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Technical Report #01-99
Tampa Bay Estuary Program

CE994438-93

Alafia River Oyster Bar Restoration Demonstration Project

Final Monitoring Report

September 1995 through December 1998



February 15, 1999

Environmental Protection Commission of Hillsborough County
1900- 9th Avenue
Tampa, FL 33605

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Final Monitoring Report

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Prepared for :

Tampa Bay Estuary Program
100-8th Ave. SE
MS I-1/NEP
St. Petersburg, FL 33701

February 15, 1999



Tom Cardinale and Tom Ash
Environmental Protection Commission of Hillsborough County
1900- 9th Avenue
Tampa, FL 33605

In Cooperation with:

Suzanne Cooper
Tampa Bay Regional Planning Council
9455 Koger Boulevard
St. Petersburg, FL 33702



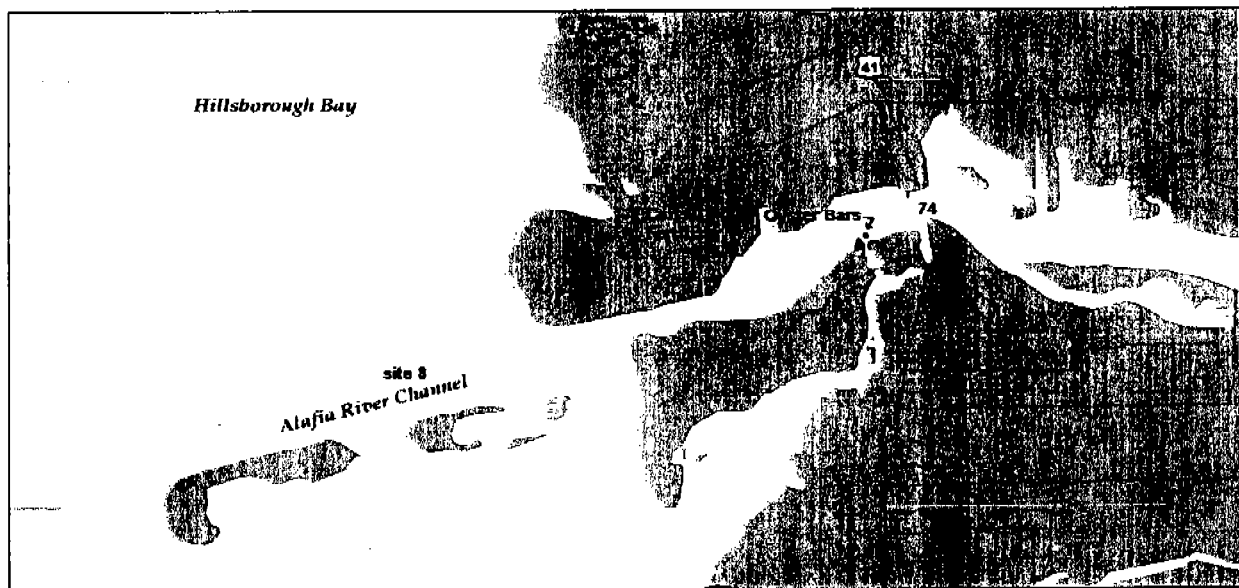
“.....thence I continued southward to the Alafia River, Big and Little Manatee, Sarasota, Boca Grande oyster bars and 100 miles farther south, and on every hand I found the same conditions - oysters, oysters everywhere. How little did I then think that in less than twenty five years every one of these bars would be partially or totally depleted.”

1898 Bulletin of the United States Fish Commission: “ The Oyster-Bars of the West Coast of Florida: Their Depletion and Restoration.” By A. Smeltz

Introduction

On September 15, 1995 construction began on the Alafia River Oyster Bar Restoration Demonstration Project. Participants in the project include the Tampa Bay Estuary Program (TBEP), Tampa Bay Regional Planning Council (TBRPC), Cargill Fertilizer, Inc., Florida Department of Environmental Protection (DEP), Florida Dredge and Dock Co., and the Environmental Protection Commission of Hillsborough County (EPC). The intent of the project was to re-establish oyster bars in the lower Alafia River which have historically been lost to dredging of the shipping channel and associated turning basin adjacent to Cargill Fertilizer Company. Oyster bar habitats are a vital part of the estuarine ecosystem serving as foraging areas for birds, raccoons, and invertebrates as well as nursery areas for numerous species of fish. They also help stabilize the shoreline and help improve water clarity. They also have the potential of providing a food resource to the community and in some areas of Florida a commercial shellfish industry has developed.

The role of the Environmental Protection Commission (EPC) in this project has been monitoring the progress of these oyster bars over a three year period so that some measure of project success can be determined. Quarterly monitoring events have occurred. These include a general visual observation of the wildlife using the oyster bars, physical characteristics of the bars themselves (i.e. size, dimensions, erosion, vegetative growth) and, of course, whether there is any evidence of oyster growth. Water chemistry of the area is measured indirectly from existing EPC water quality monitoring stations located both upstream and downstream from the oyster bars. Should this project prove to be successful then, perhaps similar oyster bars could be constructed, in other areas of the estuary that once supported oyster bars, but were lost, buried or removed for one reason or another.



Oyster Bar Monitoring Results

Physical Monitoring

The bars were constructed by draglining approximately 450 cubic yards of unwashed shell and sand from a barge. The spoil came from a small channel deepening project in the Weedon Island area of Pinellas County. Three small oyster bars were constructed on the south side of the Alafia River adjacent to Cargill Fertilizer's South Parcel. The original dimensions of the oyster bars were recorded by EPC in order to determine, for future reference, whether the bars are growing, eroding, or otherwise being moved around by tides and wave action.

Year One: Based on the data collected after one year, the general shape of the bars had not significantly changed. The sand component of the original mixture has become more apparent over the past year, particularly around the outer edges of the bars. The original measurements of the larger bar to the west remain approximately 90 ft. by 75 ft. at the bar's widest extremities. The original height of the bar (approx. 3 ft. above MLLW) has been the most dynamic feature of the project and has demonstrated obvious signs of wave and tidal influence. Two relatively large depressions in the middle of the bar have formed and subsequently a displaced narrow shell berm has formed around these depressions, presumably by high energy wave action. These waves may be the result of storms, local small boat traffic in the river and/or perhaps by displacement waves caused by large ships maneuvering in the nearby Cargill Fertilizer, Inc. turning basin. EPC staff manually re-graded the larger bar after one year, to allow for maximum submersion of the shell at high tides and therefore increase the amount of usable substrate for future oyster recruitment. This was performed by shoveling the higher accumulations of shell back into the water. As oyster and other biological growth occurs on the light weight nonliving shell, the shell will become heavier and less likely to be moved by wave energy.

Years Two & Three

Two to three years after construction, the bars are still there and close to their original size, location and appearance. Most of what you see today is a sand bar laden with dead oyster shell above the tide line. Below the tide line you find scattered but sparse live oyster clusters and dead oyster shell debris on a sandy base. The bars give the illusion of shrinking but this is due to the encroachment of the mangroves. The two depressions noticed after one year have disappeared and have leveled off under a heavy growth of mangroves.

The following aerial photo was taken shortly after the oyster bars were constructed in 1995. The top of the photo is the south side of the river. The three lighter (white) colored areas are the bars. They were placed at the mouth of a newly created ditch, reconnecting the river to the large mangrove area to the south.



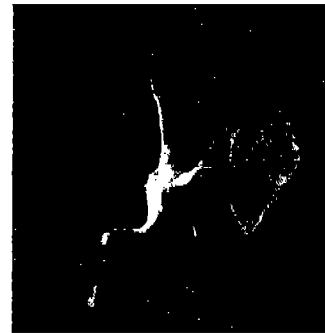
Biological Monitoring

Year One (Sept. 1995 - Sept. 1996): During this initial reporting period, live oysters were observed growing on the artificially placed oyster shells. This new growth can be easily distinguished from the transplanted oyster shell and most likely has been "seeded" by other naturally occurring oysters located in both upstream and downstream areas of the river, on mangrove roots, pilings and seawalls. Based on their current (Sept. 1996) size of 1 to 1.5 inches in diameter, these new oysters were probably spawned during the Fall of 1995. They did not become readily apparent to the naked eye until September of 1996. In addition to new oyster growth, the shells have also become substrate for other organisms to attach their eggs. Egg casings of Florida Crown Conch (*Melongena corona*) were also recorded on the new bars. A diverse community of wildlife has been recorded utilizing the oyster bars almost as quickly as they were built. The following is a list of those species observed during the reporting period:

Birds:

Roseate Spoonbill - *Ajaia ajaja*
Tricolored Heron - *Egretta tricolor*
White Ibis - *Eudocimus albus*

Osprey - *Pandion haliaetus*
Herring Gull - *Larus argentatus*
Brown Pelican - *Pelecanus occidentalis*
Double-crested Cormorant - *Phalacrocorax auritus*
Great Blue Heron - *Ardea herodias*

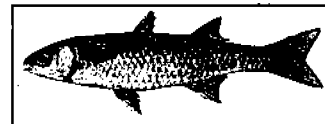


Fish:

White Mullet - *Mugil curema*
Small bait fish/Killifish

Vegetation:

Red Mangroves - *Rhizophora mangle*
Black Mangroves - *Avicennia germinans*
Beach Carpet - *Phloxerus vermicularias*
Marsh Elder - *Iva spp.*
Sea Blite - *Suaeda linearis*



Invertebrates:

Stone Crab - *Menippe mercenaria*
Oyster - *Crassostrea virginica*
Barnacles - *Balanus spp.*
Mussels - *Brachidontes spp.*
Shrimp - *Penaeus spp.*
Florida Crown Conch - *Melongena corona*
Blue Crab - *Callinectes sapidus*



Mammals:

Raccoon - *Procyon spp.*

Year Two (Sept. 1996 - Sept. 1997): In year two, the most dramatic biological changes were attributed to the continued growth of the mangroves. A stable stand of Black and White mangroves began to dominate the south-central portion of the largest oyster bar. These trees, which obviously did not exist prior to the bars creation, were now ranging from two to four feet in height. Also continuing to grow were the occasional Marsh Elder and Sea Blite. This healthy vegetation seems to have played an important role, not only by providing additional habitat for birds and mammals using the bar, but also by stabilizing the substrate. A diverse community of wildlife continues to be recorded utilizing the oyster bars. The following is a list of those species observed during the reporting period:

Birds:

Herring Gull - *Larus argentatus*
Brown Pelican - *Pelecanus occidentalis*
Scaup Duck - *Aythya spp.*

Fish:

White Mullet - *Mugil curema*
Small bait fish/Killifish
Atlantic Needlefish - *Strongylura marina*

Vegetation:

Red Mangroves - *Rhizophora mangle*
Black Mangroves - *Avicennia germinans*
White Mangroves - *Laguncularia racemosa*
Beach Carpet - *Phloxerus vermicularias*
Marsh Elder - *Iva spp.*
Sea Blite - *Suaeda linearis*



Invertebrates:

Stone Crab - *Menippe mercenaria*

Oyster - *Crassostrea virginica*

Barnacles - *Balanus spp.*

Mussels - *Brachidontes spp.*

Florida Crown Conch - *Melongena corona*

Mammals:

Raccoon - *Procyon spp.*



Jan. 27, 1999 new mangroves on the oyster bar

Year Three (Sept. 1997 - Dec. 1998): After three years the bars have changed. Live oyster clusters are growing around the bars but at a relatively low density. Most of what you see is a sand bar laden with dead oyster shell above the tidal line, scattered but sparse live oyster clusters below the tide line and a healthy growth of mangroves invading the bar (some 3 to 6 feet high). It is expected that the clusters of shell will continue to grow and eventually completely cover the sandy areas. Bird and animal tracks are common. The project sign erected in 1995 has fallen down and is resting in the mangroves. It will be removed shortly. The following is a list of those species observed during the reporting period:

Birds:

White Heron / Egret- Ardeidae Family
Green Heron - *Butorides striatus*



Fish:

White Mullet - *Mugil curema*

Vegetation:

Red Mangroves - *Rhizophora mangle*
Black Mangroves - *Avicennia germinans*
White Mangroves - *L. racemosa*
Beach Carpet - *Philoxerus vermicularias*
Marsh Elder - *Iva spp.*
Sea Blite - *Suaeda linearis*

Invertebrates:

Oyster - *Crassostrea virginica*
Barnacles - *Balanus spp.*
Florida Crown Conch - *Melongena corona*

Mammals:

Raccoon - *Procyon spp.*



Jan. 27, 1999 view of oyster bar looking NW

Lead Fishing Weights

One unexpected finding, noticed on our initial field trip to the site, was the relatively large number of lead fishing weights scattered about the shell. The sinkers were picked up, cleaned, dried, and weighed. Two hundred and eleven (211) sinkers weighing 16.6 pounds were recovered, plus 2 scuba divers weights (4 pounds each) for a grand total of 24.6 pounds of lead! Fishing pliers, pocket knives, fishing lures, soft drink glass bottles and a few coins were also found. The sinkers will be recycled by EPC fisherman.



About one month later, staff recovered another 139 lead sinkers (6.62 pounds). The lead weights consisted of many different types and styles but were mostly egg shaped sinkers. With the exception of the final monitoring event, lead fishing weights were found and removed from the oyster bars throughout the reporting period. As of the date of publication, a total of 37.6 pounds of lead has been recovered.

An unusual feature observed on most of the sinkers, were the claw marks apparently made by stone crabs. For some unknown reason the crabs apparently like to claw the sinkers. The oyster shell material came from a maintenance dredging project performed by Florida Dock and Dredge, Inc., just off of the dock at Weedon Island in the Riviera Bay area of Pinellas County. The fishing weights apparently came from this popular

fishing site which had been used for more than 50 years. EPC staff pondered the ecological effects, if any, that this lead contamination might have on the oyster bars. Visually there was no noticeable suppression of oyster growth or other biota normally associated with oyster bars. In any case, EPC staff continue to remove any man made objects found on the bars. As a result of this potential lead sinker contamination, EPC sampled the sediment from these bars in September of 1996, as part of our annual Benthic Monitoring Program. The samples were analyzed for lead and eight other metals, sediment sizing, and benthic organisms.



Claw marks on lead fishing sinkers

Benthos in the vicinity of the Alafia River Oyster Bar

A single benthic sample was collected within the area of the oyster bar during October 1996. Bottom salinity (0.9 m) was 16 ppt and the near-bottom dissolved oxygen concentration was 4.1 ppm. Species diversity was relatively high at this site (3.52) and a total of 20 taxa were identified. Compared to nine other sites in the Alafia River sampled during 1995-1997 within the salinity range of 10-25 ppt, this diversity is quite high (mean/maximum diversity was 1.17/3.37; numbers of species was 6/28; EPC unpublished data). Numerical dominants at the oyster bay site included tubificid oligochaete worms (39% of the >3,500 total organisms per m² at the site). Subdominants included the amber glassy bubble shell *Haminoea succinea* (11.9%), and an unidentified nemertean worm (6.3%). Although the numbers of oligochaete worms is quite high, compared to other Alafia River sites (maximum of 225 per m²), the data as a whole suggests that this new habitat is supporting a viable and diverse assemblage of organisms.

Sediment Metals

The oyster bar sediment was tested for eight metals. Lead was detected at a concentration of 5.0 µg/gram but at this concentration the sediment would be considered clean. Cadmium, zinc, chromium, arsenic, silver, and nickel were also detected, but at concentrations also considered clean. Copper was detected at a concentration of 19.4 µg/gram and at this concentration, EPC staff would place it into a marginally degraded category.

Surface Water Monitoring

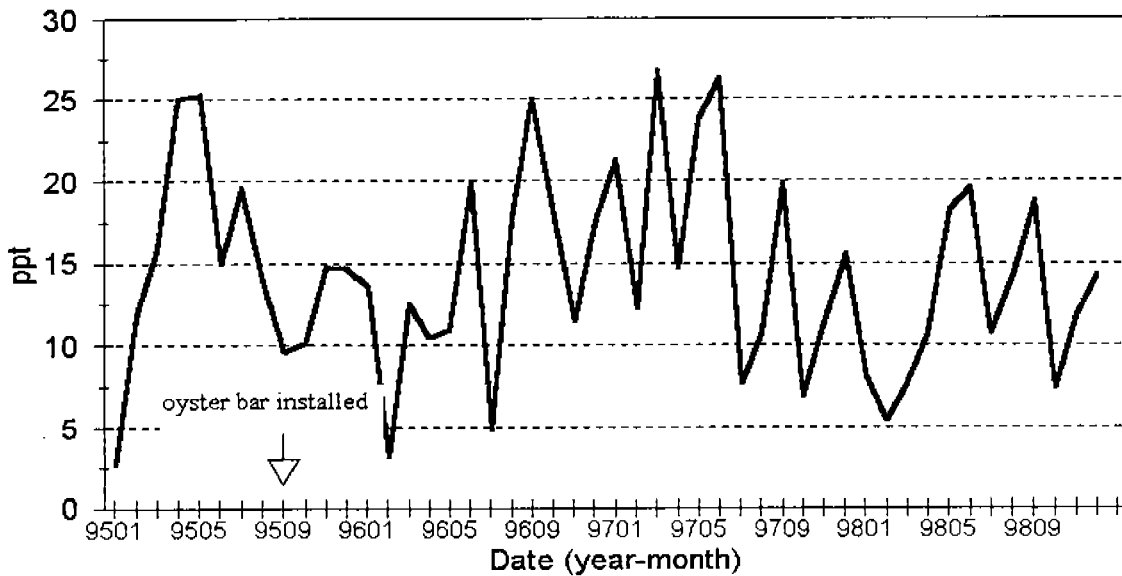
EPC has maintained two surface water monitoring sites in the vicinity of the bars since about 1972. These sites are monitored monthly for over 25 different parameters. Site 8 is located about 1.5 miles west of the bars near the mouth of the river and site 74 is located at the highway 41 bridge, or about 1500 feet east of the oyster bars.

Oyster bars are thought to improve water quality as a result of the filter feeding habits of the oysters and other inhabitants. They also provide a soil stabilizing function typical of hard bottom communities, which helps stabilize adjacent softer shoreline environments. The purpose of EPC's monitoring, however, was never intended to demonstrate or measure the direct water quality effects that this small reef had on the bay or river. The surface water monitoring data is used to determine environmental conditions in relation to the oyster bars biological condition.

Salinity in the vicinity of the oyster bars is of particular interest because oysters will not survive in very low salinity waters. Since the bars are at or near the surface of the water, only surface water quality data were reviewed for this monitoring report, even though EPC also monitors the water column at middle and bottom depths. A list of seventeen (17) surface water quality parameters with maximums, minimums and means are included in the appendix. This data listing in the appendix, covers the period from January 1995 through December of 1998 for EPC sites 8 and 74.

Salinity at surface (Alafia River)

Average of sites 8 & 74



Salinity

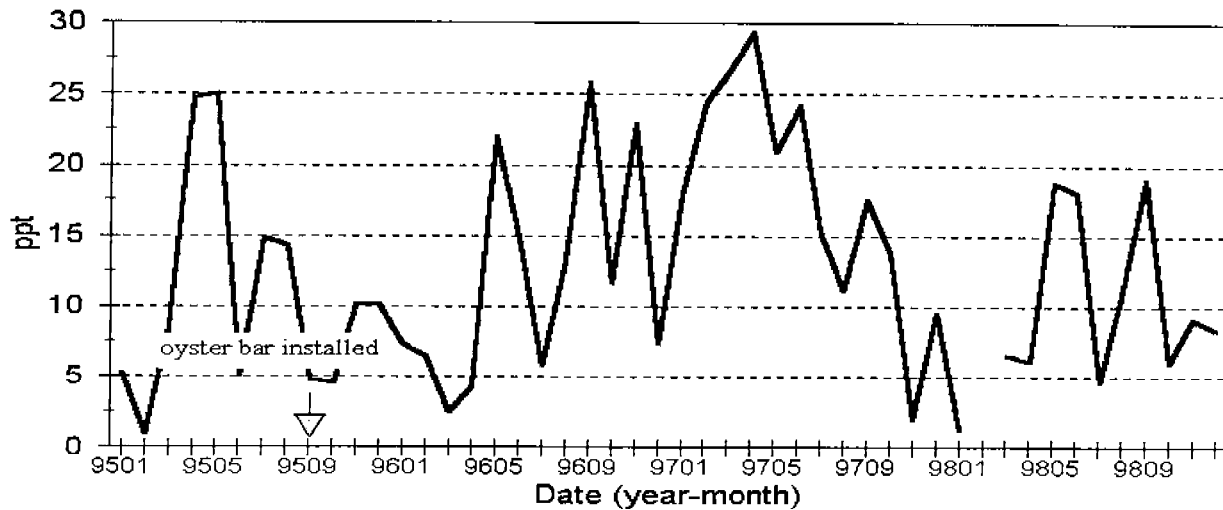
Salinity in the oyster bar area appears to have varied widely from a low of 1 ppt to a high of 29 ppt, based on a review of average surface salinities at sites 8 and 74 for the period January 1, 1995 through December 31, 1998. Salinity over the past three (3) years has probably been averaging about 16 ppt. This salinity regime appears to sustain this oyster bar. Farther upriver larger oyster bars appear to be thriving under similar salinity ranges. Water flow, food supply, disease and predation all play a role in oyster bar productivity.

pH

As a result of the Mulberry Phosphates, Inc. acid spill in December of 1997, the oyster bar was exposed to a low pH of about 5.0 for about 24 to 48 hours. The oysters and other associated organisms appeared to have survived, although another nearby artificial oyster reef (Williams Park Pier) appears to have sustained about a 33% loss.

Salinity at surface (Alafia River)

Site 74 (0.5 mile E. of Oyster Bar)



Other surface water quality parameters measured by EPC indicate that the oyster bar is located in a very nutrient rich environment with relatively high concentrations of phytoplankton. Water temperature varied between 13 and 31°C over the past three years. Water color also varied greatly with a maximum of 101 and a minimum of 5 PtCo units.

The monthly EPC water quality data for 17 parameters for the period from January 1995 through December of 1998 is provided in appendix B.

Monitoring Report Conclusions

- Siting of these artificial oyster bars was probably the most overriding concern for successful emplacement. To date the siting appears to have been satisfactory because oysters are growing, however the density is still relatively light. There are other artificial and natural oyster bars thriving within ½ mile east of this bar. Buried relic oyster bars were also discovered about ½ to ¾ mile farther west, at the mouth of the river. These relic bars are buried under 6 to 18 inches of sand and were found on both the north and south sides of the river.
- A diverse biological community is attracted to and is using the oyster bars. Bird and raccoon tracks are commonly observed.
- Physical changes to the size and shape of the bars have occurred but appear to be relatively minor so far. Apparently a relatively large amount of soil also accompanied the shell placement during construction. This soil shell mixture has gradually separated and stabilized. The perimeter of the bar is currently more sand-like, with the oyster shell closer to the shoreline and above the shoreline. Perhaps, more careful consideration should be given to the soil/shell ratio when planning new artificial oyster bars.
- A surprisingly large number of lead fishing weights have been found on the oyster bars. Extra monitoring for sediment metal and benthic analysis has occurred. The data suggests that this new oyster habitat is supporting a viable and diverse assemblage of organisms. Lead sediment concentrations indicated a clean or non-degraded environment.
- Salinity at the reefs has varied greatly, ranging between 1 and 29 ppt, however this does not appear to be detrimental to oyster bar growth.
- The December 7, 1997 Mulberry Phosphate, Inc. acid spill killed most if not all of the epi-benthic organisms associated with the nearby **Williams Park Pier** artificial oyster reef project. Small crabs, amphipods, copepods and the like were not observed anywhere on that particular reef, however about 33% of the oysters were killed. **This projects oyster bars did not seem to be affected at all and no signs of environmental stress could be found subsequent to the spill.**

Appendix A

EPC Field Data Report Forms

EPC Oyster Projects Field Data Sheet

Date: 11/18/96	Time: 1340	Reef Project: Alafia Oyster Bars		
Bird Species Observed: None	Weather: Partly Sunny	Field Crew: Ash/Lockwood	Y	N
	Air Temp: 25 C	Live Oysters Observed ?	X	
	Water Temp: 22 C	Oyster Samples Collected?		X
	Wind: E 10-15	Fish Observed ?	X	
	Tide Height: 0.5ft.	Juvenile Mullet		
	Ebb Flood X			
		Plant Growth Observed ?	X	
	Total Time Spent: 3.0 Hrs.	Mangroves/Beach carpet/Iva		

General Observations/Notes: More lead sinkers found, rutting holes near SE shoreline
juv. stonecrabs present, oysters 1-1.5 in, Melongena present

Mangroves: Blacks 18-41in. tall / Whites 17-25in. tall Iva spp. 23in. tall

Project Dimensions:
(Measured From Benchmark)

GPS Coordinates at Benchmark: Site 1
N 27°
W 82°

Mound Height at Center: 32 in.

Project Dimensions:
(Measured From Benchmark)

GPS Coordinates at Benchmark: Site 2
N 27°
W 82°

Mound Height at Center:

Project Dimensions:
(Measured From Benchmark)

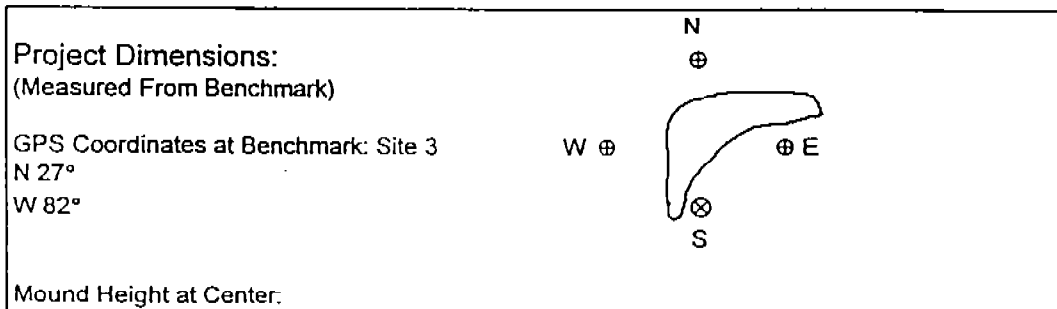
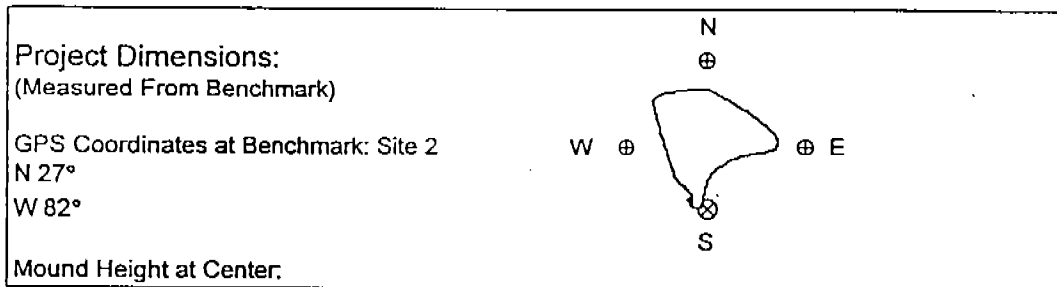
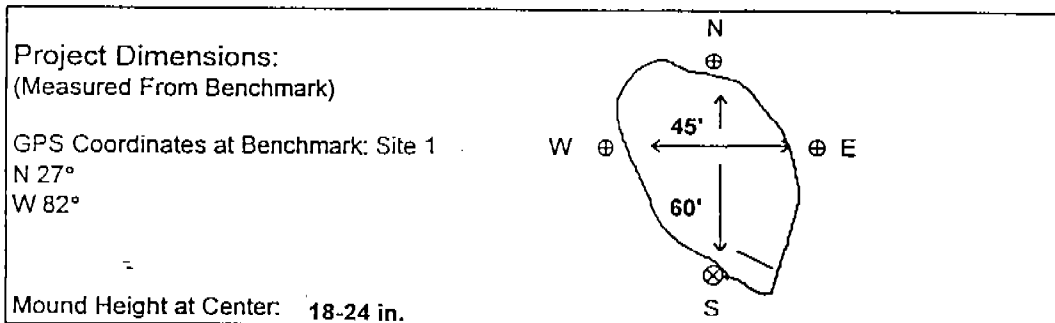
GPS Coordinates at Benchmark: Site 3
N 27°
W 82°

Mound Height at Center:

EPC Oyster Projects Field Data Sheet

Date: 5/14/97	Time: 0936	Reef Project: Alafia Oyster Bars		
Bird Species Observed:	Weather: Sunny	Field Crew: Ash / Lockwood	Y	N
Scaup Duck	Air Temp: 26 C	Live Oysters Observed ?	X	
Brown Pelican	Water Temp: 24 C	Oyster Samples Collected?		X
	Wind: SW 5	Fish Observed ?	X	
	Tide Height: 1.5ft.	Juv. Mullet, Atlantic Needlefish		
	Ebb Flood X			
		Plant Growth Observed ?	X	
	Total Time Spent:	Mangroves, Beachcarpet, Iva,		
	2 Hrs.	Sea blite		

General Observations/Notes: Melongena, Stone crabs, Horseshoe crabs, Hermit crabs
Mangroves: Blacks 2-4ft. tall, Whites 2-3ft. tall,
Found additional 1.1 lbs. of fishing leads



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EPC Oyster Projects Field Data Sheet

Date: 12/4/97	Time: 1355	Reef Project: Alafia Oyster Bars		
Bird Species Observed:	Weather: Clouds/Drizzle	Field Crew: Cardinale/Ash/Lockwood	Y	N
Green Heron	Air Temp: 24 C	Live Oysters Observed ?	X	
	Water Temp: 19 C	Oyster Samples Collected?		X
	Wind: WSW 5	Fish Observed ?	X	
	Tide Height: 1 ft.	Mullet		
	Ebb Flood X			
		Plant Growth Observed ?		
	Total Time Spent: 3.5 Hrs.	Black/Red/White Mangroves		
		Iva spp.		

General Observations/Notes: Found 90 fishing leads (Total 5.35lbs.)
 White Mangroves 1-2ft Tall (50%) 3-4ft Tall (50%) Oysters 1.5-2inches
 Black Mangroves 1.5ft Tall Iva spp. 3ft Tall . . . Melongena corona present

Project Dimensions:
(Measured From Benchmark)

GPS Coordinates at Benchmark: Site 1
N 27°
W 82°

Mound Height at Center: 1 ft. (Center Depression now level)

Project Dimensions:
(Measured From Benchmark)

GPS Coordinates at Benchmark: Site 2
N 27°
W 82°

Mound Height at Center:

Project Dimensions:
(Measured From Benchmark)

GPS Coordinates at Benchmark: Site 3
N 27°
W 82°

Mound Height at Center:

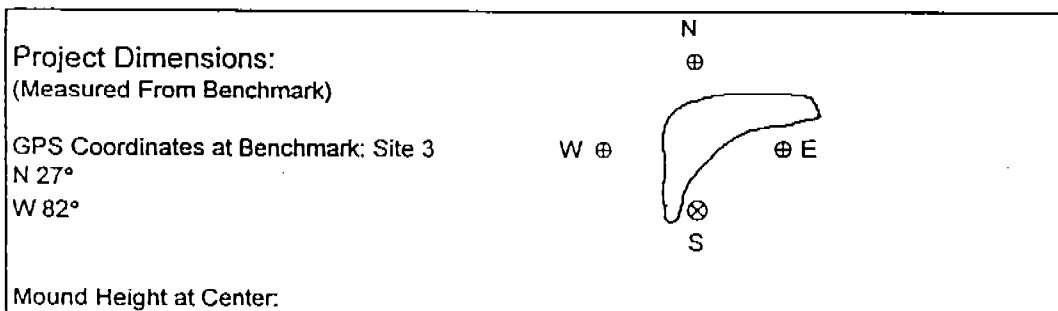
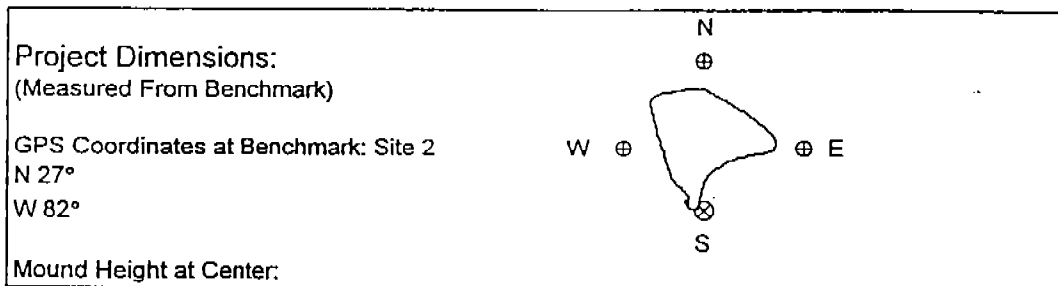
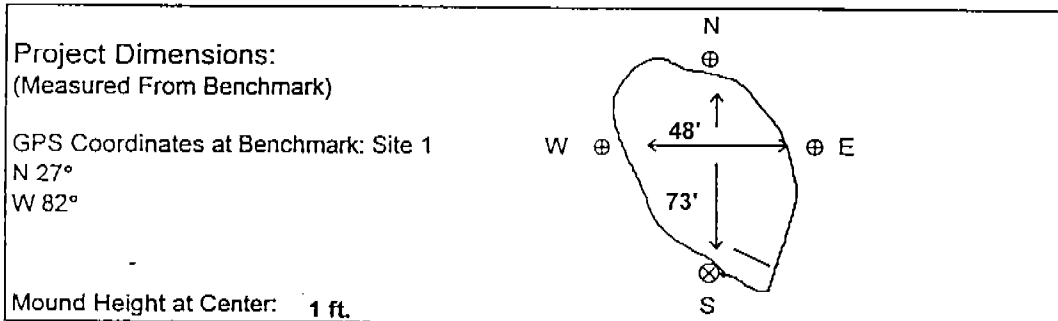
EPC Oyster Projects Field Data Sheet

Date: 1/27/99	Time: 0938	Reef Project: Alafia Oyster Bars		
Bird Species Observed:	Weather: Partly Sunny	Field Crew: Ash / Lockwood	Y	N
White Heron	Air Temp: 20 C	Live Oysters Observed ?	X	
Large bird footprints in sand.	Water Temp: 19.5 C	Oyster Samples Collected?		X
Raccoon footprints in sand	Wind: SE 5-10	Fish Observed ?		X
	Tide Height: 0.2 ft			
	Ebb <input checked="" type="checkbox"/> Flood			
		Plant Growth Observed ?	X	
	Total Time Spent: 3 Hrs	Mangroves, <i>Iva. spp.</i>		

General Observations/Notes: Depression behind mangroves has filled in, shells more scattered

Mangroves are now 5-6 ft. tall, *Iva. spp.* is 4-5 ft. tall

Project sign and memorial are both down.



Appendix B

EPC Water Quality Data

Environmental Protection Commission - Water Quality Monitoring Results

Site #	DATE yymmdd	COLOR P/Co	TURB NTU	SECCHI inches	COND.T umhos	PH Top	T.WAT.T deg C	DO.T mg/l	SALT ppt	P.ORTHO mg/l	P.TOTAL mg/l	N.KJEL mg/l	NH3N mg/l	N.TOTAL mg/l	CHL.A ug/l	BOD.5 mg/l	MF.COLI #/100ml	MF.FECAL #/100ml
74	950125	33	5	42	9200	7.6	13.0		5.3	0.98	1.15	0.78	0.01	1.30	1.7	0.5	280	80
74	950222	41	8	36	3000	7.8	17.3	7.1	1.0	1.16	1.56	0.91	0.01	1.64	3.6	1.0	790	480
74	950322	29	4	54	15200	7.6	20.8	6.7	8.5	0.86	1.04	0.96	0.04	1.44	2.0	1.4	280	80
74	950426	13	5	36	38700	7.8	24.2	4.8	24.8	0.68	0.78	0.85	0.11	0.96	4.5	1.7	40	10
74	950524	12	4	54	39500	7.9	28.1	4.2	25.0	0.51	0.61	0.65	0.01	0.65	3.6	1.4	30	30
74	950628	66	7	30	9510	7.7	27.6	5.2	5.1	0.98	1.65	1.15	0.07	1.70	11.5	1.1	460	160
74	950726	42	4	36	25400	7.8	28.9	2.4	14.9	0.82	1.03	1.10	0.17	1.34	9.8	2.1	220	100
74	950823	47	4	42	24500	7.5	29.1	2.4	14.3	1.30	1.84	1.05	0.05	1.40	6.1	1.4	300	90
74	950927	42	4	42	9200	7.4	27.9	4.8	4.8	1.22	1.42	0.96	0.01	1.37	14.8	1.6	390	80
74	951025		5	48	8300	7.4	23.6	5.4	4.6	0.86	1.04	1.20	0.02	1.54	29.6	3.0	260	30
74	951129	16	3	60	17500	7.0	20.9	10.1	10.2	0.27	0.37	0.52	0.01	0.58	11.2	ND	40	10
74	951213	17	5	60	17400	6.8	16.9	8.2	10.2	0.64	0.73	0.52	0.02	0.84	9.1	2.7	180	50
74	960124	18	7	42	13700	7.7	17.5	7.6	7.3	0.31	0.51	0.77	0.01	0.92	12.1	1.4	230	70
74	960221	21	8	54	11200	8.0	17.1	8.0	6.4	0.55	0.72	1.13	0.03	1.32	18.8	2.1	240	30
74	960320	35	10	42	9900	7.8	17.2	8.4	2.5	1.02	1.06	0.86	0.05	1.74	5.2	1.2	390	200
74	960417	22	5	42	9040	7.6	20.6	6.0	4.3	0.76	0.95	0.97	0.14	1.40	4.6	0.2	180	90
74	960515	11	5	60	35600	7.6	26.2	3.8	22.0	0.38	0.50	1.17	0.13	1.22	5.0	2.7	10	10
74	960619	11	4	54	24700	7.5	27.8	3.3	14.9	0.38	0.53	0.88	0.12	0.92	9.3	1.9	30	30
74	960717	30	3	36	10880	7.4	27.9	3.9	5.8	1.06	0.76	1.00	0.19	1.09	4.9	1.5	90	20
74	960821	13	7	54	22000	7.8	27.7	4.8	13.3	0.50	0.61	0.70	0.08	0.74	8.3	0.7	200	180
74	960925	13	5	54	40600	7.8	28.2	3.0	25.8	0.70	0.70	1.06	0.05	3.01	8.6	1.0	400	240
74	961016	27	3	60	19900	7.6	23.8	5.0	11.7	0.93	1.01	0.96	0.07	3.23	3.7	1.4	440	170
74	961120	5	3	66	36400	8.0	21.0	7.9	23.0	0.23	0.24	0.42	0.01	0.79	8.4	1.1	40	20K
74	961211	21	3	60	12600	7.3	16.6	5.9	7.3	0.49	0.71	0.84	0.10	0.95	31.4	5.1	320	150
74	970122	9	3	78	29300	8.2	15.1	9.5	17.9	0.39	0.49	0.71	0.01	0.84	5.4	1.5	50	10K
74	970219	7	7	48	39900	8.1	19.2	6.8	24.5	0.18	0.31	0.71	0.07	0.75	8.1	1.1	20	10
74	970319	5	9	42	42400	7.9	23.5	6.1	26.7	0.19	0.39	0.90	0.08	0.92	6.2	1.1	10K	10K
74	970416	5	12	54	45400	8.0	22.2	5.6	29.4	0.15	0.31	0.76	0.07	0.78	7.2	0.3	20	10
74	970521	10	7	48	33800	8.0	27.6	5.7	20.9	0.38	0.54	0.93	0.03	0.95	8.7	2.5	80	10K
74	970618	7	10	48	37000	7.8	30.1	4.1	24.2	0.28	0.33	0.95	0.05	0.97	9.9	2.0	10	10K
74	970723	20	7	48	24700	7.4	28.7	2.5	15.3	0.51	0.48	1.26	0.07	1.30	78.7	4.8	20	10
74	970820	41	5	36	19000	7.4	29.5	2.6	11.1	0.68	0.71	0.93	0.11	1.08	19.2	2.1	40	10
74	970917	21	9	30	28500	7.9	28.4	5.8	17.5	0.50	0.65	1.14	0.02	1.16	47.9	2.7	50	40
74	971015	14	6	42	22900	7.6	24.8	4.8	13.8	0.47	0.56	0.86	0.11	1.05	18.5	1.4	70	10
74	971119	83	10	30	4860	7.2	18.1	6.8	2.0	1.07	1.33	1.08	0.08	1.53	6.7	1.1	450	200
74	971210	17	5	60	16600	7.0	18.7	7.2	9.5	0.35	0.36	0.70	0.08	0.76	11.6	2.3	40	20
74	980121	27	7	36	3140	7.4	16.7	7.7	1.3	0.61	0.72	0.67	0.19	0.84	4.4	1.5	150	50
74	980218	101	26	12	190	6.8	19.0	6.7		1.29	1.30	1.10	0.09	1.43	8.0	2.9	2000L	1130
74	980318	25	7	48	11310	7.5	18.6	7.8	6.5	0.47	0.61	0.67	0.05	0.77	7.7	2.2	190	30
74	980422	26	5	30	10900	7.7	23.4	6.7	6.1	0.84	1.04	0.95	0.06	1.15	13.5	2.9	360	70
74	980520	11	7	48	30600	7.7	28.2	4.6	18.8	0.41	0.54	0.78	0.06	0.79	15.4	1.8	30	10K
74	980617	13	4	36	28800	8.2	30.6	6.0	18.0	0.56	0.70	0.88	0.07	0.89	13.7	1.9	10	10K
74	980722	17	3	42	8800	7.3	27.0	4.0	4.6	0.52	0.53	0.92	0.32	1.00	5.2	2.5	110	70
74	980826	21	6	30	19200	7.9	29.4	6.1	11.3	0.74	0.94	1.19	0.09	1.36	26.2	2.2	100	20
74	980916	8	6	54	30900	7.8	27.0	4.2	19.0	0.21	0.40	0.85	0.18	0.87	7.3	0.9	10K	10K
74	981021	35	6	48	11400	7.3	25.1	4.6	6.0	0.90	1.09	0.75	0.11	1.37	4.3	0.9	280	80
74	981118	20	11	36	16000	7.6	23.4	6.7	9.1	0.56	0.87	1.07	0.02	1.39	15.7	4.5	110	40
74	981209	18	3	48	14400	7.8	22.5	7.7	8.3	0.71	0.86	0.63	0.03	1.30	10.6	1.2	260	60
Max		101	26	78	45400	8.2	30.6	10.1	29.4	1.30	1.84	1.26	0.32	3.23	78.7	5.1	800	1130
Mln		5	3	12	190	6.8	13.0	2.4	1.0	0.15	0.24	0.42	0.01	0.58	1.7	0.0	4K	2K
Avg		24	6	46	20707	7.6	23.5	5.7	12.7	0.64	0.78	0.89	0.07	1.19	12.2	1.8	215	90

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Environmental Protection Commission - Water Quality Monitoring Results

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Site #	DATE yymmdd	COLOR PtCo	TURB NTU	SECCHI inches	COND.T umhos	PH Top	T.WAT.T deg C	DO.T mg/l	SAL.T ppt	P.ORTHO mg/l	P.TOTAL mg/l	N.KJEL mg/l	NH3N mg/l	N.TOTAL mg/l	CHL.A ug/l	BOD.5 mg/l	MF.COLI #/100ml	MF.FECAL #/100ml
8	950110	13	4	36						0.32	0.42	0.92	0.01	0.93	19.5	3.2	40	4
8	950207	12	4	48	35900	8.0	16.7	9.6	22.7	0.19	0.33	0.81	0.01	0.81	5.0	2.8	4	2K
8	950307	10	3	48	36500	8.1	21.9	7.6	23.1	0.22	0.33	0.69	0.01	0.69	6.7	0.9	4	2
8	950411	9	8	48	39700	8.0	24.1	6.3	25.3	0.23	0.36	0.80	0.01	0.81	6.4	1.2	20	2K
8	950509	9	8	36	40200	7.9	28.7	7.5	25.6	0.29	0.40	0.78	0.01	0.79	8.8		16J	20
8	950613	10	5	30	39000	8.2	29.6	8.4	24.8	0.29	0.50	0.98	0.01	0.99	16.6	5.8	4	2
8	950711	10	11	36	38300	8.2	31.4	7.7	24.3	0.30	0.47	0.90	0.01	0.91	21.1	4.3	4K	2K
8	950808	42	4	36	22100	8.3	32.5	12.4	13.3	0.77	0.90	0.93	0.01	0.94	12.1	3.7	24	8
8	950912	38	6	36	24200	8.2	28.9	10.2	14.4	0.55	0.73	1.41	0.01	1.41	69.5	9.5	108	24
8	951010	33	4	42	25800	7.9	27.8	6.5	15.8	0.47	0.56	0.90	0.01	0.94	24.3	1.8	96	50
8	951107	21	5	36	31200	8.1	25.0	8.2	19.4	0.30	0.42	0.97	0.01	0.97	32.9	2.8	12	12
8	951206	14	5	36	31200	8.1	22.4	9.4	19.3	0.22	0.39	0.88	0.01	0.89	21.7	4.0	32	6
8	960117	18	5	36	32200	8.2	16.0	10.5	20.0	0.18	0.31	0.60	0.01	0.62	13.4	0.9	20	10
8	960213	14	7	36						0.16	0.36	1.21	0.01	1.21	26.8	4.2	20	4
8	960313	11	4	48	35600	8.2	16.7	9.6	22.5	0.13	0.30	0.95	0.01	0.95	5.2		4K	2K
8	960409	19	8	42	27300	8.0	22.6	7.5	16.6	0.32	0.42	0.95	0.05	0.97	7.8	1.4	12	2K
8	960508	13	12	42						0.29	0.45	1.32	0.09	1.34	3.9	7.9	16	14
8	960611	7	2	54	38900	8.1	29.4	5.8	24.9	0.24	0.29	0.67	0.06	0.68	6.3	2.0	4	2K
8	960709	36	6	24	8300	7.3	27.6	4.0	4.0	0.46	0.61	0.69	0.11	0.70	6.1	1.0	180	118
8	960813	12	4	42	35200	8.0	29.5	7.0	22.3	0.32	0.41	0.93	0.01	0.94	23.5	4.4	12	4
8	960910	9	4	42	38000	8.1	30.3	7.1	24.2	0.32	0.44	0.75	0.03	0.75	16.2	2.5	16	12
8	961009	13	5	48	38800	8.1	26.8	9.5	24.9	0.22	0.31	0.76	0.01	0.76	23.6	3.9	20	20
8	961113	7	8	36						0.20	0.45	0.58	0.01	0.62	10.0	1.6	12	10
8	961217	6	5	42	43200	8.2	19.3	9.0	27.8	0.08	0.15	0.52	0.01	0.52	13.2	1.1	4K	2K
8	970114	6	3	60	39700	7.9	17.7	7.3	24.7	0.25	0.26	0.53	0.02	0.62	7.7	2.1	84	34
8	970211	5	5	36						0.01	0.16	0.50	0.01	0.51	3.4	2.1	4J	40
8	970311	8	5	48	41800	8.0	26.2	7.7	26.8	0.24	0.37	0.62	0.01	0.63	13.1	2.8	4K	2
8	970408	7	7	42						0.30	0.43	0.66	0.05	0.70	8.1	2.4	4J	8
8	970513	7	4	36	41600	7.9	26.4	7.0	26.6	0.20	0.35	0.73	0.01	0.76	9.4	1.5	4J	6
8	970610	5	8	36	44000	7.8	27.2	5.3	28.4	0.19	0.30	0.63	0.02	0.65	7.7	1.3	8	6
8	970715	9	4	36	42100	8.1	30.0	5.4		0.26	0.39	0.72	0.02	0.74	27.5	2.7	4	2K
8	970812	73	5	24	17400	7.4	30.6	2.8	10.5	0.62	1.01	0.99	0.14	1.22	10.7	1.5	76	46
8	970909	12	5	36	40900	8.5	35.3	9.8	22.1	0.32	0.38	0.82	0.01	0.85	20.6	2.4	12	12
8	971007	36	4	30						0.58	0.68	1.12	0.11	1.35	22.5	1.7	800L	110
8	971112	21	5	42	32500	8.1	21.8	7.9	20.4	0.26	0.36	0.80	0.01	0.81	13.2	2.4	16	12
8	971203	16	3	36	34600	7.8	20.4	6.5	21.7	0.27	0.37	0.69	0.13	0.81	8.7	1.8	44	10
8	980113	35	3	42	24700	7.7	18.8	6.9	15.0	0.69	0.80	0.82	0.01	1.07	14.1	3.1	148	84
8	980210	23	5	36	18500	8.0	18.9	10.2	10.9	0.38	0.47	0.85	0.01	0.92	30.3	4.6	32	22
8	980310	59	6	18	15300	8.2	19.6	10.1	8.9	0.36	0.57	1.25	0.01	1.27	75.7	4.2	36	14
8	980414	27	5	54	25400	7.8	22.4	8.3	15.4	0.37	0.47	0.86	0.01	0.87	19.9	4.0	52	28
8	980512	25	6	30	29000	8.0	28.6	7.8	17.8	0.33	0.44	0.71	0.01	0.72	17.2	2.5	56	2
8	980609	13	3	42	33800	7.9	30.2	5.0	21.2	0.49	0.55	0.62	0.02	0.64	11.1	1.7	52	48
8	980714	16	6	30	27300	7.9	30.3	5.8	16.8	0.47	0.60	0.87	0.06	0.92	31.8	3.0	140J	116
8	980811	16	6	42	25400	8.0	32.1	5.8	17.5	0.38	0.60	1.03	0.04	1.05	53.3	6.8	8	2K
8	980908	13	10	36	30200	8.2	30.8	7.1	18.7	0.33	0.49	0.90	0.01	0.91	22.6	3.4	72	22
8	981013	34	5	30	15500	7.5	28.2	4.2	8.8	0.82	0.98	1.17	0.08	1.48	36.4	3.8	140	22
8	981109	16	8	36	24000	8.0	22.3	7.6	14.6	0.24	0.32	0.75	0.01	0.80	12.8	2.4	56	12
8	981202	11	3	42	32600	7.9	24.1	7.2	20.2	0.25	0.30	0.59	0.04	0.61	13.5	2.1	4	2
Max		73	12	60	44000	8.5	35.3	12.4	28.4	0.82	1.01	1.41	0.14	1.48	75.7	9.5	800	118
Min		5	2	18	8300	7.3	16.0	2.8	4.0	0.01	0.15	0.50	0.01	0.51	3.4	0.9	4K	2K
Avg		18	5	39	31656	8.0	25.6	7.5	19.6	0.33	0.46	0.84	0.03	0.88	18.6	3.0	53	21