

Ecological Performance Evaluation Report

Alcoa Constructed Oyster Reef in Lavaca Bay

In accordance with the Alcoa Consent Decree and Oyster Reef Implementation Plan (2004), Alcoa will conduct a series of post-construction evaluations of the constructed oyster reef to determine if the reef has met specific design-based performance standards and ecological performance criteria. Alcoa has agreed to conduct;

- An elevation and areal survey after at least 70% settlement has occurred, to document reef size and elevation above surrounding bay bottom, and,
- An ecological evaluation to demonstrate that ecological performance criteria have been achieved.

Performance criteria for the oyster reef project as listed in the *Oyster Reef Implementation Plan* are:

3.1 Performance Criteria

Performance criteria for the Oyster Reef Restoration Project are:

- a. *The presence of a suitable solid reef base that has a surface elevation that is on average 12 inches higher than the surrounding bay bottom. Due to the slight unevenness of the bay bottom, and the shape of the reef construction material, reef surface elevation will be an arithmetic average of 12 inches above the surrounding bay bottom, but no individual spot will be less than 6 inches above bay bottom.*
- b. *The reef may consist of multiple reef segments constructed at the same site, but the combined areal size of the segments, not counting open water between segments, will be 10.9 acres.*
- c. *Evidence of sessile mollusk colonization on the constructed reef within 30 months post-construction.*

Compliance with the design-based performance criteria (i.e., items a and b above) shall be documented during each monitoring event that will occur during the October-December time period approximately 18 and 30 months after construction has been completed. Compliance with the ecological performance criterion (i.e. item c, above) may be determined during any of the scheduled monitoring events or other inspections approved by the Lead Administrative Trustee.

Reef construction was initiated on 13 April 2005 and was completed on 2 May 2005 (20 work days). The reef is composed of 27 parallel segments separated by 50 ft wide (approximate) gaps of open bay bottom. Reef construction progressed from the southeast end to the northwest end (Figure 1).

A preliminary inspection conducted 16 June 2005 found that the water over the reef site was cloudy and underwater photography was not possible. Pieces of substrate (limestone rock) were retrieved from the reef for evaluation. The density of oyster spat on the substrate was much greater than expected. All exposed surfaces of each of the rocks were covered with spat of various sizes. Some of the spat were 1.5 cm across, indicating they were several weeks old. The inspection indicated that all parts of the reef were being utilized by oysters.

An official ecological evaluation of the reef was conducted by Alcoa on 18 and 19 July 2005. The objective of this study was to collect substrate samples from reef segments in each of the potentially different aquatic environments occurring over the oyster reef, and to determine if the substrate is being utilized by oysters and other encrusting invertebrates.

Samples of oyster reef substrate were collected from 14 stations distributed over the reef complex. Listed below is a summary of the field sampling procedures, data summary and discussion of results.

Field Sampling Procedures

A 20 meter grid was established over a map of the constructed reef segments. Sample stations were established at gridline intersections that fell on portions of reef segments that were selected for evaluation. Ten perimeter stations and four interior stations were sampled. Sample stations are shown in Figure 1 and station coordinates are listed in Table 1.

Table 1 - Sample Stations and Coordinates

Station	Easting ¹	Northing ¹
OYS 01	2774167.087	13412786.613
OYS 02	2774422.487	13412958.972
OYS 03	2774413.313	13412496.968
OYS 04	2774558.918	13412621.909
OYS 05	2774678.313	13412795.269
OYS 06	2774917.266	13412856.195
OYS 07	2774841.670	13412470.340
OYS 08	2774684.762	13411856.045
OYS 09	2774813.625	13412101.533
OYS 10	2774933.329	13411719.671
OYS 11	2775063.600	13411917.371
OYS 12	2775187.088	13411955.472
OYS 13	2775191.493	13411448.563
OYS 14	2775463.407	13411658.364

¹Coordinates reported in NAD 1983 Texas South Central Survey Feet

A 20-foot aluminum boat was used as the sampling platform. Sample stations were located with a sub-meter Global Positioning System and marked with a small buoy. Coordinates for each station were recorded in the GPS and on a field data form.

At each station physical and chemical parameters were measured and the results were recorded on field data forms. Water depth, temperature (mid-depth), pH, and salinity were measured. Parameters are listed in Table 2 and copies of the field data forms are located in Attachment A.

A Benchmark diver collected five rocks from each station within one square meter (approximate) of reef surface. Each rock was carried to the surface and placed in a sample tray. An onboard biologist inspected the rocks to ensure that all rocks were similar in size. Rocks that did not meet the size requirements were placed back on the reef. Acceptable samples were positioned on the tray so that the side of the rock that was unexposed (bottom) was facing down. The diver continued to collect samples until 5 rocks meeting these requirements were collected.

The samples were placed on a stainless steel tray that was covered in black plastic aboard the sampling vessel. The biologists used a digital camera on a tripod to photograph the sample. Samples were rotated several times to capture different sides and angles of the substrate. Photographs are shown in Attachment B. Biologists recorded the following information for each rock sample;

- Photo ID,
- Species of invertebrates growing on the substrate,
- Number of oysters and oyster spat, and
- Percent coverage of oysters and oyster spat (0-25%, 25-50%, 50-75%, and 75-100%).

All data collected was recorded on field data sheets and are located in Attachment A.

Data Summary

A summary of the data collected at the sample stations is presented in Table 2.



Legend

- Oyster Reef Segments
- 20 meter grid
- Monitoring Stations
- ### Stations ID's

Notes

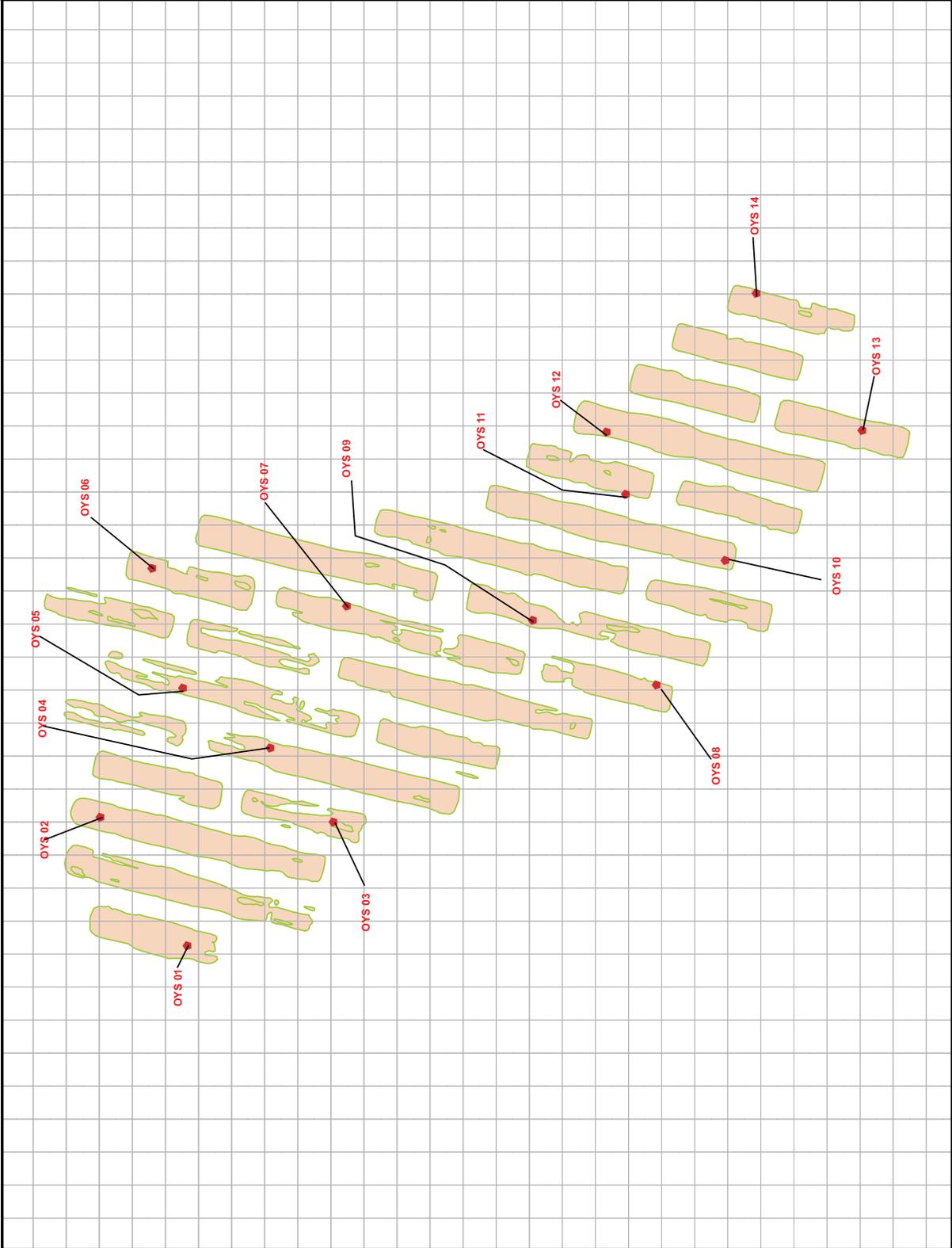
Coordinates are shown in UTM NAD1983 zone 14N

ALCOA Oyster Reef Restoration Monitoring Program

Oyster Reef Monitoring Stations

Project: 98000204063005001
Date: 07/25/05

Figure 1



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Table 2 – Oyster Reef Ecological Performance Evaluation Stations, Parameters and Field Notes

Station ID	Date	Time	Depth (ft)	pH	DO (mg/L)	Temp. (°C)	Salinity (ppt)	Rock ID	Spat	Oyster	Barnacles	Hooked Mussels	Serpulid Worm Cases	Sponge	Limpet	Other	Number Oyster and Spat	% Oyster Cover
OYS01	7/18/2005	1020	5.0	8.31	6.25	29.5	23.9	1	Yes	Yes	No	Yes	No	No	Yes		54	75-100
								2	Yes	Yes	Yes	No	No	Yes		64	75-100	
								3	Yes	Yes	Yes	No	No	Yes	Algae	73	75-100	
								4	No	Yes	No	No	No	No		103	75-100	
								5	No	Yes	Yes	Yes	No	No		48	50-75	
OYS02	7/18/2005	1130	3.9	8.21	5.50	29.9	23.9	1	No	Yes	Yes	No	No	No	No		63	75-100
								2	No	Yes	Yes	No	No	No	Snails	63	50-75	
								3	No	Yes	Yes	No	Yes	Yes		59	75-100	
								4	Yes	Yes	Yes	No	No	No		36	75-100	
								5	Yes	Yes	Yes	No	No	Yes		78	75-100	
OYS03	7/18/2005	1235	5.4	8.18	6.00	30.8	23.9	1	Yes	Yes	Yes	No	No	No	No		17	25-50
								2	No	Yes	No	Yes	No	No		33	50-75	
								3	Yes	Yes	Yes	Yes	Yes	Yes		36	50-75	
								4	Yes	Yes	Yes	No	No	No		26	50-75	
								5	Yes	Yes	Yes	Yes	Yes	Yes		62	75-100	
OYS04	7/19/2005	0805	5.3	8.29	5.96	26.9	24.1	1	No	Yes	Yes	No	No	Yes	No		86	75-100
								2	No	Yes	Yes	No	Yes	Yes	Algae	79	75-100	
								3	No	Yes	Yes	No	Yes	Yes	Snails	79	50-75	
								4	Yes	Yes	No	No	No	No	Algae	63	50-75	
								5	No	Yes	Yes	No	No	Yes	Snails	48	25-50	
OYS05	7/18/2005	1320	4.4	8.16	5.86	30.4	23.9	1	Yes	Yes	Yes	No	No	Yes	No		53	75-100
								2	No	Yes	No	Yes	No	No		33	25-50	
								3	No	Yes	Yes	No	No	No		42	50-75	
								4	No	Yes	Yes	Yes	Yes	Yes		57	75-100	
								5	Yes	Yes	Yes	No	No	No		49	75-100	

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Table 2 (Cont'd) – Oyster Reef Ecological Performance Evaluation Stations, Parameters and Field Notes

Station ID	Date	Time	Depth (ft)	pH	DO (mg/L)	Temp. (°C)	Salinity (ppt)	Rock ID	Spat	Oyster	Barnacles	Hooked Mussels	Serpulid Worm Cases	Sponge	Limpet	Other	Number Oyster and Spat	% Oyster Cover
OYS06	7/18/2005	1357	4.8	8.25	6.77	30.6	23.0	1	No	Yes	Yes	No	No	Yes	No	Snails	52	75-100
								2	No	Yes	Yes	No	No	Yes	No	75-100		
								3	Yes	Yes	Yes	No	No	Yes	No	75-100		
								4	No	Yes	Yes	No	No	Yes	No	75-100		
								5	No	Yes	Yes	Yes	Yes	Yes	Yes	78	75-100	
OYS07	7/18/2005	1430	4.6	8.18	6.62	31.3	23.9	1	No	Yes	Yes	No	No	Yes	No		46	75-100
								2	No	Yes	Yes	No	No	Yes	No	26	25-50	
								3	Yes	Yes	Yes	No	Yes	Yes	Yes	53	75-100	
								4	Yes	Yes	Yes	No	No	Yes	No	81	75-100	
								5	Yes	Yes	Yes	Yes	No	Yes	No	81	75-100	
OYS08	7/18/2005	1505	4.4	8.12	5.89	31.3	24.2	1	No	Yes	Yes	No	No	Yes	Yes		36	25-50
								2	No	Yes	Yes	Yes	Yes	Yes	No	94	75-100	
								3	No	Yes	Yes	Yes	Yes	Yes	No	79	75-100	
								4	No	Yes	Yes	Yes	No	Yes	Yes	116	75-100	
								5	No	Yes	Yes	Yes	Yes	Yes	Yes	51	50-75	
OYS09	7/19/2005	0825	5.2	8.31	6.40	29.7	24.3	1	No	Yes	Yes	No	Yes	Yes	Yes		95	75-100
								2	No	Yes	Yes	Yes	Yes	Yes	No	67	75-100	
								3	No	Yes	Yes	Yes	Yes	Yes	Yes	96	75-100	
								4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	66	50-75	
								5	No	Yes	No	Yes	Yes	Yes	No	44	50-75	
OYS10	7/19/2005	0845	6.4	8.31	6.05	29.7	24.4	1	No	Yes	Yes	No	Yes	Yes	Yes	Snails	47	50-75
								2	No	Yes	Yes	No	Yes	Yes	Yes	46	75-100	
								3	No	Yes	Yes	No	Yes	Yes	Yes	28	25-50	
								4	No	Yes	Yes	No	Yes	Yes	No	54	50-75	
								5	No	Yes	Yes	No	Yes	Yes	No	41	50-75	

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Station ID	Date	Time	Depth (ft)	pH	DO (mg/L)	Temp. (°C)	Salinity (ppt)	Rock ID	Spat	Oyster	Barnacles	Hooked Mussels	Serpulid Worm Cases	Sponges	Limpet	Other	Number Oyster and Spat	% Oyster Cover	
OYS11	7/19/2005	0858	5.5	8.33	6.40	29.7	24.3	1	Yes	Yes	Yes	Yes	No	Yes	No		67	75-100	
								2	No	Yes	Yes	No	Yes	Yes	Yes	No	Snails	64	50-75
								3	No	Yes	Yes	No	Yes	Yes	Yes	Yes		48	75-100
								4	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes		92	75-100
								5	No	Yes	Yes	No	Yes	No	Yes	No		57	75-100
OYS12	7/18/2005	1550	4.3	8.26	7.32	30.8	24.1	1	No	Yes	Yes	Yes	No	Yes	No	Snails	46	50-75	
								2	No	Yes	Yes	No	Yes	Yes	No	Snails	85	75-100	
								3	No	Yes	Yes	No	Yes	Yes	No	Snails	13	0-25	
								4	No	Yes	Yes	No	Yes	Yes	No	Snails	81	75-100	
								5	No	Yes	Yes	No	Yes	Yes	No	Snails	63	75-100	
OYS13	7/18/2005	1605	5.8	8.25	7.05	31.2	23.9	1	No	Yes	Yes	No	Yes	Yes	No	Snails	33	50-75	
								2	No	Yes	Yes	No	Yes	Yes	No	Snails	41	50-75	
								3	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Snails	73	75-100
								4	No	Yes	Yes	No	Yes	Yes	Yes	Yes		66	75-100
								5	No	Yes	Yes	No	Yes	Yes	Yes	Yes		27	0-25
OYS14	7/18/2005	1640	4.5	8.27	7.34	31.2	23.8	1	No	Yes	No	No	Yes	No	No	Snails	49	75-100	
								2	No	Yes	Yes	No	Yes	Yes	Yes	No	Snails	69	75-100
								3	No	Yes	Yes	No	No	No	Yes	No	Snails	52	50-75
								4	No	Yes	Yes	No	Yes	Yes	Yes	No	Snails, Crabs	73	75-100
								5	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Snails, Crabs	126	75-100

To determine if some portion of the reef complex was more attractive or effective than other parts, each piece of substrate was assigned a percent cover of oysters in the ranges; 0-25%, 25-50%, 50-75%, and 75-100% (Table 2). The percent oyster cover was a subjective assessment by the field biologists. The middle value of the range assigned to each piece of substrate collected at each station, was then used to calculate an average percent cover for that station (Table 3).

Table 3. Ranking of Percent Oyster Cover by Station

Station	Average Percent Cover	Location ¹
6	87.5	North side (facing Keller Bay)
1	83.5	Northwest end
2	83.5	North side (facing Keller Bay)
11	83.5	Middle of segment and middle of reef
14	83.5	Southeast end (facing Keller Bay channel)
9	79.5	Middle of segment and middle of reef
7	77.5	Middle of segment and middle of reef
5	73.5	Middle of segment and middle of reef
8	73.5	South edge (facing Lavaca Bay)
4	69.5	Middle of segment and middle of reef
12	68.5	North edge (facing Keller Bay)
3	65.5	South edge (facing Lavaca Bay)
10	65.5	South edge (facing Lavaca Bay)
13	64.5	South edge (facing Lavaca Bay)

¹ Refer to Figure 1

Observations

1. All substrate (rocks) collected from the reef supported small oysters (approximate diameter > 15 mm).
2. Most of the substrate collected from stations 01, 02, 03, 04, 05, 06, 07, 09, and 11 had oyster spat (approximate diameter < 15 mm).
3. No oyster spat were found on substrate collected from stations 08, 10, 12, 13, and 14, but all of the substrate had larger oysters (> 15 mm diameter). These stations were some of the first segments constructed (between April 13 and 20).
4. Oyster spat and small oysters were the dominant encrusting organisms. Photos showed that few other organisms were attached to the substrate. A small number of barnacles and tube worms were found on the substrate.
5. A ranking of average percent cover by oysters suggests that pieces of substrate from stations on the northern and eastern edge of the reef were more completely covered

than substrate from other parts of the reef. Substrate from stations on the Keller Bay side of the complex appeared to be more completely covered with small oysters and oyster spat, than substrate from stations facing Lavaca Bay.

Conclusions

Based on the abundance of small oysters and oyster spat, and the dominance of oysters on the reef substrate, construction was timed very well and the oyster set on the reef was excellent.

According to the performance criteria listed in the Oyster Reef Implementation Plan, Alcoa has met the ecological performance standard established for this project.