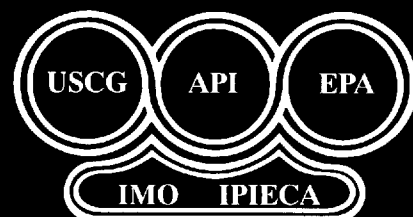


INTERNATIONAL

1995 Oil Spill Conference

*Achieving and
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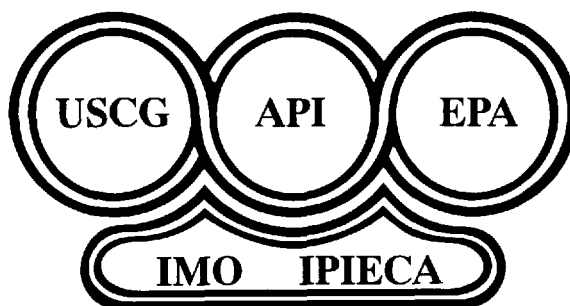
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***February 27–March 2, 1995
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In Memoriam

Kenneth E. Biglane
1927–1994

The 1995 International Oil Spill Conference Proceedings volume is dedicated to the memory of Kenneth E. Biglane in recognition of his devoted service with the Environmental Protection Agency and valuable contributions to the Biennial International Oil Spill Conferences.

Mr. Biglane was instrumental in pioneering the development of the National Response System in the United States. Early on, he was appointed to head the Emergency Response Office of the Environmental Protection Agency and served as the first Chairman of the National Response Team. It was Mr. Biglane's foresight in working with his government and industry counterparts that identified the need to establish a routine forum for information exchange on oil spill prevention, preparedness, and response that resulted in the first Oil Spill Conference in 1969. Mr. Biglane continued to provide vital guidance and commitment to the Conference through 1993.

1995 International Oil Spill Conference

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FOREWORD

This proceedings represents the 14th biennial International Oil Spill Conference (IOSC). Since its inception a quarter of a century ago, the Conference has slowly evolved upward as the political winds of oil spill interest have waxed and waned. Today, this Conference stands as the premiere international technical conference and trade exposition for the world's oil spill community. In a maturing and more sophisticated industrialized world, nations of all sizes have recognized the importance of international environmental stewardship. Oil spills, though generally of relatively short term, localized influence, are one more environmental perturbation that can be minimized and mitigated by man's active intervention. The goals of this Conference remain much as they were in 1969: "... to delineate the overall dimensions of the oil spills problem, explore the present state of the art of prevention and control of oil spills, and review the relevant research and development efforts of government and private industry, both here and abroad."

The 1995 Conference takes another step forward to maintain its position as the premiere international conference on oil spill issues. To further develop the international cooperation and flow of information, the long time sponsors—the American Petroleum Institute, U.S. Coast Guard, and Environmental Protection Agency—are joined this year by two international organizations. Representing the international regulatory community is the International Maritime Organization (IMO), and representing the international petroleum industry is the International Petroleum Industry Environmental Conservation Association (IPIECA). With this new partnership, the IOSC will greatly enhance its international balance of technical contributions and trade exhibits. More importantly, it will help to communicate the latest in oil spill information to nations of all sizes throughout the world. The long term benefits should include reduced loss of oil to the seas, quicker cleanup, and less environmental impact due to cleanup practices.

During the past half dozen years, new oil spill management regulations have been implemented in the United States and internationally. Although complex and detailed, one primary facet is better preparation and training of response personnel. Unfortunately, the level of interest and involvement in oil spill activities in the world communities is inversely related to the length of time since the last major, newsworthy oil spill event. For that reason, the theme chosen for the 1995 Conference is "Achieving and Maintaining Preparedness." How do we get and stay prepared? The technical papers to be presented, although covering a broad range of topics, were selected with this theme in mind.

What is new for the 1995 Conference? Many changes have been made to continue the process of improving the Conference and to meet the needs of the attendees. This year, one of our goals was to continue the improvement of the technical quality of the papers accepted. A selected group of 45 international reviewers chose 136 papers for this Proceedings and presentation at the Conference. This was from more than 490 submitted. Additionally, 126 poster presentations will be displayed in seven special sessions over a two day period, and are also included in this Proceedings. A new Abstract Book and a day-at-a-glance chart has been developed to assist attendees in selecting the presentations of their choice. Almost 300 vendors of oil spill related goods and services are participating in the associated trade show. Two major west coast spill cooperatives are conducting an on-water demonstration of spill equipment and techniques.

Many other special events are planned. A theme session, highlighted by a keynote luncheon address by the Rt. Honorable Lord Donaldson of Lymington, will feature the *Braer* oil spill in the Shetland Islands. IMO and IPIECA are hosting a special evening session summarizing a recent world-wide seminar series they have sponsored. There also will be a special evening session dealing with Natural Resource Damage Assessment.

Another new feature is the preparation and distribution of three selected topic "white papers." These reviews will cover major topics of interest and will be formatted to provide detailed discussions and information on relevant issues. Corresponding panels of experts have been invited to discuss and debate the issues raised in these white papers.

A sponsors' scholarship program has been instituted to support students and other interested parties who might contribute to and participate in the Oil Spill Conference. Most importantly, this Conference provides a place where the world's experts can meet, visit, and exchange the latest information.

As can be seen, many changes have been made to ensure that the Conference continues to improve to meet the needs of the oil spill community that supports it. In order to continue fulfilling this role, it is most important that attendees provide feedback on the content and quality of this Conference.

The sponsors of the 1995 IOSC would like to thank all of the contributors, reviewers, and others who have made this Proceedings volume possible. I would also like to acknowledge the considerable contribution of time by the various members of sponsoring organizations who have staffed the Steering and Program Committees. They are the heart and soul of the IOSC. Finally, I would like to recognize the professional contributions of Courtesy Associates, and Trade Associates, who have been responsible for the organization and management of this Conference and the trade show. Their considerable expertise brings order out of chaos on a biennial basis.

James P. Ray

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Program Sessions

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T4A: Training/Exercises II

W1A: Low API Gravity Oils,
Response to Oils that Sink

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W3C: Response Considerations I

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VII—POSTER PRESENTATIONS**Poster Session T2**

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Program Sessions

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Poster Session T4

Poster Session W1

Poster Session W2

Poster Session W3

Poster Session W4

OPENING PLENARY SESSION

CLOSING PLENARY SESSION

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Program Sessions

**The Use and Misuse of Science in
Natural Resource Damage Assessment (NRDA)**

Implementing an Effective Response Management System

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TRACKING BUOYS FOR OIL SPILLS

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ABSTRACT: *The use of tracking buoys in oil spill response, planning, and training and criteria for the selection of these buoys were studied in conjunction with an experiment conducted in the Gulf of Mexico during March 1994 on the relative motions of several oil spill drifter buoys. For the test, wood chips and cottonseed hulls were used to simulate the motion of the oil. Six different types of buoys and three different positioning and tracking systems, in various combinations, were tested. The first day of the program was conducted in Galveston Bay, the second in the Gulf of Mexico off Galveston. Significant differences were noted in the movements of the various buoys. Analysis of the data from these experiments suggests that tracking of the buoys should occur for a longer time period than in the experiments in order to reduce the influence of positioning errors.*

In order to respond to an oil spill, it is necessary to know where the oil is and to be able to predict its possible motion. This can be accomplished by using visual observations, following the oil from the source of a spill, and using various remote-sensing techniques. In many situations, such methods do not work due to poor visibility or the lack of equipment. For these situations, the use of tracking buoys provides an alternative method of following the motion of the slick.

Data from drifter buoys is useful in the relocation of the slick after the weather has cleared or to provide information to be used as input into trajectory models. For tracking buoys to be effective, they must simulate the motion of an oil slick over a wide range of wind, waves, and ocean currents. This is an extremely difficult task for several reasons. First, the slick is quite thin, a tenth of a millimeter to a few millimeters, while the drifters are, of necessity, orders of magnitude thicker. Due to the necessity of carrying power supply and transmitting equipment, drifter buoys have a minimum weight of several hundred grams. A heavy battery pack for power increases the buoys' mass and places limits on hull shapes. This means that the interaction of a buoy with winds, waves, and currents is quite different from that of an oil slick. Second, the oil disperses, often becoming a collection of sub-slicks, each one seeing a different micro-current regime. A single drifter cannot duplicate this dispersion. Third, the slick drift properties change as the oil weathers so that a drifter calibrated to follow fresh oil may not be able to track weathered oil correctly. Buoy designers

attempt to overcome or minimize these problems by careful design of the buoy hull and proper ballasting.

Uses of tracking buoys

Oil-spill tracking buoys are used in a number of ways in the development and implementation of an oil spill response. Four common uses are the following.

Contingency planning. A significant component of contingency planning is prediction of the motion of an oil spill and development of the probability of impact for critical resources. Such calculations frequently use oil spill trajectory models. The use of spill simulating drifters can help to calibrate these models. In an area of complicated oceanography, where it might be difficult and expensive to generate surface current patterns from a fundamental analysis, a forecasted surface drift field can be generated using a large number of drifters and objective analysis or a neural network analysis scheme.¹ In order to obtain accurate and statistically significant data on areas of probable input, the oil drifter buoys should be inexpensive so that a large number can be deployed. In most cases, only short distances are involved and thus range and long operation times are not important. The positional accuracy of these buoys should be a few tens of meters.

Oil spill exercises. Since it is virtually impossible to use oil during an oil-spill exercise, some method of simulating the oil motion and spreading is required. This can be accomplished using computer models, but this is not effective if actual cleanup equipment is being used and recovery success is to be evaluated. A number of methods of simulating the oil have been used involving the deployment of wood chips, oranges and lemons, cotton husks and other nearly neutral buoyancy, biodegradable materials. There is some question as to the accuracy of the simulation using these materials. One alternative to these biologically degradable materials is to use oil spill tracking buoys as a method of simulating the motion of the oil. As for the contingency planning needs, such buoys should be inexpensive so that a large number can be used during a simulation. Since there will be a response effort as part of the exercise, the positional accuracy of these buoys is not a consideration.

Tracking during a spill. The main method of determining the loca-

tion of spilled oil, during an oil spill response, is the use of observers visually tracking the oil. If required, remote sensing techniques such as infrared and ultraviolet sensors, or various forms of radar may be used.⁵ The visual, and some of the remote sensing methods, are only useful during daylight hours and good visibility conditions. In many spill situations, this leaves a serious gap in knowledge of the location of the slick. One method used to overcome this problem is to deploy, either from the air or by boat, a number of oil spill tracking buoys in the spill or around the slick. Since only the general motion of the slick is needed, only a few buoys are used. These buoys should be able to follow the slick for several hours to a few days and use telemetry methods to transmit their position to a central facility. The buoys should have adequate battery power to operate for a few days, and a positional accuracy of a few tens of meters up to a hundred meters. This accuracy is consistent with current GPS (global positioning system) technology.

Oceanographic studies. A number of different types of drifting buoys are used in oceanographic studies. Undrogued buoys have been designed to follow surface currents, while buoys with drogues at a depth of a meter or so have been deployed to study near-surface ocean motion. Buoys used in most oceanographic studies are deployed for extended periods of time and generally cover large distances. The design criteria for such buoys are significantly different from those of buoys used for oil spill tracking. Some oceanographic systems have been proposed for use as oil spill trackers.¹² However, most oil spill tracking buoys are designed specifically for this purpose, and are not based on oceanographic buoy designs.

Design considerations for tracking buoys

There are four primary design considerations for an oil spill tracking buoy.

Hull shape. The major factor that determines how well the buoys will emulate the motion of a surface oil slick is the hull shape. An oil slick is moved by waves, currents, and wind. The complicated interaction of the slick with the wind is usually approximated, in trajectory models, by a drift factor of about three percent of the wind speed with the motion in the direction of the wind, although studies have shown significant variations in this value. Any hull that is used as an oil spill tracker must be able to simulate this interaction. This is difficult for a number of reasons mentioned in the introduction. About ten years ago, extensive research was conducted on hull design. Several designs were found to be effective in tracking oil slicks for periods of up to several hours.⁹

Mass of the buoy. The total mass of the buoy is critical to its effectiveness at emulating an oil spill. If the oceanographic situation is simple, however, the mass is of little importance and hull shape is critical. If the oil or buoys are in a complex oceanographic environment where ocean fronts, tidal rips, and other strong shear features exist, then the mass, and hence the inertia, of the buoy becomes critical. The oil has very little mass and thus is easily stopped by any ocean frontal system. If the mass of the buoy is too large, it will pass through an ocean frontal system and will move in a very different advection regime than does the oil. Thus, in the design of a buoy there is a compromise between buoy life and its mass. If the mass is low, this implies only a limited power source and thus somewhat limited capabilities and lifetimes.

Position determination and telemetry. The simplest and cheapest oil spill tracking buoys are entirely passive and rely on visual tracking and manual location. Such buoys are simple and inexpensive and can be very useful in a number of applications.⁴

The next level of complexity is a buoy that contains a simple transmitter which emits a short radio signal every few seconds. The location of the buoy is determined using direction finding equipment.¹⁰ This can be either by triangulation, or by using the signal to find the buoy and manually determining the drift. Such buoys are relatively inexpensive. However, the direction finding equipment is awkward to use and finding a buoy is a time consuming and hence expensive process.

The third level of buoy uses a somewhat more powerful and stable transmitter, which allows the determination of the buoy location, using a satellite system. Such systems are commonly used for ocean drifters and have been used to position oil spill tracking buoys. The accuracy of location is hundreds of meters to kilometers and is marginal for slick

location purposes. For most oil spill tracking purposes, the accuracy needed is a few tens of meters to a hundred meters.

The fourth, and newest type of buoy uses the GPS to determine the location of the buoy and telemeters this information on a VHF communications link. The range of this link is typically line of sight. The accuracy in position of about a hundred meters is of the same order as needed for an oil spill tracking function, and is basic to the location system.

Price. The more buoys that can be deployed, the better the knowledge of the motion of the slick. If the buoys are inexpensive, a large number can be deployed, subject to environmental considerations. If the buoys are expensive, then some provision must be made to recover them, which adds to the logistics of the oil slick tracker buoy operation.

Galveston Bay and Gulf of Mexico tests

In order to determine the performance of various commercially available oil spill tracking buoys, a number were deployed as part of a major program (TexSonde '94) to measure ocean surface currents. This experiment used a land based Doppler radar known as SeaSonde to determine ocean currents in the Gulf of Mexico during March and April of 1994.^{6,7} During this period, ocean currents were also measured using moored current meters and a number of ocean drifters. One component of the TexSonde '94 program was the testing of a number of oil spill tracker buoys for a period of about six hours. Two experiments were performed: one in Galveston Bay and the other in the offshore area of the Gulf of Mexico, near Galveston, Texas.

The buoys were tracked visually from the surface and their location determined, using a hand held GPS receiver (± 100 meter accuracy). In addition to the GPS measurements from the vessel, most of the drifters had internal systems to determine their location. During the field test, five different hull designs and buoy location systems were tested (Table 1).

Orion hull. This hull is about 25 cm in diameter and 16 cm high. A 2-to-3 cm high stabilizing ring extends around the centre of the drifter (Figure 1). The hull is essentially flat with an upper and lower dome housing the electronics and power supply. The design of the hull is about ten years old. Recently, a number of different electronic packages have been designed around this hull shape. Some packages include only a pulsed transmitter, and the unit is tracked using bearing measurements from a vessel. More recent designs include a GPS receiver and VHF telemetry system.² Both types were tested in these trials, but the receiver for the bearing measurement was damaged in shipment, so these hulls were tracked visually.

Argospheres. The Minerals Management Service (MMS) of the U.S. Department of the Interior has developed a program to study the use of oil tracking buoys to stimulate the movement of spilled oil. As a result of a number of field tests performed in the Norwegian Sea, two drifter designs were selected for further testing.⁸ The first is a 30 cm diameter sphere equipped with an ARGOS transmitter and tracked using TIROS satellites. Figure 2 shows Argospheres, a discus buoy, and a Davis-type drifter. Depending on the latitude at which the drifters are deployed, the satellites can provide a position determination approximately four or more times a day with an error of ± 1 kilometer. In addition to determining the buoys location with the ARGOS system, two of the spheres were equipped with the more accurate (± 100 meter) GPS receivers. The electronics in the spheres were programmed to collect GPS positions every 30 minutes, store the position locations, and relay a set of readings through the ARGOS satellite system. Ideally, for oil spill emulation, the Argospheres are used without drogues and are ballasted to keep the drifter upright and floating with the waterline at its equator. During this field test, the GPS feature worked correctly; however, the wind drift factor on the spheres was increased due to improper ballasting. As a result, the buoys moved faster than the simulated slick.

Draper or discus hull. A second drifter evaluated by MMS consists of two 20 cm diameter concave hulls which are fastened together to form a thick disk. The interior of this disk contains the electronics and power supply.⁸ Depending on the model of the buoy, the antenna was either external or molded into the hull. Some versions of this buoy were tracked, using the ARGOS satellite system, while others used GPS location and VHF telemetry.

Davis-type drifter. This drifter is based on a 1985 design by R.

Table 1. Summary of buoys tested during Galveston Bay/Gulf of Mexico experiment

Buoy	Hull Shape	Location	Telemetry	Battery Life	Weight
Tire tracker	Small tire with flag and weight	Visual tracking	None	N/A	Medium
Orion	Plate shaped with top and bottom edges	Triangulation or bearing to visual sighting	Chirp transmitter	2-3 weeks	Light
Radio satellite integrators	Discus-shaped draper hull	GPS	VHF data link	Weeks	Medium
Trimble	Same as Orion	GPS	VHF data link	Days	Light
Met Ocean	Same as Orion	Not tested	Not tested	Not determined	Light
Argospheres	Sphere	Satellite	Satellite	Months	Light
Davis drifter	Cylinder with curtains	Satellite	Satellite	Months	Medium difficult handling

Davis;³ it consists of a vertical one-meter tube that contains a transmitter and batteries, and supports an external antenna. Four sections of plasticized cloth, extending 0.5 m from the tube, are supported by four small floats. Since the effects of wind drift and surface waves on this drifter are negligible, it is a very accurate method for measuring near-surface currents. Two Davis-type drifters were deployed during the field tests to provide an indication of how the oil tracking buoys moved, in relation to surface currents. The drifters were tracked visually from the surface and through the ARGOS satellite system.

Tire drifter. This buoy, developed by a group in the Galveston Bay area, consists of a small tire and drogue system.

Four different types of location systems were used in the buoys tested. Passive buoy tracking was performed visually, with the location identified through use of a GPS system on the accompanying vessel. This system was used for the tire-type buoys and some of the Orion hulls. The Argospheres and the Davis-type drifters were tracked visually as a backup for the satellite positioning system. The range and bearing system uses a small pulsed transmitter and a boat-based positioning system to track the buoy and guide the vessel to its location. Since the buoys were visible during both days, this system was not used. The GPS location and VHF telemetry systems were used to track three different types of buoys, with a variety of hull shapes. Finally, satellite positioning and telemetry were used to track the Argospheres and the Davis-type drifters.

Results

The Galveston Bay and Gulf of Mexico field tests illustrated the differences in the drift behavior of the various types of buoys designed

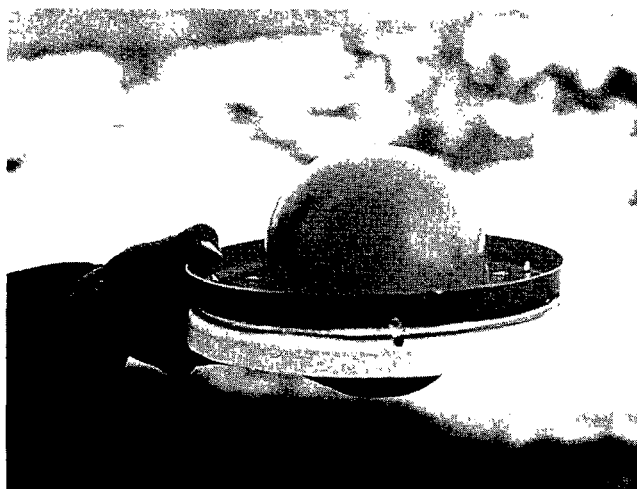


Figure 1. Orion buoy

to track the motion of oil slicks. However, due to the short duration of the field studies, several difficulties occurred when evaluating the performances of the oil tracking drifters. First, in the Gulf of Mexico field test, the movement of the Davis-type drifters indicated that there was a weak current flow, and on scene winds were very light. Most of the drifters probably stayed with the wood chips because there was very little net movement. Second, the wood chips showed some drift characteristics of an oil spill (such as windrow formation). There is no data on whether the wind drift factor for wood chips is the same as for oil. Within a couple of hours after their release, the drift factor changed as the wood chips absorbed water and began to sink. An additional error, in location of the various components of the test, was caused by the hand-held GPS receiver which was used for position measurements. The error in location was on the same order of magnitude as the scale of the experiment. Visual observations of the drifter location relative to the wood chips are probably more reliable than the coordinates recorded by the hand-held GPS.

One of the tire buoys and all the Orion-shaped hulls stayed in the same location and followed the motion of the wood chips. The discus-shaped buoys moved away from the area of the wood chips and the Orion buoys in a few hours. The Argospheres moved in the same direction as the discus buoys, but deviated from the wood chip position more rapidly.

In the Galveston Bay component of the program, the Davis-type drifters moved into the prevailing wind and in the opposite direction of the simulated slick and the other buoys. Since the Davis-type drifter is designed to track the motion of the upper one meter of the water column, it is presumed to move with the surface current. It is likely that the movement of the Davis-type drifters was the result of tidal influences inside the bay.

During the Gulf of Mexico field test, the Davis-type drifters lagged considerably behind the simulated slick and other buoys, but did slowly move in the same general direction. The observation is consistent with the field experiments conducted in the Gulf of Oman with the same type of buoy.¹¹

One of the tire buoys moved more slowly than the slick.

The receiver of one of the GPS systems did not work, while the other two systems worked well. One system had higher power and hence greater range.

Conclusions

The Orion hull based systems appeared to move in a manner similar to that of the wood chips. This is consistent with information obtained in 1993, during an experiment in the Strait of Juan de Fuca.⁷

The discus-shaped buoys moved out of the wood chip area in a few hours. Again, a similar result was obtained in the Juan de Fuca experiment.

The Argospheres consistently moved in a different manner than the wood chips. This was probably due to the ballast of the units, which rode high in the water and therefore had a higher wind-drift factor.

Figure 3 shows the data from Galveston Bay for all the buoys, and Figure 4 gives the same type of data for the Gulf of Mexico.



Documents

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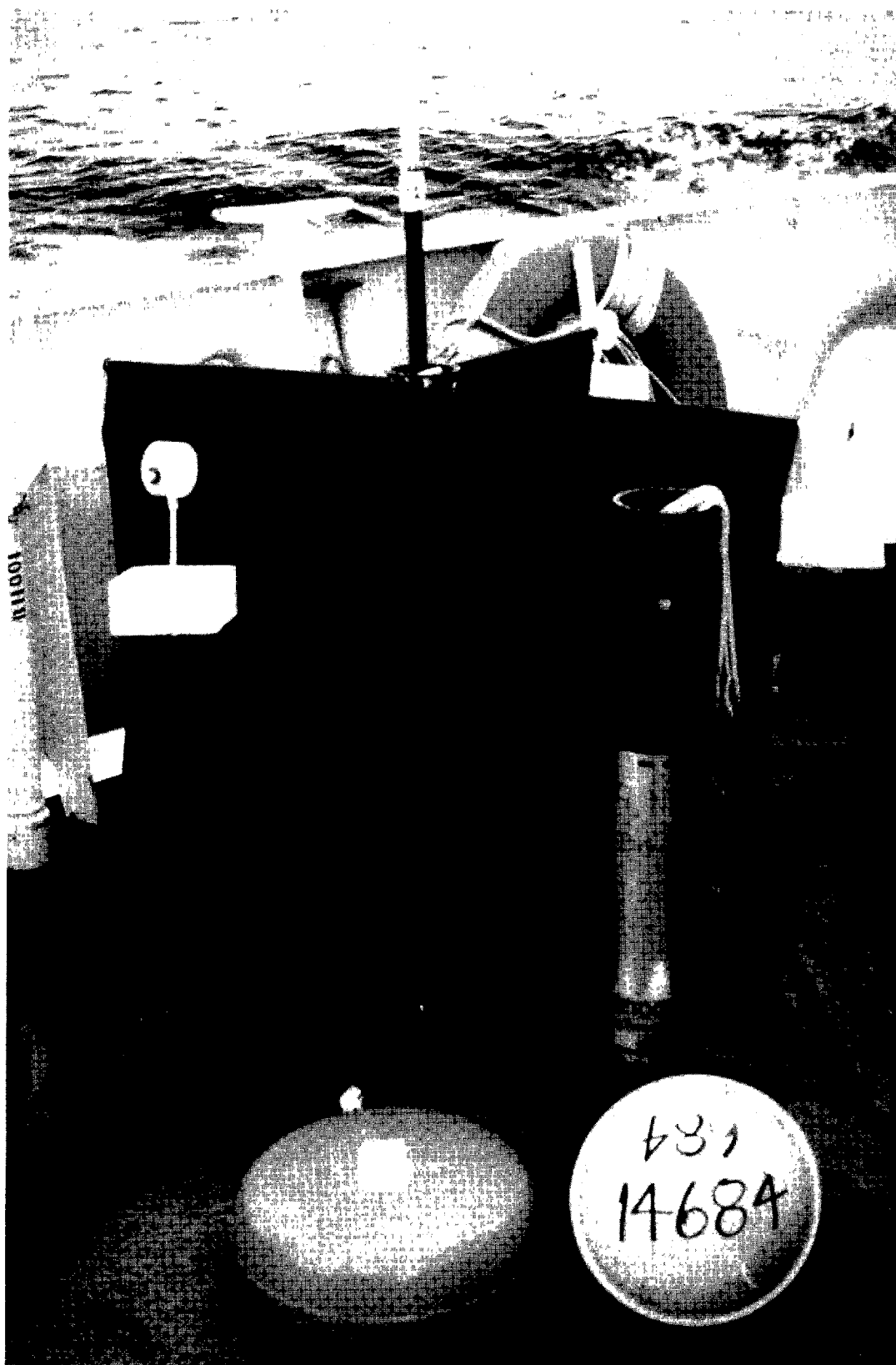


Figure 2. Argosphere, discus buoy, and Davis-type drifter

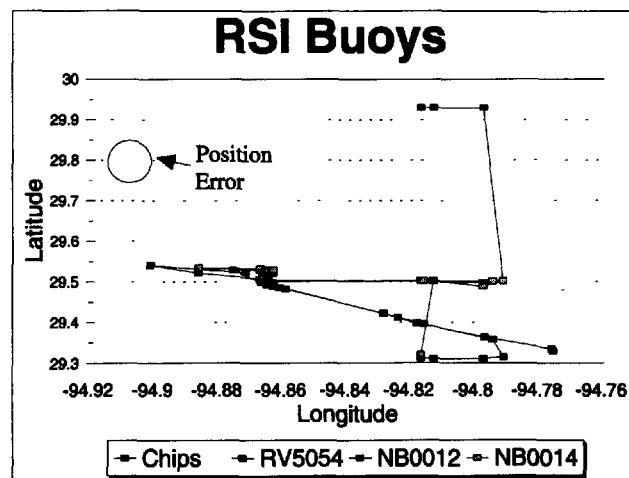
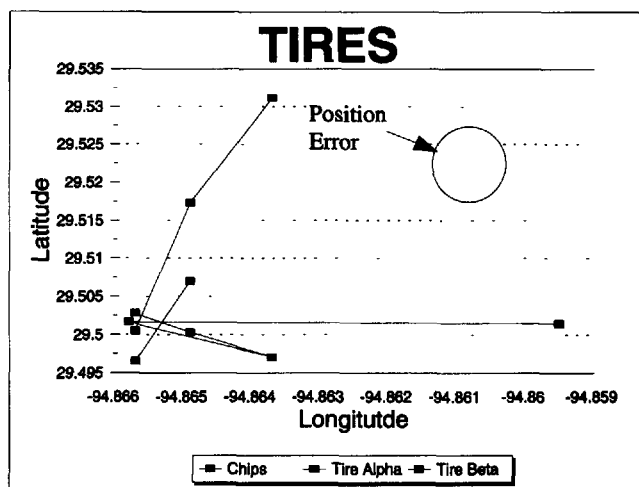
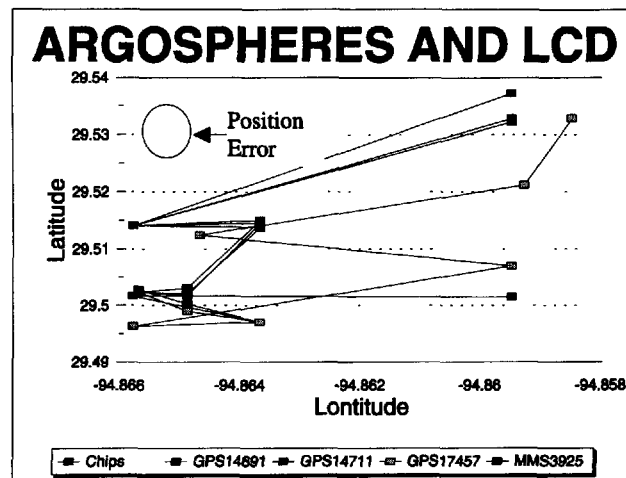
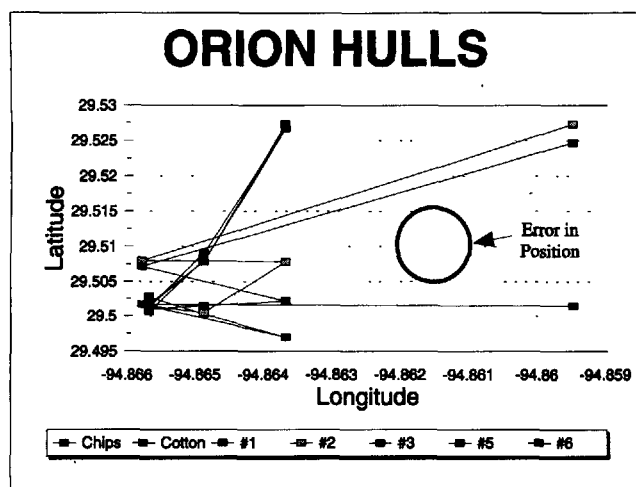


Figure 3. Motion of drifter buoys in Galveston Bay

Both the wood chips and cottonseed hulls acted in a manner similar to an oil slick. Some time after deployment they formed into windows. Both drifted in the same manner and moved in concert. Both materials remained on the water for the duration of the experiment.

Recommendations

The lack of overall movement, and the limitations of the location systems, resulted in data that is difficult to interpret. Future field tests should last longer in order to provide more differentiation between the various buoys. A 24-hour experiment would be more realistic.

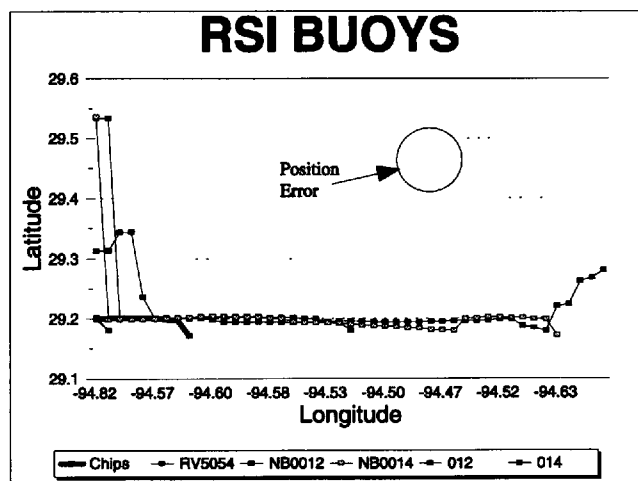
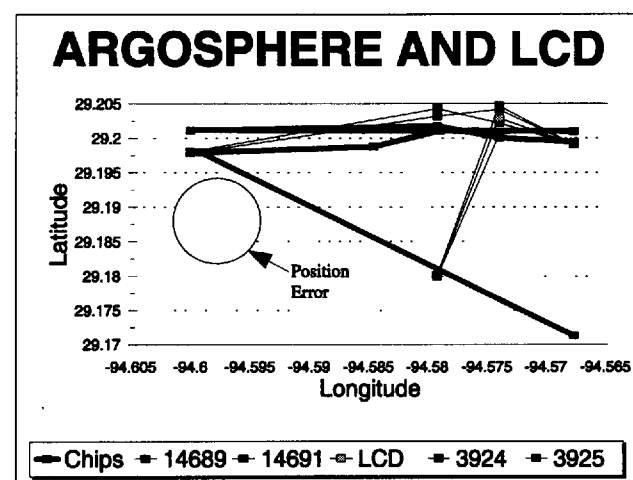
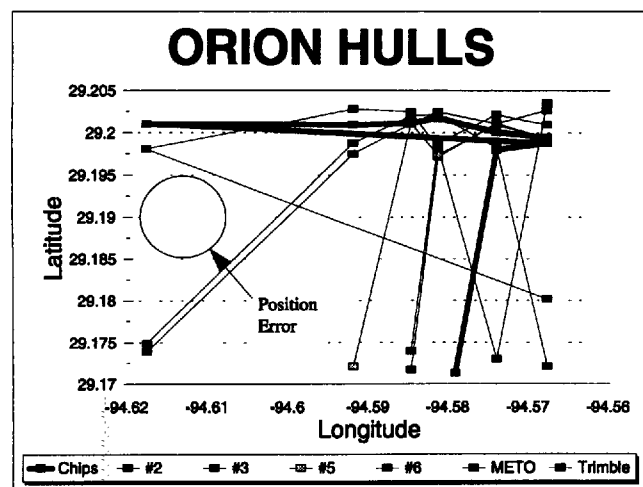
The drifters that were painted a bright fluorescent orange were easier to track visually.

During both drills and spills, a number of drifters should be de-

ployed so that some understanding of the dispersion of the buoys can be obtained.

Acknowledgments

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Figure 4. Motion of drifter buoys in the Gulf of Mexico