

Fate and Effect Studies
of
Shell Oil Spill - December 1970

Executive Summary



EXECUTIVE SUMMARY

**A Synopsis of Fate and Effect Studies
Of the Shell Oil Spill Platform B,
Block 26, South Timbalier Bay**

January 1972

Prepared By:

**RESOURCES TECHNOLOGY CORPORATION
1275 Space Park Drive, Suite 111
Houston, Texas 77058**

(Contract 68-01-0051)

Executive Summary

1.0 Introduction

This study was accomplished for the Environmental Protection Agency by RESOURCES TECHNOLOGY CORPORATION under Basic Ordering Agreement NO. 68-01-0051. Its purpose was to assess the fate and effects of the crude oil spill which resulted from a blowout on Shell Oil Company, Platform "B" in Block 26 approximately 7 miles offshore of South Timbalier Bay on December 1, 1970. Eleven of the twenty-two producing wells were involved in the incident.

This report is based on information obtained from three field surveys directed by the EPA as a result of this incident. Their purpose was to determine the areal extent of the spilled material, the fate of the spill, and the effect of the material on the biota of the area. They were:

- The Caminada Bay-Barataria Bay physical, chemical, and biological sampling conducted by EPA personnel, December, 1970.
- Oceanographic and Remote-Sensory Survey by Texas Instruments, January 1971.
- The joint physical, chemical, and biological sampling surveys conducted by an EPA team in Caminada Bay-Barataria Bay and by a Resources Technology Corporation team on three transects across Shell Platform "B" in the Gulf of Mexico June of 1971.

Laboratory analyses were conducted by RESOURCES TECHNOLOGY CORPORATION on samples collected in the vicinity of Platform "B" as well as many of the inshore bay samples.

In addition to the three cited studies, an extensive background data base was developed by RESOURCES TECHNOLOGY CORPORATION from literature dating back to 1904 on the physical, biological and zoogeographical characteristics of the Northern Gulf of Mexico with particular emphasis on the South Timbalier Bay Area. Although attempts were made, very little background chemical data was found in the literature for use in the study.

2.0 Geologic, Climatic and Oceanographic Setting of the Area in the Vicinity of South Timbalier Bay

2.1 Geology--Geomorphology

The area studied lies in the coastal region between Vermillion Bay on the west and the southeastern margin of the Mississippi Delta. The area is characterized by extensive marshland and vast areas of estuarine and marine waters. The coastline contains numerous bay systems, communicating with the Gulf through natural and artificial passes and with fresh-water distributaries of the Atchafalaya River. The lower Atchafalaya Basin exhibits an intricate system of lakes and channels. The Mississippi River, being leveed almost to its mouth, permits little drainage to the east below Baton Rouge to the Atchafalaya Basin.

The inland coastal plain of the study area slopes southward at about five feet per mile into the tidal marshes just inland from the secondary bay, lake and channel areas bordering the very irregular Gulf shoreline. The coastal plain then increases in slope at the shoreline to about 10 feet per mile except in the immediate vicinity of the Mississippi Delta.

The Louisiana Gulf Coast may be classified as "emergent" or depositional in nature, formed by deltaic processes as the Mississippi River and its distributaries sought outlets to the Gulf of Mexico. Since 1900 the Atchafalaya River has been the main distributary to the Mississippi. The deltaic deposits consist primarily of sand and silt, with deposits of clay. Underlying the silt and sand are the extensive sand and gravel deposits which resulted from deposition in the final cycle of the most recent glaciation.

2.2 Climate

The study area lies within the temperate humid zone with a mean average precipitation of from 35 to 54 inches per year and temperature ranges from mean lows in January of 19° to 44°F to mean highs in July of 85° to 91°F.

The tropical and equatorial tidal actions are damped within the Gulf of Mexico ranging from 2 to 3.5 feet. Tidal currents, however, in narrow inlets do appreciably affect the migration of organisms through the passes.

In addition to tidal action the study area is affected by severe storm surges from hurricane waves. Hurricane wave heights of 55 feet

have been recorded at deep water (100 fathom) stations. Wave heights are decreased as they travel toward shore by shoaling, refraction and friction, but cause a "piling up" of water and severe tides in excess of 15 feet along the coast.

2.3 Hydrology

The Mississippi water shed covers 1,243,600 square miles and has a maximum discharge rate of 1,360,000 cfs and a minimum of 49,200 cfs. Rainfall in the vicinity of Barataria Bay ranged from a monthly average of 3.5 to 7.0 inches with a monthly mean of 5.18 inches. Since these data cover a time span of nearly 30 years they serve well as baseline values for the study area.

Modifications of the lower Mississippi for flood control purposes have greatly altered the various bay ecosystems within the area. Blockage of the lower Mississippi distributaries have resulted in higher salinities in the bays due to diminished fresh water sources and encroachment of salt water from the Gulf of Mexico. These man-made changes have caused a new deposition-erosion equilibrium to be established.

Characterization of inshore currents of the study area was hampered by a scarcity of available information. Recent current studies, however, reveal that near shore surface currents are primarily wind-driven.

The current and remote sensing survey conducted just following the December spills showed a high correlation of oil slick movement, as monitored with ultraviolet photography and thermal infrared imagery, to nearsurface current data. Current monitoring during this study by Texas Instruments suggested that the current regime in the area near Platform "B" is relatively uniform.

3.0 Biological and Zoogeographical Description of the South Timbalier Bay Area

Investigations of the indigenous fauna of the northern Gulf of Mexico have been completed. Specific catch records and data have been compiled from the literature and a biological and zoogeographic description of the study area has been made. This investigation was quite complex due to the vigorously dynamic oceanographic and climatic conditions of the study area.

The study area lying between Vermillion Bay on the west and the western margin of the Mississippi Delta ranges from subtropical in the summer to temperate in the winter. Because of such a variation, the faunal assemblages are subjected to severe ecological stresses and populations are maintained largely through recruitment. Endemic forms constitute less than 10% of the native population while the distribution of these populations is dependent on the prevailing currents within the Gulf and subject to primary current inflow through the Yucatan Passage.

During fall and spring periods, larvae production is at its peak and large influxes of animals occur. Animals entering during the spring find environmental conditions similar to their normal habitat and thrive. Those entering during the fall, and who survive the winter extremes, establish themselves by spawning under more favorable spring conditions. The currents, upon which the recruitment depends, may flow eastward west of the Mississippi Delta without a reversal pattern during the year resulting in a strong correlation of the faunal populations between the northwestern and northcentral areas of the coast.

4.0

Bases for Analysis of Data and Techniques Employed

Hydrocarbons are quite universally distributed in nature. Certain hydrocarbon compounds are stable to the extent that they can be used to determine feeding habits and ranges of some fishes and mammals. Accordingly, distinguishing between natural hydrocarbons and those resulting from introduction of oil requires careful analysis of characteristic differences in molecular size and type distribution. With this knowledge the study effort pursued the following basic methodology:

1. Compare, as a function of time, the results of the incident-related studies to determine the effects on the ecosystems in the vicinity of the Shell spill.
2. Compare the laboratory results of the time related comparison to data compiled as background information characterizing the study area under "normal" conditions.
3. Determine the fate of the crude oil spilled.
4. Determine the effect of the spilled material on the environment.

Differences in sampling and laboratory analysis precluded an extensive comparison of data acquired during post-spill surveys. Therefore, the data from the three surveys performed as a direct result of the Shell incident were analyzed and compared to "normalized" background data.

Sediment and water chemical analyses were made of inshore and offshore samples. Total organic carbon contents were determined using a Beckman TOC analyzer; hydrocarbon content of water extractable and carbon tetrachloride extractable fractions were determined by Infrared Spectrophotometric techniques; using a gas chromatograph a fingerprint of sample crude from Shell Oil Co. Platform "A" was made; and tissue samples from selected animal and sediment samples were analyzed. Plankton, Van Veen grab, Phleger core and Otter trawl samples, as well as samples collected by divers, were analyzed. Histological examinations were made of trawl specimens. Physical measurement of salinity, temperature, conductivity, current velocity and wind directions were collected during the three surveys and such data were used in analyses performed.

Several oil sheens were observed in the near vicinity of Platform "B", within the ring of relief wells, during the sampling mission in June 1971. A major sheen was observed during this mission 4 to 6 miles north and northwest of Platform "B." Very little sedimental water-dispersible hydrocarbons were found immediately north of Platform "B" but were found to gradually increase from 2 to 4 miles north of the platform on

the north transect, the highest concentration being 5 to 6 miles north. A complete absence of these hydrocarbons was noted 7 miles north of the platform. Carbontetrachloride extractable hydrocarbons were in high concentration at the platform, measuring 4.5 ppt, but decreased to near 75 ppm at 4 miles north of the rig. However, gradual increases to approximately 175 ppm were found to 7 miles north of the platform.

Very high concentrations of CCL₄ extractable hydrocarbons were found in near proximity to the platform but decreased on all 3 transects to about 300 ppm at one mile and 50 to 100 ppm 4 miles from the platform. In the south transect at 2 and 3 miles from the platform, in 90 feet of water, significant concentration of CCL₄ extractables were present.

Bottom water samples analyzed showed 1.3 ppm total hydrocarbon within the area of the surface sheen but decreased to near zero at a distance of 3 miles south and 7 miles north of the sheen. Hydrocarbon concentrations of 3.8 ppm were found both in near bottom and near surface samples taken four miles from the platform on the south transect but decreased to 1.3 ppm at a distance of 5 miles in the same transect.

Biological samples taken by divers near the platform and bottom trawl and grab samples taken at all stations one mile from the platform revealed low faunal counts immediately around the platform. Counts along the three transects showed a general numerical increase at the 2 mile stations. The south transect revealed its highest faunal count at the 2 mile mark and counts along the north transect reached a maximum at the 4 mile mark. Beyond the 4 mile mark on the north transect there was a marked decrease. Populations along the northwest transect were intermediate in numbers and altered in population diversity.

Mega-faunal counts taken from grab samples on all transects diminished as they approached the platform. This revealed an inverse relationship between mega-faunal counts/square meter and the concentration (ppm) of CCL₄ extractable hydrocarbons.

Catch data from trawl samples revealed an inverse relationship in distribution and density patterns for the scavenger starfish, *Luidia clathrata*, and its normal food supply, ophiuroid echinoderms, and gastropod molluscs. Distributional patterns of the starfish, *Luidia*, were fairly similar to the northwest and south, showing only one high numerical density peak at the 2 mile station on each transect. The north transect, on the other hand, shows two distinct numerical peaks, one at 2 miles and the other at 4 miles with a void of *Luidia* at the 2 mile station. Concentrations of the *Luidia* are very close to "normal" along the south transect and much higher than expected along the northwest transect. When comparing starfish concentrations along each transect with recorded salinities, (using a salinity of 20-23‰ as minimal for survival) it was found that the salinities were compatible to support the *Luidia* in all locations.

On the north transect ophiuroid and gastropod populations show a numerical increase away from the platform. However, at the 2 mile station the life zone is almost devoid of any species with a complete absence of *Luidia*, ophiuroids and gastropods. Normal benthic inhabitants such as polychaete annelids and the pelecypod molluscs are also greatly reduced.

Adult and larval stomatopods are almost uniformly absent from the north transect. Along the northwest transect, however, numerical abundance of stomatopods is quite noticeable. All stomatopods taken within 4 miles of the platform were larval. No indigenous adults in the sediments could be found within 4 miles of the platform which is in contrast to the large numbers of adults found in the sediments farther out along this northwest transect.

Pelecypod molluscs were nominally present along the south transect. The predominant pelecypod near the rig was *Corbula swiftiana*. Farther out along the south transect, however, *Corbula* populations were gradually replaced - first, by *Nucula* and then by *Tellina*. This represents a fairly normal succession from clay to sandy bottoms.

Along the northwest transect, the pelecypod populations were uniformly low, but a trend of increased numbers of *Tellina* was detected as the transect neared shore. Along the north transect, there was essentially no pelecypod population near Platform "B", but the numbers tended to increase at greater distances from the platform. At miles 3, 4, and 5, the predominant pelecypods were *Tellina*, with the population peak at mile 4. Beyond the 5 mile station, the *Tellina* populations were replaced by *Nassarius* and *Mulinia*. Both of these latter species are euryhaline organisms with a habitat preference for sandy-mud bottoms and are characteristic of inshore and bay entrance biotopes.

Conclusions

Carbontetrachloride extractable and some water dispersible hydrocarbons, probably aromatics, were transported through the water column and deposited in sediments to observed depths of 90 feet. The water dispersible compounds appeared to redisperse into the overlying waters immediately after deposition.

Analysis of sedimental and water samples under an observed oil sheen verified that water dispersible fractions of crude oil were deposited in underlying sediments. This free movement of aromatic compounds of the crude oil are potentially damaging to the ecosystem. The aromatics are, in general, more toxic than aliphatic hydrocarbons and the fact that they are also more soluble in salt water increases their biological accessibility in the marine environment. The benthic populations may be damaged by these transient materials which, because of their redispersibility and subsequent dilution in the water column, may be undetectable a short time later. Pelagic organisms may also be damaged by these aromatic fractions prior to their disposition and upon redispersing, at which time these toxic fractions again may be potentially damaging even though diluted.

To detect the presence of the crude oil in the biota of the area a "fingerprint" of the Shell crude oil from Platform "A" was made using gas chromatography. The analysis showed a predominance of carbon compounds with carbon numbers between 15 and 31 with a concentration of crude fractions of carbon numbers less than 24. "Uncontaminated" megafauna reveal a preference for aliphatic hydrocarbon compounds from 22 through 30 carbons. Organisms of different types tend to reflect this same preference. Suspected megafauna were examined and revealed the presence of even-numbered hydrocarbon chains of 16, 18, 20, and 22 carbons. The presence of odd-numbered chains was noticeably low in these organisms. (Insufficient data is available at this time to explain the absence of these odd numbered chains). The fact that the uncontaminated organisms that were examined revealed the lack of hydrocarbon compounds with carbon numbers below 22 is a baseline used for determining the presence of crude oil contamination in organisms examined in the study.

Samples of fish from Caminada and Timbalier Bays revealed the presence of even-numbered chain hydrocarbons below 24 which indicates contamination by crude oil.

Findings in the vicinity of the oil sheen on the northwest transect showing the presence of hydrocarbon in the water column and in the sediments directly underlying the sheen formed the basis for further investigation. Supportable evidence exists that various petroleum fractions are toxic to pelagic marine species. This study has shown that such hydrocarbon fractions were transported from the water surface to the sedi-

ments and back again. Because of these factors, fish could be expected to show very recent signs of gill damage within the vicinity of the sheen. Histological examinations were performed on both benthic and nectonic fish samples taken on the three transects and at transect stations nearest the platform. Fish from Aransas Bay were used as control specimens for this investigation.

Specimen fish taken from the south transect did not exhibit abnormal loss of gill tissue. Abnormalities were found, however, in all fish from the north and northwest transects. Two bottom swimming fish taken 3 miles north of the platform in the wake of the observed sheen, fish taken 4 miles northwest of the platform and those specimens examined from transect stations near the platform exhibited damaged gill tissue. The evidence of the presence of hydrocarbon in the water column and in the sediments, and the damaged gill tissues of bottom dwelling and pelagic organisms strongly infer environmental stress due to the presence of crude oil. It is of interest to note also that the area immediately around the platform was almost devoid of fish and those areas along the transects which theoretically showed environmental stress exhibited very low fish populations.

Stomatopod populations are valuable indicators of differential environmental stress since the adults are burrowing benthic organisms and the larvae are planktonic. In the north transect, both the stomatopod adult and larval forms were conspicuously low in numbers which correlates well with the high hydrocarbon concentration found along that transect. Only larval forms were found, however, within 4 miles of the platform with no evidence of indigenous adults or settling of larvae.

Two conclusions can be drawn from this evidence. First, the absence of adult stomatopods and settling of larvae indicate a continuing environmental stress in the sediment; while, secondly, the large numbers of planktonic stomatopod larvae indicate that recovery in the area may be in process.