INTRODUCTION

The Louisiana Offshore Terminal Authority (LOTA) Monitoring Program was initiated in 1979 and began with pre-construction monitoring of the Louisiana Offshore Oil Port (LOOP) and associated facilities (Clovelly, offshore brine diffuser, pipelines). The LOOP facilities were monitored yearly for 15 years, after which monitoring was performed every five years. Barry A. Vittor & Associates, Inc. (BVA) was contracted by LOTA to carry out the 2001-02 marine/estuarine monitoring.

OBJECTIVES

The objectives of the monitoring program are (1) to maintain seasonal environmental and ecological data so that conditions existing during operations can be related to historical baseline conditions; (2) to detect during the operation of the deepwater port any adverse alterations or damages to the environment so that corrective action can be taken as soon as possible; (3) to maintain sufficient data to determine the cause or causes of environmental damages or alterations so that responsibility can be properly placed; and (4) to provide information in order to evaluate long and short-term impacts of the deepwater port.

SCOPE

The current LOOP monitoring program includes seasonal monitoring of aquatic and marine resources, sediment composition, and water quality on a five -year cycle. These data provide an update to the existing long-term LOOP dataset that was collected annually from 1979 to 1994, as well as a measure of natural environmental variability in the project area. The monitoring program was designed to identify environmental impacts that could occur due to offshore vessel operations (at the Single-Point Mooring and Terminal Complex), brine discharge, storage facility operations, and pipeline construction and operation.

METHODOLOGY

Vittor & Associates (BVA) conducted each study element of the monitoring program in accordance with the specifications in the previous section, using methodologies similar to the past program to ensure that proposed program data were compatible with previously collected data.

BVA's principal modifications to the present program included use of Differential Global Positioning System for sample station positioning, availability of back-up field equipment for all survey tasks, use of certified analytical laboratories for water and sediment chemistries, and use of a database management system that provides monthly data compilation/reduction.

Biological Methods

Benthos

Benthic samples were collected at various inshore and offshore sample stations (Figure 1). Inshore benthic samples were collected utilizing a 0.023 m^2 Ekman grab sampler. Five replicates were collected at each inshore benthic station. Offshore samples were collected with a 0.1 m^2 Smith-McIntyre grab sampler. There were six replicates collected at each station adjacent to the LOOP brine diffuser and seven replicates collected at each station in the area of the LOOP Marine Terminal Complex (= offshore). Samples were sieved through a 0.533 mm-mesh brass screen. All material retained on the screen was preserved in a 10-15% solution of filtered ambient water and buffered formalin stained with Rose Bengal. Samples were collected during August and November 2001 and June 2002.

Benthic Sample Analysis

In BVA's laboratory, benthic samples were inventoried, rinsed gently through a 0.5–mm mesh sieve to remove preservatives and sediment, stained with Rose Bengal, and stored in 70% isopropanol solution until processing. Sample material (sediment, detritus, organisms) was placed in white enamel trays for sorting under Wild M-5A dissecting microscopes. All macroinvertebrates were removed with forceps and placed in labeled glass vials containing 70% isopropanol. Each vial represented a major taxonomic group (*e.g.* Oligochaeta, Mollusca, Arthropoda). Oligochaetes were individually mounted and cleared on microscope slides prior to identification. All sorted macroinvertebrates were identified to the lowest practical identification level (LPIL), which in most cases was to species level unless the specimen was a juvenile, damaged, or otherwise unidentifiable. The number of individuals of each taxon, excluding fragments, was recorded. A voucher collection was prepared, composed of representative individuals of each species not previously encountered in samples from the Gulf of Mexico region.

Assemblage Analyses

All data generated as a result of laboratory analysis of macroinfauna samples were first coded on data sheets. Enumeration data were entered for each species according to station and replicate. These data were reduced to a data summary report for each station, which included a taxonomic species list and benthic community parameters information. Documentation of BVA's standard QA/QC procedures can be seen in the Quality Assurance Plan submitted to LOTA (BVA 2001) and QA/QC results for this project are available upon request.

Several numerical indices were chosen for analysis and interpretation of the macroinfaunal data. Abundance is reported as the total number of individuals per station and the total number of individuals per square meter (= density). Taxa richness is reported as the total number of taxa represented in a given station collection. Taxa diversity, which is often related to the ecological stability and environmental "quality" of the benthos, was estimated by the Shannon-Weaver Diversity Index H' (Pielou 1966), according to the following formula:

$$H' = -\sum_{i=1}^{s} p_i(ln\ p_i)$$

where, S = is the number of taxa in the sample,

i = is the i^{th} taxon in the sample, and

p_i = is the number of individuals of the i^{th} taxon divided by the total number of individuals in the sample.

Taxa diversity within a given community is dependent upon the number of taxa present (taxa richness) and the distribution of all individuals among those taxa (equitability or evenness). In order to quantify and compare the equitability in the fauna to the taxa diversity for a given area, Pielou's Evenness Index J' (Pielou 1966) was calculated as $J' = H'/ln\ S$, where $ln\ S = H'_{max}$, or the maximum possible diversity, when all taxa are represented by the same number of individuals; thus, $J' = H'/H'_{max}$.

Density and taxa richness data for a given facility (Offshore Pumping Station and Single Point Mooring Complex, Brine Diffuser, Lake Jesse pipeline crossing, Clovelly Salt Domes) were graphically and statistically analyzed for potential impacts (comparisons to control stations) and seasonal differences.

Hydrography

Continuous hydrographic profiles were conducted in conjunction with the benthic sampling. The following environmental data were collected at all sampling stations:

Air Temperature:	Brunton portable weather station, degrees Centigrade
Barometric Pressure:	Brunton portable weather station, mm of mercury
Wind Speed:	Brunton portable weather station, recorded in knots
Wind Direction:	Brunton portable weather station, recorded in degrees from which the wind is coming
Cloud Cover:	Visually estimated percentage of the celestial dome covered by clouds
Wave Height:	Visually estimated in meters from crest to trough
Secchi Depth:	30 cm Secchi disc lowered until no longer visible, then raised until visible and the average of two readings recorded in meters.

A HydroLab Surveyor and a Datasonde 4 were used to collect instantaneous measurements (depth, temperature, salinity, dissolved oxygen) at all monitoring stations. Continuous hydrographic profiles were collected at all offshore stations during each sampling event. The instrument was lowered by hand to discrete depths (1 meter intervals or surface, middle, and bottom) and the data recorded on field data sheets. In August 2001 there was an equipment failure at the Offshore site and a continuous profile was not captured for Station 484.

Sediment

Sediment samples were collected in conjunction with benthic sampling events. Sediment core samples were collected at the inshore benthic stations using a Barret-type coring device. Sediment core samples collected at the offshore benthic stations were collected using a Smith-McIntyre Grab sampler. There were two

samples collected at each station. The samples were collected in a butyrate core tube (6.99 cm outside diameter x 6.67 inside diameter x 30.48 cm long). The interstitial pH of one sample was tested in the field with a hand-held Orion pH probe by the slurry method. One sediment sample was analyzed for Polynuclear Aromatic Hydrocarbons (PAH; Appendices I, II and III) and another was analyzed for grain size (percent gravel, sand, silt, clay).

Laboratory Analysis Specifications

Water and sediment chemistry analysis USEPA methods, and method detection limits, are: Dissolved Oxygen, Method 4500-OG, 0.01 mg/L; Salinity, Method 2520-OB; Turbidity, Method 180.1, 0.1 NTU; and Sediment PAH, Method 8100. Severn Trent Laboratories (STL-Mobile) are certified for sediment PAH analysis, and used standard QA/QC procedures such as sample spikes, sample blanks, and duplicate analyses.

BVA's taxonomy laboratory conducts routine QA/QC checks for all benthic analyses, including re-analysis of 10% of all samples, use of verified reference collections, and use of outside taxonomic experts for verification of laboratory identifications.

RESULTS

Clovelly

Sediment Characteristics

August 2001. Station location and sediment data for the Clovelly stations in August are given in Table 1 and Figure 2. Station 461 was dominated by silt (68%), while Stations 463 and 464 were dominated by clay (79% and 48%, respectively). Sand composition varied from 5% at Station 463 to 32% at Station 464.

November 2001. Station location and sediment data for the Clovelly stations in November are given in Table 2 and Figure 2. Stations 461 and 464 were dominated by silt (45% and 43% , respectively) and Station 463 was dominated by clay (70%). Sand composition varied from 5% at Station 463 to 41% at Station 464.

June 2002. Station location and sediment data for the Clovelly stations in June are given in Table 3 and Figure 2. Stations 461 and 463 were dominated by silt + clay (79%) and the sediment at Station 464 was all organic material.

Weather and Water Quality Data

August 2001. Weather condition and water quality data for the Clovelly stations in August are given in Tables 4 and 5. Bottom temperatures ranged from 30.6 °C at Station 463 to 31.4 °C at Station 461. Bottom dissolved oxygen levels ranged from 3.8 mg/l to 4.9 mg/l, and bottom salinities were < 2 ppt.

November 2001. Weather condition and water quality data for the Clovelly stations in November are given in Tables 6 and 7. Bottom temperatures ranged from 20.5 °C at Station 464 to 21.8 °C at Station 461. Bottom dissolved oxygen levels for all stations were above 7.8 mg/l and bottom salinities ranged from 2.7 ppt to 3.7 ppt.

June 2002. Weather condition and water quality data for the Clovelly stations in June are given in Tables 8 and 9. Bottom temperatures ranged from 29.1 °C at Station 461 to 29.8 °C at Station 463. Bottom dissolved oxygen levels for all stations were > 7 mg/l and bottom salinities ranged from 3.52 ppt at Station 463 to 6.34 ppt at Station 464.

Benthic Assemblage Characteristics

August 2001. Thirty-one taxa representing 5,013 individuals were collected from the Clovelly stations in August (Table 10). Polychaetes, malacostracans (primarily amphipods), and gastropods were the most numerous taxa collected representing 36%, 23%, and 16% of the total taxa, respectively (Table 10). Gastropods, malacostracans, and polychaetes also represented 66%, 22%, and 7% of the total number of individuals collected, respectively.

Major taxonomic groups collected from the Clovelly stations in August are summarized by station in Table 11 and Figure 3. The distribution and abundance of individual families collected at the Clovelly stations are given in Table 12. Those families which made up greater than 10% of the total assemblage at a given station are listed in Table 13.

The distribution and abundance of individual taxa collected at the Clovelly stations are given in Table 14. The gastropod, *Probythinella louisianae*, made up 52% of the total assemblage, and several taxa were widely distributed occurring at 100% of the Clovelly stations (Table 14). Those taxa which made up greater than 10% of the total assemblage at a given station are listed in Table 15.

A summary of assemblage parameters for the Clovelly stations in August is given in Table 16 and Figures 4, 5, 6, and 7. Mean macroinvertebrate densities ranged from

2904.3 nos/m^2 (± 1170.0) at Station 461 to 36373.9 nos/m^2 (± 6550.6) at Station 464 (Figure 4). Mean number of taxa (taxa richness) ranged from 11.4 (± 1.3) at Station 463 to 16.4 (± 3.4) at Station 461 (Figure 5). Diversity (H') ranged from 1.48 at Station 464 to 2.68 at Station 461 (Figure 6). Evenness (J') ranged from 0.46 at Station 464 to 0.76 at Station 461 (Figure 7). Taxa richness at Station 463 was significantly higher than at Stations 461 and 464 (Table 17; $F = 5.643$, Prob > $F = 0.019$). Densities at Station 464 were significantly higher than at Stations 461 and 463 (Table 17; $F = 114.344$, Prob > $F < 0.0001$).

November 2001. Sixty-seven taxa representing 5,905 individuals were collected from the Clovelly stations in November (Table 18). Aquatic insects, malacostracans (primarily amphipods), and polychaetes were the most numerous taxa collected representing 28%, 19%, and 16% of the total, respectively (Table 18). Gastropods, malacostracans and aquatic insects also represented 33%, 30%, and 23% of the total number of individuals collected, respectively.

Major taxonomic groups collected from the Clovelly stations in November are summarized by station in Table 19 and Figure 3. The distribution and abundance of individual families collected at the Clovelly stations are given in Table 20. Those families which made up greater than 10% of the total assemblage at a given station are listed in Table 21.

The distribution and abundance of individual taxa collected at the Clovelly stations in November are given in Table 22. The gastropod, *Amnicola limosa*, made up 18% of the total assemblage, and several taxa were widely distributed occurring at 100%

of the Clovelly stations (Table 22). Those taxa which made up greater than 10% of the total assemblage at a given station are listed in Table 23.

A summary of assemblage parameters for the Clovelly stations in November is given in Table 24 and Figures 4, 5, 6, and 7. Mean macroinvertebrate densities ranged from 736.0 nos/m^2 (± 703.5) at Station 463 to 6464.0 nos/m^2 (± 862.7) at Station 464 (Figure 4). Mean number of taxa (taxa richness) ranged from 12.4 (± 4.2) at Station 463 to 25.6 (± 3.6) at Station 461 (Figure 5). Diversity (H') ranged from 2.07 at Station 464 to 2.68 at Station 461 (Figure 6). Evenness (J') ranged from 0.58 at Station 464 to 0.71 at both Stations 461 and 463 (Figure 7). Taxa richness at Station 463 was significantly higher than at Stations 461 and 464 (Table 17; F = 17.630, Prob > F = 0.0003). Densities at Station 464 were significantly higher than at both Stations 461 and 463, and densities at Station 461 were significantly higher than at 463 (Table 17; F = 32.669, Prob > F < 0.0001).

June 2002. Seventy-four taxa representing 1,743 individuals were collected from the Clovelly stations in June (Table 25). Aquatic insects, malacostracans, and polychaetes were the most numerous taxa collected representing 28%, 27%, and 19% of the total, respectively (Table 25). Malacostracans, bivalves and aquatic insects also represented 32%, 24%, and 18% of the total number of individuals collected, respectively.

Major taxonomic groups collected from the Clovelly stations in June are summarized by station in Table 26 and Figure 3. The distribution and abundance of individual families collected at the Clovelly stations are given in Table 27. Those families which made up greater than 10% of the total assemblage at a given station are listed in Table 28.

The distribution and abundance of individual taxa collected at the Clovelly stations in June are given in Table 29. The bivalve, *Mytilopsis leucophaeata*, made up 12% of the total assemblage, and several taxa were widely distributed occurring at 100% of the stations (Table 29). Those taxa which made up greater than 10% of the total assemblage at a given station are listed in Table 30.

A summary of assemblage parameters for the Clovelly stations in June is given in Table 31 and Figures 4, 5, 6, and 7. Mean macroinvertebrate densities ranged from 2991.3 nos/m^2 (± 740.7) at Station 463 to 7730.4 nos/m^2 (± 3421.1) at Station 464 (Figure 4). Mean number of taxa (taxa richness) ranged from 15.2 (± 5.1) at Station 461 to 21.8 (± 5.3) at Station 464 (Figure 5). Diversity (H') ranged from 2.58 at Station 461 to 2.85 at Station 463 (Figure 6). Evenness (J') ranged from 0.70 at Station 464 to 0.77 at Station 463 (Figure 7). There was no significant difference in taxa richness between the stations (Table 17; F = 3.932, Prob > F = 0.049). Densities at Stations 461 and 463 were significantly higher than at Stations 463 (Table 17; F = 6.296, Prob > F = 0.014).

Lake Jesse

Sediment Characteristics

August 2001. Station location and sediment data for the Lake Jesse stations in August are given in Table 32 and Figure 8. Station 407 was dominated by silt (49%) and Station 462 was dominated by clay (52%). Sand composition varied from 7% at Station 407 to 14% at Station 462.

November 2001. Station location and sediment data for the Lake Jesse stations in November are given in Table 33 and Figure 8. Stations 407 and 462 were dominated by

silt (62% and 52%, respectively). Sand composition varied from 9% at Station 407 to 21% at Station 462.

June 2002. Station location and sediment data for the Lake Jesse stations in November are given in Table 34 and Figure 8. Stations 407 and 462 were both dominated by silt + clay (93% and 88%, respectively). Sand composition varied from 7% at Station 407 to 12% at Station 462.

Weather and Water Quality Data

August 2001. Weather condition and water quality data for the Lake Jesse stations in August are given in Tables 35 and 36. Bottom temperatures ranged from 31.8 °C at Station 407 to 32.0°C at Station 462. Bottom dissolved oxygen was 7.8 mg/l for both stations and bottom salinities were 4.67 ppt and 6.84 ppt for Stations 407 and 462, respectively.

November 2001. Weather condition and water quality data for the Lake Jesse stations in November are given in Tables 37 and 38. Bottom temperatures were 20.7 °C and bottom dissolved oxygen was 7.8 mg/l at both stations. Bottom salinities were 6.87 ppt and 7.38 ppt at Stations 407 and 462.

June 2002. Weather condition and water quality data for the Lake Jesse stations in June are given in Tables 39 and 40. The bottom temperature was 30.6 °C at both stations. Bottom dissolved oxygen levels were 7.2 mg/l and 7.6 mg/l, and bottom salinities were 4.94 ppt and 5.33 ppt at Stations 407 and 462, respectively.

Benthic Assemblage Characteristics

August 2001. Forty-three taxa representing 695 individuals were collected from the Lake Jesse stations in August (Table 41). Polychaetes, malacostracans, bivalves, and gastropods were the most numerous taxa collected representing 44%, 30%, 7%, and 7% of the total, respectively (Table 41). Polychaetes, oligochaetes, and malacostracans also represented 53%, 28%, and 13% of the total number of individuals collected, respectively.

Major taxonomic groups collected from the Lake Jesse stations in August are summarized by station in Table 42 and Figure 9. The distribution and abundance of individual families collected at the Lake Jesse stations are given in Table 43. Those families that made up greater than 10% of the total assemblage at a given station are listed in Table 44.

The distribution and abundance of individual taxa collected at the Lake Jesse stations in August are given in Table 45. The oligochaete family, Tubificidae (LPIL), made up 28% of the total assemblage, and several taxa were widely distributed occurring at 100% of the Lake Jesse stations (Table 45). Those taxa which made up greater than 10% of the total assemblage at a given station are listed in Table 46.

A summary of assemblage parameters for the Lake Jesse stations in August is given in Table 47 and Figures 10, 11, 12, and 13. Mean macroinvertebrate densities ranged from 2791.3 nos/m^2 (± 1113.8) at Station 462 to 3252.2 nos/m^2 (± 1206.2) at Station 407 (Figure 10). Mean number of taxa (taxa richness) ranged from 13.4 (± 3.9) at Station 462 to 16.4 (± 2.3) at Station 407 (Figure 11). Diversity (H') ranged from 2.50 at Station 462 to 2.52 at Station 407 (Figure 12). Evenness (J') ranged from 0.71 at Station

407 to 0.74 at Station 462 (Figure 13). There was no significant difference in taxa richness (Table 17; F = 2.185, Prob > F = 0.178) or densities (Table 17; F = 0.394, Prob > F = 0.548) between the stations.

November 2001. Fifty-four taxa representing 551 individuals were collected from the Lake Jesse stations in November (Table 48). Polychaetes, malacostracans , and gastropods were the most numerous taxa collected representing 37%, 19%, and 13% of the total, respectively (Table 48). Polychaetes, malacostracans, and other taxa also represented 64%, 16%, and 6% of the total number of individuals collected, respectively.

Major taxonomic groups collected from the Lake Jesse stations in November are summarized by station in Table 49 and Figure 9. The distribution and abundance of individual families collected at the Lake Jesse stations are given in Table 50. Those families which made up greater than 10% of the total assemblage at a given station are listed in Table 51.

The distribution and abundance of individual taxa collected at the Lake Jesse stations in November are given in Table 52. The polychaete, *Mediomastus* (LPIL), made up 34% of the total assemblage, and several taxa were widely distributed occurring at 100% of the Lake Jesse stations (Table 52). Those taxa which made up greater than 10% of the total assemblage at a given station are listed in Table 53.

A summary of assemblage parameters for the Lake Jesse stations in November is given in Table 54 and Figures 10, 11, 12, and 13. Mean macroinvertebrate densities ranged from 1991.3 nos/m^2 (± 979.7) at Station 462 to 2800.0 nos/m^2 (± 951.9) at Station 407 (Figure 10). Mean number of taxa (taxa richness) ranged from 14.0 (± 3.1) at Station 462 to 15.4 (± 2.7) at Station 407 (Figure 11). Diversity (H') ranged from 2.25 at Station

462 to 2.71 at Station 407 (Figure 12). Evenness (J') ranged from 0.63 at Station 462 to 0.76 at Station 407 (Figure 13). There was no significant difference in taxa richness (Table 17; F = 1.624, Prob > F = 0.238) or densities (Table 17; F = 0.036, Prob > F = 0.853) between the stations.

June 2002. Forty-five taxa representing 938 individuals were collected from the Lake Jesse stations in June (Table 55). Polychaetes, malacostracans, and bivalves were the most numerous taxa collected representing 44%, 18%, and 11% of the total, respectively (Table 55). Polychaetes and oligochaetes also represented 45% and 11% of the total number of individuals collected, respectively.

Major taxonomic groups collected from the Lake Jesse stations in June are summarized by station in Tables 56 and Figure 9. The distribution and abundance of individual families collected at the Lake Jesse stations are given in Table 57. Those families which made up greater than 10% of the total assemblage at a given station are listed in Table 58.

The distribution and abundance of individual taxa collected at the Lake Jesse stations in June are given in Table 59. The ascidiacean family, Ascidiacea (LPIL), made up 31% of the total assemblage, and several taxa were widely distributed occurring at 100% of the Lake Jesse stations (Table 59). Those taxa which made up greater than 10% of the total assemblage at a given station are listed in Table 60.

A summary of assemblage parameters for the Lake Jesse stations in June is given in Table 61 and Figures 10, 11, 12, and 13. Mean macroinvertebrate densities ranged from 3887.0 nos/m^2 (± 3494.3) at Station 462 to 4269.6 nos/m^2 (± 2808.5) at Station 407 (Figure 10). Mean number of taxa (taxa richness) ranged from 12.2 (± 5.4) at Station 407

to 15.8 (± 3.3) at Station 462 (Figure 11). Diversity (H') ranged from 2.18 at Station 407 to 2.42 at Station 462 (Figure 12). Evenness (J') ranged from 0.65 at Station 407 to 0.68 at Station 462 (Figure 13). There was no significant difference in taxa richness (Table 17; $F = 0.583$, Prob > $F = 0.467$) or densities (Table 17; $F = 1.753$, Prob > $F = 0.222$) between the stations.

Brine Diffuser

Sediment Characteristics

August 2001. Station location and sediment data for the Brine stations in August are given in Table 62 and Figure 14. The sediment at Station 475 was dominated by sand (45%), and the sediment at Stations 435, 473, and 474 was dominated by clay (50%, 63%, and 75 %, respectively).

November 2001. Station location and sediment data for the Brine stations in November are given in Table 63 and Figure 14. The sediment at all stations was dominated by the silt + clay fraction. Sand composition varied from 4% at Station 475 to 13% at Station 474.

June 2002. Station location and sediment data for the Brine stations in November are given in Table 64 and Figure 14. The sediment at all stations was dominated by the silt + clay fractions (99%, 94%, 95%, 80% for Stations 435, 473, 474, and 475, respectively). Sand composition varied from 0.5% at Station 435 to 20% at Station 475.

Weather and Water Quality Data

August 2001. Weather condition data for the Brine stations in August are given in Table 65. Water quality data and depth profiles are provided in Tables 66, 67, 68, and 69 and Figures 15, 16, 17, and 18. Bottom temperatures ranged from 29.3 °C at Station 473 to 30.1 °C at Station 475. Hypoxic conditions were present at Station 435 (9.8 m depth; 1.88 mg/l DO). Bottom dissolved oxygen levels were above hypoxic levels at Stations 473 (9.5 m depth; 2.79 mg/l DO), 474 (9.4 m depth; 3.30 mg/l DO) and 475 (9.4 m depth; 3.66 mg/l DO). Bottom salinities were between 28 ppt and 30 ppt at the four stations.

November 2001. Weather condition data for the Brine stations in November are given in Table 70. Water quality data and depth profiles are provided in Tables 71, 72, 73 and 74 and Figures 15, 16, 17, and 18. The bottom temperature was 23°C at all stations. Bottom dissolved oxygen levels ranged from 4.8 mg/l at Station 475 to 7.1 mg/l at Station 435. Bottom salinities were between 31 and 32 ppt for the four stations.

June 2002. Weather condition data for the Brine stations in June are given in Table 75. Water quality data and depth profiles are provided in Tables 76, 77, 78, and 79 and Figures 15, 16, 17, and 18. The bottom temperature was 24.8°C for all stations. Hypoxic conditions were present at Stations 435 (9.5 and 10.1 m depth; 1.5 and 1.4 mg/l DO), 473 (9.2 and 10.4 m depth; 1.1 and 1.2 mg/l DO), 474 (8.9 and 10.5 m depth; 1.5 and 1.3 mg/l DO), and 475 (8.8 and 10.1 m depth; 1.0 and 1.2 mg/l DO). Bottom salinities were between 35 and 36 ppt at all stations.

Benthic Assemblage Characteristics

August 2001. Twenty-eight taxa representing 1,553 individuals were collected from the Brine stations in August (Table 80). Polychaetes, gastropods and other taxa were the most numerous taxa collected representing 57%, 25%, and 14% of the total, respectively (Table 80). Polychaetes and gastropods also represented 94% and 5% of the total number of individuals collected, respectively.

Major taxonomic groups collected from the Brine stations in August are summarized by station in Table 81 and Figure 19. The distribution and abundance of individual families collected at the Brine stations are given in Table 82. Those families which made up greater than 10% of the total assemblage at a given station are listed in Table 83.

The distribution and abundance of individual taxa collected at the Brine stations in August are given in Table 84. The polychaete, *Paraprionospio pinnata,* made up 67% of the total assemblage, and several taxa were widely distributed occurring at 100% of the stations (Table 84). Those taxa which made up greater than 10% of the total assemblage at a given station are listed in Table 85.

A summary of assemblage parameters for the Brine stations in August is given in Table 86 and Figures 20, 21, 22, and 23. Mean macroinvertebrate densities ranged from 4741.7 nos/m^2 (± 365) at Station 473 to 916.7 nos/m^2 (± 414) at Station 474 (Figure 20). Mean number of taxa (taxa richness) ranged from 5.7 (± 2.4) at Station 473 to 6.5 (±2.4 and ±1.5, respectively) at Stations 435 and 474 (Figure 21). Diversity (H') ranged from 0.89 at Station 435 to 1.21 at Station 473 (Figure 22). Evenness (J') ranged from 0.31 at Station 435 to 0.44 at Station 473 (Figure 23). There was no significant difference in taxa richness (Table 17; F = 0.120, Prob > F = 0.895) or densities (Table 17; F = 1.441, Prob > F = 0.261) between the stations.

November 2001. Ninety-three taxa representing 4,048 individuals were collected from the Brine stations in November (Table 87). Polychaetes, bivalves, and gastropods were the most numerous taxa collected representing 47%, 14%, and 14% of the total, respectively (Table 87). Polychaetes, bivalves and rhynchocoels represented 69%, 10%, and 8% of the total number of individuals collected, respectively.

Major taxonomic groups collected from the Brine stations in November are summarized by station in Tables 88 and Figure 19. The distribution and abundance of individual families collected at the Brine stations are given in Table 89. Those families

which made up greater than 10% of the total assemblage at a given station are listed in Table 90.

The distribution and abundance of individual taxa collected at the Brine stations in November are given in Table 91. The polychaete, *Paraprionospio pinnata*, made up 23% of the total assemblage, and several taxa were widely distributed at 100% of the Brine stations (Table 91). Those taxa which made up greater than 10% of the total assemblage at a given station are listed in Table 92.

A summary of assemblage parameters for the Brine stations in November is given in Table 93 and Figures 20, 21, 22, and 23. Mean macroinvertebrate densities ranged from 1153.3 nos/m^2 (± 566) at Station 475 to 2093.3 nos/m^2 (± 668) at Station 435 (Figure 20). Mean number of taxa (taxa richness) ranged from 21.5 (± 6.1) at Station 473 to 28.8 (±4.9) at Station 435 (Figure 21). Diversity (H') ranged from 2.62 at Station 473 to 3.07 at Station 435 (Figure 22). Evenness (J') ranged from 0.68 at Station 473 to 0.75 at Station 475 (Figure 23). There was no significant difference in taxa richness (Table 17; F = 1.779, Prob > F = 0.184) or densities (Table 17; F = 1.965, Prob > F = 0.152) between the stations.

June 2002. One hundred and fourteen taxa representing 3,791 individuals were collected from the Brine stations in June (Table 94). Polychaetes, bivalves and gastropods were the most numerous taxa collected representing 47%, 18%, and 17% of the total, respectively (Table 94). Polychaetes, bivalves and other taxa also represented 73%, 17%, and 6% of the total number of individuals collected, respectively.

Major taxonomic groups collected from the Brine stations in June are summarized by station in Tables 95 and Figure 19. The distribution and abundance of individual

families collected at the Brine stations are given in Table 96. Those families which made up greater than 10% of the total assemblage at a given station are listed in Table 97.

The distribution and abundance of individual taxa collected at the Brine stations in June are given in Table 98. The polychaete, *Mediomastus* (LPIL), made up 28% of the total assemblage, and several taxa were widely distributed occurring at 100% of the Brine stations (Table 98). Those taxa which made up greater than 10% of the total assemblage at a given station are listed in Table 99.

A summary of assemblage parameters for the Brine stations in June is given in Table 100 and Figures 20, 21, 22, and 23. Mean macroinvertebrate densities ranged from 938.3 nos/m^2 (± 302) at Station 473 to 2001.7 nos/m^2 (± 1096) at Station 435 (Figure 20). Mean number of taxa (taxa richness) ranged from 15.5 (± 4.0) at Station 473 to 32.2 (± 7.3) at Stations 435 (Figure 21). Diversity (H') ranged from 2.23 at Station 473 to 3.07 at Station 435 (Figure 22). Evenness (J') ranged from 0.57 at Station 474 to 0.71 at Station 435 (Figure 23). Control station 435 had significantly greater taxa richness than Stations 473, 474, and 475 (Table 17; F = 8.128, Prob > F = 0.001). There were no significant difference in taxa densities (Table 17; F = 1.440, Prob > F = 0.261) between the stations.

Offshore Stations

Sediment Characteristics

August 2001. Station location and sediment data for the Offshore stations in August are given in Table 101 and Figure 24. Clay was the dominant sediment type at all stations (>54%). Sand composition varied from 7% at Station 482 to 18% at Station 484.

November 2001. Station location and sediment data for the Offshore stations in November are given in Table 102 and Figure 24. The sediment at stations 481 and 484 were dominated by silt (49% and 52%, respectively), and sediments at Station 482 were dominated by clay (62%). Sand composition varied from 0.5% at Station 482 to 22% at Station 481.

June 2002. Station location and sediment data for the Offshore stations in November are given in Table 103 and Figure 24. The sediment at stations 481 and 482 was dominated by silt (54%), and sediments at Station 484 were dominated by clay (47%). Sand composition varied from 0.7% at Station 482 to 14% at Station 481.

Weather and Water Quality Data

August 2001. Weather condition data for the Offshore stations in August are given in Table 104. Water quality and depth profile data are provided in Tables 105, 106, and 107 and Figures 25, 26, and 27. No bottom water quality data was collected at Station 482 in August due to a mechanical problem with the sampling equipment. The bottom temperature was 24°C at both stations. Hypoxic conditions were present at Stations 481 (30.1 and 32.7 m depth; 1.55 and 1.60 mg/l DO) and 484 (32.7m depth; 1.88 mg/l DO). Bottom salinities were 32.4 and 38.6 ppt at Stations 481 and 484, respectively.

November 2001. Weather condition data for the Offshore stations in November are given in Table 108. Water quality data and depth profiles are provided in Tables 109, 110, and 111 and Figures 25, 26, and 27. The bottom temperature was 24°C at all stations. Bottom dissolved oxygen levels ranged from 2.8 mg/l at Station 481 (33.2 m depth) to 8.1 mg/l at Station 482 (31.8m depth). Bottom salinities were 35 ppt at the three stations.

June 2002. Weather condition data for the Brine stations in June are given in Table 112. Water quality data and depth profiles are provided in Tables 113, 114, and 115 and Figures 25, 26, and 27. Bottom temperatures were between 25 and 26°C at all stations. Bottom dissolved oxygen levels ranged from 6.0 mg/l at Station 482 (31.6 m depth) to 6.9 mg/l at Station 484 (32.7 m depth). Bottom salinities were 36 ppt at the three stations.

Benthic Assemblage Characteristics

August 2001. Eighty-seven taxa representing 490 individuals were collected from the Offshore stations in August (Table 116). Polychaetes, malacostracans, and bivalves were the most numerous taxa collected representing 63%, 12%, and 10% of the total, respectively (Table 116). Polychaetes, gastropods, and bivalves represented 76%, 9%, and 6% of the total number of individuals collected, respectively.

Major taxonomic groups collected from the Offshore stations in August are summarized by station in Table 117 and Figure 28. The distribution and abundance of individual families collected at the Offshore stations are given in Table 118. Those families which made up greater than 10% of the total assemblage at a given station are listed in Table 119.

The distribution and abundance of individual taxa collected at the Offshore stations in August are given in Table 120. The polychaete, *Paraprionospio pinnata*, made up 16% of the total assemblage, and several taxa were widely distributed occurring at 100% of the Offshore stations (Table 120). Those taxa which made up greater than 10% of the total assemblage at a given station are listed in Table 121.

A summary of assemblage parameters for the Offshore stations in August is given in Table 122 and Figures 29, 30, 31, and 32. Mean macroinvertebrate densities ranged

from 141.4 nos/m^2 (± 91.0) at Station 484 to 341.4 nos/m^2 (± 204.0) at Station 481 (figure 29). Mean number of taxa (taxa richness) ranged from 8.4 (± 1.5) at Station 482 to 17.3 (± 6.0) at Station 481 (Figure 30). Diversity (H') ranged from 2.15 at Station 482 to 3.55 at Station 481 (Figure 31). Evenness (J') ranged from 0.66 at Station 482 to 0.93 at Station 484 (Figure 32). Station 481 had significantly greater taxa richness than Stations 482 and 484 (Table 17; F = 6.407, Prob > F = 0.008). Station 481 had significantly greater taxa richness than Station 484 and Station 482 had significantly greater taxa richness than Station 484 (Table 17; F = 3.892, Prob > F = 0.039).

November 2001. Eighty-nine taxa representing 527 individuals were collected from the Offshore stations in November (Table 123). Polychaetes, gastropods, and bivalves were the most numerous taxa collected representing 57%, 12%, and 11% of the total, respectively (Table 123). Polychaetes, gastropods, and rhynchocoels represented 58%, 15%, and 10% of the total number of individuals collected, respectively.

Major taxonomic groups collected from the Offshore stations in November are summarized by station in Table 124 and Figure 28. The distribution and abundance of individual families collected at the Offshore stations are given in Table 125. Those families that made up greater than 10% of the total assemblage at a given station are listed in Table 126.

The distribution and abundance of individual taxa collected at the Offshore stations in November are given in Table 127. The gastropod, *Vitrinella helicoidea*, made up 8% of the total assemblage, and several taxa were widely distributed occurring at 100% of the Offshore stations (Table 127). Those taxa which made up greater than 10% of the total assemblage at a given station are listed in Table 128.

A summary of assemblage parameters for the Offshore stations in November is given in Table 129 and Figures 29, 30, 31, and 32. Mean macroinvertebrate densities ranged from 95.7 nos/m^2 (± 68.0) at Station 482 to 434.3 nos/m^2 (± 140.1) at Station 481 (Figure 29). Mean number of taxa (taxa richness) ranged from 10.0 (± 1.4) at Station 482 to 23.1 (± 6.7) at Station 481 (Figure 30). Diversity (H') ranged from 3.18 at Station 482 to 3.70 at Station 481 (Figure 31). Evenness (J') ranged from 0.87 at Station 481 to 0.91 at Station 482 (Figure 32). Station 481 had significantly greater taxa richness than Stations 482 and 484 (Table 17; F = 11.704, Prob > F = 0.0006). Station 481 had significantly greater densities than Stations 482 and 484 (Table 17; F = 15.532, Prob > F = 0.0001).

June 2002. Ninety-eight taxa representing 844 individuals were collected from the Offshore stations in June (Table 130). Polychaetes, malacostracans, and gastropods were the most numerous taxa collected representing 54%, 15%, and 14% of the total, respectively (Table 130). Polychaetes, bivalves and gastropods also represented 65%, 15% and 8% of the total number of individuals collected, respectively.

Major taxonomic groups collected from the Offshore stations in June are summarized by station in Table 131 and Figure 28. The distribution and abundance of individual families collected at the Offshore stations are given in Table 132. Those families that made up greater than 10% of the total assemblage at a given station are listed in Table 133.

The distribution and abundance of individual taxa collected at the Offshore stations in June are given in Table 134. The polychaete, *Paraprionospio pinnata*, made up 14% of the total assemblage, and several taxa were widely distributed occurring at

100% of the Offshore stations (Table 134). Those taxa which made up greater than 10% of the total assemblage at a given station are listed in Table 135.

A summary of assemblage parameters for the Offshore stations in June is given in Table 136 and Figures 29, 30, 31, and 32. Mean macroinvertebrate densities ranged from 374.3 nos/m^2 (± 245.2) at Station 484 to 451.4 nos/m^2 (± 284.1) at Station 481 (Figure 29). Mean number of taxa (taxa richness) ranged from 14.9 (± 5.6) at Station 482 to 19.7 (± 7.5) at Station 481 (Figure 30). Diversity (H') ranged from 3.03 at Station 482 to 3.53 at Station 481 (Figure 31). Evenness (J') ranged from 0.77 at Station 482 to 0.84 at Station 481 (Figure 32). There was no significant difference in taxa richness (Table 17; F = 0.815, Prob > F = 0.459) or densities (Table 17; F = 0.223, Prob > F = 0.802) between the stations.

CONCLUSIONS

Clovelly

1. Sediments at the Clovelly stations during all seasons were dominated by silt+clay (except Station 464 in June). Sediments at Station 464 were greater than 20% sand during August and November, but were completely organic during June.

2. Estuarine salinities were present during all seasons, ranging from < 2 ppt in August to 6 ppt in June.

3. Dissolved oxygen levels varied seasonally. DO levels were lowest in August (< 5 mg/l) and were greater than 7 mg/l during November and June.

4. The gastropod *Probythinella louisianae* dominated the benthic assemblage in August; the gastropod *Amnicola limosa*, dominated in November; and the bivalve; *Mytilopsis leucophaeata* dominated in June.

5. There were significant differences in density and taxa richness between stations for each season. In no instance was the control station significantly different than both of the test stations. These differences could be explained by subtle variations in sediment type between stations as well as stochastic variability inherent in benthic assessments.

6. There was no measurable impact of the LOOP facilities on benthic macroinfaunal assemblages at the Clovelly site.

Lake Jesse

1. Sediments at the Lake Jesse stations during all seasons were dominated by silt+clay.

2. Estuarine salinities were present during all seasons, ranging from 4.7 ppt in August to 6.8 ppt in November.

3. Dissolved oxygen levels did not vary seasonally and were between 7 and 8 mg/l during all sampling events.

4. The oligochaete family Tubificidae (LPIL) dominated the benthic assemblage in August; the polychaete *Mediomastus* (LPIL) dominated in November, and he ascidiacean family Ascidiacea (LPIL), dominated the assemblage in June.

5. There were no significant differences in density or taxa richness between stations for each season.

6. There was no measurable impact of the LOOP facilities on benthic macroinfaunal assemblages at the Lake Jesse site.

Brine Diffuser

1. Sediments at the Brine Diffuser stations during all seasons were dominated by silt + clay. The sediment at Station 475 in August was 45% sand.

2. Bottom salinities varied seasonally and were between 28-30 ppt in August, 31-32 ppt in November, and 35-36 ppt in June.

3. Hypoxic conditions (DO = 1.88 mg/l) were present at Station 435 during August; however, DO levels at the remaining stations ranged from 2.79 mg/l at Station 473 to 3.66 mg/l at Station 475. In November, bottom DO levels ranged from 4.8 mg/l at Station 475 to 7.1 mg/l at Station 435. In June, hypoxic conditions were present at all stations with DO ranging from 1.0 mg/l at Station 475 to 1.5 at Stations 435 and 474.

4. The polychaete *Paraprionospio pinnata* dominated the benthic assemblage in August and November, while the polychaete *Mediomastus* (LPIL) dominated the benthos in June.

5. There were no significant differences in densities between stations for each season. There were no significant differences in taxa richness between stations during August and November; in June, Station 435 had significantly greater taxa richness than the remaining stations. It is probable that the hypoxia experienced by the benthic assemblage in June was responsible for variations in taxa richness.

6. There was no measurable impact of the LOOP facilities on benthic macroinfaunal assemblages at the Brine Diffuser site.

Offshore Stations

1. Sediments at the Offshore stations during all seasons were dominated by silt + clay.

2. Bottom salinities varied seasonally and ranged from 32.4 ppt at Station 481 in August to 38.6 ppt at Station 484 in August.

3. Hypoxic conditions were present at Stations 481 (DO = 1.60 mg/l) and 484 (DO = 1.88 mg/l) during August; no bottom DO data was collected from Station 484. In November, bottom DO levels ranged from 2.8 mg/l at Station 481 to 8.1 mg/l at Station 482. In June, bottom DO levels ranged from 6.0 mg/l at Station 482 to 6.9 mg/l at Station 484.

4. The polychaete *Paraprionospio pinnata* dominated the benthic assemblage in August and June, while the gastropod *Vitrinella helicoidea* dominated the benthos in November.

5. There were significant differences in density and taxa richness between stations in August and November. Station 481 had significantly higher density and taxa richness than Stations 482 and 484. There were no significant differences in density and taxa richness between stations in June.

6. There was no measurable impact of the LOOP facilities on benthic macroinfaunal assemblages at the Offshore site.

LIST OF ABBREVIATIONS

BVA – Barry A. Vittor & Associates, Inc.

cm - centimeter

°C – degrees Celsius

DO – dissolved oxygen

H' – Shannon-Weaver Diversity

J' - Evenness

LOTA – Louisiana Offshore Terminal Authority

LOOP – Louisiana Offshore Oil Port, Inc.

LPIL – Lowest Possible Identification Level

m - meter

m^2 – square meter

mg/l – milligrams per liter

mm - millimeter

NTU – Nephelometric Turbidity Unit

PAH – Polyaromatic Hydrocarbon

ppt – parts per thousand

QA/QC – Quality Assurance/Quality Control

USEPA – U.S. Environmental Protection Agency

REFERENCES

Barry A. Vittor & Associates, Inc. 2001. "Quality Assurance Plan." Submitted to the Louisiana Department of Transportation and Development, July 2001.

Pielou, E.C. 1966. "The Measurement of Diversity in Different Types of Biological Collections." *Journal of Theoretical Biology* 13:131-144,1966.