seagrass habitat during the summer of 2006, winter of 2007, and during June of 2007 (the first month of the 4-month summer sampling season); (ii) at bird and fish sampling locations in six other habitats during the same time period (n=572); (iii) at each of ten regular monitoring stations spread throughout Sarasota Bay on a biweekly basis during the past year (n= 240); and (iv) at two monitoring sites in Sarasota Bay (New Pass Channel and City Island Grass Flats) that are sampled each weekday by Mote Marine Laboratory's Phytoplankton Ecology Program. The first sampling regime described above is supported by this grant, whereas the latter three are supported by other funding mechanisms. All cell counts were conducted within five days of water sample collection, using the same protocols, equipment, and personnel.

Red tide cell counts were ≤5,000 cells/liter throughout June and July of 2006. A red tide bloom reached Sarasota Bay on August 4, 2006 (Figure 3). From mid-August to early November, *K. brevis* cell counts were consistently >100,000 cells/liter. The daily monitoring at New Pass conducted by Mote's Phytoplankton Ecology Program recorded a maximum cell count of nine million cells per liter. The three other red tide monitoring regimes associated with this project that spanned the entire Sarasota Bay study area revealed that the bloom was temporally and spatially patchy (much more patchy than the daily monitoring at New Pass and City Island Flats would suggest), with a maximum cell count of 8.9×10^7 cells/liter. Cell counts peaked in early September and slowly diminished in the Bay, returning to levels below 5,000 cells/liter in November 2006. From November 15, 2006 to June 30, 2007 cell counts have been ≤5,000 cells/liter.

Fish Sampling

Tables 1 and 2 show fish sampling effort. During summer 2006, a total of 39,405 fish from 54 species were caught in 33 seine sets made in the seagrass habitat. During winter 2007, 24 seine sets made in seagrass resulting in the capture of 67 species and a mean CPUE (all species combined) of 213.3. As seen from table 1, fish sampling has occurred in eight habitats every summer and winter since summer 2004. Sampling of additional habitats and years were covered by other funding sources. From summer 2004 to winter 2007, 644 purse se ine sets have been made, which captured 179,572 fishes from 124 species. In the first month of the 2007 summer season (June 1-30, 2007), 12 seine sets were made in seagrass habits and 24 sets were made in the other habitats. Sampling for the 2007 summer season is currently underway and will continue until September 30.

Overall CPUE (all species combined) in the seagrass was significantly lower during the summer of 2005 than it was in the summers of 2004 and 2006 (one way ANOVA: $df=2,70$, $F=13.91$, $P<0.01$). Overall CPUE was also lower in the seagrass during red tide than non-red tide periods (red tide samples were defined as all seine sets made within a month following any cell count ≥100,000 cells/liter anywhere in the study area) (t-test: $df=71$, $t=-3.32$, $P<0.01$). Combining data from the summers of 2005 and 2006, we found that there were no significant correlations between *Karenia brevis* cell counts and any of the water quality parameters measured at the same time and location (Table 3). Likewise, there were no significant correlations between total CPUE and any water quality parameters measured at the time of seining. However, there was a statistically significant negative correlation between total CPUE and *K. brevis* cell count (Spearman rank correlation: n=45, r_s=-0.34, p=0.02). The average number of fish species captured per seine set was significantly lower during red tide periods than non red tide periods in all habitats, including seagrass (Table 4).

Bird Sampling

A total of 2477 individual birds were counted during the 2006 summer season between two survey vessels, R/V Lorry and R/V Flip. R/V Lorry conducted dedicated bird surveys. R/V Flip, the fish sampling vessel, was used as a vessel of opportunity to collect data on birds during fish sampling trips. R/V Flip conducted 30 bird surveys over 23 days, representing 749 individual birds and 283 observations. The "sighting per unit effort" was 9.43 ± 5.53 observations per station and 24.97 ± 44.29 birds per station, respectively. R/V Lorry conducted 61 bird surveys over 18 days, representing 1727 individual birds and 1024 observations (Figure 6). The "sighting per unit effort" was 16.79 ± 10.91 observations per station and 28.31 ± 35.79 birds per station, respectively. In total there were 19 different species or taxonomic groups of bird represented in the surveys. The most abundant bird species were laughing gulls (*Larus atricilla*), and brown pelicans (*Pelecanus occidentalis*) (Table 5).

A total of 3624 individual birds were counted during the 2007 winter season between two survey vessels, R/V Lorry and R/V Flip. R/V Flip conducted 22 bird surveys over 16 days, representing 270 individual birds and 122 observations. The "sighting per unit effort" was 5.55 ± 3.67 observations per station and 12.27 ± 20.47 birds per station, respectively. R/V Lorry conducted 94 bird surveys over 29 days, representing 3354 individual birds and 1146 observations. The "sighting per unit effort" was 12.06 ± 7.63 observations per station and 35.31 ± 45.69 birds per station, respectively. In total there were 40 different species or taxonomic groups of bird represented in the surveys. The most abundant bird species were laughing gulls (*Larus atricilla*), and double-crested cormorants (*Phalacrocorax auritus*). Bird species present during the winter season included migrating species such as the American white pelican (*Pelecanus erythrorhynchos*), Merganser sp. (*Mergus sp.*), Common loon (*Gavia immer*), and Forster's tern (*Sterna forsteri*).

Total bird counts were analyzed for differences before and after red tide entered the bay on August 4, 2006. For R/V Flip, 14 stations were sampled prior to August 4^{th} and 16 stations were sampled subsequent to August 4^{th}. Overall sightings per unit effort changed from 10.64 ± 7.85 birds per station before August 4th to 37.50 ± 58.14 birds per station after August 4^{th} (Mann-Whitney test, p=0.4). For R/V Lorry, 41 stations were sampled prior to August 4^{th} and 19 stations were sampled subsequent to August 4^{th}. Sightings per unit effort changed from 21.98 ± 27.85 birds per station before August 4th to 42.79 ± 47.14 birds per station after August 4^{th} (Mann-Whitney test, p=0.02).

A total of 2477 individual birds were counted during the summer season between two survey vessels, R/V Lorry and R/V Flip. R/V Lorry conducted dedicated bird surveys. R/V Flip, the fish sampling vessel, was used as a vessel of opportunity to collect data on birds during fish sampling trips. R/V Flip conducted 30 bird surveys over 23 days, representing 749 individual birds and 283 observations. The "sighting per unit effort" was 9.43 ± 5.53 observations per station and 24.97 ± 44.29 birds per station, respectively. R/V Lorry conducted 61 bird surveys over 18 days, representing 1727 individual birds and 1024 observations (Figure 1). The "sighting per unit effort" was 16.79 ± 10.91 observations per station and 28.31 ± 35.79 birds per station, respectively. In total there were 19 different species or taxonomic groups of bird represented in the surveys. The most abundant bird species were laughing gulls (*Larus atricilla*), and brown pelicans (*Pelecanus occidentalis*) (Table 5).

PLANS

Observational field studies on the ecological effects of disturbance phenomena require long time series of data. This annual report covers the first year of a 3-year project. The current field season will continue until September 30, 2007. We will then have two more winter field seasons (2008 and 2009) and one more summer season (2008) to conduct under the current grant. Final analyses will be performed at the conclusion of this project when we will have fish data from 5 years and bird data from 3 years. However, preliminary analyses of the effects of red tides on the abundance of fish and birds, and of potential changes to the structure of the estuarine community have already begun. These preliminary analyses are intended to verify that our sampling and analytical methods are appropriate for addressing the hypotheses identified in our original proposal. The bird portion of the project will be comprise a portion of Dr. Fauquier's Ph.D. research.

LITERATURE CITED

Baden, D.G. 1989. Brevetoxins: unique polyether dinoflagellate toxinx. FASEB Journal 3:1807-1817.

Bossart, G.D., D.G. Baden, R.Y. Ewing, B. Roberts and S.D. Wright. 1998. Brevetoxicosis in manatees (*Trichechus manatus latirostris*) from the 1996 epizootic: gross, histologic, and immunohistochemical features. Toxicologic Pathology, 26: 276-282.

Bossart, G.D., D.G. Baden, R.Y. Ewing, B. Roberts and S.D. Wright. 1998. Brevetoxicosis in manatees (*Trichechus manatus latirostris*) from the 1996 epizootic: gross, histologic, and immunohistochemical features. Toxicologic Pathology, 26: 276-282.

Eby, L.A. and L.B. Crowder. 2001. Hypoxia-based habitat compression in the Neuse River estuary: context-dependent shifts in behavioral avoidance thresholds. Canadian Journal of Fisheries and Aquatic Sciences 59:952-965.

Eby, L.A. and L.B. Crowder. 2004. Effects of hypoxic disturbances on an estuarine nekton assemblage across multiple scales. Estuaries 27:342-351.

Flewelling, L.J., Naar, J.P., Abbott, J.P., Baden, D.G., Barros, N.B., Bossart, G.D., Bottein, M.-Y. D., Hammond, D.G., Haubold, E.M., Heil, C.A., Henry, M.S., Jacocks, H. M., Leighfield, T.A., Pierce, R.H., Pitchford, T.D., Rommel, S.A., Scott, P.S., Steidinger, K.A., Truby, E.W., Van Dolah, F.M. and Landsberg, J.H. 2005. Brevetoxicosis: Red tides and marine mammal mortalities. Nature, 435: 755-756.

Foote, J. J., N. L. Park, and J. M. Sprinkel. 1998. An increase in marine turtle deaths along the west central coast of Florida: (1995–1996): is red tide the culprit? Pages 180–182 *in* S. P. Epperly and J. Braun, compilers. Proceedings of the 17th Annual Sea Turtle Symposium. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-415.

Gunter, G., R.H. Williams, C.C. Davis and F.G.W. Smith. 1948. Catastrophic mass mortality of marine animals and coincident phytoplankton bloom on the west coast of Florida, November 1946 to August 1947. Ecological Monographs, 18:309-324.

Heck, K.L., C. Hays and R.J. Orth. 2003. A critical evaluation of the nursery role hypothesis for seagrass meadows. Marine Ecology Progress Series, 253:123-136.

Kirkpatrick, B., L.E. Fleming, D. Squicciarini, L.C. Backer, R. Clark, W. Abraham, J. Benson, Y.S. Cheng, D. Johnson, R. Pierce, J. Zaias, G.D. Bossart, D.G. Baden. 2004. Literature review of Florida red tide: implications for human health effects. Harmful Algae 3:99-115.

Kreuder, C., J.A.K. Mazet, G.D. Bossart, T.E. Carpenter, M. Holyoak, M.S. Elie, and S.D. Wright. 2002. Clinicopathologic features of suspected brevetoxicosis in double-crested cormorants (*Phalacrocorax auritus*) along the Florida gulf coast. Journal of Zoo and Wildlife Medicine, 33:8-15.

Landsberg, J.H. and Steidinger, K.A. 1998. A historical review of *Gymnodinium breve* red tides implicated in mass mortalities of the manatee (*Trichechus manatus latirostris*) in Florida, USA. In:*Harmful Algae*, pp. 97-100. (eds.) B. Reguera, J. Blanco, M.L. Fernandez and T. Wyatt. Xunta de Galicia and IOC of UNESCO.

Lund, J. W. G., Kipling, C., LeCren, E. D., 1958. The inverted microscope method of estimating algal numbers and the statistical basis of estimations of counting. Hydrobiologia, 11, 143-170.

Paerl, H.W. and J.L. Pinckney. 1996. Hypoxia, anoxia, and fish kills in relation to nutrient loading in the Neuse River estuary: why was 1995 a "bad" year? Water Wise, 4:2. University of North Carolina Sea Grant Program, Raleigh, NC.

Paerl, H. W., J. L. Pinckney, J. M. Fear and B. L. Peierls. 1999. Fish kills and bottom-water hypoxia in the Neuse River and Estuary: reply to Burkholder et al. Marine Ecology Progress Series 186:307-309.

Sellner, K.G., G.J. Doucette, and G.J. Kirkpatrick. 2003. Harmful algal blooms: causes, impacts, and detection. J. Ind. Microbiol. Biotechnol. 30:383-406.

Smith, G.B. 1975. The 1971 red tide and its impact on certain reef communities in the eastern Gulf of Mexico. Environmental Letters 9(2): 141-152.

Sournia, A. 1978. Phytoplankton manual. "Monographs on Oceanographic Methodology," No.6, pp. 337. UNESCO. Paris.

Steidinger, K.A., M. Burklew, and R.M. Ingle. 1973. The effects of *Gymnodinium breve* toxin on estuarine animals. Pages 179-202 *in* Martin, D.F. and G.M. Padilla, eds. Marine Pharmacognosy: Action of Marine Toxins at the Cellular Level. Academic Press, New York, NY.

Van Dolah, F.M. 2000. Marine algal toxins: Origins, health effects, and their increased occurrence. Environmental Health Perspectives (Supplement) 108(S1):133-141

Wessel, M.R. & B.L. Winner. 2003. Using a modified purse seine to collect and monitor estuarine fishes. Gulf and Caribbean Research 15:61-71.

Table 1. Purse seining effort in Sarasota Bay, Florida conducted to investigate the effects of red tide on the fish community. Number of field days and number of purse seine sets (in total and by habitat) are shown for each summer and winter field season from 2004 to 2007.

	Summer 2004	Winter 2004-2005	Summer 2005	Winter 2005-2006	Summer 2006	Winter 2006-2007	Total
Field Days	**30**	**31**	**40**	**35**	**43**	**33**	**212**
Seine Sets	**81**	**82**	**141**	**105**	**134**	**101**	**644**
Seagrass	16	21	24	19	33	24	137
Mangrove	13	19	26	12	25	16	111
Unvegetated (Sand)	10	13	19	27	24	17	110
Open Bay	18	16	23	13	30	18	118
Pass	1	0	5	1	0	0	7
Channel	7	3	11	8	1	3	33
Shallow Gulf	13	7	15	11	11	8	65
Deep Gulf	3	3	18	14	10	15	63

Table 2. Total number of fish species captured, total number of fishes captured, and the subset of fish that were counted and measured, and subset of fish that were counted only for each field season from summer 2004 to winter 2007 during purse seine survey of Sarasota Bay, Florida.

	No. Species	No. Measured Fish	No. Counted Fish	No. Total Fish
Summer 2004	89	10,090	15,026	**25,116**
Winter 2004-2005	73	7,592	12,293	**19,885**
Summer 2005	55	9,054	12,474	**21,528**
Winter 2005-2006	58	6,606	6,831	**13,437**
Summer 2006	77	22,399	54,687	**77,086**
Winter 2006-2007	67	8,667	13,853	**22,520**
Total	**124**	**64,408**	**115,164**	**179,572**

Table 3. Spearman rank correlation coefficients for *Karenia brevis* cell counts (cells/liter) and water quality parameters (dissolved oxygen, temperature, and salinity), overall catch per unit effort and water quality parameters, and catch per unit effort and *K. brevis* cell count from purse seine surveys of seagrass beds in Sarasota Bay during summers of 2005 and 2006.

	n	r_s	p
***K. brevis* vs. D.O.**	48	0.07	0.65
***K. brevis* vs. Temp.**	48	-0.14	0.36
***K. brevis* vs. Salinity**	48	-0.09	0.52
CPUE vs. D.O.	50	0.25	0.09
CPUE vs. Temp.	50	0.07	0.64
CPUE vs. Salinity	50	-0.02	0.90
CPUE vs. *K. brevis*	45	**-0.34**	**0.02**

Table 4. Mean number of fish species caught per seine set by year and by red tide vs. non-red tide during the summers of 2004-2006 in five habitats within the Sarasota Bay study site. Average number of species caught in summer 2005 was significantly lower than the average for either 2004 or 2006 in each habitat (one-way ANOVAs and Tukey's post-hoc tests, $p<0.05$). Average number of species caught per seine during red tide periods was significantly lower than during non-red tide periods for each habitat (t-tests, $p<0.05$)

		2004	**2005**	**2006**	**Non-Red Tide**	**Red Tide**
Mangrove	Mean	11.23	4.50	11.88	11.93	6.43
	S.D.	2.65	2.75	4.56	2.91	4.93
Gulf	Mean	5.19	2.52	4.38	5.48	2.56
	S.D.	3.25	1.62	3.06	2.83	2.02
Open Bay	Mean	12.28	2.09	9.03	11.44	4.46
	S.D.	4.28	1.78	3.21	4.02	3.55
Sandflat	Mean	10.90	4.11	9.38	10.10	6.25
	S.D.	4.75	2.28	2.89	3.71	3.77
Seagrass	Mean	15.38	6.04	13.42	15.38	7.97
	S.D.	4.91	4.20	5.01	4.62	4.99

Table 5. Relative abundance of birds in seagrass habitats of Sarasota Bay during summer 2006,

A. R/V Lorry (dedicated bird surveys)

Species	SPUE
Laughing gull, *Larus atricilla*	8.68
Brown pelican, *Pelecanus occidentalis*	8.10
Sandwich tern, *Sterna sandvicensis*	2.62
Double-crested cormorant, *Phalacrocorax auritus*	2.25
Sterna sp.	2.13
Larus sp.	1.62
Great egret, *Andea alba*	0.97
Royal tern, *Sterna maxima*	0.68
Least tern, *Sterna antillarum*	0.62
Great blue heron, *Ardea herodias*	0.20
White ibis, *Eudocimus albus*	0.17
Corvus sp.	0.15
Little blue heron, *Egretta caerulea*	0.13
Osprey, *Pandion haliaetus*	0.07
Magnificent frigatebird, *Fregata magnificens*	0.05
Snowy egret, *Egretta thula*	0.05
Black skimmer, *Rynchops niger*	0.03
Belted kingfisher, *Ceryle alcyon*	0.02
Egretta sp.	0.02

B. R/V Flip (opportunistic bird surveys)

Species	SPUE
Brown pelican, *Pelecanus occidentalis*	8.83
Laughing gull, *Larus atricilla*	5.37
Larus sp.	3.40
Sterna sp.	3.33
Double-crested cormorant, *Phalacrocorax auritus*	1.70
Great egret, *Andea alba*	0.57
Least tern, *Sterna antillarum*	0.57
Sandwich tern, *Sterna sandvicensis*	0.47
Royal tern, *Sterna maxima*	0.30
Magnificent frigatebird, *Fregata magnificens*	0.20
Great blue heron, *Ardea herodias*	0.13
Snowy egret, *Egretta thula*	0.07
Corvus sp.	0.03

Figure 1. Bird survey sampling sites in seagrass habitats of Sarasota Bay and adjacent estuarine waters during summer 2006.