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The Search for the Caravel Gallega

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THE SEARCH FOR THE CARAVEL

GALLEGA

RIO BELEN, PANAMA

1990 SEASON REPORT

prepared by

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INTRODUCTION

The 1990 season of Ships of Discovery's search for the caravel *Gallega* began with the arrival of an advance party in Panama in mid-August. They met two containers of equipment and supplies shipped to Colon and accompanied them up the coast to Rio Belen. Field work began September 4 and ended November 26. The 1990 season continued implementation of the same search procedure instituted at the beginning of the project in 1987 (Myers and Thompson 1988): 1) careful interpretation of historical documents to identify the smallest area in which *Gallega* must lie (Lakey 1988; Hajovsky 1988b); 2) application of the most appropriate remote-sensing and positioning equipment; 3) reduction of the search area using remote-sensing technology; 4) prioritizing the search area from most promising to least promising; and 5) excavation of targets identified by remote-sensing.

Careful reading of the first-hand accounts of eye-witnesses and matching the physical characteristics of Rio Belen with their descriptions led us to the following assumptions: 1) Rio Belen is the place where Columbus abandoned *Gallega* in 1503; 2) *Gallega's* remains lie buried in the bed of Rio Belen or beneath its eastern bank; 3) Columbus's men built Santa Maria de Belen on the western side of the river; and 4) the most easily detectable parts of *Gallega's* remains will be the stone ballast in its hull or large iron artifacts such as cannons and anchors which may have been on board.

Aerial photography, interviews with the inhabitants of Santa Maria de Belen, analysis of core samples, excavations, our own observations and experiences in Rio Belen, and geomorphological research conducted in the field by Dr. Antonio added the following: 1) the western side of the river is eroding, while the eastern side is accreting (Hajovsky 1988a); 2) Spanish explorers were in Rio Belen early in the sixteenth century (Keith, Carrell and Lakey 1990); and 3) the location of the river mouth has not altered substantially in approximately 3,500 years (Tourino 1988).

Results of previous seasons' work reduced the search area and acquainted us with the difficulties we could expect to encounter in surveying Rio Belen. The magnetic background is complex and difficult to interpret. Excavation is difficult due to the deep sediments that cover the river bed. Layers of decomposing leaves and organic material buried in the sediments generate and trap gas bubbles, making them opaque to vertical-scanning sonar (Keith and Carrell 1991).

Extending the field season to twelve weeks, rather than limiting it to the six-weeks originally proposed for 1990, allowed us to complete the proposed plan of work. Unlike previous seasons, the 1990 search concentrated on locating *Gallega,* and no attempt was made to look for the associated sixteenth-century settlement of Santa Maria de Belen. Five different techniques were employed to search for the vessel.

SEARCH STRATEGY

The objectives of the 1990 season of the search for *Gallega* were: I) to conduct a high-resolution magnetometer survey of the portions of the survey area covered by water; 2) to test the effectiveness of a refined version of the acoustic subsurface penetrating sonar under research and development by Applied Sonics Corporation; 3) to probe to a depth of five meters below water level the submerged portions of the survey area using a specially built self-propelled barge; 4) to test excavate all targets detected by the magnetic, acoustic and mechanical probe surveys; and 5) to conduct a complete bathymetric survey of the river.

In order to more easily compare the results of surveys conducted using different instruments, coordinate mapping replaced the system used in previous seasons (reference to angles and distances from datum points). The new coordinate system has many advantages over the old system because any location in the survey area is identifiable with a single pair of reference coordinates. In the new system, our primary reference point (Datum 1 in previous reports), is at the coordinate 2000N, 2000E.

Magnetometer Survey

Our magnetic survey of Rio Belen in 1988 revealed the presence of a number of naturally-occurring (geophysical) factors that compromised the reliability of our results. Lightning, magnetic sand and rocks, and a geologic fault running diagonally across the river generate strong magnetic readings that could mask *Gallega.* Not satisfied with the results of this survey, we arrived in Rio Belen in 1990 prepared to conduct a specific type of high-resolution magnetometer survey using a gradiometer. As the name implies, a magnetometer measures the earth's natually occurring magnetic field. During an archaeological search, this information is evaluated against the magnetic qualities present in buried man-made iron objects in the survey area. The observed difference in the measured readings between the earth's magnetism and that resulting from a man-made iron object is referred to as an anomaly. It is the anomaly that is later excavated and identified. The use of a gradiometer makes it possible to further refine magnetic anomalies and the process is capable of detecting extremely small, weak anomalies and separating them from the complex magnetic background.

We assembled a system comprised of three sub-systems: data collection, positioning, and computer mapping. The data-collection system consisted of two EG&G Geometrics G856 magnetometers in a gradiometer configuration. This involves the use of two instruments, rather than one, collecting and storing readings simultaneously (Figure 1). It also required special configuration on the boat and of the magnetometers to insure that each pair of readings would be synchronous.

Figure 1. Magnetometer boat in operation using gradiometer instrument configuration. Two sensors are boomed out from the boat collecting readings simultaneously.

After data collection, the gradiometer process involves subtracting the top from the bottom reading. This eliminates the earth's natural magnetic field, the effects of lightning, and limits the influence of the fault. This process helps to refine and isolate anomalies, making them easier to identify.

The magnetometers were housed in a special console installed in a small, flat-bottomed aluminum boat that also housed a laptop computer, positioning telemetry, signal-processing computer and visual display unit. A shore-based laser tracking and navigation system, leased from lnternav Inc., gathered initial positioning data (Figure 2). The position of the boat and the exact location of each pair of magnetic readings was relayed to the boat by telemetry and collected by our on-board laptop computer.

Figure 2. Internav laser navigation system used for magnetic survey in the North Bay.

The river was divided into four search zones for the magnetometer survey: the west and east sides of the North Bay and the west and east sides of the South Bay. The riverine search required survey along tightly controlled lanes spaced three meters apart. This extremely narrow lane spacing was necessary because of the subtle nature of the remains we expect to be preserved with *Gallega.* Magnetometer readings were taken every four seconds along these lanes.

Unfortunately, the electronic components of the magnetometer and positioning systems were no match for the heat and humidity of the tropics. Additionally, the on-board navigation computer was damaged during shipping--perhaps when the plane carrying it careened off the runway in Rio Belen. We were able to partially repair the damage and use the equipment for three weeks, but the navigation system was used only during the survey of the North Bay. During this same time the control

board on one of the magnetometers failed, eliminating the option to continue in gradiometer mode.

Rather than abandon the survey, we chose to continue the magnetic search in a standard one-instrument configuration. With the loss of the navigation system, location control in the South Bay was maintained by using a Pentax Total Station theodolite and electronic distance meter (Figure 3). The Pentax was able to calculate location using our overlay coordinate grid. The beginning and end of each lane was surveyed in and the location of each magnetic reading was arithmetically extrapolated. These location readings were manually input into the computer program and matched to the individual magnetic readings.

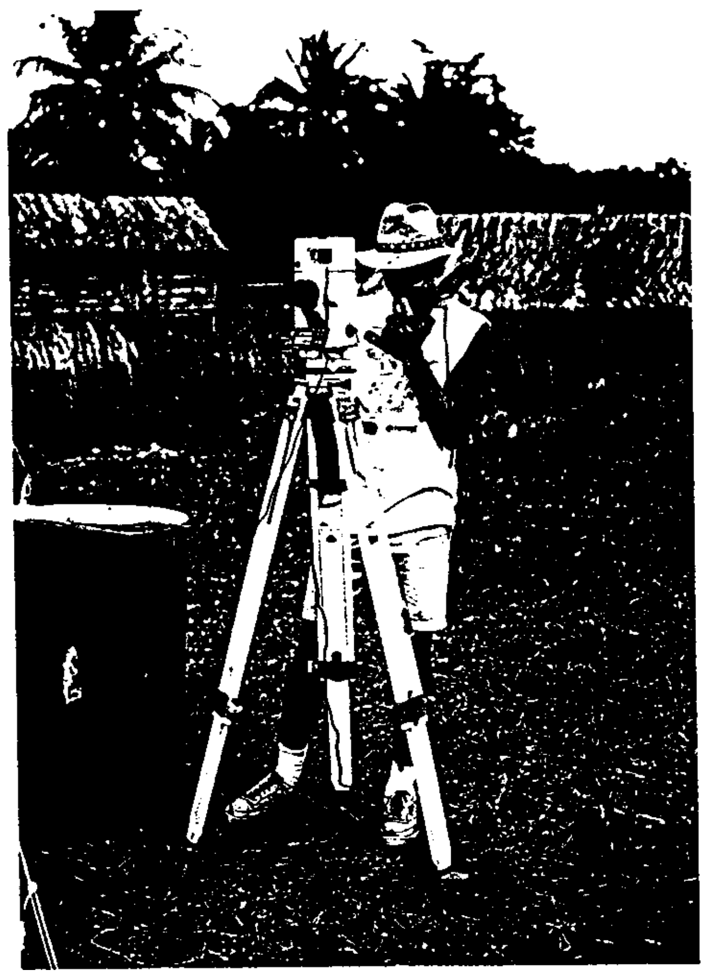

Figure 3. Pentax total survey station used for magnetic survey, probe barge and test excavation positioning.

The magnetometer survey was extended onto the shore of the east side of the river, in the event that a portion or all of *Gallega* is now buried under the present river bank. The three-meter lane spacing used for the river survey was continued, and readings were taken every three meters. Our ideal survey grid for the readings both on shore and on the river was a reading taken every three meters down lanes spaced three meters from adjacent lanes. In this case, the location of each reading was known and not extrapolated. These too, were manually entered into the computer program for mapping.

During the 1990 survey more than 353,000 square meters on land and water were magnetically surveyed (Figure 4), and more than 83,000 magnetometer and positioning readings were generated. The position data, gradiometer and magnetometer readings were ultimately processed using Surfer, a commercially available contouring and graphics program. Magnetic contour maps, similar to topographic maps but with magnetic readings instead of elevation, were produced in the field for the entire survey area (Figure 5).

Each map was contoured at five gammas (units of magnetic intensity). This is a very fine grain contour interval roughly equivalent to a topographic map contoured at one-meter intervals. In an effort to further refine our interpretation and visualization of the potential anomalies, we contoured the land areas at two gamma intervals. We did not attempt this refinement with the large riverine maps because the process involves intensive arithmetic calculation that was well beyond the capabilities of the computers available to us in the field. The relative difference between a two gamma map and a five gamma map, while obvious, does not result in the appearance of anomalies that are not apparent at the slightly larger scale. For comparison, most magnetic maps of shipwreck sites are contoured at fifty or one hundred gamma intervals.

Upon completion of the magnetic maps for each search zone, we selected potential target anomalies for follow up. Their selection was based upon overall size and magnetic intensity. All anomalies greater than fifteen gammas were considered for further investigation. More than 35 anomalies were initially identified in the South Bay and west side of the North Bay. The coordinate locations of the anomalies and the magnetic readings responsible for them were verified and the raw data reexamined prior to any attempt at field location. In this manner "phantom" anomalies resulting from aberrant readings were eliminated. After verification, each anomaly was relocated and rerun with the magnetometer for fine positioning and placement of target buoys. Based upon the results of the re-magging effort, the anomalies were scheduled for either mechanical probing or dredging. Ultimately thirteen anomalies, five the west side of the South Bay, six in the east side of the South Bay, and two in the west side of the North Bay, were chosen for additional investigation.

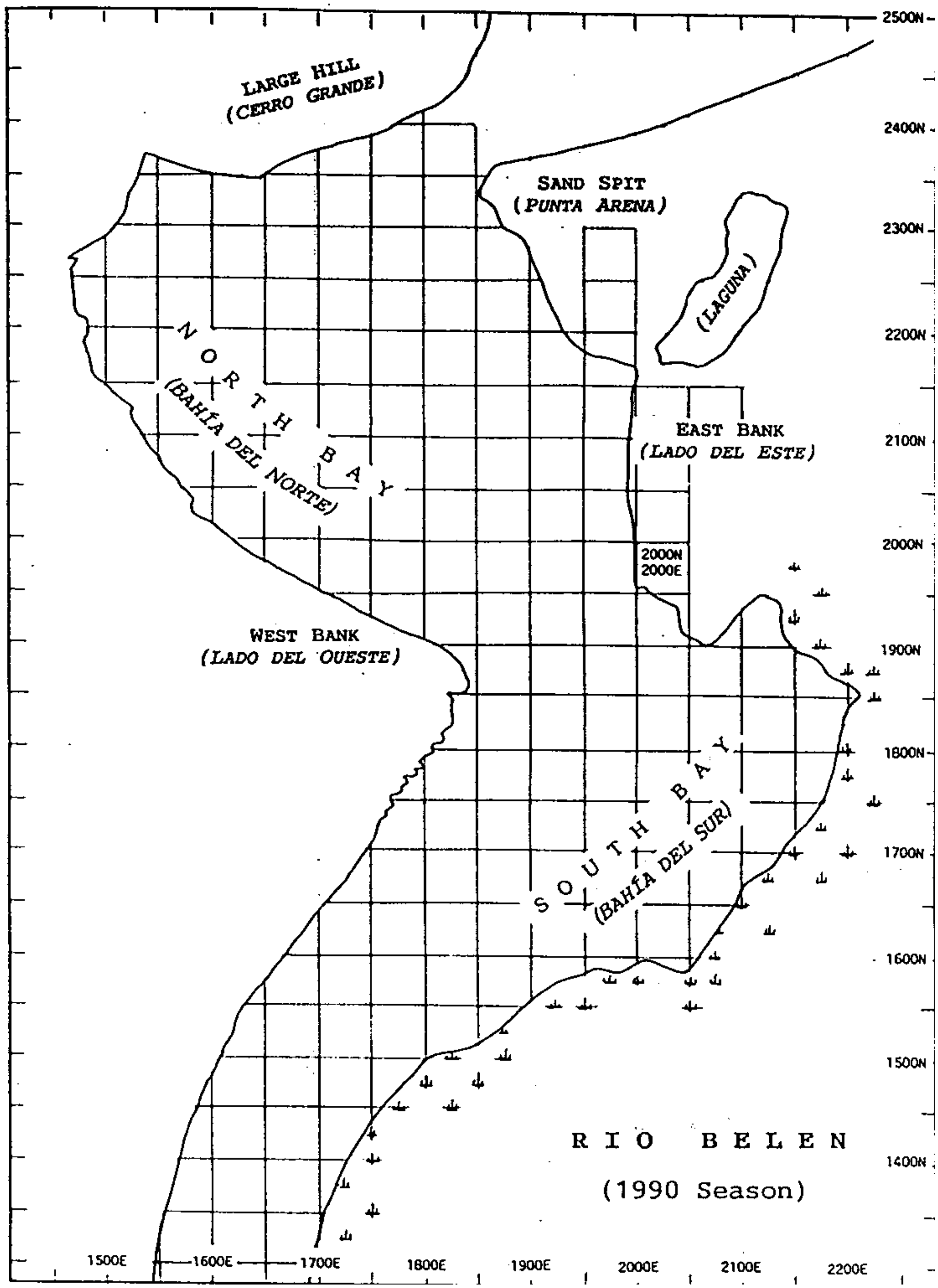

Figure 4. Portions of the search area covered during the 1990 magnetic survey overlaid by a 50-meter by 50-meter grid.

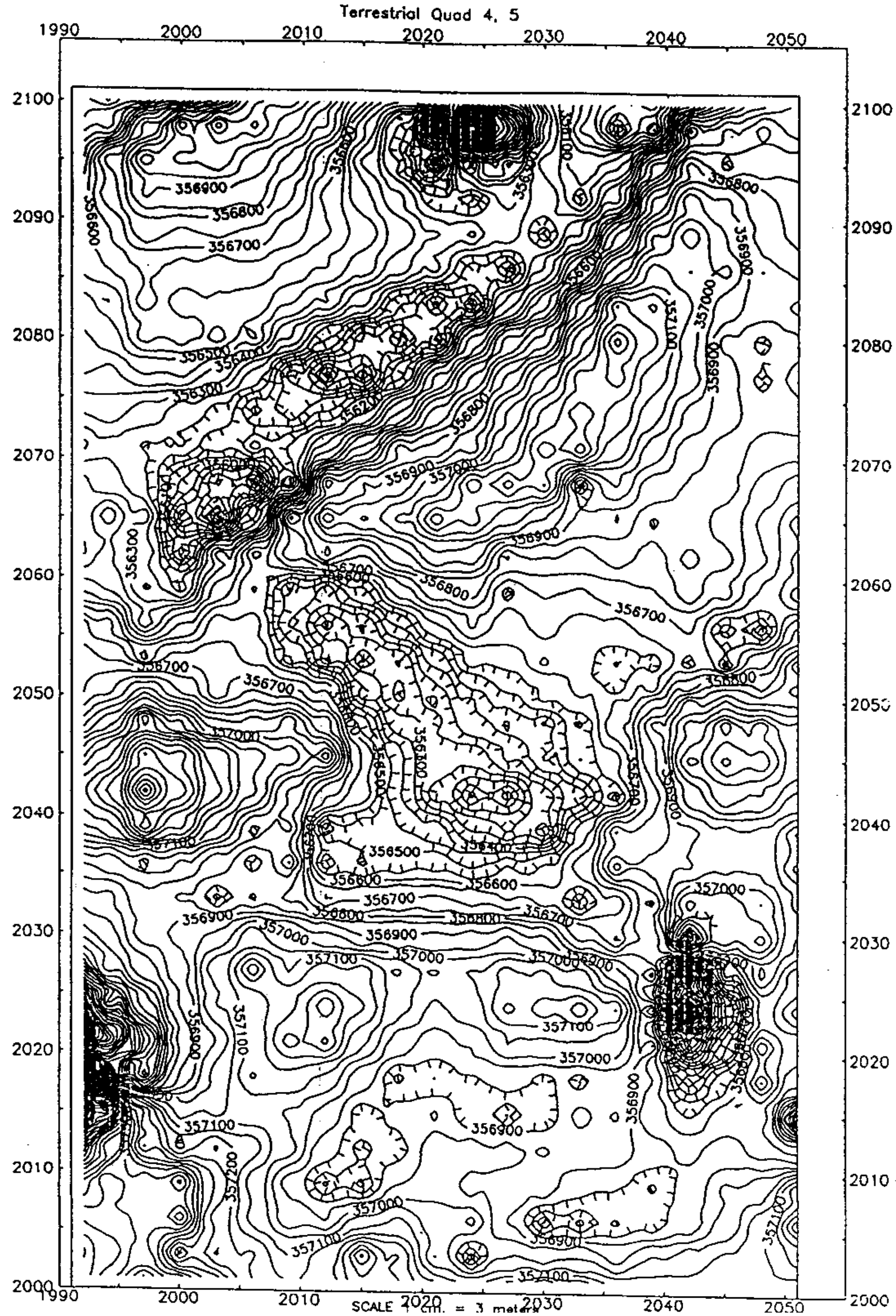

Figure 5. A five gamma contour interval magnetic map of a portion of the land area. The anomaly at 2020N, 1990E is the landward end of the dock. The anomaly at 2100N, 2025E is a coil of wire rope and the anomaly at 2025N, 2040E is an iron pipe storage area. (Magnetic intensities are read with a decimal point preceeding the trailing zero)

The east side of the North Bay proved to be the most magnetically active, due to its modern use by the Belenenos and the proximity of the fault, and the most difficult, because of the water depth and the river current. We also have the least confidence in the magnetic readings collected from this area because of equipment failures encountered while running these lanes. Twenty anomalies were identified, however after evaluation, only two were chosen for mechanical probing.

During the magnetic survey in 1988, six potential target anomalies were identified. These anomalies were compared to the results obtained from the 1990 survey and five were found to have a very general match and were included in the total of 15 anomalies chosen for investigation.

Acoustic Subsurface Probe

The ASP (Acoustic Subsurface Probe) is an experimental prototype designed by Applied Sonics Corporation to image what lies beneath the river bed using low-frequency sound pulses. Objects buried in the river bed that are more dense than the sediments surrounding them will reflect part of the sound energy back to a transducer suspended from the survey boat. The reflected signals are then processed by a computer that produces a video display in which objects buried in the river bed are differentiated according to density. Although the ASP was deployed practically every day for a month, it failed to produce useful information. The operator and designers of the ASP are suspicious that the subsurface environment of Rio Belen may compromise the effectiveness of any subbottom penetrating sonar. In the process of excavating and probing in various locations on the river bottom, we encountered layers of leaves and vegetable matter between sediment beds. Each time we penetrated these layers an eruption of bubbles was released, the gaseous by-products of decomposition. The layers themselves are virtually transparent to low-frequency acoustic signals, but pockets of gas trapped beneath them apparently absorbs the ASP's signals preventing imaging below the layers.

Probe Barge Survey

A simple search tool of our own design and manufacture used with great effectiveness and reliability this season was the probe barge (Figure 6). The barge is capable of lowering four pipe probes simultaneously in a square pattern two meters on a side. Two-meter spacing between probes insures that a ballast mound three meters wide and twelve meters long would be encountered by more than one probe, regardless of its orientation.

An on-board pump supplied water to each probe through a manifold. Water jetted from the open end of each probe facilitated penetration. In operation, each probe either passed through the sediments unhindered to its full length, or was stopped by contact with a denser object. When a probe failed to penetrate the sediments, the crew could determine the type of obstruction, e.g., wood, rock or gravel, by tapping the object with the end of the probe. Samples of wood could be recovered by turning off the flow of water and ramming the obstruction hard enough to capture a plug in the 2.5-centimeter inside diameter of the probe. The barge crew chief logged the locations of all obstructions encountered on a simple chart. The occurrence of a cluster of obstructions along one lane or in adjacent lanes was marked on the chart as an anomaly worthy of further investigation.

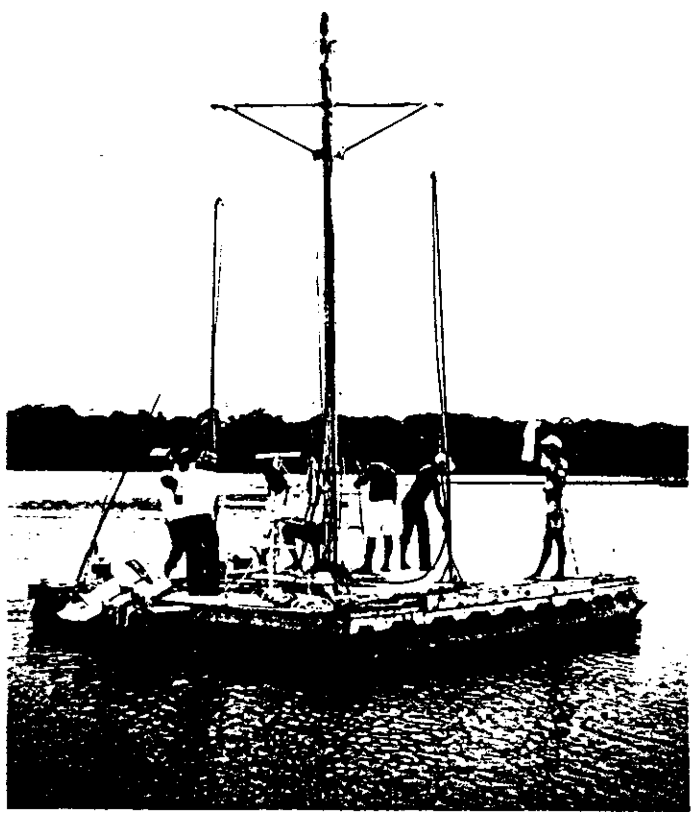

Figure 6. Probe barge in operation in the North Bay.

The barge progressed in a straight line by raising three of its probes and rotating 180 degrees on the fourth probe. A pair of pole men provided a slow, steady rotation. To keep the barge on course, the crew chief sighted along the pivot probe and the probe directly behind it. When the two probes on the barge lined up with the two range poles the crew chief gave the order to drop the other three probes and the process started over. The degree of accuracy achieved by this simple navigation method was astounding. In one test, after covering a distance of 40 meters in 20 revolutions the probe holes were found to be less than 50 centimeters off in the direction of travel and only 20 centimeters off the transverse axis. On a good day the probe barge crew could log 900 probes; the record was 1100! While it was originally planned to log the depth that each probe penetrated, this proved to be unnecessary. The vast majority of the probes sank to their maximum depth of penetration.

Designed and constructed in Texas, the probe barge required about one week to assemble in Rio Belen. About a week was lost to repairs and maintenance and about three weeks of experimentation were necessary before the barge and its crew achieved optimum performance. In the remaining seven weeks the probe barge completely tested the western side of the North Bay, sinking more than 26,000 probes (Figure 7).

Excavation and Underwater Survey

A second pre-fabricated barge was constructed to support diving and excavation operations (Figure 8). The barge was equipped with a 10-centimeter suction dredge with a water-jet cutting head, a 15-centimeter water-induction dredge, and a high-capacity low-pressure breathing air compressor. The 10-centimeter dredge is for the removal of fine silts while the larger, more powerful dredge is intended to remove heavy overburden. The air compressor is used in conjunction with a hookah, which allows divers unlimited excavation time without the necessity of using scuba cylinders.

A team of divers conducted a visual reconnaissance of the river channel from a position approximately one kilometer upstream to the mouth of the river. The diving team encountered a relatively featureless sand and mud bottom in the channel until reaching the vicinity of the sand spit. Here, deep craters, apparently caused by tidal eddies, break channel floor. Between the sand spit and the large hill at the river mouth, currents sweep the bottom clean, exposing large boulder conglomerates overlying a pavement of rounded rocks. Although identical to ballast stones in appearance, these rounded rocks are a naturally-occurring geologic phenomenon.

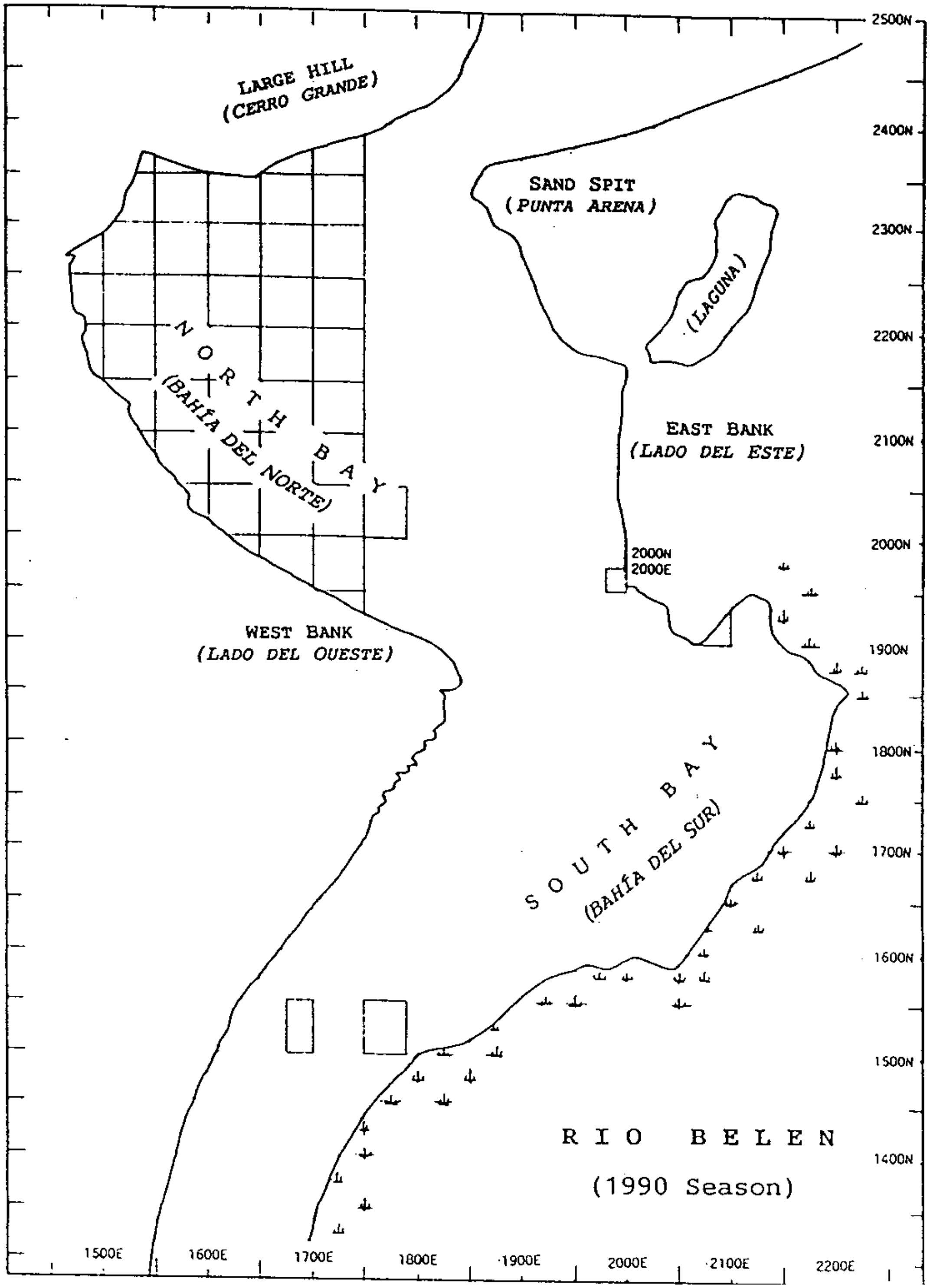

Figure 7. Portions of Rio Belen covered by the probe barge during the 1990 survey overlaid by a 50-meter by 50-meter grid.

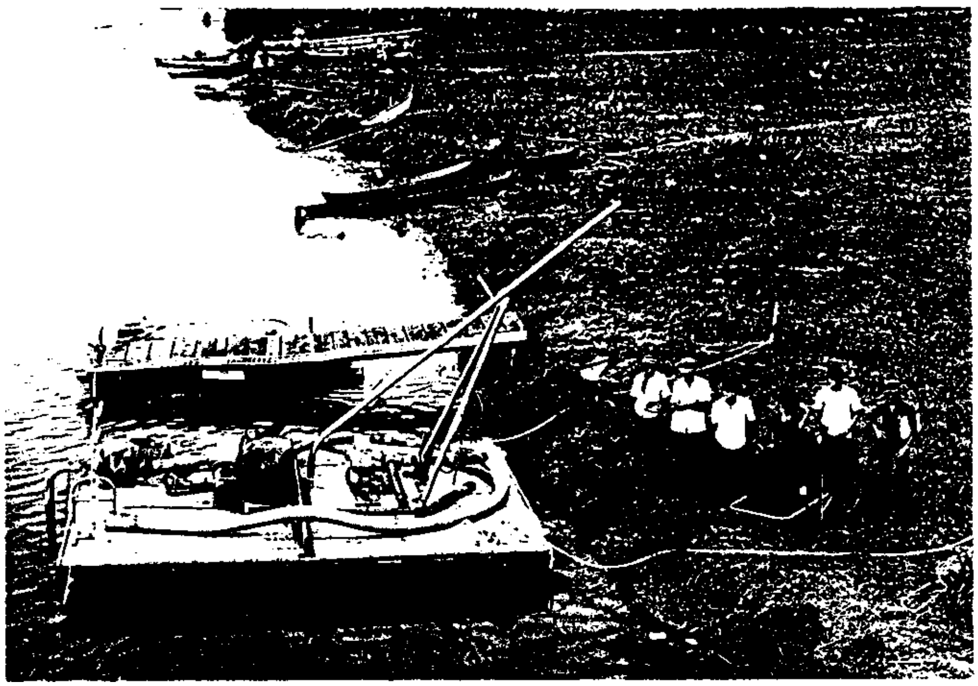

Figure 8. Excavation barge after assembly. A flexible 15-centimeter induction dredge hose wraps around the lifting frame, pumps and air compressor. The floating dock is in the background.

FIELD HEADQUARTERS

Realizing that a systematic, scientific search and excavation of *Gallega* would require several years, we built a field headquarters in Santa Maria de Belen in 1988. The headquarters accommodates our archaeological staff during field seasons and is used to store our equipment between seasons. In 1990 the headquarters was expanded by adding a storehouse, a dock, a fuel depot and a building to house our generators and air compressor station (Figure 9). Like the expedition field house, these structures will become the property of the community when the *Gallega* project is finished.

In addition to providing full-time and part-time employment for many of the people of Santa Maria de Belen, the 1990 season provided other benefits to the community. Throughout the season our headquarters single side band radio (SSB) served an important function as a communication link with PROESA in Panama City and with the other Atlantic coast communities in the area. Expedition medical doctor Randel Davis assisted local doctor Manuel Gonzales and supplied antibiotics and other medicines to his clinic. At the end of the season, the Rio Belen medical clinic and the SSB radio stations maintained by PROESA received a donation of 20 automobile batteries. The medical clinic also received a donation of surplus gasoline. Various civic groups in the village recieved a donation of food that would not keep until the next season. In our absence, the community continues to benefit from use of the dock and gasoline storage shed.

A large amount of equipment was left in storage in our field headquarters. Only cameras, electronic equipment, radios, and personal dive gear were taken out at the end of the season. The two barges were stripped of their engines and other equipment and anchored in the South Bay in the calmest, safest part of the river.

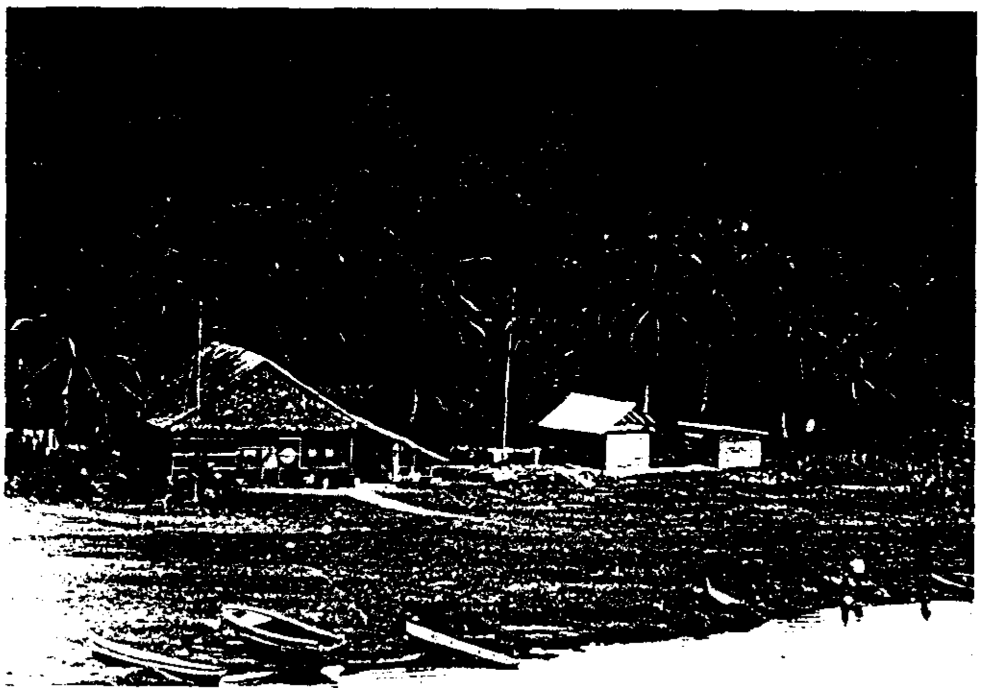

Figure 9. Field headquarters in Rio Belen: main field house (left), compressor and generator shed (center), and fuel depot (right). The single side band radio aerial is stretched between two tall poles in front of the house.

FILM AND PHOTO DOCUMENTATION

An effort was made to record all aspects of the field work on 35mm color and black and white film, as well as on 16mm movie film. Approximately 2,400 meters of 16mm movie film were shot on the surface and underwater; however, due to budget restrictions we were not able to record sound with the film. The filming was done to make an educational documentary about Columbus' debacle at *Rio* Belen and Ships of Discovery's search for *Gallega.* In addition to recording the elements of the search, filming was done at other locations near *Rio* Belen where events important to the Columbus story occurred. They are: a site on *Rio* Veraguas which may have been the village of the Indians who attacked and drove out the Spanish; an abandoned nineteenth-century mine far *up Rio* Belen, the location of which may have been the source of the gold the Indians showed Columbus' men, and hence the reason they decided to establish an outpost there; and the mouth of *Rio* Escribano where a bronze stirrup was found, possibly lost by the conquistadors of the Nicuesa expedition who saw the hulk of *Gallega* seven years after Columbus discovered *Rio* Belen.

The raw movie footage has been developed, printed and transferred to video for review and editing. A short, narrated video tape has been produced to show our sponsors the nature of the search, but no other film product has resulted. Ships of Discovery is trying to find sponsorship for an hour long documentary film on the mystery of the caravel and the search for *Gallega.* Aired on public broadcasting, such a film will reach more people than the traditional approaches most often used by archaeologists: scientific journals, popular magazines and books.

RESULTS AND FUTURE PLANS

Results

The highest priority of the 1990 season was to complete a detailed gradiometer survey of the search area. Lower priorities were assigned to the probe barge and ASP surveys. Provision was made to excavate potential targets discovered by the remote sensing surveys. There were two departures from the plan of work: no bathymetric survey of the river was attempted and a terrestrial magnetic survey encompassing 12,500 square meters on the east bank was initiated. The season was stretched to 12 weeks duration in order to accomplish as much as possible.

A gradiometer survey of the river was begun, but technical problems with both the magnetometers and navigating equipment forced us to scale back to a simple single-magnetometer survey. Due to equipment failures, the appropriateness of the gradiometer technique for the search for *Gallega* was never accurately assessed, but a magnetometer survey of the entire search area, approximately 350,000 square meters was completed. The magnetic survey information was processed in the field and maps showing the locations of anomalies were produced. Fifteen anomalies were deemed worthy of further investigation; two were excavated and thirteen were tested by the probe barge. Further analysis and reduction of the magnetic *survey* information using programs and equipment not available to us in the field may reveal additional, more subtle targets.

Unable to image objects below the river bottom, the Acoustic Subsurface Probe requires further research, development and testing. In contrast, the probe barge proved to be the most effective and reliable tool at our disposal this season. Operated by a team of Belenenos, the probe barge exceeded our expectations with regard to reliability, durability, and speed. The team quickly became adept at determining the nature of the objects the probes encountered and were able to differentiate between wood, stone and gravel. The barge tested the west side of the North Bay (refer to Figure 7) as well as magnetometer targets In the South Bay, effectively eliminating the possibility that *Gallega's* ballast mound lies within 4 meters of the surface in the 30,000-square meter area surveyed (Figure 10). While probing the west side of the North Bay, the barge encountered four areas where an obstruction buried in the river bottom stopped more than one probe in one or more adjacent lanes. Each of these targets was excavated, and in each case the obstruction was determined to be either accumulations of rocks weathered from the high hills or concentrations of tree trunks and limbs, both apparently natural occurrences.

The probe barge tested and eliminated six magnetometer targets as well; two each in the west and east sides of the North Bay and two in the South Bay (Figure 10). The two targets on the west side of the North Bay were located in deeper water just east of the contiguous area covered by the probe. Systematic probing here revealed a bed of gravel. The two targets on the east side of the North Bay were adjacent to the shoreline near the end of the runway. The probes encountered both wood and stone, but subsequent excavation revealed that these were natural deposits. Testing the two magnetic anomalies in the South Bay, the probe barge again encountered beds of gravel. Seven additional magnetic anomalies, all in the South Bay, remain to be probed.

Test excavation of potential targets located during the probing and the gradiometer surveys occurred throughout the field season. Although the larger dredge. enabled us to dig pits as deep as 3 meters into the river bottom, no cultural materials thought to be associated with *Gallega* were discovered. Deeply buried organic materials such as tree trunks and foliage found in the excavations were typically extremely well-preserved. Excavations at the foot of the hills on the west side of the river revealed a steeply-inclined "talus," which apparently accumulated as stones weathered from the hill and sank into the muddy bottom.

Test excavations were conducted on a total of seven targets: four discovered by the magnetometer and three by the probe barge (refer to Figure 10). Excavation of the four magnetometer targets, two in the South Bay and two on the east side

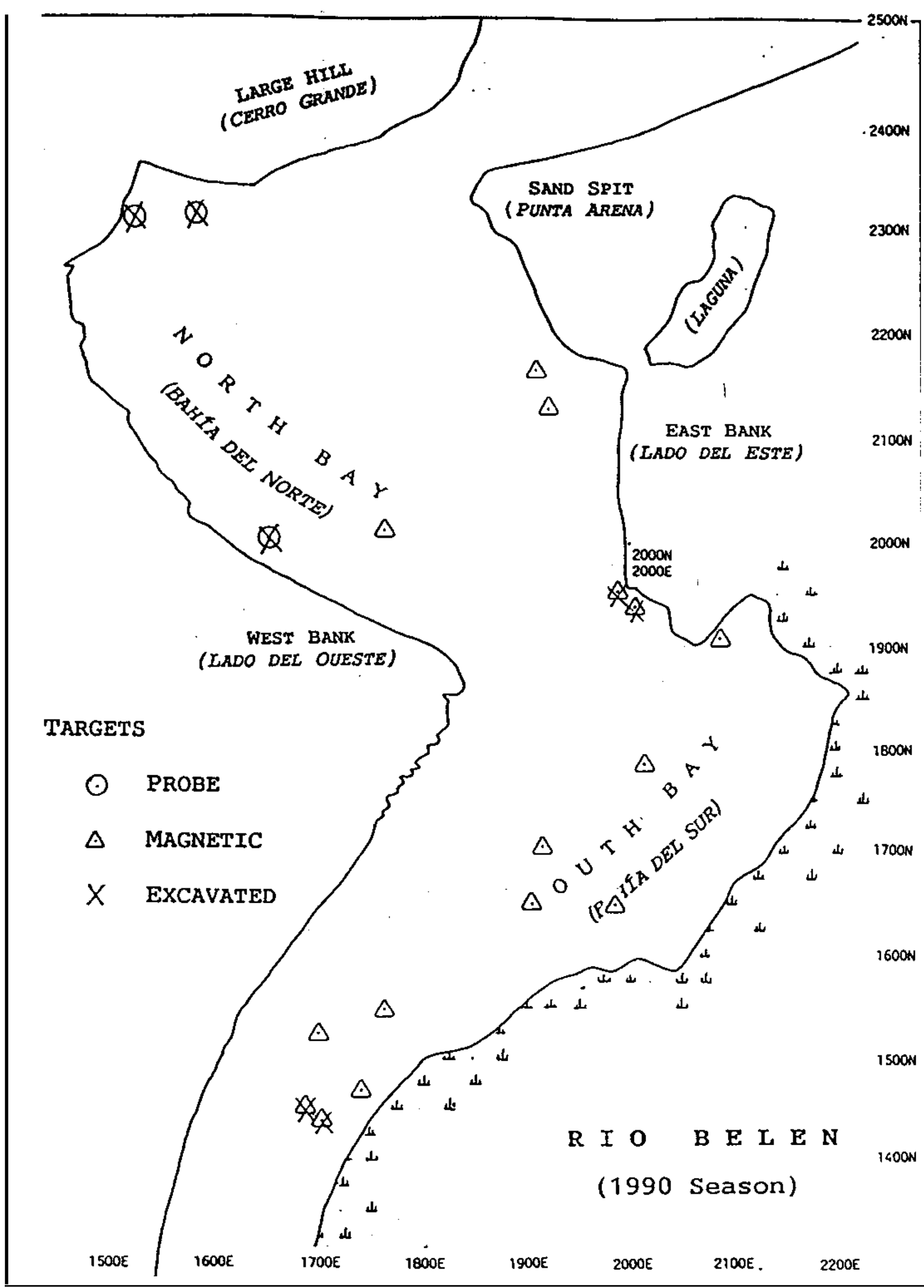

Figure 10. Base map showing magnetic and probe barge targets and test excavation locations, 1990 season.

of the North Bay, were inconclusive. Our failure to discover the sources of any of the anomalies may have been due to the limitations of our ability to excavate deep, large test pits, or to the possibility that the source of the anomalies was naturally-occurring magnetic sand or gravel that we could not differentiate from the rest of the sediments in the low visibility of the test pit. In contrast, the sources of the probe barge targets were easily discovered. Wood and stone were found at all three targets, but no shipwreck materials were discovered.

The visual underwater reconnaissance produced three important observations. First, while the bays and most of the length of the river channel are relatively stable, the deep channel between the sand spit and the large hill on the west side of the river appears to be fairly dynamic. Secondly, throughout most of the search area dense, salty sea water lies under the fresh river water. A modern machete found exposed on the river bottom between the sand spit and the large hill provides a relative measure of the rate of oxidization of iron in the river. The steel blade of the machete had disintegrated entirely, leaving only a fragile crust of corrosion products. If the small iron artifacts associated with *Gallega* suffered the same fate, the amount of metallic iron preserved in them may be insufficient to produce a detectable magnetic anomaly. Lastly, the presence of naturally-occurring deposits of rounded rocks, similar to ballast stones, at the bases of the large and small hills provides a zone where *Gallega's* ballast mound could be masked.

As a non-profit, educational and research institution, Ships of Discovery is charged with the responsibility to communicate the results of its research to the public and to other archaeologists alike. For this reason, a great deal of effort was put into filming the 1990 season of the search for *Gallega.* The immediate product of this effort will be a one-hour documentary film about Columbus' debacle at Rio Belen and Ships of Discovery's search for *Gallega.* Parts of the film will be edited together with footage from other Ships of Discovery projects to make a longer documentary about our overall research program.

<u>Future Plans</u>

The 1990 search for *Gallega* failed to discover any trace of the ship. However, there is a good deal of additional analysis yet to be performed on the data we obtained and a considerable amount of work still remains to be performed in the field (Figure 11). The magnetic survey should be extended to include both banks of the river; the west side because that is probably where Columbus' men built Santa Maria de Belen, and the east side because *Gallega* may lie partially or completely beneath the bank. Systematic probing for *Gallega's* ballast mound should continue, as should excavation of the targets discovered in 1990. Excavations on land should be resumed. Searches using promising new techniques should be undertaken.

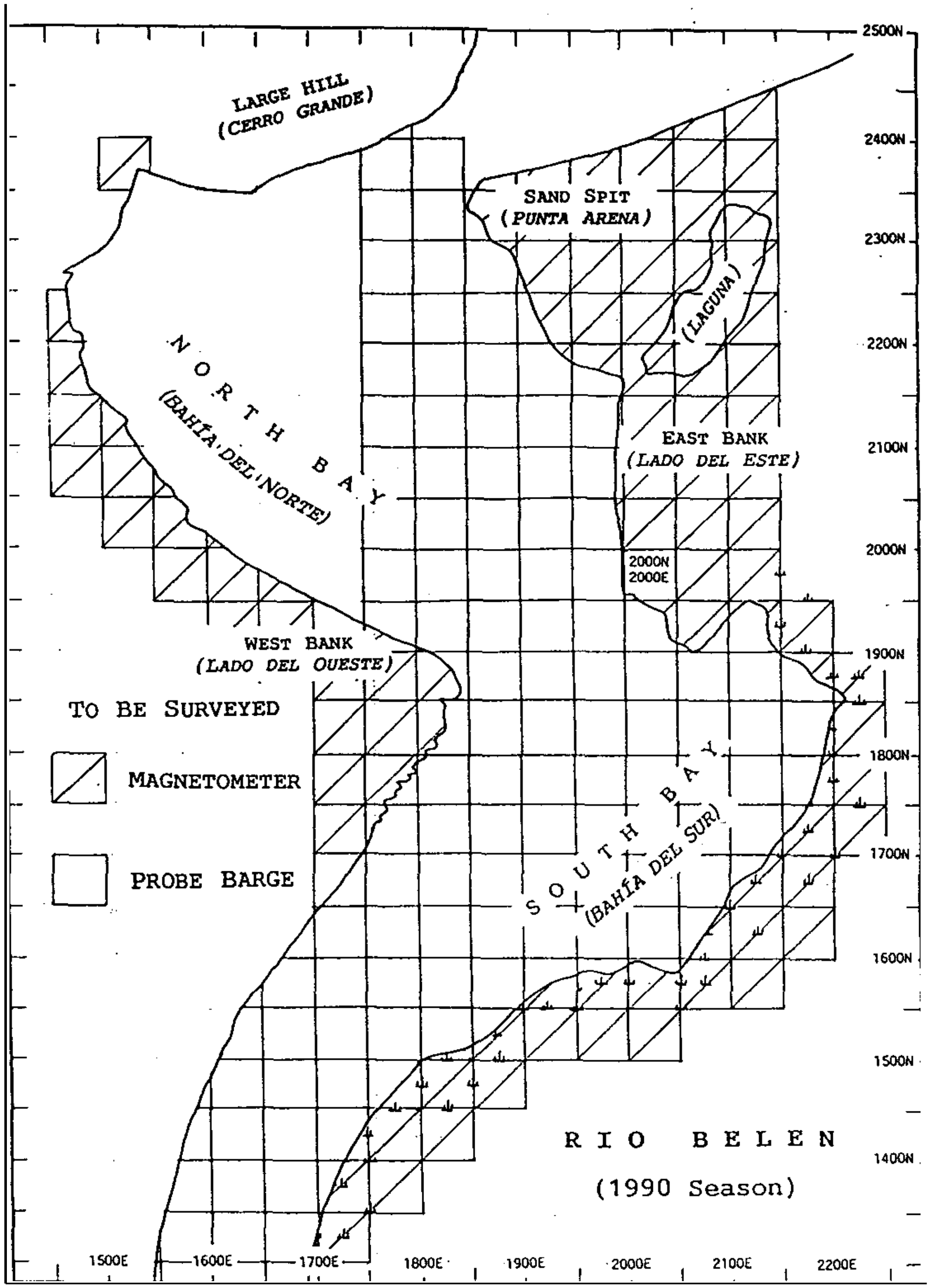

Figure 11. Areas to be probed and magnetically surveyed in future field seasons.

The cost of any search efforts at Rio Belen subsequent to the 1990 season will be greatly reduced as a result of the fact that virtually all of the supplies and equipment brought in for the 1990 season were left in storage there. Additionally, less set-up and preparation lead time will be required because the barges are already constructed and their crews do not need training. Air transportation for crew and volunteers, comprising a third of the 1990 budget, will be considerably reduced as because Belenenos can perform most of the necessary tasks involved in the search.

Although the 1990 magnetic survey was plagued with technical problems, primarily the result of the vulnerability of delicate electronic instruments to heat, humidity and unavoidable rough handling, these can be overcome. Future magnetic surveys should be supplied with an abundance of back-up equipment, including a minimum of four magnetometers. As a control on all surveys, one magnetometer should be dedicated to serve as a base station. A self-contained, submersible magnetometer would enable excavators to better locate and identify the sources of magnetic anomalies underwater.

Some replacement parts and additional supplies will be required to reactivate the probe barge. Following replacement of its probes and rigging, the probe barge will be ready to resume working in the South Bay and the east side of the North Bay. The shallow areas of both bays -- the highest probability zones -- will be probed first. Following installation of longer probes the deeper portions of the river can be probed to a depth of 9 meters below the surface. Because the area remaining to be probed is approximately three times the size of the area tested during the 1990 season, it is anticipated that 21 weeks will be required to finish the entire search area.

Subsurface scanning sonar offers the possibility for rapid scanning of the search area with a minimum of effort; however, no suitable commercially-available unit has been located so far. The problems associated with using subsurface penetrating sonar in Rio Belen involve the physical limitations imposed by water depth and sediment composition. In the shallow waters of the North and South Bays, echoes produced by sound reflecting off the water surface can obscure large zones below the surface of the river bed. Sonar sound pulses propagate efficiently through water, but are absorbed when they encounter gas pockets. Our excavations revealed that the sediments of Rio Belen typically contain large amounts of gas produced by the slow decomposition of organic matter so there is the distinct possibility that the effectiveness of any sonar will be limited throughout large portions of the search area.

Like the probe barge, the excavation barge will be easy to reactivate. However, it needs the addition of a more powerful excavation device. Although a larger dredge greatly increased our excavation capacity in 1990, it is evident that another type of excavation tool will be needed to uncover large areas. The excavation barge could be modified to carry a propwash deflector powered by an outboard engine. If the barge were equipped with heavy mushroom anchors, it could be positioned precisely over a target on a four-point mooring.

The discovery of fragments of coarse melado and morisco green earthenware at the old well in 1989 are still our best indicators of the presence of Spanish visitors to Rio Belen early in the sixteenth century. Additional excavations in the vicinity of the well may provide us with clues to the location of Santa Maria de Belen, which in turn could help us locate *Gallega.*

ACKNOWLEDGEMENTS

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The 1990 season was conducted under the auspices of the Panamanian Instituto Nacional de Cultura, directed by Lcda. Julia R. de Wolfschoon, and Nacional del Patrimonio Histörico, directed by Prof. Marcela Camargo. Logistical support and radio communications with the outside world were provided by Ella Valdez and Marcos Antonio Perez of Proyectos Especiales del Atlantico (PROESA). The Hon. Hermann Gnaegy, director of PROESA, gave the project his blessing and friendship. Sr. Luis Alvarado helped us keep in touch with our headquarters in the U.S. by relaying via telephone our radio messages to Panama City.

None of the work this season would have been possible without the enthusiastic support and cooperation of the people of Santa Maria de Belen. Special recognition goes to Sr. Herminio Mata, the project foreman in Rio Belen, and to Sr. Arturo Sanders, mayor of Santa Maria de Belen and probe barge crew chief. Dr. Manuel Gonzalez Reyes assisted the project on numerous occasions, loaning us his boat and engine to make the long passage by sea from Rio Belen to Colon. Congratulations also must be extended to the four Belenenos who began each day an hour before the rest of us in order to take a formal diving course offered by NAUI instructor and expeditioneer Maria Teresa Morfin.

To the expedition participants, many of whom were unpaid volunteers, goes credit for any successes achieved. Special recognition goes to Pilar Luna E. and Santiago Analco R. who put aside their responsibilities with the Underwater Archaeology section of the Mexican National Institute of Anthropology and History to assist us. Engineer Michal Birdsell should be recognized as the man who translated the probe barge from an idea to reality. The expedition actually began with the months of planning and preparation that preceded our arrival in Panama. Credit for the successful completion of this part of the project belongs to Ric Hajovsky and Marie-France Lemire. Ships staff members Joe Simmons and Denise Lakey maintained headquarters while the rest of us were in Rio Belen. Volunteer John C. Griggs deserves special recognition as both the hardest-working member of the team and the one who worked the longest.

The loan of a state-of-the-art PTS-III total station survey system from Pentax corporation enabled the project to institute a new mapping system based on coordinates. EG&G Geometrics provided remarkable field support for the project magnetometers. Applied Sonics donated use of the experimental ASP as well as its operator. The expedition leased the positioning and telemetry systems used initially for the magnetic *survey* from InterNav of Houston.

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APPENDIX I: LIST OF PARTICIPANTS

(Alphabetical order)

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